Optimization of Ameristar's Montage Department

Senior Design Project Report

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Executive Summary

Ameristar is a Fencing and Security Solutions manufacturer based out of Tulsa, OK and is the largest ornamental fence manufacturer in the world. The company produces both steel and aluminum products for residential, commercial, and industrial settings. They offer a very extensive catalog of order options for nearly every fencing need in addition to taking custom orders for more unique customer needs. Within the production process of these various styles of fencing is the Montage department which deals only with steel products but with all sizes, decorative styles, and levels of security. The Montage department consists of both fence assembly and fence welding. For each individual order or type of order, a plant employee will bring the pickets and bars from inventory that correspond to that specific order to the respective Montage machine. The pickets and cross bars are manually loaded into the pallets and then the fully loaded pallets are moved along the line to reach the robots that weld the pickets together. There are four Montage machines that all complete the same function, but each machine has limitations on what size of fencing it is conducive to. Based on the established capabilities for each of the four parallel machines, RWC2, RWC3, G4, and G5, each order is assigned by the Ameristar scheduling department to be completed on one of the four machines.

Currently, the employees of the Montage scheduling department create the production schedule approximately three weeks in advance. First, the orders are scheduled based on customer catalog orders. These have the shortest turnaround times for shipments based on their quick production times and customer expectations. Extra catalog fencing is also built into the schedule in order to intuitively build inventory that is readily available to ship to customers in a quicker manner. In the current state of Ameristar's production, orders are being manufactured after they are already sold, which causes the customer to have to wait longer for their order to be shipped. The last step of the scheduling step is to fill in the custom orders. These orders have a longer lead time due to the complexity of their designs. Only two of the machines can fill custom orders. The scheduling team must make sure they do not overschedule those two machines initially to build inventory in order to leave room for custom orders.

When viewing the daily schedule, plant employees who operate the Montage machines receive the schedule via an excel sheet showing all the orders that must be completed for that day. While the scheduling team intends for the machine operators to complete the orders by following the schedule exactly, the machine operators view this schedule as a "suggestion." In order to combat this, disconnect in communication, our team has created a two-part solution to the scheduling problem. The team will create first an Interdepartmental Communication Improvement Guideline and Machine Scheduling Guidelines for each of the four Montage machines. First, the Machine Scheduling Guidelines will help the scheduling team create a schedule that reduces changeover time between orders because reducing downtime and therefore reducing changeovers is the main metric to measure success for this project. After producing more optimal daily schedules for production, Ameristar employees need to be able to make sure that this schedule is being completed exactly as given to reduce confusion and improve operating time on each machine. This is where the Interdepartmental Communication Improvement Guideline will be enacted. Plant employees should no longer view the daily schedule as a "suggestion" and by doing this, they should find that their job becomes a bit more simple due to the reduced amount of picket height and length changeovers and the smaller amount of time spent waiting for these changeovers to be completed.

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1 Introduction

1.1 Company Background

Ameristar is an industry-leading fence manufacturing company. Ameristar has a highly functioning plant. They have a vast catalog of fencing options including options for special orders. Having all different types of orders requires intensive scheduling so the team will be evaluating the scheduling in the Montage department. The Montage department is the second main step in which the fence pickets are assembled into panels, as seen in Figure 1. The Montage department has four machines to fulfil the work. The team will improve the usage of each machine in order to avoid purchasing new equipment. Since there are so many variations of orders, the machines must switch out parts to cater to the different orders, adding down time for the switch out. The team will be evaluating the scheduling of these products and the way to find the scheduling with the smallest down time and optimal number of orders produced daily.

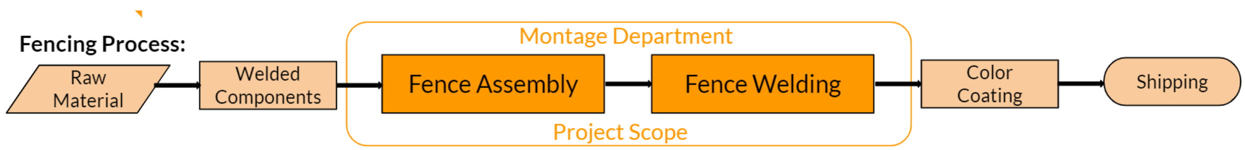


Figure 1 : Fencing Process and Project Scope

1.2 Problem Statement

In the Montage department at Ameristar, orders are being scheduled in a way where there are excessive daily changeovers. There is also a lack of communication between the production floor and scheduling department as to what sequence the orders should run in each day. As a consequence, there are significant productivity losses. An updated scheduling system is needed for this department to improve output of standard and custom-sized fence orders.

1.3 Project Scope

Review the Montage process to seek opportunities to improve the usage of machinery and to provide a production capacity for projected growth. The team will create a scheduling system that allows Ameristar to meet demand of both make to order and make to stock products. The scheduling system will include a clear set of expectations as well a product grouping plan to best improve overall throughput.

1.4 Project Objectives

Objective 1: Establish a workflow diagram to use with the client to clearly define the current state of the Montage process and develop metrics to track improvements to the process. Metrics include manufacturing time per unit and changeover time.

Objective 2: Use engineering methods to identify and advance improvements. These improvements will be documented using metrics established in Objective 1. The end goal is to improve the scheduling process for orders in the Montage departments. This may include but is not limited to items such as: reducing time and organizing a balance between special and catalog orders.

Objective 3: Provide recommendations based on data/information analysis, metric measurement and applying engineering methods to identify and confirm our findings.

2 Project Methodology

The project is broken down into four major phases: development and project initiation, planning and design, solution alternatives establishment, and project finalization. Each of these phases are built on the previous to ensure a successful final project deliverable in a calculated, meticulous approach. The scope of the project was determined within the first phase and further concentrated in the second phase once additional information had been collected and reviewed by the team.

The project has a substantial focus on the analysis of data and research focused on the operations of the problem. Much of the data analysis occurs in the first two phases of the project. From there, the solution alternatives were able to be established based on the findings from the data analysis and observations from site visits. The solutions alternatives generated are founded on meetings with the client, engineering methods and feedback from the team's faculty and IAB mentor.

To ensure project improvement, metrics have been created by the team to track progress. This will occur during phase two of the project and is used consistently throughout. In phase three of the project, solutions and alternatives are created through engineering methods and reviewed through the generated metrics, along with feedback from the team's mentors and client.

Once the solution is finalized through metrics reviews and stakeholder feedback, the team is able to present the findings. This process included the steps of implementation of the solution as well as a focus on the sustainable and long-term aspects of the project solution. The sustainable aspects were generated through consulting with the client to determine the most realistic implementation plan to ensure a successful outcome of the solution.

2.1 Development and Project Initiation

The first of the major phases of the project methodology is the development and project initiation phase. This phase included the steps in understanding the background and overarching concepts of the problem. These steps in understanding the problem background include researching the company history, using the company website to gain further information, as well as meeting with the client consistently to gain their perspective on the problem.

In addition, the development and initiation phase includes the project step of site visits to develop the team understanding of the overall company operations that involve the project problem, as well as focusing on the Montage department where the scope of the project problem takes place. The site visits are seen as a privilege, especially during the COVID-19 pandemic occurring, and are used to their full capacity in order to acquire a deeper understanding of the project scope and requirements.

This phase is also the start of the collection of project data. The data is provided by the client. Once the initial data is collected, the start of analysis begins. The analysis includes reviewing the data to check for abnormalities as well as commonalities, and meeting with the client to better comprehend the information provided. After the initial review of the provided data, the team starts to determine what additional data is needed in order to accomplish a successful solution to the problem.

2.2 Planning and Design

The second major phase is the planning and designing phase. The goal of this phase was to define the project scope and limit the study to ensure a completed and effective deliverable. This took place by continued site visits and meetings with the client which allowed the team to narrow the focus of the project. Through the additional visits and client meetings, the team was able to observe the Montage department operations, speak with the department manager, and recognize where the in the operations the project problem occurs. With these steps, the team was able to define the scope of the project through identifying where the root of the problem takes place within the operations. Additionally, this phase included the team discerning the machine capabilities and identifying where the data provided by the client is collected from.

During this phase, the team used integer programming to determine if this method would be suitable for a solution alternative. In order to generate the integer programming for the problem, the team constructed constraints for all the machines, parameters for the system, decision variables, and the integer programming formulation, as seen in the Figure 2 below. After obtaining the integer programming formulation, the team decided this method would not be the best solution since it would not effectively address all the concerns of the client. Since there was such a large number of constraints and order types, the code would have been very overwhelming for the client and the team would not have been able to provide a feasible or highly accurate solution. In addition, the team decided that the integer programming approach would not be a sustainable option after discussing the long-term maintenance with our client.

