Scheduling in a High-Mix Low-Volume Job Shop

by

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Abstract

This research explores the intricate challenges and strategies involved in the scheduling operations of high-mix low-volume manufacturing environments. It discusses the complexities of managing diverse production requirements while optimizing resource utilization and minimizing lead times. Through a thorough analysis of scheduling methodologies and use case studies, the research offers valuable insights into enhancing operational efficiency and meeting customer demands in a job shop manufacturing setting.

This project is still ongoing, as further research and implementation learnings have not been fully realized. However, the learnings and suggestions in this research can be used to achieve a more effective and efficient scheduling process in the job shop manufacturing setting.

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Chapter 1

Introduction

1.1 Company Overview, Rainier Industries

Rainier Industries was founded in 1896 by Henry Carstens as Puget Sound Tent and Duck in Seattle, Washington. During that time, Seattle had become an important city for the Alaskan Gold Rush, as many prospectors would stop there for specialty equipment before heading north. The company started producing tents and selling camping equipment to gold miners from the Seattle docks. In 1917, Puget Sound Tent and Duck was sold to George Schaffer and continued its operations of selling tents. During World War II in the 1940s, the company experienced a significant increase in revenue by joining the war efforts and selling a high volume of tents to the military. In 1962, Bob Campbell and Al Cox purchased the company and changed its name to Puget Sound Tent and Awning. They diversified into the awning business and began selling awnings to businesses in the rapidly growing downtown Seattle area. In 1984, the company underwent another ownership change when Scott Campbell, the son of Bob Campbell, acquired it. Over the next several years, Scott acquired several long-time competitors, including Seattle Tent and Awning, Everett Awning, and Seattle Awning Maintenance. Through these acquisitions, Scott also gained ownership of the Rainier brand, which was the brand name used by Seattle Tent and Awning to sell its tents and sleeping bags. In 1992, reflecting its national focus and expanded product offering, Puget Sound Tent and Awning changed its name to Rainier Industries. Rainier Industries began diversifying into various products such as outdoor power screens, awnings, yurts, and custom displays, and relocated its headquarters to Tukwila, Washington. In 2021, Rainier announced a partnership with LFM Capital, a Nashville-based private equity firm that focuses on U.S.-based manufacturing companies. Chris Inverso is currently serving as the CEO, and Scott Campbell continues to be an owner and board member. Rainier has witnessed continuous growth, acquiring two additional businesses in 2022: Eclipse Awning Systems in Middletown, New York, and OAI Visual Branding in Tampa, Florida. Rainier operates a diverse range of businesses, including Rainier Shade, Rainier Outdoor, Rainier Display, Rainier Industrial, and Rainier Tent. Its customer base includes Starbucks, the NFL, the NCAA, Jack Porter, and HOK. This thesis will focus on the operations involved in the Tukwila manufacturing plant which include the display, outdoor, industrial and tent business lines. [1]

1.1.1 Rainier Display

The Rainier Display business stands out in the market due to its wide range of capabilities, providing Rainier Industries with a distinctive competitive edge. They have the ability to undertake not only standard projects but also more intricate and unique ones, offering a wide range of options to their customers. From straightforward print jobs to projects that need the use of the metal and wood shops and extensive assembly, Rainier Industries is equipped to handle a broad spectrum of requirements. Rainier excels in delivering exceptional solutions. Their target market includes retail displays, branded environments, experiential marketing, events, and any organization seeking eye-catching and effective visual displays to enhance their brand presence and engage their audience.They have a display shop in the Tukwila, Washington facility and one in the recently acquired OAI Visual Branding facility in Tampa, Florida. Together they provide unique display solutions across the country. Examples of some projects including the canyon wall art display at the Salt Lake City airport and the grandstands fabric at the 2022 and 2023 Miami Grand Prix can be seen in Figure 1-1. [11]

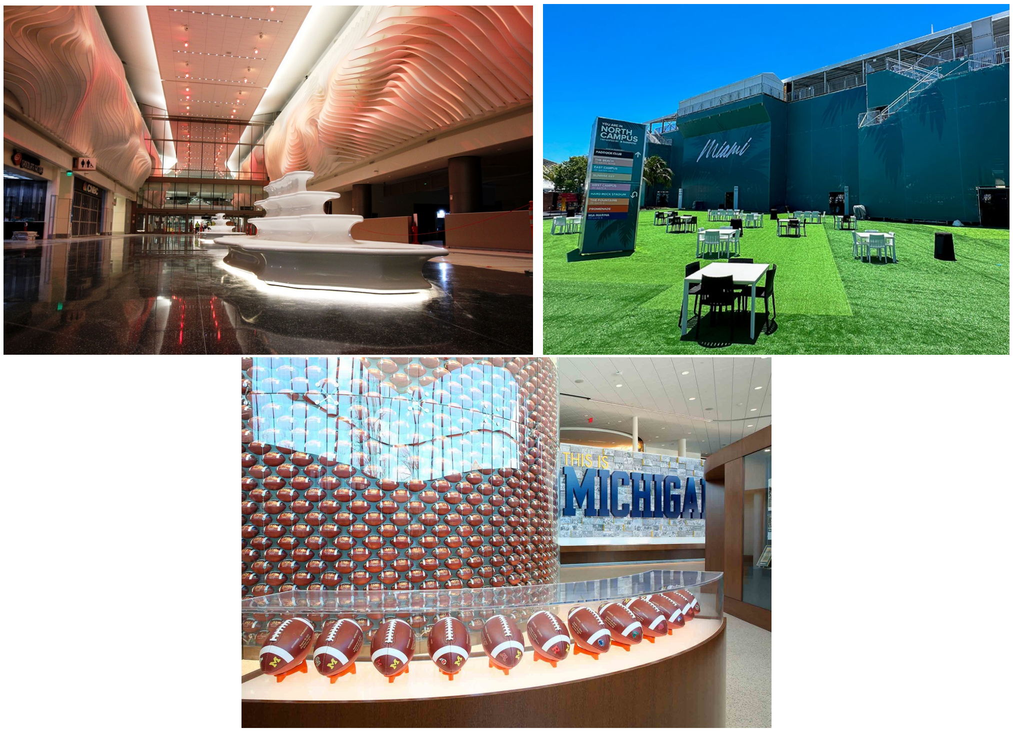

Figure 1-1: Rainier Display Project Examples [11]

1.1.2 Rainier Outdoor, Industrial and Tent

The Rainier Outdoor, Industrial and Tent business segments craft high-quality outdoor structures and industrial fabrications. With great attention to detail and innovative designs, Rainier has become a trusted name in the industry. Their tent and fabric offerings range in size and shape, providing versatile options for various outdoor occasions in the event and commercial spaces. They also specialize in designing and manufacturing yurts, offering unique and customizable living spaces that blend comfort and functionality. Their industrial division excels in producing a wide array of industrial fabrications, including shade structures and custom fabrications tailored to meet specific business needs. The Tukwila facility utilizes their engineering department, fabric shop, wood shop and metal shop to keep pace with the changing market and provide their customers with top of line custom fabric shelters. Examples of different types of fabric shelters designed and made at Rainier can be seen in Figure 1-2. [12]

Figure 1-2: Rainier Outdoor, Tent and Industrial Products [12]

1.2 Project Origin

A large majority of the products that Rainier produces are customer-specified, made-to-order jobs. As a result, the 140,000 square foot facility in Tukwila operates as a high-mix, low-volume shop, also referred to as a job shop. The plant consists of four different business lines: display, outdoor, industrial, and tent. Each business line offers unique products, while also sharing many resources throughout the shop floor. These four product lines share the following production shops:

- Graphics shop: equipped with grand format printers, CNC cutting tables and lamination tables.
- Fabric finishing shop: equipped with CNC cutting tables, sewing equipment, and fabric welding and sealing equipment.
- Wood shop: equipped with a wide range of capabilities and both manual, automated, and CNC equipment.

- Metal shop: equipped with a wide range of capabilities and both manual, automated, CNC, and robotic equipment.

- Powder-coating shop.

Depending on the scope of each custom job, work-in-process goods may flow through one or more of the production shops for each business line, including flowing through the variety of resources within each shop. Consequently, predicting and scheduling the utilization of any shop at any given time becomes challenging. It becomes entirely reliant on the type of jobs that are coming into the system on any given day. The complexity of each job, which may require different processes, machines, and resources, further complicates the development of an efficient production schedule that maximizes throughput while minimizing lead times and costs. Additionally, high-mix low-volume shops face the frequent challenge of managing changes to customer requirements, such as rush orders or product specification alterations, which adds complexity to scheduling.

Without an effective scheduling system in place, delays, bottlenecks, and inefficiencies can occur, impacting the ability to deliver products on time and maintain customer satisfaction. Therefore, establishing an effective scheduling strategy is crucial for lean and efficient operations in this high-mix low-volume shop.

Rainier also has plans to transition their Epicor ERP (Enterprise Resource Planning) system from the onsite mainframe system to the cloud in the near future. Consequently, the dashboards currently utilized on the production floor to complete operations will become obsolete. In light of this business decision, a new method must be found to provide the production floor with visibility into their tasks, in addition to aiding in scheduling.

1.3 Project Goal

This project aims to develop a comprehensive process and tool that can be utilized in a high-mix low-volume job shop to improve overall production scheduling. The updated process and tool will effectively and efficiently schedule jobs on a regular basis by prioritizing production based on profitability, customer needs, and the efficient utilization of capacity. This will grant stakeholders control over production decisions, enhancing visibility and tracking of scheduled versus completed tasks. Additionally, the project will address inefficiencies introduced by the scheduling process and seek opportunities to improve the flow of products within the system. The implementation of this enhanced scheduling process will enable Rainier to minimize bottlenecks, reduce production delays, and ultimately enhance on-time delivery and customer satisfaction.

