Kennesaw State University

Final Design Review

Senior Design

Team: We Got the Power

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Executive Summary

We Got the Power (WGP) is an industrial engineering consulting firm that has been tasked by Mercedes-Benz USA, a luxury car company, to optimize their parts distribution centers (PDC) labor planning dashboards. The company's current dashboard has an abundance of manual entry, is not easily accessible by all necessary employees, and is also not supported by its business intelligence team. WGP was initially asked to move the dashboard to PowerBI, a powerful visualization tool, with the goal of the software being more user-friendly, having a better way of collecting historical data, better visualizations, and being easily accessible by employees. After conducting preliminary research and testing WGP found that PowerBI would not be a better choice for the dashboard as the manual entry was too abundant and much of the team lacked experience in PowerBI. The estimated time it takes to manually enter employees into the dashboard each morning is 2 hours. As a result, WGP decided to focus on the major manual entry sections of the dashboard: Inbound and Outbound, by finding ways to reduce manual entry and automate the dashboard. WGP created three assignment problems: General, Inbound, and Outbound. The General Assignment Problem pulls information from the PDCs training document to place employees within Inbound and Outbound based on their experience within those sections. The Inbound and Outbound Assignment Problems pull headcount information from the original dashboard as well as training information from the General Assignment Problem to place employees into the subtasks of each section based on their level of experience. In addition to these Assignment Problems, WGP created a Manual Entry Check that would allow leadership to document unavailable employees and if they wanted a specific employee to work a hybrid schedule. Macros were added to this sheet so that once all the information was entered and estimated labor totals match the three assignment problems would automatically run and update into a Dashboard sheet. The Dashboard is automatically updated each time the “Assignment Problem” macro is done and reflects labor planning for the PDC for that day. On a new day, the Manual Entry Check can be cleared by the “Clear Manual Entry” macro which gives the Manager a clean sheet to start the new day and the “Refresh Dashboard” macro that would refresh the dashboard after each “Assignment Problem” macro is run. To address historical data concerns, WGP created a “Save Copy of Dashboard” macro that would save to a shared folder and keep the dashboard from the previous workday. Due to the differences in PDC operations and the number of workers, WGP worked closely with the smallest PDC, Chicago, and used them as a case study for this project. WGP believes that their solution would be optimal for labor planning for the PDCs as the time taken for manual entry is dramatically reduced and after meeting with the leadership team, they also agreed that the teams' solution is something that can be rolled out to the other PDCs.

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Chapter 1: Background and Overview

1.1 Introduction

We Got the Power (WGP) is an industrial engineering design firm that is centered around optimization and supply chain. The objective of this project is to design a solution for labor planning dashboards that can be used by any automotive distribution center. WGP is collaborating with the Business Intelligence (BI) team and Parts Distribution Center (PDC) teams that are associated with a Mercedes-Benz USA. Mercedes-Benz USA focuses on designing vehicles with competitive features and technologies at relatively low costs while maintaining its goals and key principles. The final goal of this project is to provide a non-manual entry labor planning dashboard for the PDCs to work simultaneously with limited human errors that can provide essential information for the company. By doing so, it can interpret data in simple terms to aid decision-making that can improve productivity, identify root causes, and optimize the current process.

1.2 Overview

Over the year, the Mercedes-Benz USA's PDCs [Fig. 1] have been utilizing an Excel spreadsheet as a dashboard to report data on Inbound and Outbound. PDCs are facing challenges and barriers that are preventing them from optimizing their current dashboard. Now, only one individual at each PDCs can view and make edits to the dashboard, which limits the number of users, so it makes it difficult for multiple users to work on it simultaneously. Also, the managers at the PDCs have recognized there are common human errors when using the current dashboard since they are manually inputting some data. Therefore, the team has been tasked with optimizing labor output for Inbound and Outbound tasks while minimizing manual entry associated with the current process.

Figure 1- Map of PDCs

1.3 Objective

To optimize the current labor planning dashboard that is created in Excel. WGP shall optimize labor output by maximizing labor hours for each Inbound and Outbound task for the PDCs. To do so the team will be utilizing software like Excel with associated add-ins to create assignment problems that will optimize labor while minimizing manual entry into the dashboard. WGP intends for the new dashboard to reduce the manual process of the current dashboard, add data collaboration, visualization, and address some real-time update issues that are in the current daily labor plan dashboard.

1.4 Justification

For any company that has a warehouse or parts distribution center to stay competitive the company must have enough labor and proper scheduling to run efficiently. Most distribution centers or warehouses run into many day-to-day issues like limited resources, demand, machine maintenance, worker skill, availability, etc. [12]. Creating the perfect balance, in a schedule, to meet company metrics is what helps a company stay competitive. Not only does the company stay competitive but it allows for smoother operations in labor workflow and communication across departments. Proper planning/scheduling can increase overall performance and provide real-time updates that help leadership catch issues before they disrupt daily operations. Implementation of a proper labor plan or schedule will not only help in this project but can help any business, automotive or otherwise, increase productivity, planning, and performance.

1.5 Problem Statement

The PDC teams create a daily plan to determine where to place warehouse labor based on the Inbound and Outbound volume for the day. The PDC currently creates these plans using an Excel template. While the Excel template is useful, it is very manual and can be slow to use due to macros and connectivity to the database. It also uses a database that is not supported by the Business Intelligence Team. WGP shall discover what strategies to implement that will meet PDC requirements while also being able to optimize labor output and minimize manual entry. To this end, WGP shall find what tasks are necessary within the PDC's Inbound and Outbound process, how much labor is essential for each process, how to create constraints that will assist with added or missing labor, and how to remove the manual process in the most efficient way possible.

1.6 Challenges

Initially, WGP was tasked to move the dashboard into PowerBI. PowerBI is a powerful visualization tool and would have been a great transition for the company. However, because of the abundance of manual entries in their current dashboard and the team's lack of knowledge in the software, WGP decided to focus on reducing the abundance of manual entries in the Inbound and Outbound sections of the labor planning dashboard. Another considerable challenge that WGP faced was being able to meet the requirements for each PDC. While all the PDC have the same common goal, how they reach that goal is different in each of the locations [Fig. 1]. For this project, the team decided to use the smallest PDC, in Chicago, as a case study. The next

challenge is creating an assignment problem that will accommodate changing variables and constraints unique to each PDC and labor task assignment for each day.

1.7 Progress Improvement

WGP focused on finding a way to implement an assignment problem that will allocate the companies employees in an ideal section per day based on factors such as meeting production, level of expertise of each employee, unavailable employees, etc. The team came across some issues when creating the assignment problem, such as variable constraints and removing and adding new employees without major changes and were able to find solutions to these recurring issues. For instance, the embedded macros that would update the dashboard within their respective areas and display a visual aid of assigned tasks to employees. While also creating an assignment problem that assigns employees to a familiar task and combats daily issues that may occur at the PDC. WGP was given a training matrix by one of the PDCs, which the team used to delegate and determine the classification of each employee based on their level of expertise, established a range of levels, and integrated it within the assignment problems. WGP identified real-life scenarios that can occur, such as employees calling out, new employees joining the company, production being higher than usual, etc. These scenarios were addressed by implementing macros that coordinate with the visual dashboard and assignment problems. WGP adjusted the assignment problem and met the needs of the PDC by keeping it up-to-date and making it accessible for supervisors to navigate.

Chapter 2: Literature Review

2.1 Literature Review

Dashboard Design: Why Design is Important

There are several key factors to think about when designing a dashboard for metrics. Dashboards are used to communicate key information to users and make supporting information easily accessible. The most important step is understanding what the users need the dashboard to be able to do. Richard Brath and Michael Peters explain the importance of spending time in the beginning to meet with users and completely understand what they need. They also highly recommend the use of mockups, sketches, or prototypes to reduce the risk of delivering the wrong solution. The last principle the authors put emphasis on is creativity, they explain that without creativity there can be no increase in efficiency.

An Application of Lean Assessment in a Cross-Docking Distribution Center

Ammar Aamer conducted an analysis using lean principles on a Distribution Center to minimize waste and decrease lead times for a DC operation plant in the USA. After conducting initial data collection and analysis Aamer concluded that planning and staffing were by far the most critical issues leading to long lead times. In his case study, he saw a majority of supervisors had no labor plan and instead relied on previous experience. This conclusion highlights the importance of standardization documents and effective system implementation.

Workforce Planning and Scheduling for the HP IT Services Business

This paper highlights the findings from Cipriano Santos and his teams' investigation of daily labor planning to solve the problem of matching employees with job requirements. In their case study of a Parts Delivery Center, they propose a plan to face uncertainty in supply and demand. First, they identify the center's main funnel of opportunities. This is a term that describes the pipeline of potential projects. Supply and Demand Consolidation is then used to map job requirements into a string of job opportunities. The team's solution approach investigates mixed integer programming and was implemented at the Global Delivery Applications Center in Bangalore India.

Optimization of Assignment Plan of Workers to Job in Kere Farms

A poultry farm named Princess Kere Farms utilized and implemented a type of assignment problem, so they can assign their workers to job(s) that will minimize the hours of labor to be more efficient and productive. For this case, the Hungarian method was utilized to achieve their end goal by assigning workers to a job that would maximize the efficiency of production while decreasing the overall cost associated. An assignment problem's objective is to delegate the number of jobs to the number of employees at a minimum cost/time. In this project, the PDCs are trying to come up with a solution or way to implement a similar process so they may utilize their resources in the most efficient way. This case gives us an overview of where we should begin with our assignment problem and have an idea of what direction we are heading. However, there are some constraints that need to be accounted for the assignment problem to give us an accurate solution. The PDCs need to take into consideration the constraints and variables that will play a role in the assignment problem.

