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Process Optimization of Boatmate Trailers, LLC

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1. Abstract

Boatmate Trailers, LLC, located in Maryville, Tennessee, is a small-scale manufacturing plant that produces custom boat trailers for several original equipment manufacturers (OEMs). Due to an expanding customer base, the company needs to be able to produce trailers quicker with the same level of quality as before. However, the highly customized nature of Boatmate's business, especially in the rigging department, and lack of trailer manufacturing process documents made standardization difficult. This also resulted in varying cycle times and training problems. Thus, the company hired Jasmine Kelley and Jamie Smotherman, two senior Industrial Engineering students, to complete a project to standardize these processes by creating work instruction documents.

The team used several Industrial Engineering tools in order to successfully complete the project. After the team was formed, an economic analysis was done to justify the project, and a project plan was formulated with intermediate deadlines to keep the team on track. The actual value-added processes were then observed with notes, pictures, and diagrams taken as necessary. This information was translated into work instruction documents that guided readers through the company approved processes. In order to store all work instruction information and associate training, a database was created with various manager and associate tasks. The project was then implemented via a line-side computer that enabled associates to view the documents while simultaneously working on the trailer. All the necessary training was also provided for both the associates and managers using the system. To sustain this system, an instruction manual that included any needed maintenance was completed. Due to the success of the project's implementation in the rigging department, the team recommended that Boatmate Trailers take steps to expand this project with some improvements to the remaining four departments. This recommendation was accepted, and documents were created for the paint, prep, welding, and small parts departments.

2. Background Information

Boatmate Trailers, LLC, located in Maryville, Tennessee, is a small-scale manufacturing plant that produces custom boat trailers for various original equipment manufacturers (OEMs) throughout the United States, Canada, and Australia. The plant receives raw materials which are then transformed to a finished product as the trailer progresses through Boatmate's five departments: small parts, welding, prep, paint, and rigging. In small parts, the trailer's various components are assembled. These subassemblies are then passed on to the welding department where the trailer itself comes together. Next, the trailer is suspended on a monorail system where it passes through the prep area and into the paint booth. After the paint sets, the rigging department accessorizes the trailer by adding custom decals, tires, lights, etc. The completed trailer then passes through quality control and is transported to the appropriate customer.

Boatmate Trailers' tries to exceed their customers' expectation by continuously improving their processes, thinking outside the box, and allowing each trailer to be extremely customized. These factors have allowed their customer base to expand; thus, the company needs to be able to produce trailers quicker with the same level of quality as before. However, the highly customized nature of the company's business makes line balancing extremely difficult. In addition, Boatmate Trailers relies heavily on temporary labor, especially in the rigging department, to meet their seasonal demands, which translates into an untrained workforce and high employee turnover.

3. Problem Statement

At the onset of this project, none of the trailer manufacturing process documents reflected Boatmate's current practices. Thus, each associate performed tasks in their own way which resulted in varying cycle times and quality issues. The lack of documentation also compounded the company's training problems since new employees had to rely on other associates for instruction instead of a company approved process. Furthermore, the documents were haphazardly placed throughout the departments with no central storage location or indexing system.

4. Methodology

The following strategy was pursued in the process optimization of Boatmate Trailers, LLC.

1. Formed team.
2. Performed economic analysis to validate project.
3. Established project plan using project management techniques.
4. Observed current value-add processes in rigging department.
5. Created standard work instruction documents.
6. Developed information system to store, track, and distribute documents.
7. Implemented work instruction system on production floor.
8. Formulated sustainment plan.

i. Team Formation

Jasmine Kelley and Jamie Smotherman, two Industrial Engineering seniors, were hired by Boatmate Trailers' production manager to complete the project. These two individuals made up the team and were responsible for project's development and completion. Since the team was the only entity working as industrial engineers for the company, all managers and associates were named as the team's resources.

ii. Economic Analysis

The team performed economic analysis to justify the completion of the proposed project. While some values were known, the majority were estimated based on the managers' past experience and industry standards. The project's life was set at 5 years with an assumed discount rate of 10%. All labor rates were $15/hour.

If the new system was built, Boatmate Trailers would see an annual benefit of $5,500, which includes a stream-lined training process, higher quality, and increased productivity and customer confidence. The one-time cost of the new system was determined to be $5,820. These costs covered the hardware (refurbished central processing unit and 20" flat-screen monitor) and labor costs for creating the information system and work instructions (observations, writing the actual document, and auditing). Both maintenance and training expenses were named recurring annual costs with a value of $1,560. Economical analysis, shown below in Figure 1, reveals a return on investment of 86.26% with break-even, as shown in Figure 2, occurring in 1.5 years.