Chapter 2

Literature Review

2.1 High-Mix Low Volume Job Shops

High-mix low-volume job shops specialize in producing a wide variety of products in relatively small quantities. While the traditional low-mix high-volume manufacturers focus on producing a high volume of similar products with very little variation, high-mix low-volume job shops are characterized by their ability to handle diverse product lines and customized orders, catering to the specific requests of their customers. These job shops often have a flexible production system that allows them to efficiently switch between different product configurations and adapt to changing demands. Their focus is on providing personalized solutions and maintaining a high level of customer satisfaction.

As a result of the extensive range of product lines and capabilities offered by job shops, they encounter numerous complexities and common challenges that are typically avoided by traditional low-mix high-volume shops. There is a high degree of variability in product specifications, order quantities, and production processes. Each order may require different materials, equipment setups, and production sequences, making it challenging to achieve standardized processes and maximize efficiency. This variability makes scheduling, inventory management, and quality extremely hard to standardize as priorities are always changing. Resource allocation can vary day-to-day based on the nature and requirements of the jobs entering the system. A job shop requires careful planning, efficient resource management, skilled labor, effective scheduling, and quality control systems. Oftentimes, rather than leading to smooth operations and customer satisfaction, these requirements lead to chaos and uncertainty on the shop floor. To combat the constant variability, job shops must create flexible production systems to maximize production capability. [2]

2.1.1 Lean Manufacturing in Job Shops

Lean manufacturing is a systematic approach and philosophy aimed at maximizing value and minimizing waste in production processes. It originated from the Toyota Production System and has become widely adopted in manufacturing processes across a wide variety of industries. At its core, lean manufacturing focuses on eliminating activities that do not add value to the final product, such as overproduction, waiting times, unnecessary movement, defects, and excessive inventory. Lean manufacturing strives for continuous improvement and waste reduction to create a lean and efficient production system. The five core principles of lean manufacturing can be seen in Figure 2-1.

Figure 2-1: Lean Principles [9]

1. *Define Value*: Focus on understanding and delivering value to the customer. Identify what is valuable to them and eliminate activities that do not contribute to that value.

2. *Mapping the Value Stream*: Analyze the entire value stream and identify the steps and processes required to deliver the product or service. Eliminate waste by optimizing and streamlining the value stream.

3. *Creating Flow*: Create a smooth and uninterrupted flow of work by eliminating bottlenecks, reducing waiting times, and minimizing disruptions. Ensure that work moves efficiently from one step to the next without unnecessary delays or interruptions.

4. *Establish Pull*: Establish a system where production is based on actual customer demand. Instead of producing based on forecasts or predetermined schedules, manufacture products based on the customer's pull. This reduces overproduction and excessive inventory.

5. *Pursue Perfection*: Strive for ongoing improvement in all aspects of the manufacturing process. Encourage employees to identify and eliminate waste, suggest improvements, and implement changes. Continuously seek ways to optimize processes, enhance quality, and increase efficiency.

Given that lean principles were initially developed to enhance efficiency in low-mix high-volume production environments, their implementation in high-mix low-volume job shops encounters notable obstacles. Job shops operate in a volatile environment with fluctuating demand and changing routines, making the repetitive application of lean principles difficult. However, several principles within the lean framework can still be effectively utilized to bring value to high-mix low-volume job shops. Production floors should initiate their efforts by focusing on the identification and elimination of waste. Various forms of waste, such as information waste, rework, excessive inventory, and administrative waste, can be present on a job shop floor. By effectively eliminating common waste throughout the process, the value added for customers can be increased while reducing costs. Moreover, shops should adapt their approach to create a smooth flow by transitioning from a product-based view to a process-based view. Workstations should be strategically arranged to optimize product flow and minimize unnecessary movement between steps. These changes will ultimately lead to an increase in capacity, resulting in a higher volume of completed products. One of the most crucial decisions a job shop can make is to establish transparency and clarity throughout the process. Given that job shops often face chaotic and unpredictable situations, implementing tools and systems that provide clarity and visibility into the production process becomes essential. By implementing these types of lean principles, high-mix low-volume job shops can experience higher efficiencies and improved productivity within their production systems. [7] [5]

2.2 Little's Law

The earliest reference to Little's Law was made by Alan Cobham in 1954, where he merely mentioned the principle and assumed its correctness. In 1961, John Little published the principle along with the equation that is used to this day, providing the theorems and proof to support it. Little's Law is a fundamental principle of queuing theory that has been applied in numerous fields, including the teaching and practice of operations management. In simplistic terms, a queuing system consists of items that arrive and depart at a given rate from a service system, as depicted in Figure 2-2.

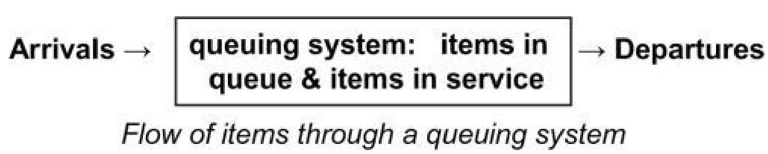

Figure 2-2: Standard Queuing System [8]

Little's Law provides a mathematical relationship in a queuing system, stating that the average number of items in a queuing system equals the average rate at which items arrive multiplied by the average time that an item spends in the system.[8] Little wrote the equation as:

$$L = \lambda W \tag{2.1}$$

L = average number of items in the queuing system

λ = average number of items arriving per unit time

W = average waiting time in the system for an item

Over the last 30 years, Little's Law has been used in operations management to analyze production within a system. The equation can be expressed in new terms as a relationship between work in progress, cycle time, and throughput. It is important to note that this modified equation references the average output, or the departure rate from the system instead of the arrival rate into the system.[6] Equation 2.2 shows the modified form.

$$TH = \frac{WIP}{CT} \tag{2.2}$$

TH = Throughput, average output of a production process per unit time

WIP = Work In Process, inventory between the start and end of a product routing

CT = Cycle Time, average time to produce part, the time the part spends as WIP

This principle holds true for various types of queuing systems and provides valuable insights into system behavior and performance. It can become a useful tool for managers to make informed decisions about capacity planning, resource allocation, and throughput time that can lead to improved efficiency, reduced customer wait times, and enhanced customer satisfaction.

Little's Law is an important concept in high-mix low-volume shops. As jobs on the shop floor are started regularly, understanding Little's Law provides valuable insights into the relationship between WIP and average cycle time. It shows that an increase in WIP into the system or into a given resource leads to a corresponding increase in the average cycle time, assuming that the throughput does not change. This can lead to inefficiency in the upstream resources. Instead of adding more jobs to the affected resource, it becomes more effective to allocate those jobs to another resource with available capacity. By doing so, the production floor can optimize resource usage, maintain a smoother workflow and decrease the average cycle time.

2.2.1 The Kingman Equation

While Little's Law reveals the lead time, it does not provide much insight into how to influence it, other then reducing work in process into the system. The Kingman equation was first published in 1961 by the British mathematician Sir John Kingman and provides a variation of Little's Law. This new equation gives an approximation of the waiting time based on the processes utilization and variance as seen in Figure 2-3.

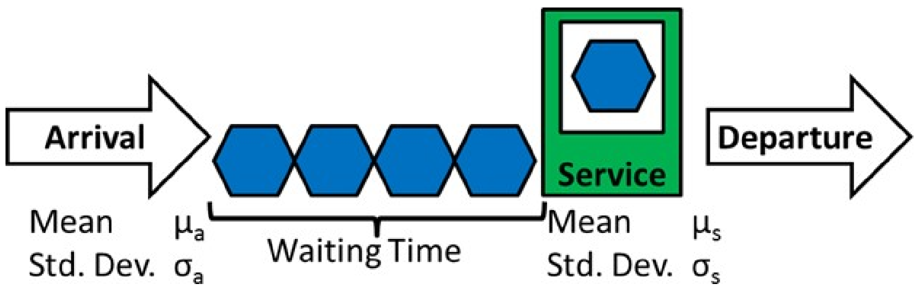

Figure 2-3: Visual of the Kingman Equation [13]

$$E(W) = (\frac{p}{1-p}) \cdot (\frac{C_a^2 + C_s^2}{2}) \cdot \mu_s \tag{2.3}$$

$E(W)$ = The expected waiting time

μ_s = The mean of the time to process one part

p = Utilization, the percentage of the time a machine is working. Calculated by dividing the mean time for service μ_s by the mean time between arrival μ_a

C_a = The coefficient of variation for the arrival

C_s = The coefficient of variation for the service

Equation 2.3 shows that two factors, the utilization and variation, have a large impact on the cycle time and queue length. Higher utilization (p) leads to longer queues, and as utilization approaches 100 percent, the queue length trends towards infinity as seen in Figure 2-4. Higher variation also increases queue waiting time as seen in Figure 2-5.