Scheduling Medical Residents to Rotations: Solving the Large-Scale Multiperiod Staff Assignment Problem

The article "Scheduling Medical Residents to Rotations: Solving the Large-Scale Multiperiod Staff Assignment Problem" by Lori Franz addresses the challenge of staffing medical residencies efficiently. The author highlights the complexity of the problem due to factors such as varying resident specialties, constraints on work hours, and the need to balance workload across rotations. The study proposes a mathematical model that uses linear programming to optimize resident schedules, considering factors such as the size of the residency program, the duration of rotations, and the number of residents in each specialty. The model was tested on real-world data from a large academic medical center and showed significant improvements in efficiency compared to traditional scheduling methods. The article emphasizes the importance of using advanced analytics to solve complex scheduling problems in the healthcare industry, particularly in the context of medical residency programs. Overall, the article provides a comprehensive overview of the challenges of large-scale staff assignment problems in medical residency programs and highlights the potential benefits of using mathematical models to optimize staff schedules.

Solving a Dynamic Assignment Problem in the Socio-Economic System

The article "Solving a dynamic assignment problem in the socio-economic system" by Irina Zaitseva aims to solve a dynamic assignment problem in a socio-economic system. The study highlights the complexity of the problem and the need to consider multiple factors such as resource allocation, time constraints, and decision-making processes. The proposed approach uses a multi-agent system with intelligent agents that can learn from past experiences and adapt to changing conditions. The study presents a case study of the assignment problem in the healthcare system and shows the effectiveness of the proposed approach in improving resource allocation and reducing waiting times for patients. The findings of this study have important implications for large-scale assignment problems in socio-economic systems, as the proposed approach can be applied to a wide range of domains such as transportation, logistics, and supply chain management. Overall, the article provides a comprehensive overview of the challenges of dynamic assignment problems and presents a promising approach to solving them using intelligent agents.

The Multi-skilled Multi-period Workforce Assignment Problem

A multi-skilled workforce management (MSWM) problem was used to assign cross-trained workers to multiple jobs. Our project's purpose is to assign the employees to certain jobs within Outbound and Inbound and place the employees that are cross trained in different areas in those locations that they are the most proficient in. This paper demonstrates the way they were able to implement this type of assignment problem by assigning cross trained workers to various jobs and that is the direction this project is heading. Since the number of times the variables will change, we need to take that into account when creating an assignment whether the employees are trained and available. They used a multiple-period production model to help solve the issues they were having as an agriculture company by maximizing the number of employees to more

than one job depending on the level of expertise the employees obtained. They were able to minimize the overall cost and our project also focused on trying to reach the target when it comes to the lines per hour, but we are finding ways to find that solution. Also, maximizing the labor output while minimizing manual input and this paper explains how they were able to implement these two by utilizing a multiple period production modem and a multi-skilled workforce management problem.

Using MS Power BI Tools in the University Management System to Deepen the Value Proposition

The university implemented Power BI and built a dashboard to see if that approach will improve the efficiency of the university management and their decisions on the value proposition [9]. Power BI created graphs and charts with the data it was given and identified some problems in the university management system. The university focus was on educational programs on key consumer, differentiation of educational programs for the level of competitiveness, and educational services market to determine if it will have a lasting and positive impact on the university financially and if they are meeting the needs of the internal stakeholders. The university discovered with the aid of Power BI the necessary steps and decisions they need to make to fulfill their goals and resolve issues. To improve the quality of the process while proving the value proposition based on an established set of factors and meeting the demand of market.

Improving Company Performance by The Correctness of Management Decision through Implementation Dashboard using Power BI Tools (Case Study at Company Y)

Company Y's dashboard at the time implemented Power BI to help make management decisions to increase the company overall performance. Power BI can collect, process, and analyze data which can help companies make a decision based on the results Power BI can predict will occur in the future. It has the potential to discover future problems and propose solutions to avoid these issues. Also, it can be viewed by those who are allowed access and complied various sources into one integrated data package. Power BI can refer to historic data and give the company the chance to plan which gave Company Y to thoroughly analyze the Therefore, the implementation of Power BI can make decisions for companies that can lead to the improvement of the company and increase or manage productivity.

Developing Integrated Performance Dashboards with Power BI – a Case Study in a Medium-Size Manufacturer

Organizations are always finding and using ways to measure their performance to control their productivity so it's visible for management to allocate resources in an appropriate manner. Implementing Power BI in the dashboard can handle complex data, breakdown it into simple terms for users making it user-friendly, and easy to interpret to make decisions. It helps define short and long-term goals based on the visualizations and interpretations of the data shown. However, the key to a successful dashboard is creating a dashboard that is easy to understand and only contains essential information, because too much information can make it difficult and confusing for users which defeats the purpose. The strengths of Power BI include visualization for users to easily interpret data, create interactive reports, secured mobile applications making it easy to access it anytime and anywhere.

An Automated Data Analytics and Overall Equipment Effectiveness Visualization Technique for Assembly Line on Continuous Manufacturing System Using Power BI

In Thailand, the company implemented Power BI to analyze and visualize the Overall Equipment Effectiveness (OEE) of the assembly line on continuous manufacturing system. OEE optimizes limited resources and helps improve the performance in a company or business such as the quality of the product, efficiency, etc. There are three components that fall under OEE which are Availability Rate (A), Performance (P), and Quality Rate (Q). However, they even applied the Kaizen process into the project to strengthen the overall equipment effectiveness, so the focus of the project was to reduce loss. By doing so, they first identified the root causes of this recurring issue, where the losses are coming from, and explained the reasons they selected those losses to improve the OEE. They identified Power BI as one of the two top business intelligence due to the data visualization, user friendly, etc. Using Power BI, it can analyze, track, and visualize the OEE and the OEE loss by focusing on two parts: (1) Equipment: loading time, working hours, operating time, etc. and (2) Material: Input material by weight and number [13]. Power BI has two applications which is the Power BI Desktop and Power Query Editor which helps illustrate the data into graphs, charts, etc. and cleans/transform the data for the user to easily interpret and comprehend. For instance, it has features that can remove duplicates, change data type, and much more. In this project, Power BI created an interactive report and was able to identify the root cause of the problems that were happening in each station that were feeding into the assembly line. In result, the visualization made it easier for them to identify those issues and resolve it to improve the overall OEE that they were not able to determine prior to using Power BI.

Using Data Analytics and Visualization Dashboard for Engineering, Procurement, and Construction Project's Performance Assessment

This is a study in Engineering, Procurement, and Construction (EPC) project which implemented Power BI to analyze the performance of the construction company by breaking it down and analyzing the current situation, demonstrating root causes, etc. Also, encourages the use of proper data analytics and visualization to monitor performance which they were able to use for a construction company on its current state, evaluate it, and proposed decisions that can aid the company in the future regarding performance so they may plan accordingly. They state that using the proper and appropriate data visualization software along with worthy analytics method would result in the most favorable use of information for future expectations. Understanding what is essential to measure and record because it will be taken into consideration with other data to make proper decision. The main component for a successful outcome is for the use of data to be accurate so Power BI can give the appropriate findings and results, it is no use to utilize data that is using incorrect analytics techniques. Dashboards and Power BI work closely with one another which they used for this project and noticed a significant change. In other words, it was a game changer for the construction company since they transitioned from a traditional to a "data driven approach" and it has helped them make decisions based on the results.

Robotic Process Automation

RPA (Robotic Process Automation) as a technology automates already existing tasks, that are iterative and requires no change to an existing system. Today, where time and efficiency is the most sought after for success, RPA allows for the least amount of time, while also eliminating the human error factor. There are advantages and disadvantages which are the following:

Advantages –

1. RPA is easy to configure.

2. RPA interfaces work by simply dragging, dropping steps in a process. Ass uses drag and drop icons to automate a process, a code is generated automatically in the backend.
3. RPA software is non – invasive, it sits on top of existing systems – without the need to create, replace or further develop expensive platforms.
4. It accesses other computer systems the way a human does (through user interface)
5. RPA is enterprise safe.

Disadvantages –

1. Budgetary Reason: RPA provides stability and cost-effective work in the industry but due to the commercial version the RPA tool is so high.
2. Lack of technical ability: Many people believe that to use RPA, the end user should be technically sound.
3. Redundancy: Fear of "robots" will replace humans
4. Major changes: shifting a business system from traditional to a more advanced one might seem intuitive if not done with the correct tool. Could become more disruptive and less productive.

Dynamic Task Scheduling with Load Balancing using Hybrid Particle Swarm Optimization

This optimization method is used for solving the Task Assignment Problem. The problem of scheduling a set of dependent or independent tasks in a distributed computing system as well within an area. The meta heuristics included – Simulated Annealing algorithms, Genetic Algorithm, Hill Climbing, Tabu Search, Neutral Networks, Particle Swarm Optimization, and Ant Colony Algorithm. Load balancing algorithms are created to spread the load on processes by maximizing their utilization while minimizing the total task execution phase. Though it is subject to resource constraints. Each particle is evaluated by calculating a fitness function – this indicates the goodness of the schedule. Fitness function was given as:

Fitness (p_1) = (1/max span) x average utilization

- Where fitness (p_1), is the fitness function of the process – function used to evaluate the quality of the task assignment.

Objective function is a maximization problem; calculated the average of the total execution time of the set of tasks allocated per processor.