Maximize:

$$\Sigma T_i = \Sigma(Z_i P_{ij} - D_i)$$

(maximize total manufacturing time which is equal to to panel output per day divided by hours worked minus downtime)

Subject to:

$T_i \geq 0$

$N_{ij} \leq Z_i$ *total orders needs to equal to or greater than required orders per day*

$\Sigma C_i = \Sigma(N_{ij} X_{ij})$ *total changeover needed = sum of the total jobs per machine per day * if the job requires a changeover*

$D_i = \sum C_i S_{ijk}$ downtime = *number of changeover per machine * the time that is taken for each changeover per machine*

$Z_{i=} = \Sigma \frac{N_{ij} P_{ij}}{W_i}$ *panels produced per day per machine = (jobs per day per machine * time per job) / work hours per day*

$N_{ij} = H_{y_1 \cdot y_n} X \, W_{w_1 \ldots w_n}$ *a job is defined by the height and width options*

$i = \{$ *if* $j = RMB246, RMB258, RMB346, RMB358, RMB370$ *then* $i = G4$

Else if h < 46" and w≠ 1" then i = RWC2

Else if h > 46" and w ≠ ⅝" and then i = RWC3,

Else if h > 46" and then i = G5, $\}$

Determining what machine a job can go through

Figure 2: Integer Programming Approach

In addition, the planning and design phase of the project continued the analysis of the data collected and provided. Any additional data was gathered or collected during this phase of the project. The data was analyzed by engineering methods such as the use of production planning and MRP techniques and then reviewed by the team. The additional data allowed the team to fixate on the area of operations that can be adjusted through a solution to the project problem. Engineering metrics such as a current state analysis and a current state of the downtime were also determined during this phase to allow the improvements to be documented. Then the team consulted with the client, IAB mentor and faculty mentor to begin the process of determining the most appropriate solutions to the problem based on the research of the data.

2.2.1 Data Collection

The data collected was all provided by the client. The data involved in the project is described in Table 1.

Data Type	*Description*
Runtime per part per machine	Production times on each machine for each type of panel offered in the catalog
Average changeover times by machine	Average time taken for changeovers per machine
Scheduling ERP	Shown a walkthrough of current scheduling software and it's capabilities
Past work order history	A comprehensive list of all orders manufactured and shipped out in the past two years. Gives a good idea of the volume and pattern of production on Montage machines
Machine capabilities	Provided detailed constraints for the solution alternatives being constructed
Key Stakeholder Interviews	Interviews of key stakeholders involved in the manufacturing process to determine communication effectiveness

Table 1: Data Collection

2.3 Establishment of Solution Alternatives

The third phase of the project is the creation of solutions and alternatives for the project. The team used engineering methods such as Simio modeling, and data analysis to establish the solution alternatives.

2.3.1 Communication Infrastructure Approach

The manufacturing floor currently uses the provided schedule as a recommendation and can manufacture in any order they wish. After reviewing the scheduling data provided, describing the order in which the floor produced the panels, the team discovered that if there were a few adjustments in the schedule to reduce changeovers, there could have been a significant decrease in total production time, which would improve panel output. Therefore, the team focused on the communication between the scheduling department and the manufacturing floor and conducted interviews to get a good grasp on the current communication. This communication can create the potential to allow the floor to understand that the schedule can improve their manufacturing output as well as give the opportunity for the manufacturing floor to provide their input if they think they can improve the schedule.

2.3.2 Simio Approach

Once the recommended guidelines were created and found to be effective in reducing downtime, the team decided to test these initial guidelines in a simulation environment to ensure it is a feasible solution. Simulation modeling was done in Simio and was created to determine the effectiveness of the recommended machine and scheduling guidelines. The goal of using Simio modeling was to demonstrate how a scheduling system can be effective in reducing changeovers and decreasing overall needed processing time. The Simio model included a model of what a production day would look like if the manufacturing floor followed the recommended schedule versus the sequence that the products were actually produced. Then, these two models were compared to show how much time can be saved, potential to increase throughput of individual paneling produced, and percent utilization of the machines.

In order to model the manufacturing process using Simio, the team utilized several of the data sets involved in the project. These included runtime per part per machine, average machine changeover, scheduling enterprise resource planning, past work order history, machine capabilities. Through the combination of these data sets, the team was able to compare the processing time for one selected week, versus the improved model, which used the proposed guidelines to emphasize the impact of following the guidelines, which are discussed in the solution alternatives section.

2.3.3 Data Analysis Approach

Additionally, the team used the past scheduling data provided to compare results with the Simio modeling result in order to verify and validate the findings. The team used the scheduling data to compare the overall needed processing time for a week versus how much time would have been needed if the schedule was improved and followed the guidelines established. After this data analysis, the team received similar results, and thus was able to confirm the findings from the Simio modeling.

The data analysis approach involved several of the datasets, as well as utilizing data analysis skills, optimization, data normalization. The data sets included runtime, machine changeover times, past work order history, machine capabilities. Looking at the past schedules provided in these datasets, allowed the team to further empathize the impact of reducing processing time if the recommended guidelines were in place, which are discussed in the solution alternatives section.

The team then consulted with our faculty mentor, client and IAB mentor to determine feasibility and effectiveness of our solution and alternatives. Once this is completed, a finalized solution will be chosen based on the feedback received from our client and mentors and the team will present our proposal and refine it based on any additional recommendations.

2.4 Project Finalization

The last phase is the finalization of the project. This phase included establishing a sustainable solution which can be implemented to improve the scheduling process for orders in the Montage department. The sustainable solution has a focus but not limited to reducing downtime and organizing the balance between special and catalog orders.

After several reviews and consulting with the stakeholders involved in the project, the team decided that the communication guidelines, machine guidelines, scheduling modeling, and data analysis solution were all necessary. This was decided because without the guidelines, the scheduling improvements would not be possible. As well as acknowledging the importance of having Simio modeling and improved scheduling analysis to emphasize the need for the guidelines. The combination of these solutions add up to the overall solution of the guidelines and the modeling.

The process of establishing a final solution included weighing all possible recommendations and alternatives to show that the solution presented is the most feasible based on the data and informational analysis, metric measurements and applied engineering methods. In addition, client and mentor feedback influenced the final solution decision to ensure the stakeholders involved recognized value in the final solution and intended for it to be implemented. The team consulted with the client to ensure a success transfer of knowledge of the solution and a customized implementation plan. The implementation plan was created by the team based on the observations of the current state to ensure a sustainable solution to last long after the proposal.

3 Current State Analysis

Currently, the Montage Department consists of four machines that can all operate simultaneously and complete the same job, but cannot all process the same size of fencing models. The layout can be shown below in Figure 3.

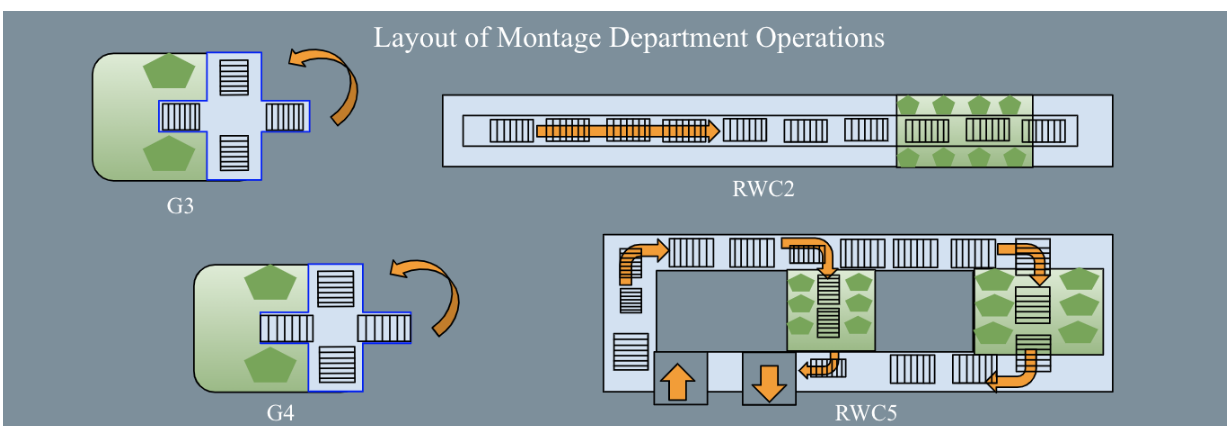


Figure 3: Layout of Montage Department Operations

The main action of the process is to connect the pickets of each fencing section together by placing each individual picket into the pallet molds so that the robots can weld the pickets to the horizontal bars that run perpendicular to the pickets. There are certain limitations on each machine based on mainly height picket diameter restrictions that can be seen below in Table 2.

WORK CENTER	RAN HERE	CANNOT BE RAN HERE	NOTES
RWC2	46'" up to 70" tall panels All flush bottom panels except 5/8" Flush bottom majestic 3/4"	234 or anything smaller than a 46" tall panel	No 1" panels AT ALL
RWC3	1" and 3/4" panels Cresent and special panels Hand carry samples		5/8" panels ran here but having issues welding. The welds breaking resulting in rework
G4	RMB246, RMB258, RMB346, RMB358, RMB370		These are the only panels scheduled here
G5	Some special panels Cresent panels 3/4", 5/8", 1" panels		Tooling change is required to swtich to 1" panels from 3/4" or 5/8". This changeover takes 1 hours. No changeover is required to switch between 3/4" or 5/8"

Table 2: Machine Capabilities

The Ameristar team has not been able to provide us with an accurate schedule for each of the machines. However, the team does have a schedule of all work orders shipped out within a given month. From this information, the team is able to calculate the current volume of orders produced per week to be able to compare with the calculations of the number of changeovers per week that the team will get from the data from the exact schedule of orders once received.