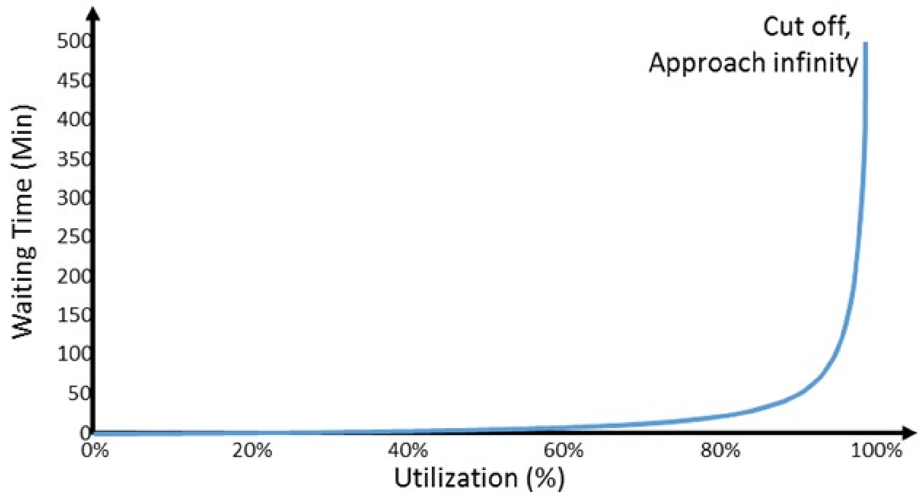

Figure 2-4: Utilization Impact on Wait Time [13]

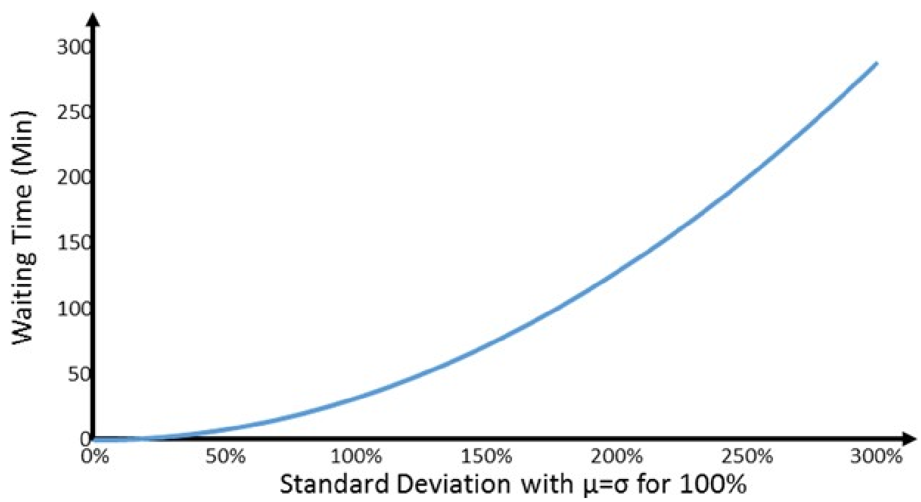

Figure 2-5: Variation Impact on Wait Time [13]

Decreasing either of these variables will result in shorter cycle times for the process. Understanding and managing these variables within a production floor are crucial in optimizing system performance and minimizing wait times. [13]

2.3 Theory of Constraints

The Theory of Constraints, also known as TOC, was first introduced in 1980 by Dr. Eliyahu M. Goldratt, an Israeli physicist and management consultant. The theory became popular through his book "The Goal," published in 1984. The book presents a fictional story about a plant manager who faces various operational challenges in his manufacturing plant and learns to apply the principles of TOC to improve the plant's performance. Since the book's publication, the Theory of Constraints has been widely adopted in various industries outside of manufacturing, such as supply chain management, project management, and business process improvement. It has become an influential approach to optimizing systems and achieving operational excellence. [14]

"The Goal" illustrates the critical role of constraints, also known as bottlenecks, in enhancing system performance. Goldratt defines a bottleneck as "any resource whose capacity is equal to or less than the demand placed upon it. A non-bottleneck is any resource whose capacity is greater than the demand placed on it." Constraints, in general, can encompass a wide range of factors that restrict a system from achieving higher performance relative to its intended goal. These limitations can arise not only on the production floor but also stem from management decisions and existing processes. [4]

According to the Theory of Constraints, every system must have at least one constraint. Without a constraint, an organization would generate unlimited profit. The Theory of Constraints highlights that the bottleneck, represented by the slowest operation in the process, governs the speed of the overall production and the maximum achievable throughput of the system. Any time lost at the bottleneck stage results in overall time loss for the entire system. Although bottlenecks and constraints may be viewed as negative obstacles, Goldratt emphasizes that their existence presents opportunities for exploitation. As constraints play a decisive role in a system's performance and flow, making improvements to them leads to an overall performance enhancement across the entire system. By understanding the principles of constraints and their impact on system performance, organizations can strategically identify and prioritize areas for improvement, allowing them to streamline processes, optimize resource utilization, and achieve greater efficiency. Goldratt's theory shows that constraints, when properly managed and leveraged, can serve as catalysts for driving continuous improvement and attaining long-term success in various industries and sectors.

2.3.1 The Five Focusing Steps

Goldratt also emphasizes the importance of implementing a continuous improvement process for achieving genuine success when utilizing the Theory of Constraints. He demonstrates that by directing attention to the bottleneck and making improvements in that area, the bottleneck may actually shift to another part of the system. Without this understanding, a production floor runs the risk of encountering the same problems it initially faced. The book laid out the steps of this process, which Goldratt later labeled as the five focusing steps in 1990. [3] These steps are outlined in the following order:

1. *Identify the system's constraints*: Find the bottleneck that limits the system's overall performance. This can be a physical resource, a process, or a policy that impedes the system's ability to achieve its goal.

2. *Decide how to exploit the system's constraints*: Once the bottleneck is identified, exploit it fully. Ensure that it is operating at its maximum capacity and remove any unnecessary downtime or interruptions.

3. *Subordinate everything else to exploit the constraints*: Align all other non-bottleneck elements within the system to support the bottleneck. This ensures that the flow of work or resources is regulated to match the pace of the constraint, preventing the accumulation of excess inventory or overloading of the bottleneck.

4. *Elevate the system's constraints*: If the constraint is still limiting the system's performance, elevate the constraint's capacity. This can involve increasing

the constraint's efficiency, improving its capabilities, or investing in additional resources to overcome the limitation.

5. *Overcome Inertia*: Continuously reassess the system, identify new constraints, and repeat the focusing steps. This iterative process ensures a continuous improvement cycle as constraints are resolved, leading to ongoing optimization of the system's performance.

The five focusing steps can be seen as a cyclical and continuous process in Figure 2-6.

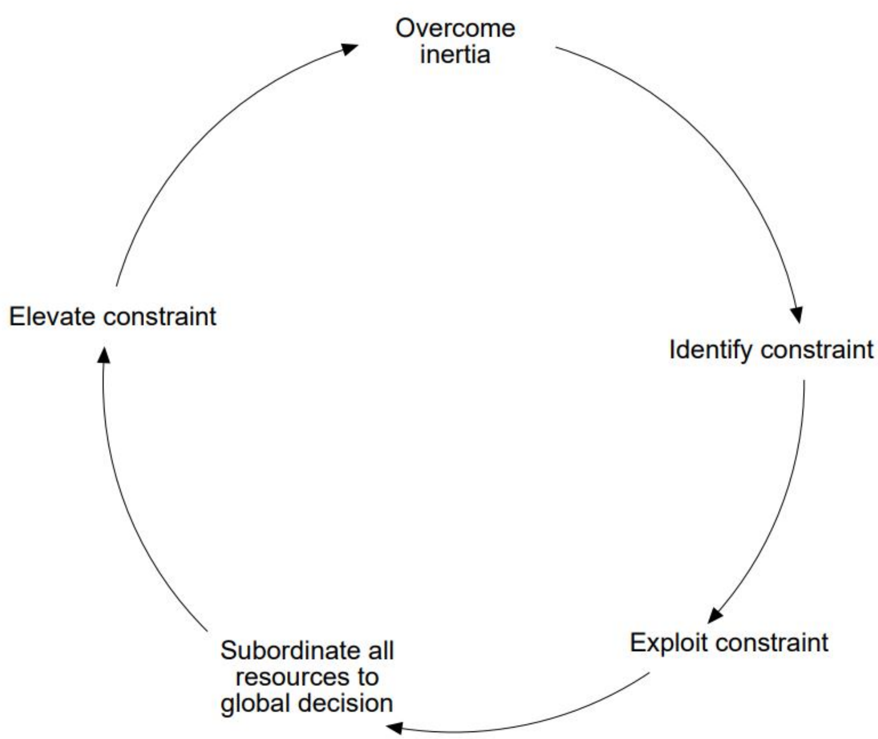

Figure 2-6: Process of On-Going Improvement [10]

2.3.2 TOC in High-Mix Low-Volume Shops

The Theory of Constraints holds significant importance in a high-mix low-volume job shop environment due to its capability to address bottlenecks and enhance overall system performance. Understanding the specific area within the system that determines the throughput production rate and effectively exploiting it is crucial. In a high-mix low-volume job shop, the bottleneck is subject to change due to the dynamic nature of the incoming jobs. A particular resource might be filled with work in one week and have none in the following week. Therefore, understanding the job shop's most common value streams and product flow becomes imperative to identify potential bottlenecks when new jobs are introduced. With this information, job shops can diligently monitor the day-to-day influx of jobs and effectively manage the release of jobs to the bottleneck. This approach enhances efficiency at other resources by strategically prioritizing jobs away from the bottleneck until it regains capacity. As a result, overall system performance improves as resources are optimally utilized, and operations run smoothly.

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Chapter 3

Project Methodology

3.1 Project Objective

The overall objective of this project was to develop a comprehensive process and tool that could be used to improve overall scheduling of the production floor in the various Rainier business lines. This new standardized process and scheduling tool would effectively and efficiently schedule jobs on a regular basis by prioritizing production based on profitability, customer needs, and the efficient utilization of capacity. This objective can be broken into three sub-goals laid out below.

- Build a dynamic scheduling dashboard in the Epicor ERP system that is updatable by the production manager and scheduling team.
- Establish a weekly meeting cadence to use the tool to schedule the production floor. Continuously discuss improvements needed and iterate on the tool and process to find best practices for each department.
- Once the process has been standardized and implemented, begin to identify inefficiencies in the production process and implement changes and improvements to create better product flow

The project approach and methodology to achieve these goals will be outlined in the following section.