Objective function = max (sigma fitness (p_1)/m) m is the number of processors

The fitness value is being maximized and each element can be update by:

1. Generate the swarm
2. Initialize the personal best of each particle and the global best of the entire swarm
3. Evaluate the initial swarm using fitness function
4. Select personal best and global best of the swarm
5. Update the velocity and the position of each particle using equations
6. Obtain the optimal solution in the initial stage

7. Apply simulated annealing algorithm to further refine the solution
8. Repeat step 3 – step 7 until the maximum number of iterations specified
9. Obtain the optimal solution at the end

Business Intelligence in Manufacturing

Manufacturing planning encompasses the hourly/ daily / weekly/ monthly production and machine schedules across multiple plants or production lines to meet order or forecasted demand. To overcome the prime areas of concern for manufacturers like improving "order promising" through analysis of historical statistics, expected lead time, and inventory levels a business intelligence is the tool that will help achieve this. The dimension and measure of elements are combined into an OLAP "cube" for analysis. The OLAP (Online analytical processing) "cube" is powerful enough and specifically designed to do this without costly modifications to the architecture of a system. OLAP analysis allows manufactures to examine data across a broad set of subsets:

- Date/time
- Shift/crew/employee
- Supervisor
- Product
- Lot/batch
- Quality code
- Area/plant

Implementation of changes using OLAP focused on discoveries in factory output that increased by 40% over the next year. By giving the end users the ability to drill down into fact tables and examine, compare, and analyze data, BI will bridge the gap between the users and large data.

Automating Software

Continuous practices are often the software development of industry practices that enable organizations to frequently and reliably release new features and products. There are four major components that are vital elements for any Business Intelligence solutions within Database Deployments (Azure SQL Data warehouse):

- Deploying the objects to the target data factory
- Linked services; Datasets; Data Pipelines; Triggers reports visualization (Power Bi)
- Deploying and uploading the Power Bi reports
- Creating workspaces
- Adding users/access rights to the workspace
- Changing Dataset connection details

For the automation to be success the deployment of quality checks and data validation (automatically) is critical before a release of a Bi tool. The last deployment component is the Power Bi which is after quality testing. Once this is released, it will be available to business users. The organization should have at least one premium capacity. Continuous integration will

increase visibility, reduce overhead, increase consistency, and mitigate risk. Continuous delivery makes software release processes efficient and repeatable as possible.

Automated Task Scheduling for Automotive Industry

The automotive industry mostly focused on developing intelligent systems for enterprise resource planning, automated production systems, supply chain management, including order – to – delivery process, sales and operation planning, warehouse system automation, and just – in – time routing for delivery. The proposed task scheduling will help improve the quality of maintenance and reduce the time of servicing. Task scheduling is the allocation of resources over the time to perform tasks. Interval scheduling consists in the allocation of a time interval that is needed to complete a task. The Rapid Application Development approach consists of two main applications. The first application, Model – View – Controller is customized and responsible for the possibility of inputting tasks into the database. The second application is presenting these tasks to the proper screen that corresponds to the workstation dashboard. Ruby on Rails structure is based on three separate components:

1. Model: responsible for connecting to the database and its relational mapping
2. View: Presentation layer of data provided by the model via controller.
3. Controller: The intermediary component between the layers of the model and view

The application also adopts active records which controls the process between the database and the application; this allows a way to access the database and can be edited. The data entry application uses a PostgreSQL relational database that stores all the tasks and Heroku cloud platform. Then after the application displays the tasks on the screen. This system provided a working set of interconnected applications that dynamically work together.

Dashboard – Innovative Instrument for the Evaluation of Performance in Mining Industry

While having a dashboard is an innovative way for companies to keep track of day-to-day operations, we want to make sure that the dashboard does not overwhelm its user. According to Marian-Catalin and Ion [4] a dashboard is meant to focus on the most important value-generating activities for the organization. The information displayed within a dashboard needs to be effective. For an effective dashboard, it is necessary for it to contain key features and indicators to not overload the user with non-essential information.

The Dashboard and Performance Improvement of the Company

Dashboards should not only show what happens daily in the company, but they should also be able to let the user react quickly to problems that arise. Nicoleta [5] suggests that are four important functions of a dashboard: informing, warning, assessing and decisional. Informing to inform the manager of the state of the managed field, warnings for unfavorable situations or certain deviations from the norm, assessing the results, and deciding what pertinent information is sent to various hierarchic positions. There should also be consistency throughout the dashboard layout as well as the way it is monitored.

Data Visualization Techniques for real -time information – A Custom and Dynamic Dashboard for Analyzing Surveys' Results

In this article, different techniques for displaying visualizations in dashboards are explored. When creating a dashboard, we not only have to focus on the information that's going into it but how the information will be displayed. Using the right graphs and having the right layout are also essential to a dashboard's usefulness. Toasa et al. [16] uses six techniques for data visualization for surveys: auto charting, correlation matrix, network diagram, Sankey diagram, word cloud, and visualization for mobile devices. While the technique depends on the data being displayed, our team shall also investigate data visualization techniques that best fit the dashboard that we are creating.

Assembly line rebalancing and worker assignment considering ergonomic risks in an automotive parts manufacturing plant

To understand varying constraints and variables of the assignment problem WGP is creating we must understand why it's important for this project. We are creating an assignment problem that involves changes in production and demand in a PDC. We should consider creating a rebalancing problem that addresses these issues. Tolga Cimen et al [20] noted that due to changes in worker schedule, varying operation times due to workers and skill, ability, physical condition of the work this directly affects operation time for tasks. We want to eliminate as much variability in task assignments as possible and create an assignment problem that can be run by the PDC without a lot of manual effort.

New models and algorithms to solve integrated problems of production planning and control taking into account worker skills in flexible manufacturing systems

In the article by Norbert Toth et al [11], it addresses much of what we are facing in our own project, resources, and variability in the production process. For the PDC Outbound is the most important focus because it needs to be satisfied daily while Inbound tasks can roll over to the next day. How the PDC decides to delegate Inbound and Outbound tasks depends on both volume and labor output. We find that some days resources, workers, and inventory are limited and ever changing each day that will be constraints in our assignment problem. We want to create our assignment problem to address these types of variances while making the problem as balanced as possible, Toth et al suggests creating a flexible problem that will address the variance by creating a problem with 2 major decision variables and constraints that address the major variability in an assignment problem.

Chapter 3: Problem Analysis and Solutions

3.1 Problem Solving Approach

WGP will focus on the Inbound and Outbound sections of the dashboard. We shall optimize labor output and simultaneously minimize manual entry that is associated with the current process. WGP shall use multiple assignment problems for Inbound and Outbound tasks to solve this problem. The assignment problem will assign a set of workers (i) to a job task (j) in Inbound and Outbound to maximize labor output and help minimize manual entry.

3.1.1 Data Cleansing and Transformation

Each PDC has a standardized training document with information on the training obtained [Fig. 2] for each of its employees. Each cell is marked with a color indicating the training level the employee has received for a specific task. Additionally, some cells contain dates on when the employee was trained. The image below shows a snippet of the training matrix for 10 employees provided by the Chicago PDC. For this PDC there are 14 total tasks, 7 belong to Outbound operations, and 7 belong to Inbound operations.

	O	1	2	3	4	5	6	7	I	1	2	3	4	5		6	7
1		-	2022	2022	-	-	-	-		2022	2022	-	-	-		-	-
2		2022	2022	2022	2022		2022			2022	2022		2022				
3		Nov-22	2017	2017	2017	2017	2017	2017		2017	2017	2017	2017	-			-
4		2002	-	-	-	-	-	-		-	-	-	-	-		-	-
5		-	-	-	-	-	-	-		-	-	-	-	-		-	-
6		-	-	-	-	-	-	-		-	-	-	-	-		-	-
7		-	-	-	-	-	-	-		-	-	-	-	-		-	-
8		-	-	-	-	-	-	-		-	-	-	-	-		-	-
9		-	-	-	-	-	-	-		-	-	-	-	-		-	-
10		-	-	-	-	-	-	-		-	-	-	2022	2022		2022	2022

Figure 2 - Chicago PDC Training Matrix Raw Data

In order to transform this data into labor constraints for our assignment problem, WGP assigned arbitrary values to each color based on the employee's level of training [Fig. 3]. The goal of our assignment problem is to maximize the assignment problem based on labor, essentially trying to find the highest-ranked available employee for each task.

10	Trainer
10	Proficient
5	Moderate
1	Begineer
0	Not Available

Figure 3 - Job Schedule Training Legend

The figure below [Fig. 4] shows the employee training matrix transformed from color to numerical values based on the previous legend. After each employee is assigned a value for each task, an average value is obtained for Inbound and Outbound. This value is then rounded up to the nearest whole number. The highlighted orange column indicates an employee's average score

within Inbound, while the column highlighted in blue indicates the average employee score for Outbound operations.

Last Name	First Name	Inbound Score	Outbound Score								
[redacted]	[redacted]	2	2	5	5	0	0	0	0	0	
[redacted]	[redacted]	3	6	10	1	0	5	0	0	0	
[redacted]	[redacted]	4	10	5	10	5	5	0	0	0	
[redacted]	[redacted]	2	5	10	0	0	0	0	0	0	
[redacted]	[redacted]	6	10	10	10	0	5	0	10	1	
[redacted]	[redacted]	1	1	1	1	0	0	0	0	0	
[redacted]	[redacted]	1	1	0	0	0	1	5	0	0	
[redacted]	[redacted]	3	8	5	0	0	1	10	0	0	
[redacted]	[redacted]	0	1	0	0	0	0	0	0	0	

Figure 4 - Transformed Labor Constraint Data

3.1.2 Inbound & Outbound Headcount Data

For the initial general assignment problem, some manual entry will be needed to set the right-hand side of the constraints. Each morning, users will need to type in values for the employee supply (availability). If the worker is not available, they will be assigned a value of 0. If they are working, one schedule (Inbound or Outbound) they will be assigned a value of 1. If they are working both schedules (Hybrid) they will be assigned a value of 2.

The daily planner will automatically update the demand value. Managers will have the option to make slight adjustments to these numbers before running the solver. The Outbound headcount [Fig. 5] is estimated by dividing the estimated number of hours by shift length. The Inbound headcount is estimated by dividing total lines [Fig. 6] by operating window, this is then divided by the Lines Per Hour (LPH).