To complete this analysis, the team will use the Montage Panel Shipment History from the week of January 25-30, 2021. Over this week, there were 295 orders shipped from a combination of all four machines. These orders were sent to residential, industrial, commercial, and custom order customers. Each day, a combination of each of these types of orders were sent out, indicating that there were many changeovers occurring each day. The team will need the production schedule to further complete our current state scheduling analysis.

4 Solution Alternatives

The team established four solution alternatives for the project. These alternatives include interdepartmental communication guidelines, scheduling guidelines, individual machine guidelines, data analysis, and Simio modeling. Each of these will be discussed in their respective sections below.

4.1 Interdepartmental Communication Improvement Guideline

The first of the alternatives is the Interdepartmental Communication Improvement. The Interdepartmental Communication Improvement guideline was created because there is miscommunication and distrust between the scheduling department and those working in the manufacturing plant. The distrust and miscommunication enables the floor workers to decide the manufacturing schedule as they are working, and disregard any schedule given by making last minute, unapproved schedule changes.The team has found this to be true from personal statements from both the engineering department, scheduling department and workers on the floor. This happens as often as workers on the floor feel it is necessary. The impact of this is essentially that it is a waste of time for the scheduling department to come with a schedule that is not used. In order to combat this problem, the team has created a guideline.

Interdepartmental Communication Improvement Guidelines

"The machine workers are under the impression that a schedule is a "recommended schedule" which undermines the work that the scheduling department does in researching the most efficient ways to process orders. A recommendation would be to eliminate that mindset and abide by the schedule that is worked on for weeks in advance. If there needs to be a change in the schedule there should be a point of contact who approves this change, for example, the foreman on the floor and the scheduling manager."

4.2 Readjustment of Ordering Guidelines

The second part of the solution includes the Readjustment of Ordering Guidelines. To eliminate changeovers, the team has a plan to order them in an easy and specific way that is easy to understand and saves the company's time. Since there are four different machines with different capabilities, the team is implementing guidelines for each individual machine.

Also, it should be noted that this can be implemented daily or weekly depending on the urgency of certain orders being completed. The team would recommend implementing these weekly but understand that other departments of the company may have different urgencies to get orders completed on a different time schedule.

General Scheduling Sequence Improvement Guideline

We recommend staying within the width of the panel until all heights for that width are completed. Within the specific widths of ¾", ⅝" and 1", the team recommends filling them where they are gradually increasing or decreasing in height in order to eliminate large size difference changeovers which take longer to complete. The team also believes that going in anywhere from a few days to a week in advance to fill in special orders to corresponding length sizes in the set schedule is very important. This ensures that the special orders correspond to the sizes of like-sized panels in the schedule. Lastly, implementing a weekly goal of a certain number of panels done per week will help to ensure production is on track and set trackable goals. This would also allow for special orders to be filled in while ensuring that all necessary orders are completed in the time frame of a week.

Individual Machine Scheduling Sequence Improvement Guidelines

G4 Machine Guideline

The G4 Machine only runs five different item numbers, so the team ordered the guideline in descending height order. The team recommends scheduling in order of: RMB370, RMB358, RMB258, RMB346, RMB246. Then repeat this cycle backwards, gradually increasing in height.

RWC3 Machine Guideline

The RWC3 Machine Capabilities include widths of only 1" and ¾" with any height, crescent panels, and samples. The team recommends scheduling in order of ¾" from shortest height pickets to longest height then changeover to the crescent tooling for any crescent panels that are ¾" in width, then changeover to 1" from longest height to shortest height and then doing a crescent panel changeover for panels that are 1" in width. Fill in special orders to correspond to like sizes in the schedule and add in hand carry samples at the end of the week once other orders are filled or at the very beginning of the week if they are needed sooner than the orders completed that week.

RWC2 Machine Guideline

The RWC2 Machine Capabilities include widths of only ⅝" and ¾" panels and heights ranging from 46" to 70" tall. The team recommends scheduling in order of: ⅝" from longer heights to shorter heights then once all ⅝" orders are filled, changeover to ¾" from shorter heights to longer heights. Repeat this cycle as it is shown.

G5 Machine Guideline

The G5 Machine Capabilities are the broadest of all the machines and are able to run all three widths (¾", ⅝", and 1"), crescent panels and special panels. The team recommends scheduling in order beginning with ¾" from tallest height to shortest then ⅝" from shortest to tallest then 1" tallest to shortest. Repeat this cycle backwards. Add in special orders as they come and add in crescent panels in the same way mentioned above with the RWC3 Machine (add them in at the end of the specific width/height they fall into before changing over to the next width/height.)

These guidelines help to create a schedule that makes sense to both schedulers and manufacturer workers. Having set guidelines in place confirming things are being effectively and efficiently produced ensures the inventory is increasing and that changeovers are decreasing as much as possible. Once these guidelines were established, modeling and analysis was conducted to further prove they will be effective in a manufacturing environment, which will be discussed in the following sections.

4.3 Data Analysis Solution Alternative

To ensure that the guidelines are effective in the manufacturing process, the team established a data analysis solution alternative. The purpose of this solution was to emphasize the potential processing time that could have been saved if the guidelines were implemented in a previous week's ordering schedule.

To create this solution, the team used excel to analyze and normalize the data. The datasets involved in this solution were runtime, machine changeover times, past work order history, and machine capabilities.

This alternative solution involves comparing the original processing time required for one week of production orders, versus what the production time would be if the guidelines were followed. Therefore, to improve the production schedule, the guidelines were implemented for each machine to attempt to reduce the number of changeovers. Reducing the changeovers decreases the total production time, since as discussed, the changeovers are a time-consuming process. However, the changeovers can be reduced if the orders are scheduled in a way that does not require excessive changeovers, which is one of the goals of the machine guidelines.

The data analysis solution alternative is described for each of the four machines in the Montage department below:

4.3.1 Machine G5 Data Analysis Solution Alternative

The first machine schedule improved for one day in the week of 6/1/2020 is G5. As seen in Figure 4, there were ten changeovers for the eight orders for the production selected day the team analyzed, which required 13.82 hours of total production.

Schedule Order	Order Num	Qty	Height	Picket	Run Time	HTChangeover After?	Changeover time	WDT Changeover	Changeover time
1	12691113	120	4'	5/8"	1.176	yes	0.083		
2	12691400	120	3'	5/8"	2.317	yes	0.083		
3	12691453	280	4'	5/8"	5.383			yes	0.25
4	12753958	81	4'	3/4"	2.2	yes	0.083		
5	12759875	18	3.5'	3/4"	0.4	yes	0.083	yes	0.25
6	12759930	8	4'	5/8"	0.33	yes	0.083	yes	0.25
7	12772649	13	3.5'	3/4"	0.583	yes	0.083		
8	12787573	6	3'	3/4"	0.1	yes	0.083		
				Total Run Time	12.489				
				Total HT changeover	0.581				
				Total WDT changeover	0.75				
				Total prod Time	13.82				

Figure 4: Machine G5 Original Schedule

After the guidelines were implemented into the schedule, as seen in Figure 5, there is a significant decrease in the total number of changeovers, and total production time required for the same eight orders. To reduce the number of changeovers, the machine guidelines for G5 were followed, which states to process orders with the same picket sizes together. The improved schedule of G5 saves 6.02% time of the original schedule, and only requires four changeovers.

Schedule Order	Order Num	Qty	Height	Picket	Run Time	HTChangeover After?	Changeover time	WDT Changeover after?	Changeover time
1	12753958	81	4'	3/4"	2.2	yes	0.083		
2	12772649	13	3.5'	3/4"	0.583				
3	12759875	18	3.5'	3/4"	0.4	yes	0.083		
4	12787573	6	3'	3/4"	0.1			yes	0.25
5	12691400	120	3'	5/8"	2.317	yes	0.083		
6	12691113	120	4'	5/8"	1.176				
3	12691453	280	4'	5/8"	5.383				
8	12759930	8	4'	5/8"	0.33				
				Total Run Time	12.489				
				Total HT changeover	0.249				
				Total WDT changeover	0.25				
				Total prod Time	12.988				
				Percent Time Saved	**6.02%**				
				Hours Saved	**0.832**				

Figure 5: Machine G5 Improved Schedule

4.3.2 Machine RWC3 Data Analysis Solution Alternative

The second machine involved in the data analysis solution is RWC3. The same process was conducted for RWC3 as the data analysis for machine G5. First the actual schedule was analyzed for one day in the week 6/1/2020, as seen in Figure 6. The actual schedule of RWC3 required 14 changeovers, and the total production time needed for the nine orders was 22.12 hours.