3.2 Project Approach

The project adopted an iterative and learning-based approach, encompassing multiple steps aimed at achieving its overall objectives. The first few steps involved standardizing the scheduling process for each of the Rainier business lines while the later steps focused on finding the inefficiencies and improving upon them. Prior to the start of this project, members of the Rainier team visited another company in the LFM Capital portfolio to learn about their scheduling process. It was determined during that visit and subsequent meetings that Rainier needed a similar scheduling tool built into their ERP system. However, the two businesses are very different in nature and therefore it could not be a straightforward addition. Due to this, it was decided that an iterative and learning-based approach should be taken. After the tool was built, the team needed to understand what parts of the new process worked and what areas needed to be changed to fit the Rainier business. Over the course of several iterations, the tool and process could be used to schedule the Rainier shop floor effectively, opening the opportunity to find inefficiencies and areas of improvement in the production. This section will discuss in detail each step in the approach process.

3.2.1 Build the Scheduling Tool

The first step in the process was to build an integrated scheduling tool with the Epicor ERP System that can be updated by users in real time to establish the production schedule. As mentioned, before commencing this project Rainier sought inspiration from another LFM portfolio company to gain insights into potential capabilities and processes within their ERP system. Since it was already proven that this type of dashboard could be created, this step in the process involved communicating with the necessary company stakeholders to identify requirements, collaborating with Rainier team members to develop the tool within Epicor, and ensuring updates were made through the subsequent steps as necessary.

3.2.2 Iterate and Improve

After the scheduling tool was built in the ERP system, the next step involved initiating regular weekly meetings with the relevant stakeholders and floor managers to start scheduling the production floor. During these meetings, the team would evaluate the areas of the process that functioned effectively and identify areas that required improvement. Since this tool was being adapted from a separate business, there were many areas that needed updating. These meetings followed an iterative process to acquire the best practices for scheduling within each department. During this step we employed the people, process, and technology framework to ensure a functional and robust process.

- People: Determine who is included in the meetings and what their roles are in the scheduling process.
- Process: Determine the frequency of the meetings for each department, how priority is set for each job or operation, and best process practices.
- Technology: Scheduling tool built in Epicor and outside platforms to display data pulled from Epicor.

By using this framework, the stakeholders could develop a standardized process and tool that could be used to schedule all of the product moving through the production floor.

3.2.3 Value Stream Mapping

Once the tool had been created and the process more defined, we could begin to understand the flow of product in each of Rainier's business lines. This step involved creating a value stream map to understand Rainier's optimal flow paths in terms of revenue and volume. This map allowed us to visualize the product's movement through the system, which products were coming through the system at a higher frequency and which product was most profitable for the company. We would then be able to gain a better understanding of each step involved in the production process and which areas might be overloaded based on volume. By leveraging this knowledge of the value streams, the team would be able to strategize more effectively and optimize the scheduling of the production floor, ensuring maximum efficiency and productivity.

3.2.4 Identify and Improve Inefficiencies

The final step involved identifying inefficiencies and implementing improvements to the production process. Now that the company had a stable system where job scheduling was controlled and standardized, we could see where improvements could be made to the actual production of product. We could analyze the weekly scheduled tasks and compare them with the completed ones, identifying any obstacles that hinder the realization of the schedule. Additionally, we could evaluate the production scheduling process, assess the flow of jobs throughout the system, and determine methods to enhance the overall job flow. We could also identify how decisions made upstream or downstream of the production were influencing and effecting the production of product. A large majority of the recommendations resulting from this project were determined in this step of the process.

3.3 Data Collection

Data collection and analysis was an important factor to achieve the overall objective of this project, especially in the approach taken in section 3.2.3 and 3.2.4. This section will discuss how Rainier collects data and limitations and challenges faced with data collection throughout the project.

3.3.1 ERP Epicor Data

Rainier Industries strategically utilizes the Enterprise Resource Planning (ERP) system Epicor in the effort to streamline its business processes and enhance overall operational efficiency. This tool has been in use for several years at Rainer and includes the information for each job that passes through the production floor. Each step in the production process for each job is documented and includes information such as order number, due date, estimated hours needed, actual hours used, etc. Employees across the company use this information to plan, produce and ship the Rainier product on a daily basis. This large amount of current and historical data can be organized using queries and displayed in the form of Epicor dashboards or exported to Excel or Power BI.

3.3.2 Limitations and Challenges with Data Collection

During the course of this project, collecting data from the Epicor system was straight forward and accessible. Data was most often exported and used in Excel and Power BI by using existing queries or were sourced by building new ones. The main challenge stemmed from the integrity of the data. Understanding the accuracy and quality of the data that would be used in the overall analysis proved to be difficult. By working with several employees, it was determined that the interpretation or usage of certain data points varied from department to department. For example, certain data fields like the due date were initially inputted but not updated regularly if that date had passed or changed. Often employees were found not trusting the data that was held in the system, leading to increased difficulty in the scheduling process. Another limitation stemmed from the amount of data inputted for each production job. Each job had due dates related to each process step, leading to a large quantity of dates to be tracked. The problems associated with this data overload is further explored in section 5.2

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Chapter 4

Scheduling Tool Integration

4.1 Building the Scheduling Tool

To construct a scheduling tool in Epicor, the team used the built-in features of the ERP system to create a customized dashboard. The process involved finding a way to use Epicor's tools to provide an updatable dashboard that would provide an overview of Rainier's manufacturing activities. There was a strong vision of what the dashboard could become since this process was originally inspired by another portfolio company's dashboard. There was a lot of work put into how to get the data into the dashboard, what data points should or needed to be displayed and how they should be displayed to create the most efficient user experience. The interactive nature of the dashboard was meant to create productive conversation and collaboration between different departments and the scheduling team. The team communicated often with the future users of the product (shop floor managers from the display, fabric, wood, and metal shops) in order to best understand what they would need in order to start using the dashboard to schedule the shop floor.

4.2 Results

The results of the of the dashboard build can be seen in Figure 4-1. At the very top of the tool, the user is able to select which resource they would like to view. Once that resource is selected, all jobs in the system with an operation that passes through that system will appear in the upper window. The user can then see a variety of useful information for that operation including the job number, customer, description and more. The users are also given the opportunity to filter the data by fields such as on hold, material hold and ready status. If an operation line is selected the bottom left window changes to display all the other operations tied to that job number. In the bottom right corner shows the materials needed for the selected operation. In the main screen as well there are two columns that are updatable by the user, the Op Priority field and Schedule Comment field. The Op Priority field is where the user updates the priority of the job and sets the order in which the operations should be completed. During the scheduling meetings these numbers are updated in multiples of ten, allowing the user to add a priority between two operations if needed after they had already been scheduled. The Schedule Comment field could be used to add notes on things such as production delays, special needs to complete or customer information. This dashboard was updated and iterated upon as better methods were found or needs discovered over the course of the scheduling meetings.

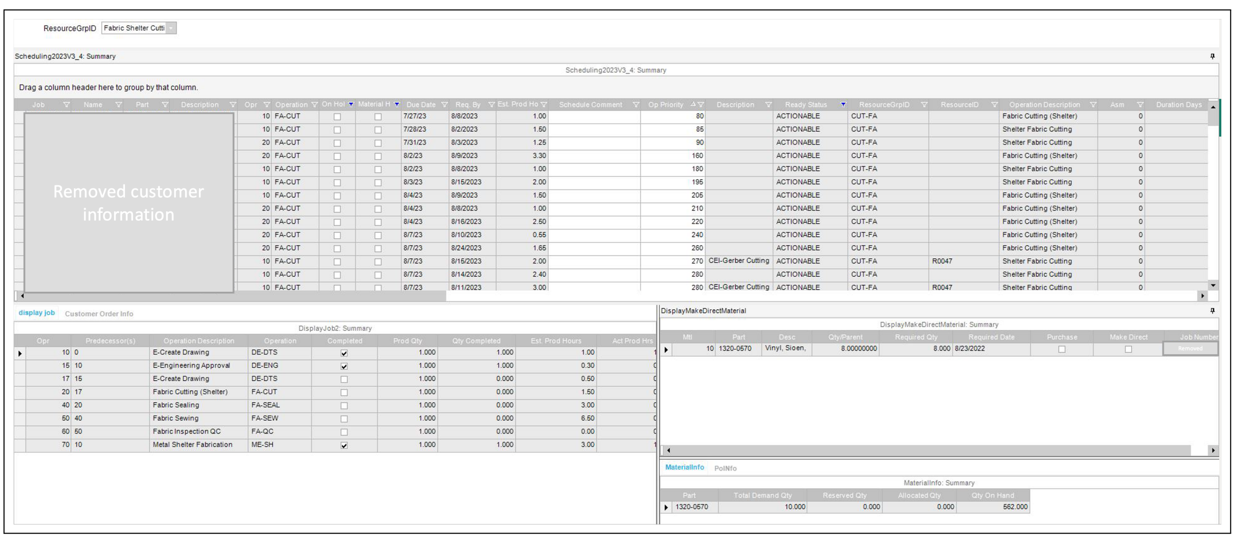

Figure 4-1: Epicor Scheduling Tool Dashboard

4.3 Challenges and Limitations

The main challenge faced when building the dashboard was accommodating the needs of each department that would end up using the tool. Each manager had different data points and information that they wanted included as the nature of their production floored varied greatly. It was a balancing game of which requests should be granted in order to better the tool for everyone and which requests were not necessary, ultimately just making the tool that much more complicated. Another issue that was faced was getting the Ready Status field into the dashboard. The Ready Status information informed the user if the operation was actionable or inactionable based on whether or not their predecessors were completed. The issue with this field was that the code was built outside of Epicor and would be lost when Rainier migrated their system to the cloud. A new way would have to be used in order to determine if an operation was actionable. A quick and easy python script was written to correct this problem as a temporary solution, while more effort was put into determining a long term solution inside the Epicor system.