Delta	Outbound Headcount Estimate
@100	17
@90	15
@85	14

Figure 5 - Daily Planner Outbound Headcount Estimate

Total Lines	2172
Adj. Lines	0
Total Daily Lines	2172
Operating Window	6.75
LPH	21
Inbound Headcount	15.3
Labor Hours	103.4

Figure 6 - Daily Planner Inbound Headcount Estimate

3.1.3 Assignment Problem Excel Graphics

To assign each employee tasks, WGP created 3 separate assignment problems. The first is used to assign employees to either Inbound or Outbound. After each employee is assigned to either Inbound or Outbound, their names feed into a more specific Inbound and/or Outbound assignment problem.

An image of the first assignment problem is shown below. The basis of this assignment problem is to maximize the total labor by changing the values of the 20 variables in the shaded pink region based on three main constraints [Fig. 7].

1. Supply Constraint – Workers are assigned based on availability (Green Box)
    a. If an employee is not available for work, Supply = 0
    b. If an employee is available for Hybrid work, Supply =2
2. Demand Constraint – Tasks are assigned based on Inbound & Outbound headcounts (Blue Box)
    a. Inbound and Outbound headcounts are pulled through the labor hour estimates forecasted by historical data and BI forecast within the Daily Planner
3. Binary Constraint – All task assignments need to be binary values (Shaded Pink)

Assignment	Inbound	Outbound	Task Assigned		Supply
Person 1	1	0	1	=	1
Person 2	0	1	1	=	1
Person 3	0	1	1	=	1
Person 4	0	1	1	=	1
Person 5	1	0	1	=	1
Person 6	1	0	1	=	1
Person 7	1	0	1	=	1
Person 8	0	1	1	=	1
Person 9	1	0	1	=	1
Person 10	0	1	1	=	1
Job Assigned	5	5			
	=	=		TotalLabor	
Demand	= 5	5		67	

Figure 7- Assignment Problem Constraints

WGP has two sets of variables [Fig.8]: if worker is trained for job task, and if worker is available for job task.

Labor	Job (j)	1	2
Worker (j)			
1		5	5
2		5	10
3		5	10
4		5	10
5		10	10
6		1	1
7		1	1
8		1	10
9		0	1
10		5	10

Figure 8 - Variable Assignment

The objective function [Fig. 9] is to maximize total labor. This is calculated as the sum-product of assignment and labor.

Assignment	Inbound	Outbound		Task Assigned		Supply
Person 1	1	0		1	=	1
Person 2	0	1		1	=	1
Person 3	0	1		1	=	1
Person 4	0	1		1	=	1
Person 5	1	0		1	=	1
Person 6	1	0		1	=	1
Person 7	1	0		1	=	1
Person 8	0	1		1	=	1
Person 9	1	0		1	=	1
Person 10	0	1		1	=	1
Job Assigned	5	5				
	=	=			TotalLabor	
Demand	5	5			67	

Figure 9 - Objective Function Assignment

3.1.4 Assignment Problem Mathematical Formulation

Objective Function

Maximize Total Labor → Max $\sum_i \sum_j C_{ij} X_{ij}$

Decision Variables

X_{ij} = {1 if worker i assigned to task j
{0 otherwise

Contraints

Supply

$\sum_i X_{ij} = 1$

Demand

$\sum_j X_{ij} = 1$

Binary

$X_{ij} = 0$ or 1

Figure 10 - Assignment Problem Formulation

Table 1 - Assignment Problem Variables

Variable	Description
i	Worker
j	Task
X_{ij}	Binary variable: 1 if worker assigned to task j, 0 otherwise
C_{ij}	Cost of worker i not getting assigned to task j

3.1.5 Inbound Specific Task Assignment

After the first assignment problem has been solved and each employee is assigned to either Inbound or Outbound, IF statements are used within Excel to move employees assigned to Inbound to a second assignment problem. If the employee is assigned Inbound, a value of 1 is placed as the new supply constraint [Fig.11]. Based on the supervisor's knowledge and information given from the daily planner, demand values are manually entered for each Inbound specific task [Fig. 12].

Labor - Inbound	Job (j)	1	2	3	4	5	6	7	8
Worker (j)									
1		5	5	0	0	0	0	0	0
2		10	1	0	5	0	0	0	0
3		5	10	5	5	0	0	0	0
4		10	0	0	0	0	0	0	0
5		10	10	0	5	0	0	10	1
6		1	1	0	0	0	0	0	0
7		0	0	0	1	5	0	0	0
8		5	0	0	1	10	0	0	0
9		0	0	0	0	0	0	0	0
10		10	1	0	5	1	0	10	10

Figure 11 - Labor Constraints for Inbound Process

Inbound - Assignment	Small Parts	Racks	DDS Packing	DDS Bulk	Fedex Small	Fedex LTL	Starhub	Worker Assigned		Supply
1	0	1	0	0	0	0	0	1	=	1
2	0	0	0	0	1	0	0	1	=	1
3	0	0	0	1	0	0	0	1	=	1
4	0	0	1	0	0	0	0	1	=	1
5	0	0	0	0	0	0	1	1	=	1
6	1	0	0	0	0	0	0	1	=	1
7	0	0	0	1	0	0	0	1	=	1
8	0	0	0	0	0	0	0	0	=	0
9	0	0	0	0	0	0	0	0	=	0
10	0	0	0	0	0	1	0	1	=	1
Task Assigned	1	1	1	2	1	1	1			
	=	=	=	=	=	=	=			
Demand	1	1	1	2	1	1	1	Objective Function		
								22		

Figure 12 - Assignment for Inbound Process

3.1.6 Outbound Specific Task Assignment

The second Outbound assignment [Fig. 13] is created in the same format as the Inbound assignment. Supply is based on information from the general assignment while the demand is pulled from the manual entry tab.

Outbound - Assignment	Small Parts	Racks	DDS Packing	DDS Bulk	Fedex Small	Fedex LTL	Starhub	Worker Assigned		Supply
1	1	0	0	0	0	0	0	1	=	1
2	0	0	0	0	1	0	0	1	=	1
3	0	0	0	1	0	0	0	1	=	1
4	0	0	1	0	0	0	0	1	=	1
5	0	0	0	0	0	0	1	1	=	1
6	0	0	0	0	0	1	0	1	=	1
7	0	1	0	0	0	0	0	1	=	1
8	0	0	0	0	0	0	0	0	=	0
9	0	0	0	0	0	0	0	0	=	0
10	0	0	0	0	0	0	0	0	=	0
Task Assigned	1	1	1	1	1	1	1			
	=	=	=	=	=	=	=			
Demand	1	1	1	1	1	1	1	Objective Function		
								20		

Figure 13 - Outbound Assignment Process

3.1.7 Assignment Problem Check

In addition to the assignment problems that were created, to address issues with daily changes, such as employee callouts or demand in more than one task or section for the day, WGP created a manual entry check for Inbound and Outbound tasks [Fig. 14]. Additionally, a check for employee availability [Fig. 15] and Hybrid scheduling [Fig. 16] was created. There are two macros [Fig. 17] associated with manual entry. After the Inbound and Outbound estimated labor final values are entered and the values match, the PDC supervisor would then run the assignment problem macro and the dashboard will then automatically update to reflect work tasks for the day. The next time the manual entry is run, there is a clear manual entry macro that will clear contents from the previous workday.

	Estimate	Manual Adjusment	Final Value
Inbound Employees	16		16
[redacted]	2		2
[redacted]	2		2
[redacted]	2		2
[redacted]	2		2
[redacted]	2		2
[redacted]	2		2
[redacted]	2		2
Total	14		14
Outbound Employees	19		19
[redacted]	2		2
[redacted]	2		2
[redacted]	2		2
[redacted]	2		2
[redacted]	2		2
[redacted]	2		2
[redacted]	2		2
Total	14		14

Figure 14 - Inbound & Outbound Manual Check

Unavailable Employees	Last Name	First Name	Full Name	Available?
1				0
2				0
3				0
4				0
5				0
6				0
7				0
8				0
9				0
10				0

Figure 15 - Employee Availability Check

Hybrid Employees	Last Name	First Name	Full Name	Available?
1				2
2				2
3				2
4				2
5				2
6				2
7				2
8				2
9				2
10				2

Figure 16 - Hybrid Schedule Check

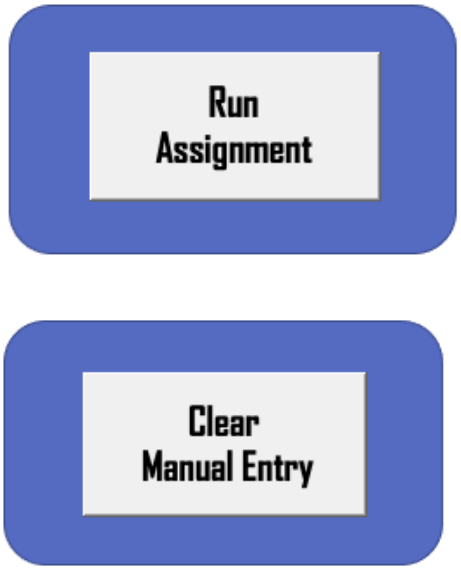


Figure 17 - Manual Entry Macros

3.1.8 Dashboard Design

The dashboard will return 3 key pieces of information for the PDC's [Fig. 18] to utilize when creating the daily schedule. The first pivot table (labeled employee assignment) will list either Inbound, Outbound, Hybrid, or Unavailable for an employee based off the first general assignment problem. The second pivot table (labeled Outbound Task) will detail the specific Outbound task for each employee, and the third column (labeled Inbound Task) will detail the specific Inbound task. Slicers and Macros are also implemented to easily refresh, view, and even save a copy of the dashboard so that historical data can be collected.