Schedule Order	Order Num	Qty	Height	Picket	Run Time	HTChangeover After?	Changeover time	WDT Changeover after?	Changeover time
1	12698800	480	6'	5/8"	7.968	yes	0.417		
2	12704384	25	4'	5/8"	0.867	yes	0.417	yes	0.417
3	12722066	45	6'	1"	2.117	yes	0.417	yes	0.417
4	12734657	150	8'	3/4"	3.583	yes	0.417		
5	12741157	2	25"	3/4"	0.033	yes	0.417	yes	0.417
6	12759911	7	6'	1"	0.05	yes	0.417	yes	0.417
7	12760923	75	8'	3/4"	1.15	yes	0.417	yes	0.417
8	12766466	26	5'	1"	0.35	yes	0.417	yes	0.417
9	12787881	22	8'	3/4"	0.183				
				Total Run Time	16.301				
				Total HT changeover	3.333				
				Total WDT changeover	2.500				
				Total prod Time	22.13				

Figure 6: Machine RWC3 Original Schedule

As with machine G5, after conducting the analysis on the original data, the team improved the schedule for RWC3 using the machine specific guidelines. As seen in Figure 7, when improving the scheduling data, there was only a need for eight changeovers. The total production time for the improved schedule of RWC3 is 19.63 hours, which saves 11.03% time from the original production schedule.

Schedule Order	Order Num	Qty	Height	Picket	Run Time	HTChangeover After?	Changeover time	WDT Changeover after?	Changeover time
1	12704384	25	4'	5/8"	0.867	yes	0.417		
2	12698800	480	6'	5/8"	7.968	yes	0.417	yes	0.417
3	12734657	150	8'	3/4"	3.583	yes	0.417		
4	12741157	2	25"	3/4"	0.033	yes	0.417		
5	12760923	75	8'	3/4"	1.15				
6	12787881	22	8'	3/4"	0.183	yes	0.417	yes	0.417
7	12722066	45	6'	1"	2.117				
8	12759911	7	6'	1"	0.05	yes	0.417		
9	12766466	26	5'	1"	0.35				
				Total Run Time	16.301				
				Total HT changeover	2.500				
				Total WDT changeover	0.833				
				Total prod Time	19.63				
				Percent time saved	**11.3%**				
				Hours Saved	**2.50**				

Figure 7: Machine RWC3 Improved Schedule

4.3.3 Machine G4 Data Analysis Solution Alternative

Then a data analysis solution was conducted for machine G4. The original data, as seen in Figure 8, explains that there are no changeovers required for this day in production. Since G4 only has a limited selection of paneling that can be produced, the team was not surprised by this selected day not needing a changeover.

Schedule Order	**Order Num**	**Qty**	**Height**	**Picket**	**Run Time**	**HTChangeover After?**	**Changeover time**	**WDT Changeover after?**	**Changeover time**
1	11921715	400	5'	5/8"	8.633				
2	12034601	480	5'	5/8"	7.968				
3	12034602	480	5'	5/8"	7.968				
				Total Run Time	24.569				
				Total HT changeover					
				Total WDT changeover					
				Total prod Time	24.569				

Figure 8: Machine G4 Original Schedule

The schedule for machine G4 required 24.56 hours of total production time, which does not include any changeover time, since there was not any involved in the scheduling time.

4.3.4 Machine RWC2 Data Analysis Solution Alternative

Lastly, the analysis for machine RWC2 involved the same process as the previous three. As seen in Figure 9, there were 13 required changeovers for the 9 orders on this specific day. This required a total production time of 15.51 hours.

Schedule Order	Order Number	Qty	Height	Picket	Run Time	HTChangeover After?	Changeover time	WDT Changeover after?	Changeover time
1	12736871	200	4'	5/8"	2.45	yes	0.25	yes	1
2	12753963	99	5'	3/4"	0.8	yes	0.25	yes	1
3	12759926	56	6'	5/8"	0.7				
4	12787812	76	6'	5/8"	0.984	yes	0.25		
5	12787813	16	4'	5/8"	0.433	yes	0.25	yes	1
6	12787829	38	5'	3/4"	0.517	yes	0.25	yes	1
7	12788609	12	6'	5/8"	0.4	yes	0.25	yes	1
8	12794564	25	4'	3/4"	0.45			yes	1
9	12794835	46	4'	5/8"	0.283			yes	1
				Total Run Time	7.017				
				Total HT changeover	1.5				
				Total WDT changeover	7				
				Total prod Time	**15.517**				

Figure 9: Machine RWC2 Original Schedule

After the schedule for machine RWC2 has been improved following the guidelines recommended, as seen in Figure 10, there is a reduction of changeover from 13 to 3 changeovers necessary for production. The total production time required for the 9 order on machine RWC2 after the improved scheduling is 8.51 hours, which saves 45.11% time from the original production time.

Schedule Order	Order Number	Qty	Height	Picket	Run Time	HTChangeover After?	Changeover time	WDT Changeover after?	Changeover time
1	12788609	12	6'	5/8"	0.4				
2	12759926	56	6'	5/8"	0.7				
3	12787812	76	6'	5/8"	0.984	yes	0.25		
4	12787813	16	4'	5/8"	0.433				
5	12736871	200	4'	5/8"	2.45				
6	12794835	46	4'	5/8"	0.283			yes	1
7	12794564	25	4'	3/4"	0.45	yes	0.25		
8	12787829	38	5'	3/4"	0.517				
9	12753963	99	5'	3/4"	0.8				
				Total Run Time	7.017				
				Total HT changeover	0.5				
				Total WDT changeover	1				
				Total prod Time	8.517				
				Percent time saved	**45.11%**				
				Hours Saved	**7**				

Figure 10: Machine RWC2 Improved Schedule

4.4 Simio Modeling Solution Alternative

The last solution enhancement is the simulation modeling. The team began working on a discrete-event simulation software called Simio after the Excel file calculations were finished.

Simio was used in order to cross check all the calculations from Section 4.3 and replicate what a day's worth of orders would look like for RWC2. The optimal schedule was used to model what the day could have looked like if the guidelines had been implemented. Below are the findings.

To set up the Simio model for the schedule of machine RWC2, the team established the entities to be produced as the paneling. Our model had nine entities, representing the nine different possible order types for this given day, a server representing RWC2, and a sink which represented Painting which is the next step of the fencing process. Table 3 lists all of the symbols that were used. Screenshots are attached of the Simio model and how this process was laid out.

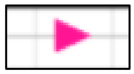
Symbol	*Description*
	Entities representing the orders for machine RWC2
	Server representing the machine RWC2
	Sink representing where the orders are sent after finished welding

Table 3: Simio Symbols

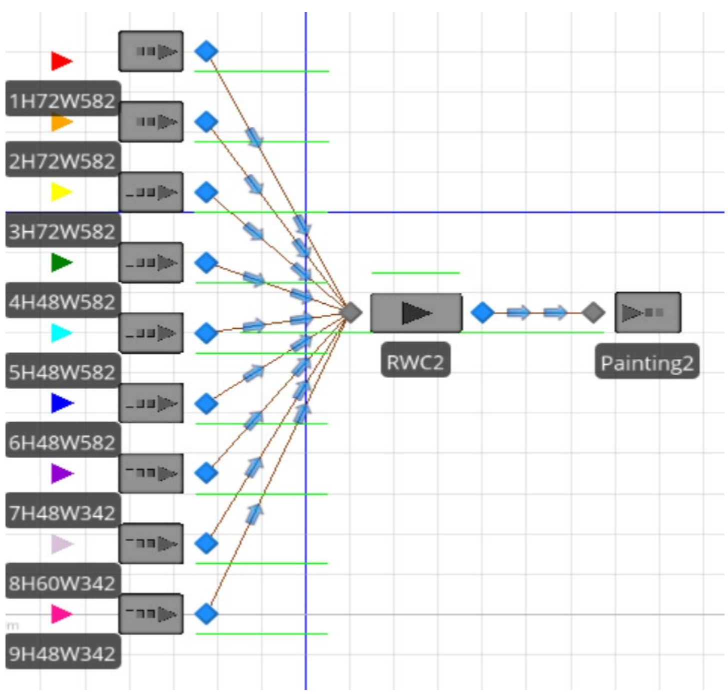


Figure 11: Simio Setup of Machine RWC2

The team modeled the improved schedule of RWC2, which is seen in Figure 11. Therefore, each of the entities required to be processed by the server, machine RWC2, in a specific order in order to follow the improved schedule. Thus, the team used a timer which regulated when each entity would be processed. Each of the entities were connected to a specific timer element to regulate when they would be processed, based on the schedule the team had improved previously.

Once the entities were scheduled to be processed in the improved order, then the server had to represent the process in which the actual machine RWC2 welds each panel, as seen in Figure 12. The process is to weld one panel at a time, therefore the Simio modeling needed to represent this, in order to receive the most accurate data to represent the actual process. To accomplish an accurate representation of the machine capabilities, the server was set to a specific processing time of 1.017, indicating that each panel took 1.017 minutes to produce. This processing time was an average of over 4000 data points based on the runtime per part per machine, and scheduling enterprise resource planning data set provided by Ameristar. In addition, the server was set for a capacity of one, which represents the capacity of the actual RWC2 machine. Although not every panel is processed in exactly 1.017 minutes, adding variability to the processing times will demonstrate how variability affects the schedules. Inside the timer, the actual run times per part are inserted. The data now reflects expected values, with real times fluctuating around these values.