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Chapter 5

Application of Scheduling Process

5.1 Scheduling Process

Once the scheduling tool was built in the Epicor system and the dashboard ready to use, the next step was to begin weekly meetings with the necessary stakeholders. Bi-weekly meetings were established with both the display and fabric shop floor managers and weekly meetings with the wood and metal shop managers. This is where the iterations on the scheduling process began. During these meetings, the list of jobs for each resource (i.e. printer, cutter, etc.) were planned based on need for final delivery, or due date. The list was then reevaluated at the next meeting and adjusted accordingly. The user would look at each job and assign a value in the priority value field, with the intent of setting the sequence in which jobs would be completed. There was also an updatable field available to add any notes onto the job that could be referenced at a future date. The time extensive nature of planning every single operation for each resource proved to be ineffective very early on. Through several weeks of iteration, the process became more defined and is outlined in further detail below.

5.1.1 Fabric Shop

During the bi-weekly meetings, the fabric shop managers continuously emphasized the need to schedule the cutting tables. Due to this request, the cutting table resource was always scheduled first and often took the duration of the meeting. Through the iteration process, the fabric shop began to schedule only the cutting table resource during these meetings. It was quickly realized that the cutting table was consistently the bottleneck (see section 2.3) of the fabric shop. Once a job had passed through the cutting table it would seamlessly flow through the rest of the shop until completion, with little risk of it being held up at another resource station due to too much work. This made it very easy to schedule the jobs for the fabric shop by simply managing and scheduling the constraint in the system. During each meeting, the priority of each job needing to go through the cutting table was set, creating an actionable list for the shop floor of what order to complete the jobs in. After going through the cutting table resource, the job would flow through the system until it was completed. This allowed the floor managers to efficiently monitor the jobs running through the shop and schedule them as needed in order to deliver on time. The scheduling tool and process proved to be very useful and successful for this department.

5.1.2 Display Shop

Similar to the fabric shop, bi-weekly meetings were held with the display shop to set priority on jobs for each resource. Unlike the fabric shop, finding the bottleneck in the print shop was not as easy. Due to the nature of the customizable product passing through the display shop, the constraints within the system would change from resource to resource depending on the type and quantity of work. Sometimes large amounts of work would pass through the system that needed to go through the lamination station for example, and sometimes there was very little work at that station. There was also the problem of the print step, which is often the first step in the process. It becomes difficult to change from job to job based on the type of material that is needed to print on. Increased set up time by switching the material can cause inefficient production and often leads to jobs printing earlier than they needed because they could be added to the end of a job with similar material. There were also issues with the upstream operations in the art and sales department that added increased complexity to the shop floor that was hard to surpass. These issues will be discussed in more detail in the following section. With all these factors it became difficult to adequately schedule the shop floor in the scheduling meetings. It became clear that further analysis of the overall system and deeper dive into the display operations would need to be assessed.

5.2 Display Shop Analysis

5.2.1 Date Management

When performing the analysis on the print shop, historical data was pulled on all the print jobs that had been completed from the start of the year 2022 to midway through 2023. A main point of emphasis that was examined was the number of dates attached to each job. Each operation that needed to be completed by a resource was attached to the job in the sequence that it needed to be completed in. To each of these operations is also attached a due date for when the operation should be completed by. As seen in table 5.1, the average amount of operations on a job during this time window was around 6, meaning that for each job in the display shop there was an average of 6 dates associated that need to be managed. When other dates were included like the start date, job due date and ship-by date, the average number of dates sat at around 9 per job. Looking at the high end, the maximum number of operations found tied to a job was 47. With the large number of jobs in Rainier's system, this becomes thousands of dates that that need to be managed and updated by the shop floor on a very regular basis. This results in dates that are not being managed by the shop floor workers and department managers.

Average # Operations per Job	Median # Operations per Job	Maximum # of Operations on Job
5.61	5	47

Table 5.1: Display Shop Operation Statistics

Art Department

Adding to the date management problem was the method by which the dates were originally inputted into the system. Since jobs were all custom in nature, there were no defined lead time set for a certain type of job. The result of this was that the sales team assigned a due date based almost entirely on the need of the customer and not on the capacity of the factory. The ship date was set along with the due dates for each operation, and it was then pushed down into the system for work.

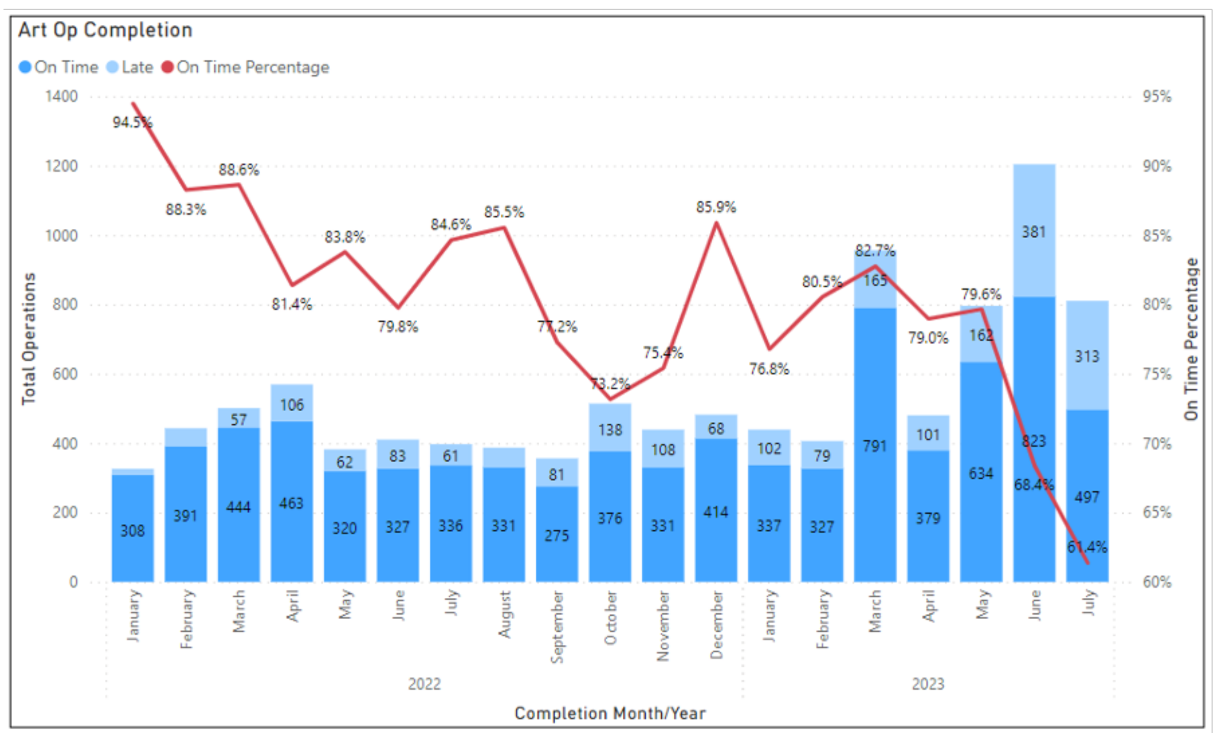

Figure 5-1: Art Department On-Time Rate

The first stop on a majority of display jobs was the art department, working on finalizing what would be printed. Depending on the job, some work at the art shop was more labor intensive and included creating the designs and some was simply waiting on the customer to send the artwork needed for print. The on-time completion rate of art operations during the given time window was measured in order to see how effective the department was at getting the work to the production floor in a timely manner. In 2023, 74% of art operations were completed on time, down from the 83% on-time completion rate in 2022. A steady decline in on-time completion can be seen in Figure 5-1 from the start of 2022 to July of 2023. The result of these late art operations meant that in 2023, 18-38 percent of jobs were entering the production system already late, causing major inefficiencies and uncertainty on the shop floor and difficulty in setting a schedule. These late jobs could jump ahead of other jobs that might have had a higher actual need if jobs were sorted by due date.

A natural first thought from this data would be that the art department did not have the needed capacity to have a high on-time completion rate. However, this was not the case as the art department was capable of being very productive. Often the reason why the art operation was not completed in time was due to the customer being late. The art department would send the finalized artwork to the customer for approval or would be waiting for the artwork from the customer and would end up waiting and watching as the due date passed. There were no business rules set in place to inform the customer that if they missed their date then Rainier would not be able to hit the ship-by date on the job. At this point as well, jobs were not always updated with a new ship-by date if the customer was late but would instead maintain the original date.

Impact

The result in this system was a large number of dates for jobs that were sometimes updated to the correct date and sometimes left as they were initially inputted. With these inconsistencies in the data, it became extremely difficult to know what dates could be trusted and what dates were inaccurate. During the course of the project, it was determined that a large majority of the workers on the shop floor did not trust the dates attached to a given job, making it extremely difficult to prioritize jobs during the scheduling process. At one point a production floor employee said, "A lot of the dates in Epicor are hard to trust. A lot of the decisions on which jobs should be worked on come from face to face interactions or by email." With such a large number of jobs, this proves to be highly inefficient and can lead to a multitude of issues.

5.2.2 Order of Operations

Another area within the product flow that was studied for the display department was the order in which operations on different jobs were completed. As seen at OAI, product flowed through the system and each resource practiced a first in first out order of operations (see Section 6.2.3). There was no risk of a job being skipped in the queue based on a job that had just entered with an earlier due date unless the job was strategically labeled as a rush job. Since Rainier used dates as a way to filter the operations at each resource, there was not always a first in first out flow. Since the due dates were set upstream at the sales department, often the order in which operations were completed was not effective or efficient.