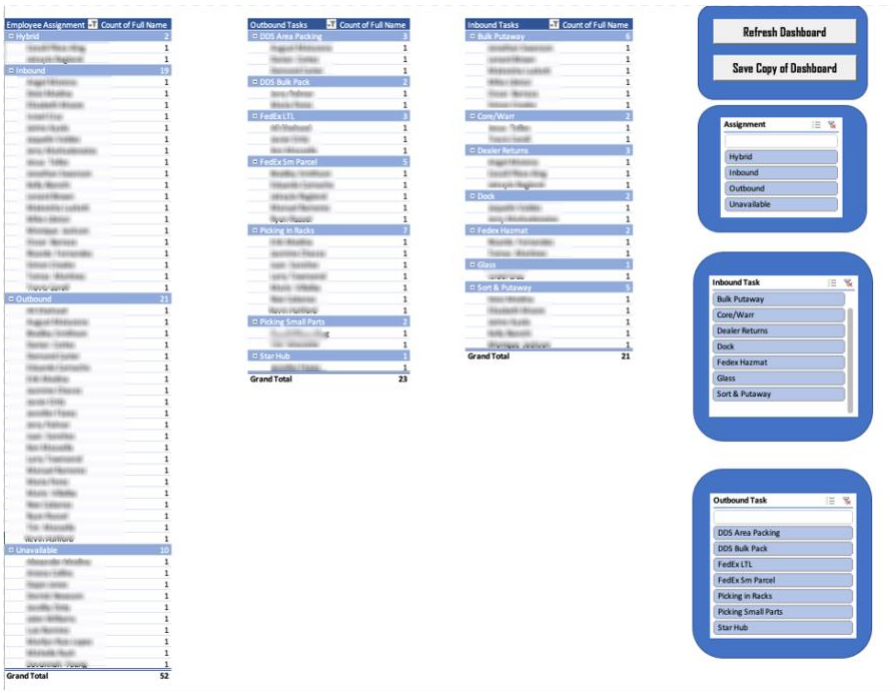
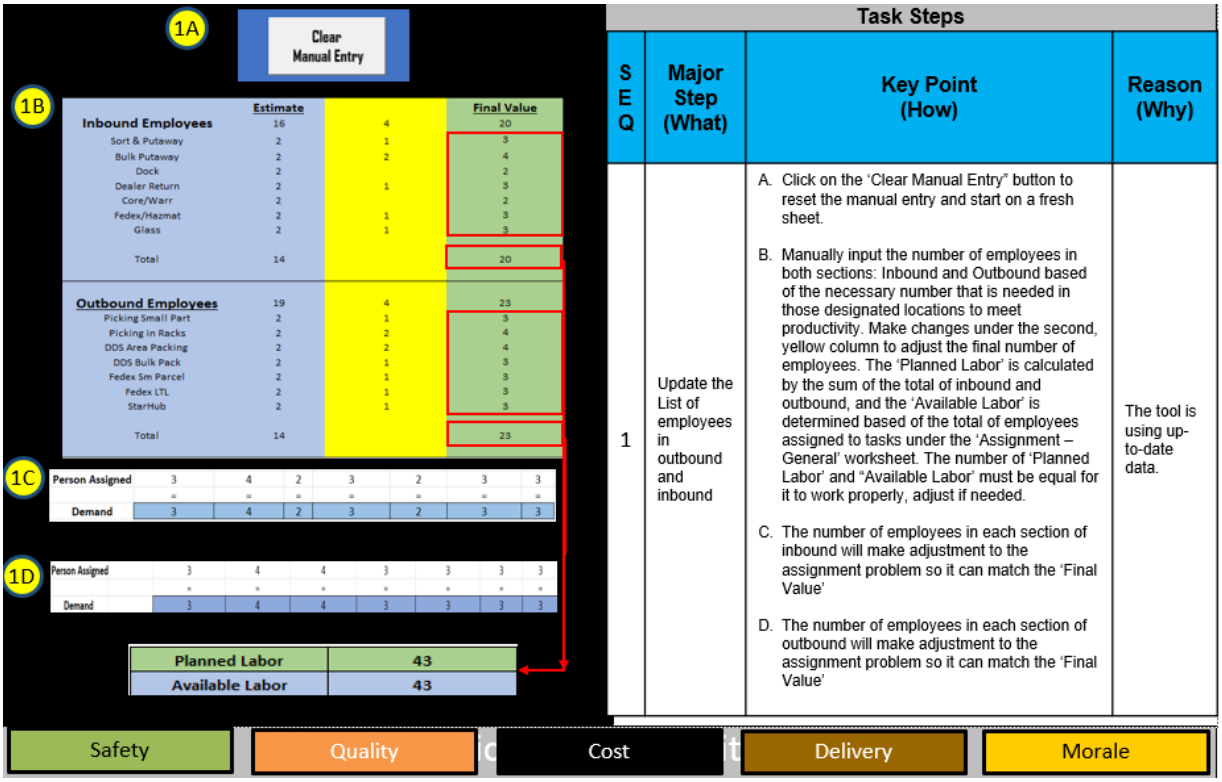


Figure 18- Dashboard Design

3.1.9 Standard Training Document

WGP created a standard training document [Fig. 19] as part of the design requirements in the template designated by Mercedes-Benz USA. This standard training document will assist leadership at the company with how to utilize the teams' new labor planning dashboard.



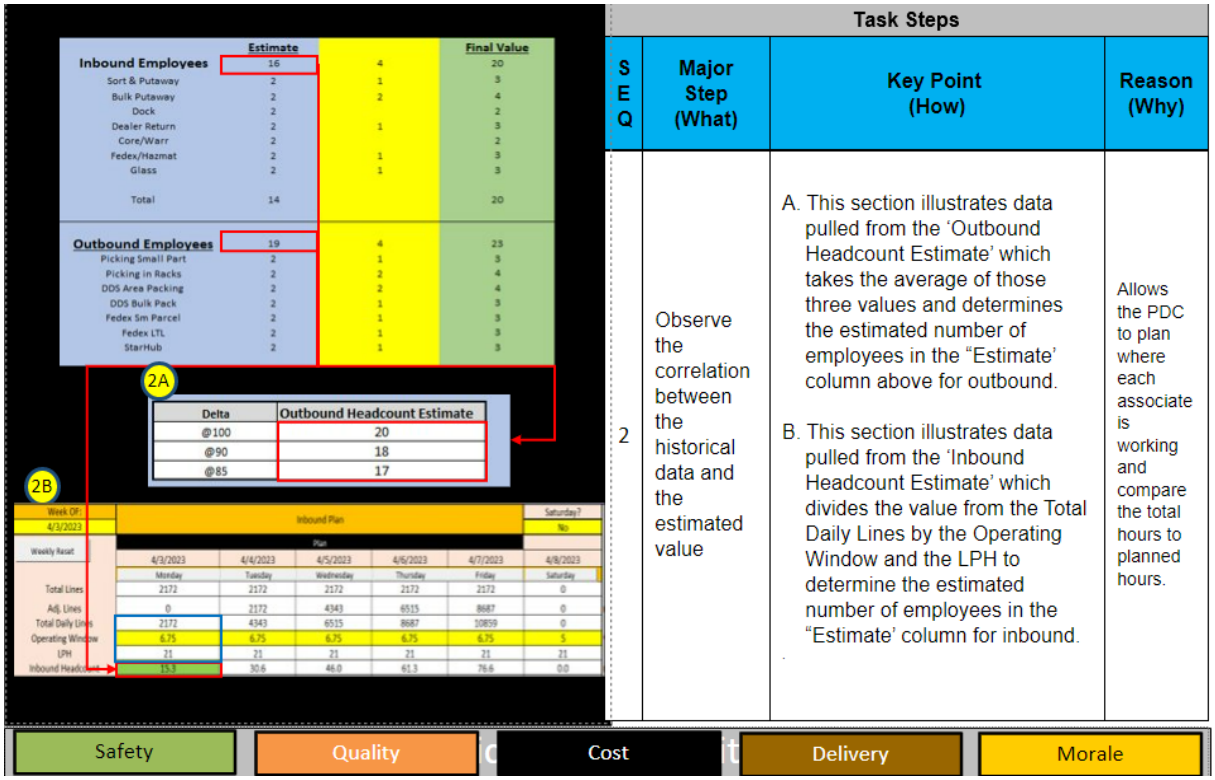


Figure 19 - Standard Training Document

3.2 Requirements

Upon submission of project WGP will deliver a solution to the labor planning dashboards Inbound and Outbound process.

WGP shall:

- Reduce manual entry from Inbound and Outbound in the dashboard by at least 10%
- Maximize labor output for Inbound and Outbound tasks
- Automatic generation of schedule for the day
- Create visual dashboard and standard training document

3.3 Gantt Chart

WGP's team schedule [Fig. 20], is currently filled with due dates for each of our reports. During this semester, in addition the teams regularly scheduled group meetings there were several meetings with the PDC teams for this project. As the semester progressed this Gantt chart was consistently updated to reflect our progress and achievements.

Figure 20 - WGP Gantt chart

3.4 Flow Charts

WGP's assignment problem process is shown in [Fig 21]. The block diagram shows how the assignment problem should run to help reduce input time, as well as making sure that labor demand can be met for the day the schedule is created.