		Years from Today						Totals
		0	1	2	3	4	5	
Benefits	Annual Benefits	$ -	$ 5,500.00	$ 5,500.00	$ 5,500.00	$ 5,500.00	$ 5,500.00	
	Discount Rate (10%)	100.00%	90.91%	82.64%	75.13%	68.30%	62.09%	
	PV of Benefits	$ -	$ 5,000.00	$ 4,545.45	$ 4,132.23	$ 3,756.57	$ 3,415.07	
	NPV of Benefits	$ -	$ 5,000.00	$ 9,545.45	$ 13,677.69	$ 17,434.26	$ 20,849.33	**$ 20,849.33**
Costs	One Time Cost	$ (5,280.00)						
	Annual Costs	$ -	$ (1,560.00)	$ (1,560.00)	$ (1,560.00)	$ (1,560.00)	$ (1,560.00)	
	Discount Rate (10%)	100.00%	90.91%	82.64%	75.13%	68.30%	62.09%	
	PV of Recurring Costs	$ -	$ (1,418.18)	$ (1,289.26)	$ (1,172.05)	$ (1,065.50)	$ (968.64)	
	NPV of Costs	$ (5,280.00)	$ (6,698.18)	$ (7,987.44)	$ (9,159.49)	$ (10,224.99)	$ (11,193.63)	**$ (11,193.63)**
	Overall NPV							**$ 9,655.70**
	Overall ROI							**86.26%**

Figure 1. Economic Analysis of Project

	Years from Today					
Break-Even Analysis	0	1	2	3	4	5
Yearly NPV Cash Flow	$ (5,280.00)	$ 3,581.82	$ 3,256.20	$ 2,960.18	$ 2,691.07	$ 2,446.43
Overall NPV Cash Flow	$ (5,280.00)	$ (1,698.18)	$ 1,558.02	$ 4,518.20	$ 7,209.27	$ 9,655.70
Break-Even occurs in 1.5 years.						

Figure 2. Break-even Analysis of Project

iii. Project Plan

Since the company did not set a firm deadline for the project's completion, the team had to determine an appropriate timeline as well as intermediate milestones in order to correctly manage the assignment. At the project's onset, the team made a rough project plan, as shown in Figure 3, utilizing Microsoft Project. This file was updated as the project developed to show current progress, completed tasks, and upcoming activities.