Roll to Roll Printer			Cutter	
Job Number	Completed Date		Job Number	Completed Date
1	11/7	→	1	11/11
2	11/8	→	2	11/11
3	11/8	→	3	11/11
4	11/8	→	4	11/11
5	11/8	→	5	11/11
6	11/8	→	6	11/11
7	11/8	→	7	11/11
8	11/8	→	8	11/11
9	11/8	→	9	11/11
10	11/8	→	10	11/13
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12	11/9	→	12	11/14
13	11/9	→	13	11/14
14	11/9	→	14	11/14
15	11/9	→	15	11/14
16	11/9	→	16	11/14
17	11/11	→	17	11/14
18	11/11	→	18	11/14
19	11/11	→	19	11/14
20	11/14	→	20	11/14
21	11/14	→	21	11/15

Figure 5-2: Ideal Example of Sequence of Operations From Roll-to-Roll Printer to Cutter (Not Based on Real Data)

Roll to Roll Printer	
Job Number	Completed Date
1	11/7
2	11/8
3	11/8
4	11/8
5	11/8
6	11/8
7	11/8
8	11/8
9	11/8
10	11/8
11	11/8
12	11/9
13	11/9
14	11/9
15	11/9
16	11/9
17	11/11
18	11/11
19	11/11
20	11/14
21	11/14

Cutter	
Job Number	Completed Date
2	11/11
3	11/11
4	11/11
12	11/11
13	11/11
14	11/11
15	11/11
17	11/11
18	11/11
5	11/13
6	11/13
1	11/14
7	11/14
8	11/14
9	11/14
10	11/14
16	11/14
19	11/14
20	11/14
21	11/14
11	11/15

Figure 5-3: Actual Sequence of Operations From Roll-to-Roll Printer to Cutter (Using Production Data)

A series of jobs were looked at in a given week that flowed from the roll-to-roll printer to the cutting table. In an ideal state, as seen in Figure 5-2, the order of jobs completed at the roll to roll printer should be the same order that is completed at the cutter. Why print a job before another job if you aren't planning on finishing it in that order as well? In Figure 5-3 it can be seen that in actual production, the sequence in which the jobs were completed differed from one operation to the next. It can be seen that the operations were completed first at the printer but then become a lower priority at the next step (cutting table). This raised the question on why the printing operation order wasn't in the same order in which the cutting table order presented itself. The priority of jobs is found changing from resource to resource. This leads to more product in the system, causing average lead times to increase (see Section 2.2). Part of this issue can stem from having to print multiple jobs on the same type of material to reduce set up times, but in the case seen in Figure 5-3 multiple materials were used at the printing step on different days of production. This makes it hard to schedule just the printers, since the priority downstream of the printer can change based on the due dates of the proceeding operations.

5.2.3 Lead Times

The data from the given time window on display jobs was also used to understand if a standard lead time could be determined for different types of products making its way through the display department. If a standard lead time could be found, it would make it easier on the front end to quote the customer on when the shop could ship the final product, assuming that the customer sent the needed art on time and the shop had the capacity. By looking at the total throughput time based on the completion dates of the first and last operation on all display jobs, it was determined that the display jobs could be broken into three different categories with similar throughputs:

1. Jobs with no assembly operation (Table 5.2)
2. Jobs with assembly operation (Table 5.3)
3. Jobs with fabric operation (Table 5.4)

As can be seen in Table 5.2, jobs with no assembly had an average throughput time of 1.76 days. Table 5.5 shows that 80% of jobs in this category were completed in 2 days or less, and 90% in 4 days or less. The jobs that required over 1 week were determined to have greater issues and delays such as changing customer requirements. Using this information, it became clear how long a typical print job should take, and therefore what lead time could be quoted to the customer. Since the jobs are still custom, bigger projects could fall outside of this window but should be handled on a case by case basis. This new method opens the opportunity to only have one important date (required by date of customer) that is heavily managed and monitored by the project management team. This date can then be used to back schedule and determine when the job should be started in order to get it to the customer on time.

No Assembly

Sequence	Avg. Throughput (days)	Median Throughput (days)	Avg. Labor (hrs)	Median Labor (hrs)	Job Count
RTRP - Wallpaper QC	0.99	1	2.47	0.72	193
RTRP - Laminate - Cutter	2.59	2	1.96	1.16	153
RTRP - Cutter	1.79	1	1.62	1.00	141
RTRP - Laminate - Wallpaper QC	1.62	1	2.90	1.15	21
RTRP - Display Inspection QC	4.63	1	8.01	2.35	8
RTRP - Laminate	0.00	0	0.91	0.61	3
Total	**1.76**	**1**	**2.18**	**0.92**	**519**

Table 5.2: Throughput With No Assembly

Includes Assembly

Sequence	Avg. Throughput (days)	Median Throughput (days)	Avg. Labor (hrs)	Median Labor (hrs)	Job Count
RTRP - Assembly	1.84	1	1.40	1.16	152
RTRP - Laminate - Assembly	2.32	1	2.74	1.26	73
RTRP - Laminate - Cutter - Assembly	4.64	4	7.98	2.07	72
RTRP - Cutter - Assembly	7.60	7	12.72	6.40	15
Total	**2.87**	**1**	**3.77**	**1.38**	**312**

Table 5.3: Throughput Including Assembly

Includes Fabric

Sequence	Avg. Throughput (days)	Median Throughput (days)	Avg. Labor (hrs)	Median Labor (hrs)	Job Count
RTRP - Fabric - Fabric QC	2.76	2	42.89	7.99	55
RTRP - Cutter - Fabric - Fabric QC	3.17	2	2.61	1.48	41
RTRP - Fabric	1.16	1	4.79	3.57	25
RTRP - Cutter - Fabric	1.64	1	5.21	2.91	11
Total	**2.49**	**1**	**20.02**	**3.72**	**132**

Table 5.4: Throughput Including Fabric

Completion Time	Total Jobs	Percentage of Total Jobs
1 day or less	324	62.43%
2 days	88	16.96%
3-4 days	55	10.60%
5-7 days	44	8.48%
More than 1 week	8	1.54%
Total	**519**	**100.00%**

Table 5.5: No Assembly Throughput Times

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Chapter 6

OAI Visual Branding Process Study

6.1 Background

OAI Visual Branding was founded in 1989 in Tampa, Florida and was acquired by Rainier and LFM Capital in 2022. OAI operates as a classic print shop, specializing in the design, production and installation of displays, décor packages, banners, billboards and signage. They strategically focus on various markets, including events and venues, sports organizations and facilities, out-of-home advertising, tradeshow and convention services, and the retail sector, to generate their main sources of revenue.

OAI operates as a streamlined graphics shop without the metal, wood, and fabric shops present at Rainier, creating great margins and efficiency. Rainier's broader capabilities for handling more complex projects come at the cost of comparatively lower operational efficiency when compared to OAI. I was able to visit OAI and observe their processes, talk with their leaders and assess their strengths and weaknesses. Although their level of complexity within the jobs differ slightly, many of OAI's operational practices can be implemented into Rainier's system to provide better efficiency.

This chapter will highlight several of the key operational practices that OAI performs well and how they lead to a winning process for the team.

6.2 Key Strengths of OAI

6.2.1 Capacity Monitoring

The shop floor manager at OAI plays a pivotal role in their operational efficiency. Due to years of experience at the company, she has gained an invaluable understanding of the production shop's capacity. She knows how many jobs they are capable of running through the shop on any given day and is able to identify red flags and risks when too many jobs are scheduled. She maintains constant communication with the sales team to ensure that jobs aren't committed to when they don't have the capacity. This is not always the case, as sometimes the sales team still sells the job. However, when this happens, the shop manager knows that the shop will have to adapt, change priorities, or work overtime on a particular day. She monitors each job that is released to the floor for production with confidence, knowing it will flow through the system within a 2-3 day lead time because she knows the capacity at each resource. With her expertise and vigilance, the shop floor manager ensures a smooth production process and the timely delivery of orders, contributing to OAI's overall operational excellence.

6.2.2 Communication and Scheduling

OAI operates with a single date, known as the ship-by date, regardless of the number of operations involved on a job. The shop manager diligently monitors this date as it is released to the floor, ensuring that all released jobs adhere to an accurate date goal. Using their knowledge of the job's required completion date and the typical duration within their system, they effectively schedule the job's start. Once started, the job seamlessly flows through their system, as discussed in section 6.2.3, until it reaches the finished and shipped state. Through this process, OAI is able to effectively schedule the workable jobs on the shop floor and can ignore due dates at each resource operation that is used on a job.

Effective communication channels play a pivotal role in facilitating smooth operations at OAI. Each day, the shop manager compiles a list of all jobs and their respective operations due on that day. This list is then distributed across various resource locations within the shop, ensuring that everyone remains well-informed about the tasks to be completed. The team prioritizes the completion of these jobs before pulling others from the queue. Such consistent communication among the team enables the shop to maintain a uniform set of goals at every step of the process, effectively minimizing the risk of non-priority jobs entering the schedule ahead of those that are needed for shipment on any given day.

6.2.3 First In First Out Flow

OAI implements the first in, first out (FIFO) principle within their system, yielding significant advantages. They accomplish this through simple measures, utilizing printed traveler sheets for each job, which follow the flow of operations performed. These travelers are placed into color-coded sleeves based on two distinct colors: standard jobs and rush jobs. Once an operation is completed, the traveler is placed in a queue at the next operation. The operator at each station pulls the job from the queue that has been waiting the longest, unless there is a rush job that takes priority. By adhering to FIFO, OAI ensures that jobs flow through different operations in the order of their initiation, resulting in minimized lead times and optimized production efficiency. This standard FIFO approach enables OAI to determine the actual lead time for each job, leveraging this information with their customers through the sales team. Maintaining a consistent order through FIFO also simplifies job tracking, coordination, and resource allocation across the shop floor. As a result, OAI can streamline production planning, minimize disruptions, and optimize resource utilization. By wholeheartedly embracing FIFO principles, OAI operates a seamless and predictable shop.