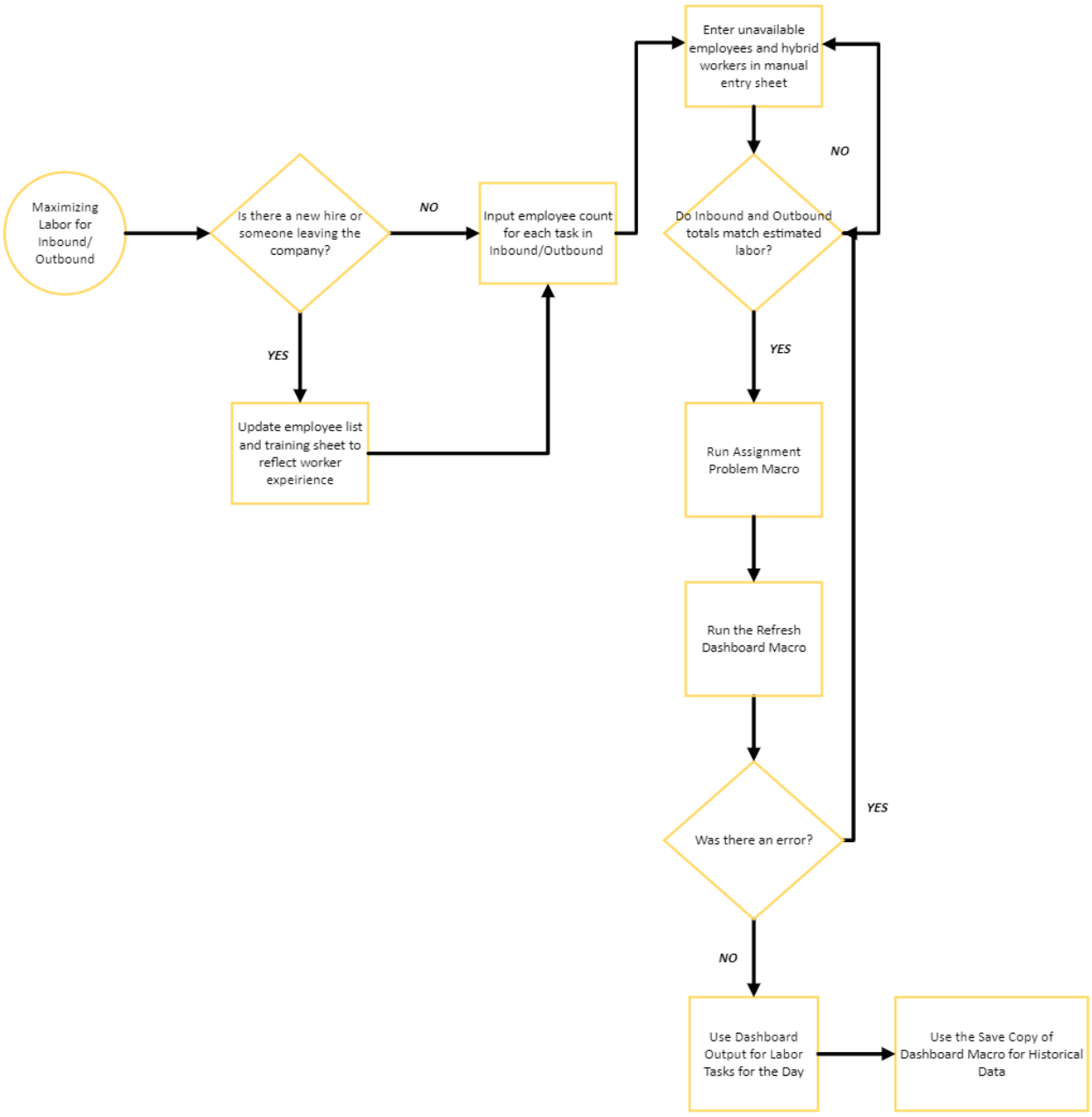


Figure 21 - Assignment Problem Block Diagram

The figure below [Fig. 22] shows why the labor planning dashboard is essential for the company as well as what part the PDCs play in the business process.

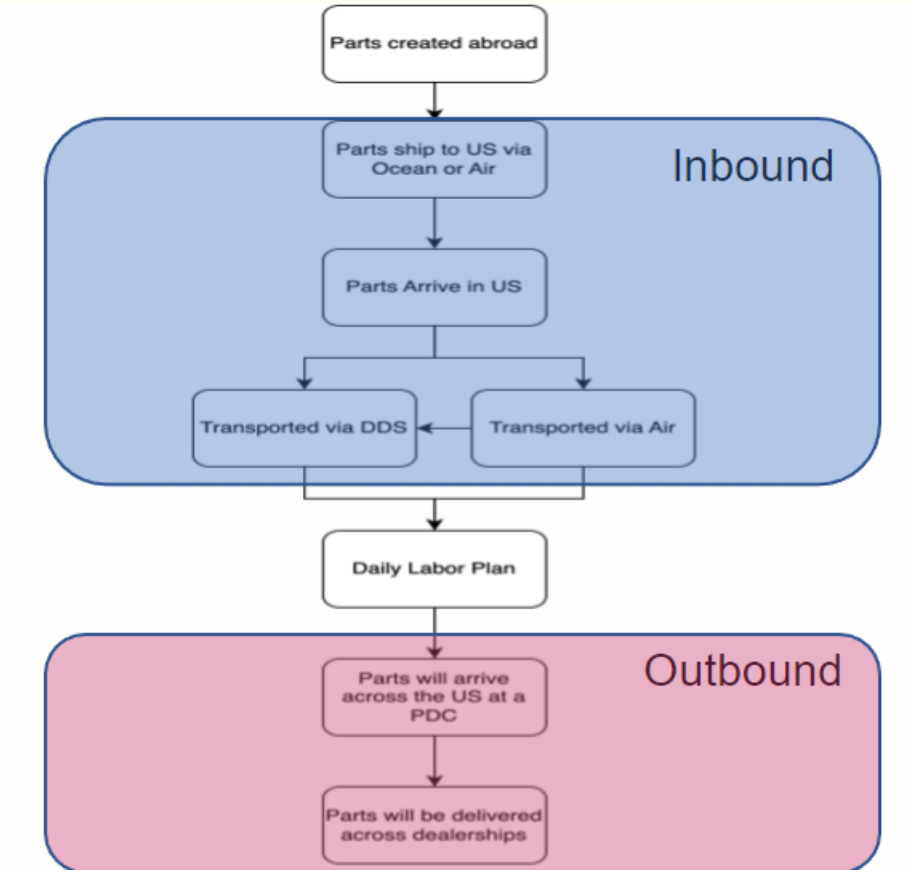


Figure 22 - The Business Process

3.5 Project Management

The members of WGP worked collaboratively throughout the entire project. However, tasks were delegated to each member to complete during the duration of the project (see Appendix D). Jayden spearheaded the teams Assignment Problem creation and was essential to troubleshooting. Also, as financial advisor, he proposed and updated the team budget. Lily as Project Manager scheduled and coordinated all the teams' meetings as well as provided documents that assisted with understanding the locations of the Mercedes-Benz USA's parts distribution centers and business process. Ashley created the teams' presentations and was the main contributor to the teams' project report. Giselle created and consistently updated the teams Gantt and Scheduling charts in addition to recording and editing the teams' video. The entire team played a role in editing the presentation and report as well as testing the Assignment Problems.

3.6 Schedule

WGP's detailed schedule [Fig. 23] for this project. It shows projected milestones, completion dates, meetings, and tasks.