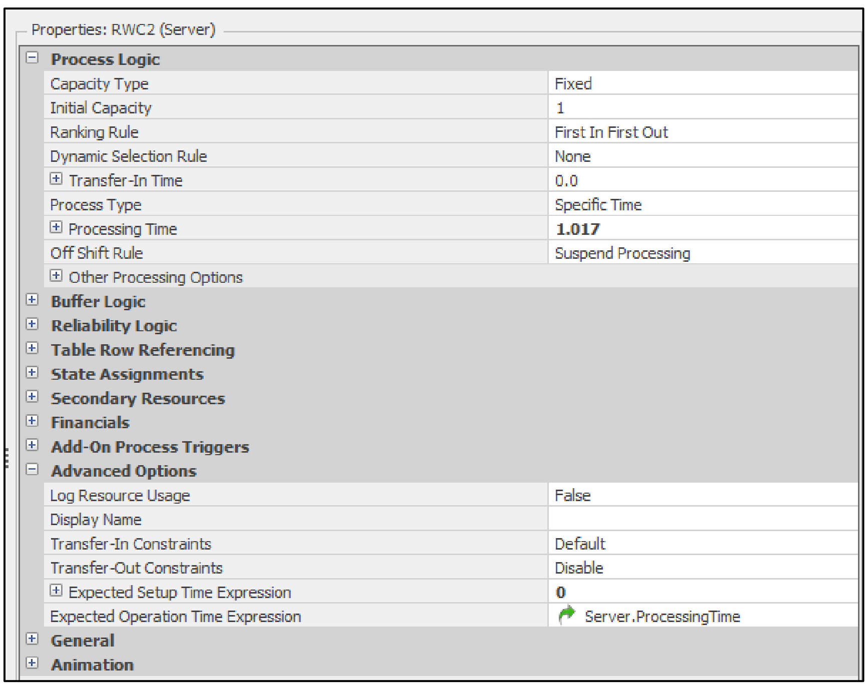


Figure 12: Simio Server Setup

After the server requirements had been established, the entities needed to be adjusted to represent the total number of panels per order for the day the team was modeling. As previously mentioned, there were nine different entities, representing the nine orders for the day the team was modeling. Each of the orders had a specific number of paneling per order. Therefore, the Simio model needed to represent the number of panels in each order. To set up the specific amount of paneling orders per entity, the team used the fixed model feature and assigned the orders per entity, as seen in Figure 13.

Properties: Model (Fixed Model)

Controls	
General	
Source1_EntitiesPerArrival	**12**
Source2_EntitiesPerArrival	**56**
Source3_EntitiesPerArrival	**76**
Source4_EntitiesPerArrival	**16**
Source5_EntitiesPerArrival	**200**
Source6_EntitiesPerArrival	**46**
Source7_EntitiesPerArrival	**25**
Source8_EntitiesPerArrival	**38**
Source9_EntitiesPerArrival	**99**
Model Properties	
Model Name	**Model**
Author	**Bing Yao**
Description	
Advanced Options	
General	

Figure 13: Simio Entity Setup

Finally, as shown in Figure 14, the results matched up exactly with the runtime calculated in the earlier Excel spreadsheet. These results indicated that Simio ran through all given orders, utilization of RWC2 was at 100%, and the overall run time was 7.1833 hours. This ensures that the team's assumptions were correct in that this really will save time and increase production in the Montage department.

ScheduledUtilization	Percent	100.0000
UnitsAllocated	Total	424.0000
TimeProcessing	Total (Hours)	7.1833

Figure 14: Results from Simio model

5 Analysis of the alternatives, results, comparisons

After collecting and analyzing the data given, the team began to consider multiple options in order to improve the performance. Our first alternative shows us the miscommunication between on-the-floor staff and scheduling team. The plant will now have a fixed schedule to follow without any misunderstandings, thanks to our removal of the mindset of a "recommended schedule." Miscommunication can be avoided by convening a monthly conference with schedulers and plant staff to resolve issues. Better communication allows them to share information with one another and to comprehend what is being said. Without first creating better lanes for communication between the scheduling department and manufacturing floor, any further work done to improve the scheduling of orders for the four Montage machines would be lost in translation. The specific guideline for communication that will be provided to Ameristar can be found in Section 4.1: Interdepartmental Communication Improvement Guideline. There are no reasonable alternatives to this portion of the solution seeing as the communication guidelines will be solving an interpersonal issue rather than a technical one.

To be able to maintain this open flow of communication between departments, the two groups should plan to meet periodically to reevaluate how the schedules are being followed and adapted on the floor. This is a decision that must be made by Ameristar employees because it will be on an as needed basis after our team hands this project off at the end of the semester.

Our initial solution involved analyzing an existing schedule for one weeks' worth of production on one of the Montage machines, RWC2. The team calculated the following values for both the existing schedule and for the optimal schedule based on our recommended machine scheduling guidelines: total machine run time, total height changeover time, total width changeover time, and total production time. Based on the summation of these calculations, the team can determine the total time saved between the two schedules. For the RWC2 machine, it is operating on two 10-hour shifts Monday through Thursday and one optional 10-hour shift on Friday to make up for any delays in production. Thus, there is a possibility of fifty hours to produce orders on RWC2. Figure 15 below shows the initial schedule provided by Ameristar for production during the week of June 1, 2020 through June 5, 2020.

Day	Daily Schedule Order	Weekly Schedule Order	Order Number	Qty	Height	Picket	Run Time	HTChangeover After?	Changeover time	WDT Changeover after?	Changeover time
6/1/20	1	1	12736871	200	4'	5/8"	2.45	yes	0.25	yes	1
6/1/20	2	2	12753963	99	5'	3/4"	0.8	yes	0.25	yes	1
6/1/20	3	3	12759926	56	6'	5/8"	0.7				
6/1/20	4	4	12787812	76	6'	5/8"	0.984	yes	0.25		
6/1/20	5	5	12787813	16	4'	5/8"	0.433	yes	0.25	yes	1
6/1/20	6	6	12787829	38	5'	3/4"	0.517	yes	0.25	yes	1
6/1/20	7	7	12788609	12	6'	5/8"	0.4	yes	0.25	yes	1
6/1/20	8	8	12794564	25	4'	3/4"	0.45			yes	1
6/1/20	9	9	12794835	46	4'	5/8"	0.283	yes	0.25	yes	1
6/2/20	1	10	12691075	240	5'	3/4"	2.201	yes	0.25		
6/2/20	2	11	12723966	120	4'	3/4"	1.234	yes	0.25		
6/2/20	3	12	12734808	210	5'	3/4"	1.817	yes	0.25		
6/2/20	4	13	12753964	12	4.5'	3/4"	0.1	yes	0.25		
6/2/20	5	14	12772652	34	5'	3/4"	0.317				
6/2/20	6	15	12787579	5	5'	3/4"	0.067	yes	0.25		
6/2/20	7	16	12799563	120	6'	3/4"	1.367	yes	0.25		
6/2/20	8	17	12802089	6	5'	3/4"	0.067	yes	0.25		
6/3/20	1	18	12690129	60	6'	3/4"	0.484				
6/3/20	2	19	12705340	330	6'	3/4"	3.133				
6/3/20	3	20	12724026	90	6'	3/4"	0.817				
6/3/20	4	21	12724188	210	6'	3/4"	1.95	yes	0.25	yes	1
6/3/20	5	22	12737254	240	5'	5/8"	3.984	yes	0.25	yes	1
6/3/20	6	23	12787865	6	6'	3/4"	0.083			yes	1
6/4/20	1	24	12691515	400	6'	5/8"	3.684	yes	0.25		
6/4/20	2	25	12691522	240	5'	5/8"	4.0008	yes	0.25		
6/4/20	3	26	12768215	400	6'	5/8"	3.65				
6/4/20	4	27	12788905	5	6'	5/8"	0.05				
6/5/20	1	28	12691545	200	6'	5/8"	2.284	yes	0.25		
6/5/20	2	29	12763720	240	4'	5/8"	2.968	yes	0.25		
6/5/20	3	30	12796982	240	6'	5/8"	2.333				
						Total Run Time	43.6078				
						Total HT changeover	5				
						Total WDT changeover	10				
						Total prod Time	**58.61**				

Figure 15: Initial Weekly Schedule

As seen above in Figure 15, the current scheduling guidelines used for the Montage department are causing machine RWC2 to be in operation for 58.61 hours per week. This shows that Ameristar is working overtime just to keep up with the required orders that must be met each week to be shipped out to customers which leaves no time for additional production to increase inventory. The Ameristar engineering team has informed our team that if possible, they would like to start adding additional orders to production each week that have not already been sold in order to build the inventory in their on-site inventory yard. By implementing our recommended machine scheduling guidelines, as seen in Figure 16 below, Ameristar will be able to significantly reduce production time for their required orders to eliminate overtime shifts or to use the saved time to build inventory for future catalog orders.