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Chapter 7

Print Shop Next Steps

By analyzing the flow of product in the fabric job and also understanding how OAI had streamlined their print process, it is recommended that Rainier pursue an updated process for their print operations. By adapting new business rules and process changes, the scheduling process will become much more streamlined, allowing the shop to become more efficient and deliver finished products on time. This section will outline the suggested steps and possible effects they could have on display related production.

7.1 Common Lead Time

A new print flow process map was developed as seen in Figure 7-1 with the purpose of setting a clear picture of how the print product should flow through the system, where the lead times fall and how the different departments interact with each other. The map lays out the three specific departments that need to establish common lead times:

1. Metal and Wood Shop
2. Print and Display Operations
3. Packaging and Staging Department

The lead times for each department should be discussed with the operations team and each department head to get realistic numbers that can be realized during production.

These lead times should be implemented at the beginning of the process, allowing the sales team to quote their customers a ship-by date given the common lead time related to the requirements of the job. This ship date should be set at the current date plus the lead time days or later. By attaching these lead times to a job, it will become clear when the job could be due at the earliest, when it will actually be due and therefore when the work needs to be started.

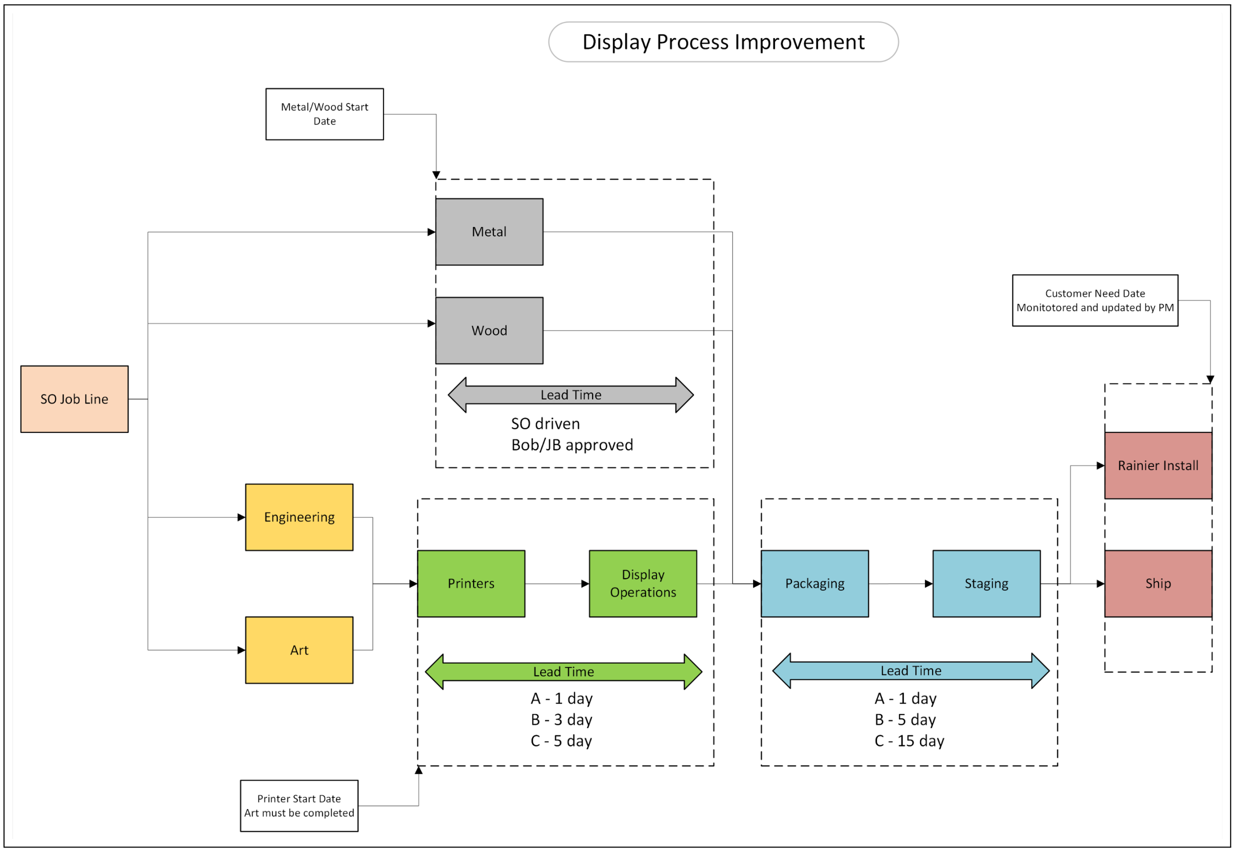

Figure 7-1: Updated Print Flow Process

7.2 Date Consolidation and Back Scheduling

Once the lead times have been implemented and can be used to determine the ship-by date for an order, it becomes important to consolidate the reminder of the dates tied to the operations to one single ship-by date. There should no longer be a need to manage the large number of dates attached to a job but rather one date. Back scheduling will then be used with the ship-by date and the lead times to understand when the job needs to be started at the print resource. This increases the understanding of what jobs have a higher priority by knowing when jobs need to be started in order for them to be shipped on time. Once a job is started at the print level it should flow through the system in a first in first out manner. There will no longer be a need to schedule each resource and determine which job has the higher priority. Once a job is started, it should flow through the production floor until it is completed.

7.3 Changing Business Rules

In order for these to changes to be effective, it becomes important for a few business rules and practices to be changed and continually enforced moving forward.

7.3.1 Ship-By Date Updates

If the ship-by dates tied to the display jobs are not continuously updated, then the process will continue to experience the scheduling and production issues that currently exist. With the implementation of the project managers at Rainier, it is important that these dates are actively managed and updated on a day-by-day basis. When changes occur on a job, like requirement changes or art deadlines not being met, it is necessary to update the dates accordingly. There should not be jobs in the system with outdated information that would affect the production schedule. Priority will be set on these jobs to set the production schedule and that priority will be based on these ship-by dates.

7.3.2 Customer Communication

In the current system, there is no clear communication to the customer on the effects of their actions. With this new system, it is important that the customer is fully aware of what needs to be done in order for the ship-by date to be met. They need to know that in order for the ship-by date to be hit, the job needs to start on a certain date, and for that job to start on that given date, all art and engineering operations need to be completed. The customer needs to know that if they do not provide or sign off on the art, then it will affect the date by which they are able to receive their product. There is no room for the customers variability to enter an already complex and complicated system. It will be on the project managers to develop the needed skills to properly communicate with their customers.

7.3.3 Scheduling and Capacity Monitoring

The scheduling process should be done multiple times a week, similar to what the fabric department has had success with. The display shop manager and floor workers should consistently know what jobs need to be started and what jobs need to be finished for each day, similar to OAI. By knowing what jobs need to either start or finish on a given day provides a clear path about where the shop focus should be and what the overall daily goals of the department are. The shop floor manager should also be monitoring the capacity in their system and how future work will affect that capacity with the tools discussed in Section 8. They can use these tools to change which order jobs are started based on the capacity at different resources downstream of the printers. By using this process, the display shop will become much more organized and efficient, opening opportunities to find additional inefficiencies in the production process.

7.4 Conclusion

In conclusion, with the analysis of the Rainier fabric shop and the streamlined print process at OAI Visual Branding suggests that Rainier needs to pursue an updated process for their print operations. Implementing process changes, such as establishing common lead times for departments, consolidating dates to a single ship-by date, and using back scheduling, can significantly improve scheduling efficiency. Moreover, changes in business rules, including continuously updating ship-by dates, enhanced customer communication, and regular scheduling and capacity monitoring, are vital for the success of these improvements. Project managers play a crucial role in managing these changes and ensuring effective communication with customers. Through these strategies, the display shop at Rainier can achieve a more organized and efficient workflow, leading to improved on-time deliveries and the identification of additional opportunities for process enhancements.

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Chapter 8

Digital Capabilities

8.1 Data Integration and Dashboards

Rainier is uniquely positioned to harness its data resources, creating increased efficiency and productivity across the shop floor. Leveraging the existing Epicor ERP system, Rainier has the opportunity use their extensive sets of data to enhance overall scheduling visibility and optimize operational processes. While Epicor proves valuable in constructing dashboards capable of querying, sorting, and displaying data, as depicted in Figure 4-1, the integration of external tools like Power BI presents the opportunity to craft more intricate and user-friendly dashboards. Different dashboard applications were explored for this project using Power BI and will be reviewed in the following section.

8.2 Power BI Dashboards

Throughout this project, significant effort was dedicated to exploring the usefulness of Power BI as a data visualization tool that could be used in the scheduling process. Power BI proved to be a strong tool, with the capabilities to process data and create customized tables and figures to help solve specific scheduling objectives. The main underlining advantage these dashboards provide to the scheduling process is visibility into the work currently available to the shop floor. Employees are able to see in real time what the current status of the shop floor is. They can see how much work is actionable vs. unactionable and what resources the job will affect through its life-cycle, in terms of estimated work hours. This visibility provides the team the correct information they need in order to most effectively schedule the shop floor.

8.2.1 Dashboard Visuals

Visuals created in Power BI using the data from Epicor are easy to build and powerful in the message they can provide. For example, the dashboard and figures seen in Figure 8-1 shows the amount of work for a given week in the print shop for each of the printers (the roll-to-roll, flatbed and dyesub). It also shows the downstream work expected for each of the jobs displayed after it goes through the printer, such as work at the cutting table, lamination station and assembly. All this information can be easily displayed on one page with the click of a button, with easy visuals to direct the eye to the information that is truly important. This differs from having to use the Epicor system where this kind of information is much harder to identify and often requires loading several different pages. With this dashboard, the user can easily understand what jobs are in the queue, what needs to be scheduled and how resources should be allocated.