GANTT CHART

	ID	Task Mode	Task Name	Duration	Start	Finish	% Work Complete	Predecessors	Resource Names
1	1		IDR Report	11 days	Mon 1/9/23	Mon 1/23/23	100%	3,4,5,6,7	Ashley,Giselle ,Jayden,Lily
2	2		IDR Presentation	11 days	Mon 1/9/23	Mon 1/23/23	100%	3,4,5,6,7	Ashley,Giselle ,Jayden,Lily
3	3		Gantt Chart Creation	11 days	Mon 1/9/23	Mon 1/23/23	100%		Ashley,Giselle
4	4		Block Diagram	11 days	Mon 1/9/23	Mon 1/23/23	100%		Ashley,Giselle ,Jayden,Lily
5	5		Group Meeting 1	1 day	Wed 1/11/23	Wed 1/11/23	100%		Ashley,Giselle ,Jayden,Lily
6	6		Group Meeting 2	1 day	Fri 1/13/23	Fri 1/13/23	100%		Ashley,Giselle ,Jayden,Lily
7	7		Group Meeting 3	1 day	Fri 1/20/23	Fri 1/20/23	100%		Ashley,Giselle ,Jayden,Lily
8	8		PDR Report	20 days	Tue 1/24/23	Mon 2/20/23	100%	10,11,12,13,14,15,	Ashley,Giselle ,Jayden,Lily
9	9		PDR Presentation	20 days	Tue 1/24/23	Mon 2/20/23	100%	10,11,12,13,14,15,	Ashley,Giselle ,Jayden,Lily
10	10		Literature Review	20 days	Tue 1/24/23	Mon 2/20/23	100%		Ashley,Giselle ,Jayden,Lily
11	11		Data Analysis	20 days	Tue 1/24/23	Mon 2/20/23	100%		Ashley,Giselle ,Jayden,Lily
12	12		Group Meeting 4	1 day	Fri 1/27/23	Fri 1/27/23	100%		Ashley,Giselle ,Jayden,Lily
13	13		Meeting w/ Luxury Car Brand	1 day	Mon 2/27/23	Mon 2/27/23	100%		Ashley,Giselle ,Jayden,Lily
14	14		Group Meeting 5	1 day	Fri 2/3/23	Fri 2/3/23	100%		Ashley,Giselle ,Jayden,Lily
15	15		Meeting w/ PDC's	1 day	Tue 2/7/23	Tue 2/7/23	100%		Ashley,Giselle
16	16		Meeting w/ Luxury Car Brand	1 day	Thu 2/9/23	Thu 2/9/23	100%		Ashley,Giselle ,Jayden,Lily
17	17		Group Meeting 6	1 day	Fri 2/10/23	Fri 2/10/23	100%		Ashley,Giselle ,Jayden,Lily
18	18		Meeting w/ Luxury Car Brand	1 day	Mon 2/13/23	Mon 2/13/23	100%		Ashley,Giselle ,Jayden,Lily
19	19		Meeting w/PDC's	1 day	Mon 2/13/23	Mon 2/13/23	100%		Jayden,Lily
20	20		Group Meeting 7	1 day	Fri 2/17/23	Fri 2/17/23	100%		Ashley,Giselle ,Jayden,Lily
21	21		Group Meeting 8	1 day	Sun 2/19/23	Sun 2/19/23	100%		Ashley,Giselle ,Jayden,Lily
22	22		IPR Report	20 days	Tue 2/21/23	Mon 3/20/23	100%	24,25,26,27,28,29,	Ashley,Giselle ,Jayden,Lily
23	23		IPR Presentation	20 days	Tue 2/21/23	Mon 3/20/23	100%	24,25,26,27,28,29,	Ashley,Giselle ,Jayden,Lily
24	24		Data Collection	20 days	Tue 2/21/23	Fri 3/31/23	100%		Ashley,Giselle ,Jayden,Lily
25	25		Assignment Problem	20 days	Tue 2/21/23	Mon 3/20/23	100%		Ashley,Giselle ,Jayden,Lily
26	26		Meeting w/ PDC's	1 day	Wed 2/22/23	Wed 2/22/23	100%		Ashley,Giselle ,Jayden,Lily
27	27		Group Meeting 9	1 day	Wed 2/22/23	Wed 2/22/23	100%		Ashley,Giselle ,Jayden,Lily
28	28		Group Meeting 10	1 day	Fri 2/24/23	Fri 2/24/23	100%		Ashley,Giselle ,Jayden,Lily
29	29		Meeting w/ Dr. Khalid	1 day	Fri 2/24/23	Fri 2/24/23	100%		Ashley,Giselle ,Jayden,Lily
30	30		Group Meeting 11	1 day	Mon 2/27/23	Mon 2/27/23	100%		Ashley,Giselle ,Jayden,Lily
31	31		Meeting w/PDC's	1 day	Mon 2/27/23	Mon 2/27/23	100%		Jayden,Lily
32	32		Group Meeting 12	1 day	Thu 3/2/23	Thu 3/2/23	100%		Ashley,Giselle ,Jayden,Lily
33	33		Group Meeting 13	1 day	Fri 3/3/23	Fri 3/3/23	100%		Ashley,Giselle ,Jayden,Lily
34	34		Group Meeting 14	1 day	Mon 3/13/23	Mon 3/13/23	100%		Ashley,Giselle ,Jayden,Lily
35	35		Meeting w/PDC's	1 day	Mon 3/13/23	Mon 3/13/23	100%		Ashley,Giselle ,Jayden,Lily
36	36		Meeting w/PDC's	1 day	Wed 3/15/23	Wed 3/15/23	100%		Ashley,Giselle ,Lily
37	37		Group Meeting 15	1 day	Thu 3/16/23	Thu 3/16/23	100%		Ashley,Giselle ,Jayden,Lily
38	38		Meeting w/ Luxury Car Brand	1 day	Thu 3/16/23	Thu 3/16/23	100%		Ashley,Giselle ,Jayden,Lily
39	39		Meeting w/ Dr. Khalid	1 day	Thu 3/16/23	Thu 3/16/23	100%		Ashley,Jayden,Lily
40	40		Group Meeting 16	1 day	Sun 3/19/23	Sun 3/19/23	100%		Ashley,Giselle ,Jayden,Lily
41	41		CDR Report	20 days	Tue 3/21/23	Mon 4/17/23	100%	43,44,45,46,47,48,	Ashley,Giselle ,Jayden,Lily
42	42		CDR Presentation	20 days	Tue 3/21/23	Mon 4/17/23	100%	43,44,45,46,47,48,	Ashley,Giselle ,Jayden,Lily
43	43		Group Meeting 17	1 day	Thu 3/23/23	Thu 3/23/23	100%		Ashley,Giselle ,Jayden,Lily
44	44		Group Meeting 18	1 day?	Fri 3/24/23	Fri 3/24/23	100%		Ashley,Giselle ,Jayden,Lily
45	45		Meeting w/ Luxury Car Brand	1 day	Mon 3/27/23	Mon 3/27/23	100%		Ashley,Giselle ,Jayden,Lily
46	46		Meeting w/ PDC's	1 day	Fri 3/24/23	Fri 3/24/23	100%		Ashley,Giselle ,Jayden,Lily
47	47		Group Meeting 19	1 day	Thu 3/30/23	Thu 3/30/23	100%		Ashley,Giselle ,Jayden,Lily
48	48		Meeting w/ PDC's	1 day	Thu 3/30/23	Thu 3/30/23	100%		Ashley,Giselle ,Jayden,Lily
49	49		Group Meeting 20	1 day	Fri 3/31/23	Fri 3/31/23	100%		Ashley,Giselle ,Jayden,Lily
50	50		Meeting w/ Luxury Car Brand	1 day	Mon 4/3/23	Mon 4/3/23	100%		Ashley,Giselle ,Jayden,Lily
51	51		Meeting w/ Dr. Khalid	1 day	Fri 4/7/23	Fri 4/7/23	100%		Ashley,Giselle ,Jayden,Lily
52	52		Meeting w/ Luxury Car Brand	1 day	Mon 4/10/23	Mon 4/10/23	100%		Ashley,Giselle ,Jayden,Lily
53	53		Group Meeting 21	1 day	Sun 4/16/23	Sun 4/16/23	100%		Ashley,Giselle ,Jayden,Lily
54	54		FDR Report	10 days	Tue 4/11/23	Mon 4/24/23	100%	56,57,58,59,60	Ashley,Giselle ,Jayden,Lily
55	55		FDR Presentation	10 days	Tue 4/11/23	Mon 4/24/23	100%	56,57,58,59,60	Ashley,Giselle ,Jayden,Lily
56	56		Group Meeting 22	1 day	Thu 4/13/23	Thu 4/13/23	100%		Ashley,Giselle ,Jayden,Lily
57	57		Group Meeting 23	1 day	Sun 4/16/23	Sun 4/16/23	100%		Ashley,Giselle ,Jayden,Lily
58	58		Group Meeting 24	1 day	Thu 4/20/23	Thu 4/20/23	100%		Ashley,Giselle ,Jayden,Lily
59	59		Meeting w/ Luxury Car Brand	1 day	Fri 4/21/23	Fri 4/21/23	100%		Jayden,Lily
60	60		Group Meeting 25	1 day	Sat 4/22/23	Sat 4/22/23	100%		Ashley,Giselle ,Jayden,Lily

Figure 23 - WGP Schedule

3.7 Budget

WGP's total budget [Tab. 3] for this project is $14,144.80, where $4,350 goes towards the teams' labor [Tab. 4], $4,594.80 goes towards hardware and software, and $5,200 is allocated for the cost of implementation and training. Mercedes-Benz USA is committed to covering all costs.

Table 2 - Budget

Labor	$4,350.00
Software	$2594.80
Hardware	$2000.00
Cost of Implementation	$4000.00
Employee Training	$1200.00
Total	**$14,144.80**

3.7.1 Labor and Equipment

WGP's labor and equipment [Tab. 4] show that Ashley and Giselle are in analyst roles, so they earn a higher hourly pay of $50/hr. while Jayden and Lily's hourly rate is $25/hr. For this project, the team will need 3 subscription-based software [Tab. 5]: Microsoft suites, Lindo API for Industry, and OpenSolver AI Add-in.

Table 3 - Labor Breakdown

	Estimated Work Hours by Task				**Total by Task**	
Task	**Lily**	**Jayden**	**Giselle**	**Ashley**	**Hrs.**	**$**
A	8	7	2	2	19	$575
B	9	5	3	3	20	$650
C	7	6	3	3	19	$625
V	8	7	2	2	19	$575
E	7	8	3	3	21	$675
F	8	9	2	2	21	$625
G	8	5	3	3	19	$625
Total hrs.	55	47	18	18	138	
Rate $/hr.	25	25	50	50		
Dollars	$1,375	$1,175	$900	$900		**$4,350**

Table 4 - Software & Hardware Breakdown

Software	Cost	Frequency	Length (Months)	Lily	Jayden	Giselle	Ashley	Total
Microsoft Suites Subscription	$9.99	Monthly	5	$49.95	$49.95	$49.95	$49.95	$199.80
Open Solver AI	Free	-	-	-	-	-	-	-
Lindo Industrial API	$2,395	One Time	5	$2,395	-	-	-	$2395.00
								$2,594.80
Hardware								
Company Laptop	$500	One Time	5	$500	$500	$500	$500	$2,000.00
								$2,000.00

3.7.2 Cost of Implementation

A good rule of thumb for estimating the cost of implementation [Tab. 5] for a project is to look at the total amount of software costs necessary for the project. In Atlanta, the estimate is that the cost of implementation will be anywhere from 1-2 times the amount spent on software. Within our budget, $2,594.80 was allocated toward software. Therefore, our estimated cost of implementation for introducing these solutions across 4 PDCs is $4,000. We will assume that managers($60/hour) will need an estimated 5 hours of training, totaling $300 for each PDC and $1,200 for the entire project.

3.8 Materials Required

WGP had weekly meetings with the lead Industrial Engineering manager and all PDC Supervisors. The team has met periodically with Dr. Lin Li and Dr. Adeel Khalid to discuss different optimization formulas that could be included into the project. For the PDCs to run the assignment problem, they needed to download Open Solver AI, Excel add-in an analysis tool, to each computer that will be utilizing the assignment problem. The Excel application must be 2016 or higher, due to the formulas that are used throughout the program. When integrating the assignment problem with the dashboard and the add ins, all of it must be within the same folder to connect with each other and run.