Day	Daily Schedule Order	Weekly Schedule Order	Order Number	Qty	Height	Picket	Run Time	HTChangeover After?	Changeover time	WDT Changeover after?	Changeover time
6/1/20	1	1	12759926	56	6'	5/8"	0.7				
6/1/20	2	2	12787812	76	6'	5/8"	0.984				
6/1/20	3	3	12788609	12	6'	5/8"	0.4				
6/1/20	4	4	12691515	400	6'	5/8"	3.684				
6/1/20	5	5	12768215	400	6'	5/8"	3.65				
6/1/20	6	6	12788905	5	6'	5/8"	0.05				
6/1/20	7	7	12691545	200	6'	5/8"	2.284				
6/1/20	8	8	12796982	240	6'	5/8"	2.333	yes	0.25		
6/1/20	9	9	12737254	240	5'	5/8"	3.984				
6/2/20	1	10	12691522	240	5'	5/8"	4.0008	yes	0.25		
6/2/20	2	11	12736871	200	4'	5/8"	2.45				
6/2/20	3	12	12787813	16	4'	5/8"	0.433				
6/2/20	4	13	12794835	46	4'	5/8"	0.283				
6/2/20	5	14	12763720	240	4'	5/8"	2.968			yes	1
6/2/20	6	15	12794564	25	4'	3/4"	0.45				
6/2/20	7	16	12723966	120	4'	3/4"	1.234	yes	0.25		
6/2/20	8	17	12753964	12	4.5'	3/4"	0.1	yes	0.25		
6/2/20	9	18	12753963	99	5'	3/4"	0.8				
6/2/20	10	19	12787829	38	5'	3/4"	0.517				
6/2/20	11	20	12691075	240	5'	3/4"	2.201				
6/2/20	1	21	12734808	210	5'	3/4"	1.817				
6/2/20	2	22	12772652	34	5'	3/4"	0.317				
6/2/20	3	23	12787579	5	5'	3/4"	0.067				
6/2/20	4	24	12802089	6	5'	3/4"	0.067	yes	0.25		
6/3/20	5	25	12799563	120	6'	3/4"	1.367				
6/3/20	6	26	12690129	60	6'	3/4"	0.484				
6/3/20	7	27	12705340	330	6'	3/4"	3.133				
6/3/20	8	28	12724026	90	6'	3/4"	0.817				
6/3/20	9	29	12724188	210	6'	3/4"	1.95				
6/3/20	10	30	12787865	6	6'	3/4"	0.083				
						Total Run Time	43.6078				
						Total HT changeover	1.25				
						Total WDT changeover	1				
						Total prod Time	**45.8578**				

Figure 16: Optimal Weekly Schedule

With these newly implemented guidelines, the following metrics are improved. With the optimal schedule, overall production time is only 45.86 hours per week, and only 2.25 hours of production is used for changeovers as compared to 15 hours with the original schedule. The percent of total production time saved, and hours saved can be seen in Table 4 below.

Percent Time Saved	21.8%
Hours Saved	12.75

Table 4: Solution Benefits

To further analyze our solution recommendations, the team created a simulation using Simio software to model a week of production using our improved schedule. The results from this simulation produced nearly identical results as the sample optimal schedule created thus further proving the validity of the solution. These Simio results can be found in *Appendix B*. Our solution has the potential to solve both parts of the problem statement. With the saved time from reducing changeovers, productivity can be increased and improve product output that could potentially lead to increased revenues and saved manufacturing costs for the company.

5.1 Monetary Benefits

The team decided to convert the results above into economics and provide an estimate at money earned if these guidelines are implemented. The team inferred that revenue per panel is around $100 and assuming that processing time is 1.017 minutes (a data point by taking the average run time of over 4,000 data points from schedules in the past). The team then took each machine's overall time saved and converted it to minutes and divided by 1.017 minutes to get the number of panels that could have been run in the time saved. The team then multiplied this number by $100. On just this day of improvement, revenue that could have been created from time saved reaches $60,955. This also assumes that during this saved time, all panels are sold and machines utilization is at full capacity. The results are as follows in Table 5:

ECONOMIC ANALYSIS						
Machine	**Actual Run Time**	**Improved Run Time**	**Time Saved (Hours)**	**Time Saved (Minutes)**	**Panels per Time Saved**	**Revenue from Panels**
G5	13.82	12.988	0.832	49.92	49.08554572	$4,908.55
RWC3	22.13	19.63	2.5	150	147.4926254	$14,749.26
RWC2	15.517	8.517	7	420	412.979351	$41,297.94
					DAILY POSSIBLE EARNINGS:	**$60,955.75**

Table 5: Daily Economic Analysis

In an effort to look into more long term analysis, the team decided to use these results from the week of scheduling for RWC2. This is able to show how much extra revenue could have been earned after a week. Table 6 represents the calculations:

WEEKLY ECONOMIC ANALYSIS - RWC2						
Machine	**Actual Run Time**	**Improved Run Time**	**Time Saved (Hours)**	**Time Saved (Minutes)**	**Panels per Time Saved**	**Revenue from Panels**
RWC2	58.61	45.85	12.76	765.6	752.8023599	$75,280.24
					WEEKLY POSSIBLE EARNINGS	**$75,280.24**

Table 6: Weekly Economic Analysis of RWC2

6 Recommendations

The team analyzed and compared the various alternatives before making recommendations for Ameristar. The recommendations are separated into two categories: interdepartmental communication and improved scheduling. The sections that follow will go over the two types of recommendations in more detail.

6.1 Interdepartmental Communication

The team recommends using one set schedule per machine with a designated point of contact between scheduling and production to resolve. No schedule change will be made without material agreements between the two departments. A set schedule ensures performance accuracy and reliability while removing the "recommended schedule" mentality. The foreman, who oversees all the machines, and scheduling manager will be the best point of contacts. The years of experience reflect the foreman and scheduling manager's knowledge of each machine's capabilities and what schedules have been effective in the past. This allows all departments to communicate with the point of contacts on any issues or concerns. The foreman and scheduling manager will meet to discuss the situation and determine the correct course of action.

6.2 Improved Scheduling

The team has come up with a few scheduling recommendations. The first is to follow the guidelines for each machine when scheduling orders. Staying within the panel's width until all heights for that width have been completed. Within the specific widths of ¾", ⅝" and 1", filling them in such a way that the height progressively increases or decreases in order to avoid large size differences that take longer to finish. Following the recommended guidelines will save up to 40% of daily production time. When the data from the improved schedule is compared to the data from the current schedule, the optimum scheduling solution can save the production floor 10 hours a week on average.

The team also recommends filling in special orders to the corresponding length sizes in the set schedule a day or two ahead of time. This ensures that special orders are placed in accordance with the sizes of similar-sized panels in the schedule. Since special orders have a shorter lead time than catalog orders, this is very important. Ameristar has window frames for shipping these out, so special orders can take the place of make-to-stock. Using communication and machine guidelines, according to the data from the analysis and modeling, will improve production efficiency.

6.3 Next Steps for Ameristar

The team saw some aspects of the Montage process where it may be out of the scope of the project but could be helpful looking into further. The first is the capabilities and recommendations on which machine certain orders should be produced. The team decided to focus more on how to improve the current state of the machines and their current capabilities but would definitely recommend toying with the capabilities of machines G5 and G4. There was not enough time to extensively look into changing the capabilities of these machines but if it is looked into further, G4 and G5's capabilities would be the best place to start. Next would be looking to reduce changeover time, itself. If there is a way that pallets can changeover sizes faster or if there could be research done there, the team would recommend looking into that. With a decrease of changeover time, as a set value. The team had also discussed looking into lead times but didn't feel they had all the information to create a solution. However, if by reducing lead times schedulers have a better grasp of what they're scheduling that would be very helpful. Lastly, the team believes looking into hiring someone or allocating an employee this job to be in quality control for scheduling could be so helpful with this change. Having one person approve the schedule one day before the schedule is sent off to the floor would be beneficial to ensure that everything is scheduled optimally and that orders are meeting the needs of sales as well.

7 Implementation Plan

The team has put together an implementation plan for Ameristar based on the several recommendations. Ameristar should begin with a monthly meeting between the production floor and the scheduling department. The monthly meetings are an opportunity to exchange ideas and encourage open discussion. This will strengthen relationships between the two departments and improve productivity. Ameristar can monitor goals to ensure that everyone is on the same page in terms of success and next steps. Both departments should approve the set guidelines that the team has provided at the first meeting. In the following meetings, discuss and revise as needed to ensure continuous improvement. A last-minute schedule change is one potential obstacle Ameristar might face. By designating a point of contact with each department, these modifications can be approved on the day of production. The point of contacts should be the foreman and scheduling manager. Their familiarity in scheduling and the manufacturing line is beneficial to the company's success. These recommendations can help you save time, increase inventory, and allow more use of each computer.

8 Benefits

There are several anticipated benefits to implementing the project recommendations. The first of those being addressing communication assumptions. The recommended guidelines would set up a stream of communication between the scheduling department and the production floor. With regular meetings between the two departments, this would allow a flow of communication, which will allow for improved production.

Then, because of the increased communication between the scheduling and production departments, this will allow for the second benefit of improved production scheduling. The improved production scheduling includes benefits such as a decrease in inefficiencies in the scheduling process, compared to the current state. As well as, an increase in the amount of throughput for make-to-stock order, allowing an increase in inventory. Lastly, as seen in improved scheduling of RWC2, the improved production scheduling allows Ameristar the opportunity to save production time by up to 40% per day.