Another example that provides utility to the user can be seen in Figure 8-2. In this dashboard example, the user can see the current jobs that are actionable to work on in a given day on the shop floor for each of the resources in the print department. They can see the total estimated work hours at each station and if that work is on time or behind schedule. By utilizing this dashboard, shop floor managers can easily understand which jobs are behind and who needs to be advised in order to resolve the delay. They will also be able to more easily pick up on trends and see where bottlenecks may be occurring.

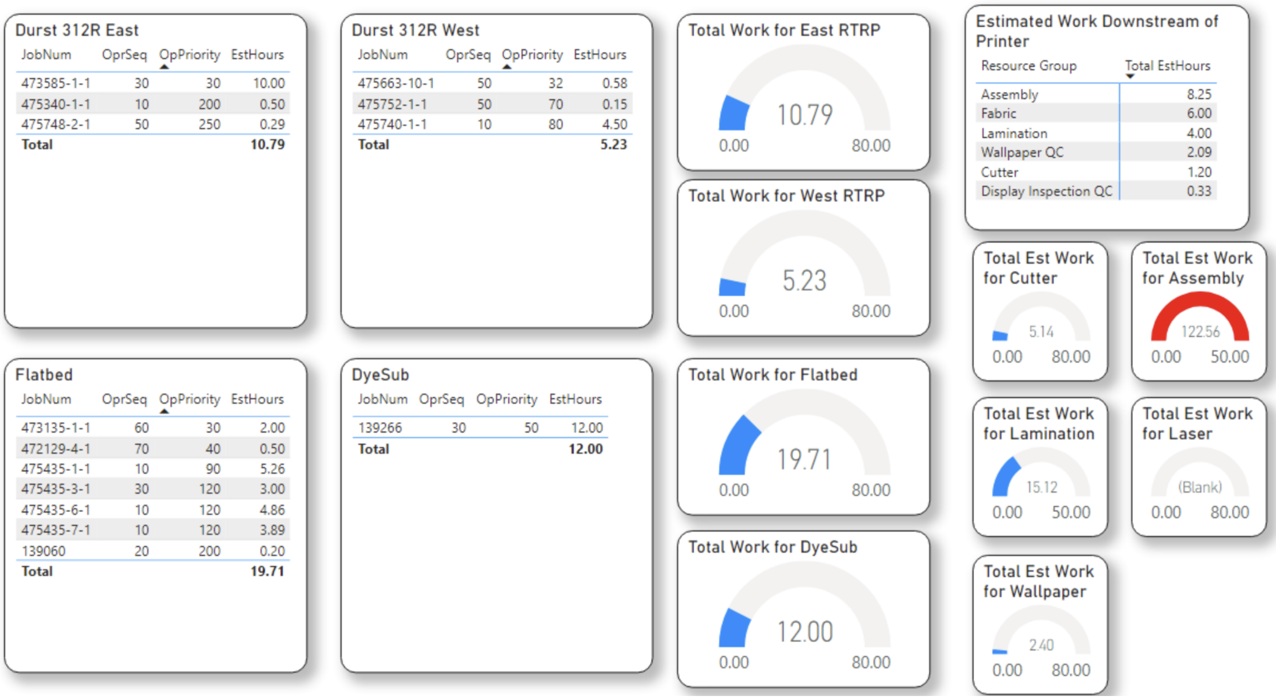

Figure 8-1: Power BI Estimated Work Dashboard

Figure 8-2: Power BI Work by Resource Dashboard

8.2.2 Interactive Dashboards

In the preceding examples, the dashboards were employed solely for presenting data to the end-users without necessitating user interaction in determining the displayed data. However, Power BI also provides the powerful capability of creating interactive dashboards that can provide the end-user with freedom to explore the data available. Figure 8-3 shows a dashboard with a series of filters that can be changed by the user to get the exact data they need to solve their objective. For example, the data can be filtered by resource group, date or material issues. With this capability, the user is able to better understand all the data they have available to them and what jobs are important to schedule for production. The possibilities on how to customize these types of dashboards are endless.

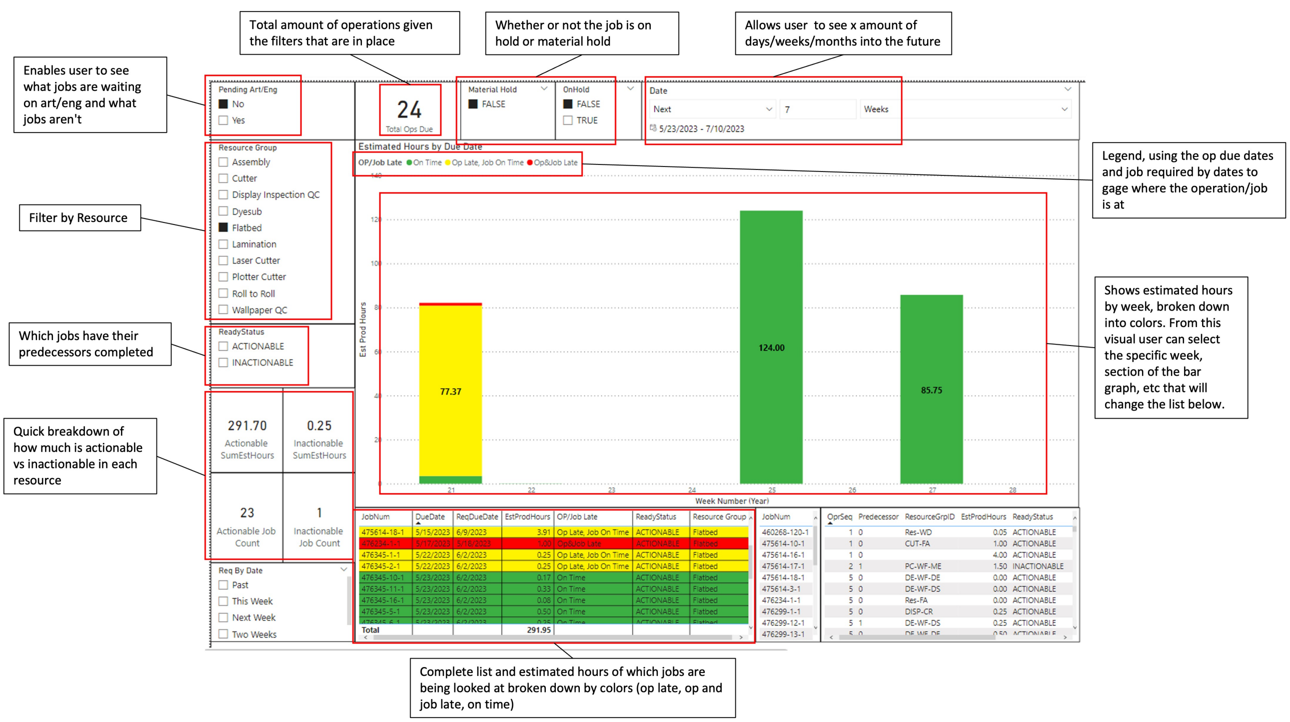

Figure 8-3: Power BI Scheduling Resource Dashboard

8.3 Power BI Limitations

Power BI, while a powerful data visualization tool, does have certain limitations. Since Power BI is a software outside of the Epicor database, one notable constraint comes from the need to update the data when using the visuals. Depending on the size of the dataset that the Power BI dashboard is accessing, wait times can vary and be cumbersome. The user also runs the risk of not looking at the correct and current information if they forget to update the dashboard. Another potential short fall comes with overcomplicating the data and creating visuals that do not provide value, or in fact are even hindering it. Because there are so many capabilities, developers can get caught up creating visuals to utilize the tool and not focus on the objective that is being solved. Despite these limitations, the benefits of incorporating Power BI into business operations often outweigh these concerns and should be further pursued for the Rainier scheduling process.

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Chapter 9

Conclusion

9.1 Summary

The purpose of this project was to first understand the production processes at the Rainier manufacturing facility and then develop a process and tool that could be used to improve overall scheduling of the production floor in the various business lines. The team focused on understanding the production process and capabilities, primarily of both the display and fabric shops. A dynamic scheduling dashboard was built in the Epicor ERP system that was capable of being updated by the production manager and scheduling team and a weekly meeting to use the tool to schedule the production floor was established. An iterative and learning-based approach was taken at this point to best understand the key pain points of the production process and where improvements could be made. The team also analyzed the production process at the recently acquired OAI Visual Branding to understand what lessons could be implemented at the Rainier facility. This led to a wide range of learning and recommended next step actions.

9.2 Next Steps

As a result of the work done throughout the project, a series of recommendations on next steps were suggested, as outlined in Chapter 7. A few of these next steps include:

- Establishing Common Lead Times - Determining common lead times for different types of projects that are consistent and could be used to quote customers during the sales process.

- Consolidating Dates and Using Back Scheduling - Reduce the amount of dates that are needed to be tracked on each job to just a few key dates, such as the ship by date. Once those dates are consolidated and reliable, back scheduling can be used to determine when a project should be started.

- Updating Business Rules - Implementing a series of new business practices that need to be implemented to improve the integrity of the data and increase efficiency in the production process. These rules include continually updating the ship by date, consistent communication with the customer on need dates and capacity monitoring of the production floor.

By using the tools that were built during the project in tandem with the suggested next steps above, it is believed that a more effective and efficient production process for Rainier can be achieved. The production managers and operators will be able to focus more on the production of each job, ultimately improving the on time delivery rate, and focus less on scheduling which jobs are available and needed to be started. Furthermore, the insights gained from analyzing the production processes at both Rainier and OAI Visual Branding have provided valuable lessons that can inform future strategies and continuous improvement efforts. By establishing these rules, and a culture of adaptability and learning, Rainier will be able to navigate the evolving industry demands with resilience and innovation.

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