Chapter 4: Results and Conclusions

Mercedes-Benz USA expressed concerns as to how the Assignment Problem can be run and just how much manual entry would be needed as compared to the original assignment problem. The team informed the company that the employee and training list would only be updated upon an employee being hired or leaving the company. The three Assignment Problems would be similar, so the expertise level of the employee. The Employee and Training list and the three Assignment problems would only need to be updated on special occasions and would also be locked so that only the manager of the document would have password access to the changes. The only manual entry WGP planned for the PDC managers to perform would be to move employees into hybrid labor, working on tasks in Inbound and Outbound, and documenting if an employee is available for the day, as an example if the employee calls out that day. The estimated time it took to manually enter employees into the previous dashboard each morning is 2 hours. WGP's complete assignment problem and dashboard generates a solution in under 5 minutes. The Dashboard will automatically update after the Assignment Problems are run and has slicers so that specific tasks and employees can be viewed in the Dashboard. The original design requirements of this project were to optimize a labor planning dashboard, provide a labor plan and historical data, and create a standard training document. WGP has created a more optimized labor planning dashboard that is automated and has less manual entry than the original. The dashboard has a macro built in that will save a copy of each generated dashboard and file it into a folder the PDC designates to retain historical data. WGP also created a standard training document into a template required by Mercedes-Benz USA to assist all employees on the ways to utilize the teams' new labor planning dashboard. The team will be submitting the completed labor planning dashboard and associated standard work document to the Mercedes-Benz USA PDC management.

Chapter 5: Suggestions

WGP would like to suggest that Mercedes-Benz USA use their shared drive that is utilized among the PDCs so that essential personnel have access to the new labor planning dashboard. As a result of the team creating macros the file should run smoothly without any time delay because the historical data is saved in a separate designated folder and not on the excel file itself. The team would also advise the PDCs teams to designate a manger to be the only person to have access to the locked sheets so that it doesn't not the disturbed any of the formulas that were utilized in the creation of the employee training list and assignment problems. Those sheets would only be changed if there is a new hire or if someone leaves the company. Lastly, the team suggests that each person utilizing the labor planning dashboard confirm that they are using a 2016 or higher version of Microsoft Excel as the formulas are tailored to those versions of the software. In addition to downloading the Open Solver analysis tool add in on the computers that will be utilizing the labor planning dashboard.

References

[1] A. Al-Sulaiti, M. Mansour, H. Al-Yafei, S. Aseel, M. Kucukvar, and N. C. Onat, "Using data analytics and visualization dashboard for engineering, procurement, and Construction Project's performance assessment," *2021 IEEE 8th International Conference on Industrial Engineering and Applications (ICIEA)*, 2021.

[2] "An application of Lean Assessment in a cross-docking distribution center." [Online]. Available: https://www.researchgate.net/publication/323723086_An_Application_of_Lean_Assessment_in_a_Cross-Docking_Distribution_Center. [Accessed: 01-Feb-2023].

[3] "Business intelligence (BI) for manufacturing - A White Paper," *Share and Discover Knowledge on SlideShare*. [Online]. Available: https://www.slideshare.net/businessintelligence/business-intelligence-bi-for-manufacturing-a-white-paper. [Accessed: 27-Jan-2023].

[4] Corici Marian-Catalin & Medar Lucian Ion, "Dashboard - innovative instrument for the evaluation of perf," *Annals - Economy Series*, 01-Jan-1970. [Online]. Available: https://ideas.repec.org/a/cbu/jrnlec/y2019v6p153-159.html. [Accessed: 09-Feb-2023].

[5] "The dashboard and performance improvement of the company - researchgate." [Online]. Available: https://www.researchgate.net/publication/227466561_The_Dashboard_and_Performance_Improvement_of_the_Company. [Accessed: 01-Feb-2023].

[6] E. Oey, S. S. Harno, and C. Zain, "Developing integrated performance dashboards with Power Bi – a case study in a medium-size manufacturer," *2021 International Conference on Information Management and Technology (ICIMTech)*, 2021.

[7] F. Sethi, "Automating software code deployment using continuous integration and continuous delivery pipeline for Business Intelligence Solutions," 2020.

[8] I. Wahyudi and Y. D. Widyasari, "Improving company performance by the correctness of management decision through implementation dashboard using power BI Tools (Case Study at company Y)," *2022 8th International Conference on Education and Technology (ICET)*, 2022.

[9] L. Shaulska, L. Yurchyshena, and Y. Popovskyi, "Using MS power BI tools in the University management system to deepen the value proposition," *2021 11th International Conference on Advanced Computer Information Technologies (ACIT)*, 2021.

[10] "The multi-skilled multi-period workforce assignment problem," *Taylor & Francis*. [Online]. Available: https://www.tandfonline.com/doi/full/10.1080/00207543.2020.1783009. [Accessed: 20-Mar-2023].

[11] Mason, Andrew. (2020). OpenSolver (Version 2.9.3) [OpenSolver_LinearMAC]. Available from https://opensolver.org/

[12] N. Tóth and G. Kulcsár, "New models and algorithms to solve integrated problems of production planning and control taking into account worker skills in flexible manufacturing systems," *International Journal of Industrial Engineering Computations*, vol. 12, no. 4, pp. 381–400, 2021.

[13] "Optimization of assignment plan of workers to jobs in Kere Farms." [Online]. Available: https://www.researchgate.net/publication/328278835_Optimization_of_Assignment_Plan_of_Workers_to_Jobs_in_Kere_Farms. [Accessed: 22-Mar-2023].

[14] P. Vejjanugraha, K. Tiwatthanont, N. Vichaidis, T. Yatsungnoen, P. Charoenpong, S. Wansopa, A. Suasaming, and P. Boonsieng, "An automated data analytics and overall equipment effectiveness visualization technique for assembly line on continuous manufacturing system using power Bi," *2022 7th International Conference on Business and Industrial Research (ICBIR)*, 2022.

[15] "Printed from dmreview.com dashboard design: Why design is important." [Online]. Available: http://cs.furman.edu/~pbatchelor/csc105/articles/TUN_DM_ONLINE.pdf. [Accessed: 01-Feb-2023].

[16] R. Lewandowski and J. I. Olszewska, "Automated Task Scheduling for automotive industry," *2020 IEEE 24th International Conference on Intelligent Engineering Systems (INES)*, 2020.

[17] R. Toasa, M. Maximiano, C. Reis, and D. Guevara, "Data visualization techniques for real-time information — a custom and dynamic dashboard for analyzing surveys' results," *2018 13th Iberian Conference on Information Systems and Technologies (CISTI)*, 2018.

[18] S. N. Sivanandam and P. Visalakshi, "Dynamic task scheduling with load balancing using parallel orthogonal particle swarm optimisation," *International Journal of Bio-Inspired Computation*, vol. 1, no. 4, p. 276, 2009.

[19] "Scheduling medical residents to rotations: Solving the large-scale Multiperiod Staff Assignment Problem." [Online]. Available: https://pubsonline.informs.org/doi/10.1287/opre.41.2.269. [Accessed: 22-Mar-2023].

[20] "Solving a dynamic assignment problem in the socio-economic system." [Online]. Available: https://iopscience.iop.org/article/10.1088/1742-6596/1172/1/012092/meta. [Accessed: 19-Mar-2023].

[21] T. Çimen, A. Baykasoğlu, and S. D. Akyol, "Assembly line rebalancing and worker assignment considering ergonomic risks in an automotive parts manufacturing plant," *International Journal of Industrial Engineering Computations*, vol. 13, no. 3, pp. 363–384, 2022.

[22] W. A. Ansari, P. Diya, S. Patil, and S. Patil, “A review on robotic process automation - the future of Business Organizations,” *SSRN Electronic Journal*, 2019.

[23] “Workforce Planning and scheduling for the HP IT services business.” [Online]. Available: https://www.researchgate.net/publication/228699201_Workforce_Planning_and_Scheduling_for_the_HP_IT_Services_Business. [Accessed: 31-Jan-2023].

Appendix A: Acknowledgements

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Appendix C: Reflections (The Educational Experience, Challenges Faced, Resolutions)

One of the biggest challenges the team faced was getting feedback from Mercedes-Benz USA. The team had some initial difficulty choosing a direction after the first meeting with Mercedes-Benz USA and sometimes failed to effectively communicate the team's project goals to the PDC team and leadership. Some of the scheduled meetings' times were not used efficiently or at all.

The team has learned how to communicate effectively and how and when to plan meetings that would provide essential updates. The team also learned some best practices from the Mercedes-Benz USA leadership on how to stay on topic during meetings without diverging the conversion from objective goals.

Appendix D: Team Member Task Assignment Table

Jayden Ayash – Financial Analysis
• Literature Review
• Proposing/Updating Budget
• Assignment Problem Creation and Editing
• Presentation and Paper Editing
Lily Frank – Project Manager
• Literature Review
• Coordinating virtual and in-person meetings
• Map for PDC Location Creation
• Business Process Flow Chart Creation
• Assignment Problem Testing
Ashley McNeal – Data Analyst
• Literature Review
• Gantt Chart Editing
• Presentation and Paper Creation and Editing
• Assignment Problem Flow Chart Creation
• Assignment Problem Testing
Giselle Reyes-Zavalza – Quality Assurance Analyst
• Literature Review
• Gantt Chart and Schedule Creation
• Video Recording and Editing
• Presentation and Paper Editing
• Assignment Problem Testing

Appendix E: Acronyms

In this document we have used multiple acronyms and have provided a consolidated list below of them all.

WGP – We Got the Power (Team Name)

PDC – Parts Distribution Center

BI – Business Intelligence

LPH – Lines Per Hour