Lastly, one of the more appealing benefits of this project is the cost savings for reducing downtime. By scheduling orders in a specific sequence it drastically reduces the amount of money wasted during unnecessary changeovers.

Appendix A: Client-Signed Proposal

PROJECT PROPOSAL FEBRUARY 9, 2021

Optimization of Ameristar's Montage Schedule

An Oklahoma State University
School of Industrial Engineering and Management
Senior Design Project
Spring 2021

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Optimization of Ameristar's Montage Schedule

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Optimization of Ameristar's Montage Schedule

Lisa and the Ameristar Team,

Thank you for taking the time to introduce our team to Ameristar, and providing us an overview of our project and the company. Our Senior Design Team has enjoyed getting to know the Ameristar team and all of the operations within the company. We appreciate your time in meeting with us, and allowing us to visit your site to further our understanding of the processes. After examining the problem, and visiting the site to understand the operations which our project is based on, our Senior Design Team is excited to be able to help develop a scheduling system that will best benefit the operations and create efficiencies in the process.

Optimization of Ameristar's Montage Schedule

1. Background

Ameristar is a 38-year-old company recently acquired by a Swedish company. Ameristar's headquarters and four manufacturing facilities are based in northern Tulsa, OK. They are a manufacturing company specializing in perimeter security including products such as barriers, fencing (for residential, commercial, and industrial needs), gates, and anything related to specialization in these orders. Ameristar is an industry leader in the Perimeter Security industry, and they pride themselves on having an extremely wide selection of fencing products while also offering custom orders to companies where they make products that are not in their catalog.

Their manufacturing begins by including receiving mass orders of raw steel or aluminum and converting them into the correct picket shapes and sizes. They then collect these pickets and send them to the montage department where they are constructed into a panel with anywhere from 15 to 30 pickets per panel. Lastly, they move them to painting and packaging to be sent off. Ameristar also has their own wood shop, cleaning areas, quality control and maintenance, lasers, and a drive-through for semi-trucks picking up their orders. Their manufacturing plant is highly functioning and has even more operations than listed above within their four facilities. Their different departments within the plant include steel coil, slitting, roll formers, tube mills, metal processing, press shop, coating lines, packaging and machine shops.

The Montage department is the specific area we will be evaluating. Their current design gives operators a specific amount of orders that need to be filled daily. They are not given in any specific order to conduct the orders however, there could be a better way to get these orders filled more efficiently and with less down time. Less down time equates to more production flexibility and understanding of the current process.

We will be looking into whether or not there is a better way of scheduling these activities. For example, custom orders are more high-maintenance and require more changing out of machine materials in order to cater to that specific order. This takes longer and there are more irregularities in the order that they have to cater to. In order to meet demand for both make-to-order and make-to-stock products, a new product schedule, set of rules, and product grouping plan need to be determined to best improve overall output. The project would be considered the most successful if we statistically prove a significant increase in the throughput of the specific department. We are to determine the optimal schedule of the different mixes and sizes of products on the line and which sales they should be running and when.

2. Objectives and Scope

The overall objective of this project is to create a scheduling system that allows Ameristar to meet demand of both make to order and make to stock products. The scheduling system will include a set of rules, as well a product grouping plan to best improve overall throughput.

Optimization of Ameristar's Montage Schedule

The Senior Design Team will limit the project scope to the scheduling of the Montage department products. The intent of this project is to increase the efficiencies of the Montage products within their four machines through a scheduling system, and therefore the project will exclude all products outside of the Montage department.

Objective 1: Understand the current state of scheduling in the Montage department and confirm this understanding with data analysis.

We need an in-depth understanding of the current scheduling system in place because this is a primary jumping off point for our research. We will back this up with the data they are going to provide for us and to confirm our understanding.

Objective 2: Use engineering methods to optimize the scheduling system for orders in the Montage department.

We will be using what we have learned in these past few years to find methods to better understand and schedule orders such as: optimization, production planning and control and possibly simulations. In this research, we will find out whether their current system is effective or ineffective.

Objective 3: Recommend a new method for scheduling or confirm their current scheduling process is the most efficient way to schedule orders.

This objective will help us decide our conclusion for Ameristar. Our project is dependent on the data we find about the scheduling system for Montage. We will have to report on and understand the optimal schedule and will need to give Ameristar a definite answer with appropriate analysis as to why we have chosen this recommendation.

3. Anticipated Methodology

The Senior Design Team will solve the problem in the following phases:

1. Project Initiation
   a. Understand the background and concepts of the problem by reading background information on the company and the provided project information.
   b. Connect with Lisa and Ameristar Team and grasp the scope of the project
   c. Learn the various operations relating to the project, with a focus on the operations involved in the project scope
   d. Collect data that is important for project from Ameristar team
2. Defining and Planning
   a. Define the project scope and limit the study to ensure a completed and effective deliverable
   b. Schedule regular site visits in order to fully understand the process of the project
   c. Analyze data provided by Ameristar and determine if additional data is needed

   d. Perform time studies at the Ameristar location in order to better understand machine functionality
   e. Use systems simulation modeling to replicate what is happening in the montage department to better understand the flow of materials
   f. Perform operations research and production planning techniques to help optimize scheduling
   g. Pinpoint the problem areas of the montage department and hone in on those operations
3. Execution of Proposal
   a. Summarize findings
   b. Develop solutions to problem and analyze alternative solutions
   c. Provide a clear methodology with all data and programs used
   d. Consult with mentors and Ameristar team to determine feasibility and effectiveness of solutions
   e. Present proposal and receive feedback
4. Closure and Sustainability
   a. Create a sustainable solution that can be implemented
   b. Weigh all possible recommendations to show that the solution we present is the most effective
   c. Finalize report and recommendations in one concise report

4. Anticipated Schedule

Project Schedule

- Jan 29: Kick off meeting with client
- Feb 2: Site visit #1
- Feb 12: Project proposal signed by all parties
- Feb 12: All proposed engineering methods submitted in detail to client
- Feb 15: Site visit #2
- Feb 15: Analysis of problem (obj. 1) completed
- Feb 19: A3 Proj. Management Form (obj. 2) completed
- Feb 26: Analysis of all proposed methods (obj. 2) presented to client
- Mar 1: Begin time trials and tests on approved methodology
- Mar 12: (week of) Site visit #3
- April 30: Virtual presentation to client
- April 30: Final solution (obj. 3) presented to client

Optimization of Ameristar’s Montage Schedule

	Week End															
Optimization of Ameristar's Montage Schedule	22-Jan	29-Jan	5-Feb	12-Feb	19-Feb	26-Feb	5-Mar	12-Mar	19-Mar	26-Mar	2-Apr	9-Apr	16-Apr	23-Apr	30-Apr	7-May
Client Kickoff Meeting		■														
(Week of) Site Visit #1			■													
Project Proposal signed by all parties				■												
Submit proposed engineering methods to client				■												
(Week of) Site Visit #2					■											
Objective 1 completed					■											
A3 Proj. Management Form completed					■											
Submit analysis of methods to client						■										
Begin time trials and tests of methodology							■									
Site Visit #3								■								
Virtual Presentation to client															■	
Final soloution presented to client															■	

*The weeks of March 26th through April 16th will be filled out in detail once the client approves our proposed methodology

5. **Anticipated Deliverables**
   - Weekly/bi-weekly status updates via email to Breanna Kimblern and Lisa Malone as frequently as necessary and/or relevant.
   - Objective 1:
     - Gather and analyze data and confirm a correct initial understanding of the current process in the Montage department. Confirm this over e-mail communication with company employees.
     - Initial analysis of the problem and be able to create a problem statement.
   - Objective 2:
     - Submit an A3 Project Management Form to Ameristar to formally introduce the project.
     - Submit analysis of new methods of optimization for approval or denial to Ameristar team
       - This will be done so they can decide what route they want to take in the optimization process.
     - Submit detailed findings of engineering methods and how they can benefit the company.
   - Objective 3:
     - Submit clear recommendations to the company about scheduling optimization, including all important methodology and reasoning.
   - Final Presentation to Dr. Baski and mentors.
   - Final Report to Ameristar including proposed scheduling of all orders in the Montage process or an analysis showing that their current scheduling methods are the most efficient way to schedule orders.

6. **Anticipated Benefits**
   - Plant workers will have a clearer schedule to follow when filling orders each day.
   - Changeover for the fencing molds will be minimized while still maximizing the mixes being run on each machine.
   - Create a standard for production to reduce guesswork in filling orders day to day.
   - Reduce the maximum number of inefficiencies in the order filling schedule.
   - Improve parts completed per hour while taking into consideration that each machine operates at a different rate and can fulfill a different volume of orders.

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Optimization of Ameristar's Montage Schedule

7. Risks and Mitigation Strategy

Risks	Mitigation Strategy
If information is not already accessible, then it will take longer than the allotted time to gather.	Build assumptions and employ sensitivity analysis.
Having many employees to please in this project could be a risk as various assumptions for the group could exist.	Focus on the project scope and work towards accomplishing the purpose stated in the proposition.
The protocols for COVID-19 may restrict in-person visits and commuting.	Review the self-assessment to ensure everybody is protected wearing face masks and having temperature checks while on site and travelling.
On location visits can be unsafe as a manufacturing plant offers many risks in the process.	Wearing the right attire, for example, long jeans, closed toe shoes and safety glasses.

Optimization of Ameristar's Montage Schedule

Endorsements

Endorsement below acknowledges receipt and acceptance of the proposal of a Senior Design Team from Oklahoma State University's School of Industrial Engineering and Management. Project will be executed on a 'best effort' basis and no warranty is stated or implied. All modifications to this proposal shall be provided, in writing, to all signatories for approval and acceptance.

On Behalf of Ameristar Perimeter Security

Lisa Malone Feb 18 2021 05:23 PST

Lisa Malone

On Behalf of Senior Design Team

Lily Anthony

Abigail Berrey

Sara Humphrey

Mallory Newell

February 18, 2021

Date of Last Signature

Appendix B: Simulation Modeling Results

Interactive Detail Report

Project: NewAndImprovedSimio
Model: Model (Academic, COMMERCIAL USE PROHIBITED)
Run Date: 4/19/21 13:29
Analyst Name: Bing Yao

Scenario: [Interactive Run]

NumberCreated - Total

Object Name	Data Source	Category	Value
1H72W582	[Population]	Throughput	12
2H72W582	[Population]	Throughput	56
3H72W582	[Population]	Throughput	76
4H48W582	[Population]	Throughput	16
5H48W582	[Population]	Throughput	200
6H48W582	[Population]	Throughput	46
7H48W342	[Population]	Throughput	25
8H60W342	[Population]	Throughput	38
9H48W342	[Population]	Throughput	99

NumberDestroyed - Total

Object Name	Data Source	Category	Value
1H72W582	[Population]	Throughput	12
2H72W582	[Population]	Throughput	56
3H72W582	[Population]	Throughput	0
4H48W582	[Population]	Throughput	15
5H48W582	[Population]	Throughput	0
6H48W582	[Population]	Throughput	0
7H48W342	[Population]	Throughput	0
8H60W342	[Population]	Throughput	0
9H48W342	[Population]	Throughput	0

NumberEntered - Total

Object Name	Data Source	Category	Value
RWC2	InputBuffer	Throughput	568
RWC2	OutputBuffer	Throughput	83
RWC2	Processing	Throughput	84
Painting2	InputBuffer	Throughput	83
Source1	OutputBuffer	Throughput	12
Source1	Processing	Throughput	12
Source2	OutputBuffer	Throughput	56
Source2	Processing	Throughput	56
Source3	OutputBuffer	Throughput	76
Source3	Processing	Throughput	76
Source4	OutputBuffer	Throughput	16
Source4	Processing	Throughput	16
Source5	OutputBuffer	Throughput	200
Source5	Processing	Throughput	200
Source6	OutputBuffer	Throughput	46
Source6	Processing	Throughput	46
Source7	OutputBuffer	Throughput	25
Source7	Processing	Throughput	25
Source8	OutputBuffer	Throughput	38

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NumberEntered - Total

Object Name	Data Source	Category	Value
Source8	Processing	Throughput	38
Source9	OutputBuffer	Throughput	99
Source9	Processing	Throughput	99

NumberExited - Total

Object Name	Data Source	Category	Value
RWC2	InputBuffer	Throughput	84
RWC2	OutputBuffer	Throughput	83
RWC2	Processing	Throughput	83
Painting2	InputBuffer	Throughput	83
Source1	OutputBuffer	Throughput	12
Source1	Processing	Throughput	12
Source2	OutputBuffer	Throughput	56
Source2	Processing	Throughput	56
Source3	OutputBuffer	Throughput	76
Source3	Processing	Throughput	76
Source4	OutputBuffer	Throughput	16
Source4	Processing	Throughput	16
Source5	OutputBuffer	Throughput	200
Source5	Processing	Throughput	200
Source6	OutputBuffer	Throughput	46
Source6	Processing	Throughput	46
Source7	OutputBuffer	Throughput	25
Source7	Processing	Throughput	25
Source8	OutputBuffer	Throughput	38
Source8	Processing	Throughput	38
Source9	OutputBuffer	Throughput	99
Source9	Processing	Throughput	99

NumberInStation - Average

Object Name	Data Source	Category	Value
RWC2	InputBuffer	Content	466.73106
RWC2	Processing	Content	1

NumberInStation - Maximum

Object Name	Data Source	Category	Value
RWC2	InputBuffer	Content	503
RWC2	Processing	Content	1

NumberInStation - Minimum

Object Name	Data Source	Category	Value
RWC2	InputBuffer	Content	0
RWC2	Processing	Content	0

NumberInSystem - Average

Object Name	Data Source	Category	Value
1H72W582	[Population]	Content	0.93142
2H72W582	[Population]	Content	27.08285
3H72W582	[Population]	Content	17.10372
4H48W582	[Population]	Content	14.61307
5H48W582	[Population]	Content	200
6H48W582	[Population]	Content	46
7H48W342	[Population]	Content	25

NumberInSystem - Average

Object Name	Data Source	Category	Value
8H60W342	[Population]	Content	38
9H48W342	[Population]	Content	99

NumberInSystem - Maximum

Object Name	Data Source	Category	Value
1H72W582	[Population]	Content	12
2H72W582	[Population]	Content	56
3H72W582	[Population]	Content	76
4H48W582	[Population]	Content	16
5H48W582	[Population]	Content	200
6H48W582	[Population]	Content	46
7H48W342	[Population]	Content	25
8H60W342	[Population]	Content	38
9H48W342	[Population]	Content	99

NumberInSystem - Minimum

Object Name	Data Source	Category	Value
1H72W582	[Population]	Content	0
2H72W582	[Population]	Content	0
3H72W582	[Population]	Content	0
4H48W582	[Population]	Content	0
5H48W582	[Population]	Content	0
6H48W582	[Population]	Content	0
7H48W342	[Population]	Content	0
8H60W342	[Population]	Content	0
9H48W342	[Population]	Content	0

ScheduledUtilization - Percent

Object Name	Data Source	Category	Value
RWC2	[Resource]	Capacity	100

TimeInStation - Average

Object Name	Data Source	Category	Value
RWC2	InputBuffer	HoldingTime	0.70343
RWC2	Processing	HoldingTime	0.01695

TimeInStation - Maximum

Object Name	Data Source	Category	Value
RWC2	InputBuffer	HoldingTime	1.40685
RWC2	Processing	HoldingTime	0.01695

TimeInStation - Minimum

Object Name	Data Source	Category	Value
RWC2	InputBuffer	HoldingTime	0
RWC2	Processing	HoldingTime	0.01695

TimeInSystem - Average

Object Name	Data Source	Category	Value
1H72W582	[Population]	FlowTime	0.11018
2H72W582	[Population]	FlowTime	0.68648
4H48W582	[Population]	FlowTime	1.2882
Painting2	[DestroyedEntities]	FlowTime	0.7119

TimeInSystem - Maximum

Object Name	Data Source	Category	Value
1H72W582	[Population]	FlowTime	0.2034
2H72W582	[Population]	FlowTime	1.1526

TimeInSystem - Maximum

Object Name	Data Source	Category	Value
4H48W582	[Population]	FlowTime	1.40685
Painting2	[DestroyedEntities]	FlowTime	1.40685

TimeInSystem - Minimum

Object Name	Data Source	Category	Value
1H72W582	[Population]	FlowTime	0.01695
2H72W582	[Population]	FlowTime	0.22035
4H48W582	[Population]	FlowTime	1.16955
Painting2	[DestroyedEntities]	FlowTime	0.01695

TimeInSystem - Observations

Object Name	Data Source	Category	Value
1H72W582	[Population]	FlowTime	12
2H72W582	[Population]	FlowTime	56
4H48W582	[Population]	FlowTime	15
Painting2	[DestroyedEntities]	FlowTime	83

TimeProcessing - Average

Object Name	Data Source	Category	Value
RWC2	[Resource]	ResourceState	1.41944

TimeProcessing - Occurrences

Object Name	Data Source	Category	Value
RWC2	[Resource]	ResourceState	1

TimeProcessing - Percent

Object Name	Data Source	Category	Value
RWC2	[Resource]	ResourceState	100

TimeProcessing - Total

Object Name	Data Source	Category	Value
RWC2	[Resource]	ResourceState	1.41944

UnitsAllocated - Total

Object Name	Data Source	Category	Value
RWC2	[Resource]	Capacity	84

UnitsScheduled - Average

Object Name	Data Source	Category	Value
RWC2	[Resource]	Capacity	1

UnitsScheduled - Maximum

Object Name	Data Source	Category	Value
RWC2	[Resource]	Capacity	1

UnitsScheduled - Minimum

Object Name	Data Source	Category	Value
RWC2	[Resource]	Capacity	1

UnitsUtilized - Average

Object Name	Data Source	Category	Value
RWC2	[Resource]	Capacity	1

UnitsUtilized - Maximum

Object Name	Data Source	Category	Value
RWC2	[Resource]	Capacity	1

UnitsUtilized - Minimum

Object Name	Data Source	Category	Value
RWC2	[Resource]	Capacity	0