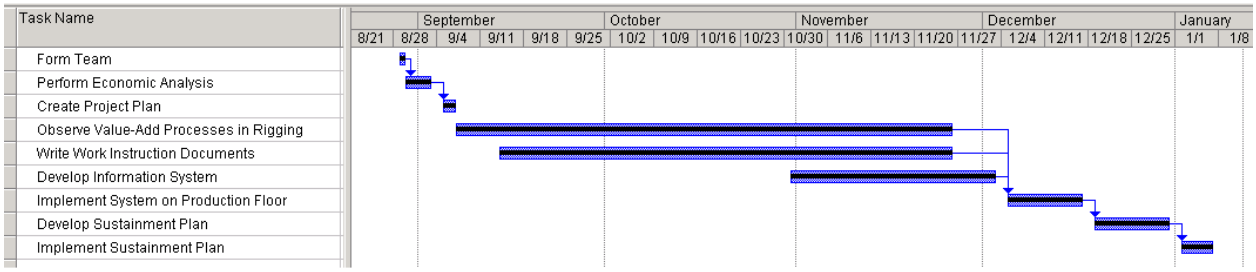


Figure 3. Process Optimization Gantt Chart

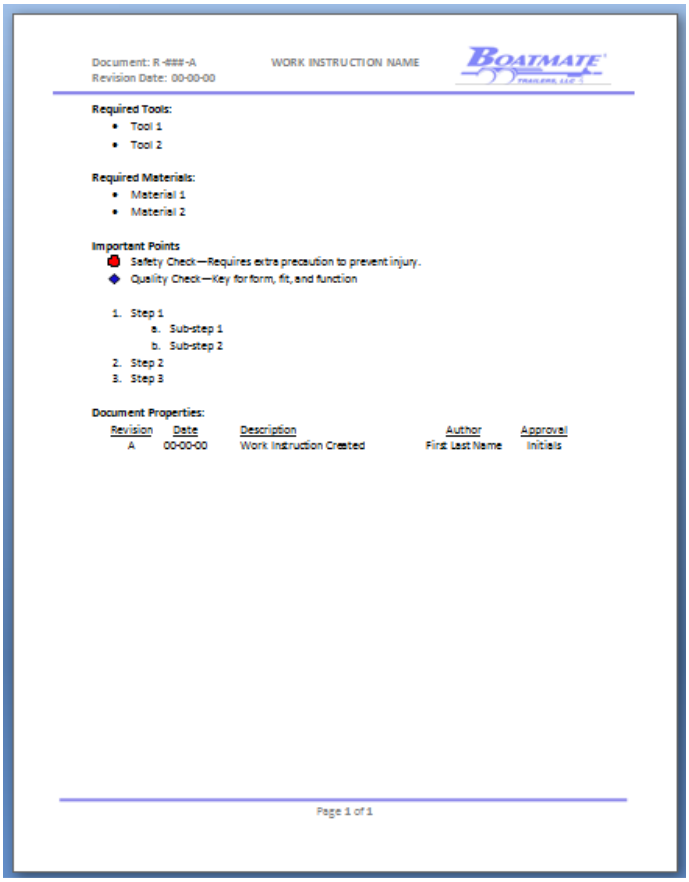
iv. Current Value-Add Processes

Initially, the team compared the previous documents with current practices to determine if any of the material was still relevant. After careful consideration, the majority of the documents was found to be obsolete and in an inconsistent format. Therefore, it was archived while consistent material was stored for future use. After going over the known processes, the team decided to split the documents into groups based on what station performed said processes.

The team members then observed each value-added process in the rigging department resulting in copious notes. The team relied heavily on the specialized knowledge of the associates and managers in order to correctly record each process. To provide realistic instructions, the team also tried to observe a variety of associates performing the same tasks as well as perform the activities themselves. These notes were accompanied by step-by-step photographs and diagrams, as necessary.

v. Work Instruction Documents

In order to create useful documents, the team first settled on a format. After consulting with several associates, the previous documents' style was found to be confusing and hard to follow. Furthermore, the software used to develop the documents was not widely known or user friendly for this type of information. Thus, the team designed a new format, seen below in Figure 4, which was more user-friendly to the author and reader. This format clearly noted the document number (in compliance with ISO 9000 standards), revision date, required tools and materials, process steps with icons signifying items that required safety or quality checks, page number, and document properties (i.e., revision level, date, description, author, and approval initials).


Document: R-###-A
Revision Date: 00-00-00

WORK INSTRUCTION NAME

BOATMATE TRAILERS, LLC

Required Tools:
- Tool 1
- Tool 2

Required Materials:
- Material 1
- Material 2

Important Points
- Safety Check—Requires extra precaution to prevent injury.
- Quality Check—Key for form, fit, and function

1. Step 1
   a. Sub-step 1
   b. Sub-step 2
2. Step 2
3. Step 3

Document Properties:

Revision	Date	Description	Author	Approval
A	00-00-00	Work Instruction Created	First Last Name	Initials

Page 1 of 1

Figure 4. Work Instruction Template

The team then translated the notes, pictures, and diagrams of the recorded observations into this format. Similar to the observation process, associates and managers were consulted for any necessary clarification. Each work instruction was then passed on to the rigging department's manager who noted any inaccurate information, steps needing further clarification, etc. The associates also audited highly complex process documents as another way to ensure the document's quality. After the requested changes were made, this auditing process was repeated until all parities were satisfied, and the manager had signed off via the approval column in the document properties. A finalized work instruction can be seen in Figure 5.

Figure 5. Example Work Instruction

vi. Information System Development

To organize and track the status of work instructions in a centralized location, an information system was developed using Microsoft Access. Thus, the team had to analyze the current way information was stored and find ways to improve upon the issues found. Previously, the information was only stored in folders on the company's shared drive. This made it difficult for documents to be retrieved and almost impossible to track any updates. Furthermore, Boatmate Trailers had difficulty tracking work instructions that should be created, needed revisions, or were completely obsolete. Thus, this database was designed to not only provide a central location for documents but to also allow managers to request that specific documents be created, revised, or pulled from the production floor.

Using the database, managers are able to manage work instructions. Records of work instruction documents are stored in a table that contains the attributes of each (i.e. work instruction name and number, revision date, author, etc.). Through the use of a form, these work instruction records can be viewed or updated as needed. In addition to storing work instructions, managers are now able to keep track of the associate training. Thus, the database has employee records and uses queries to populate associate, intern, and manager tables. Similar to the work instruction records, this table can also be updated to reflect any changes in employment. This table was then linked to a training table that tracked which associates had been trained on the various work instructions. Another form on the database served as a record of training for each employee. Once they completed training on a work instruction, the process's work instruction was checked off on their individual record. This aided managers in knowing which employees needed more training and which were able to work in multiple areas. These relationships are shown in Figure 6.

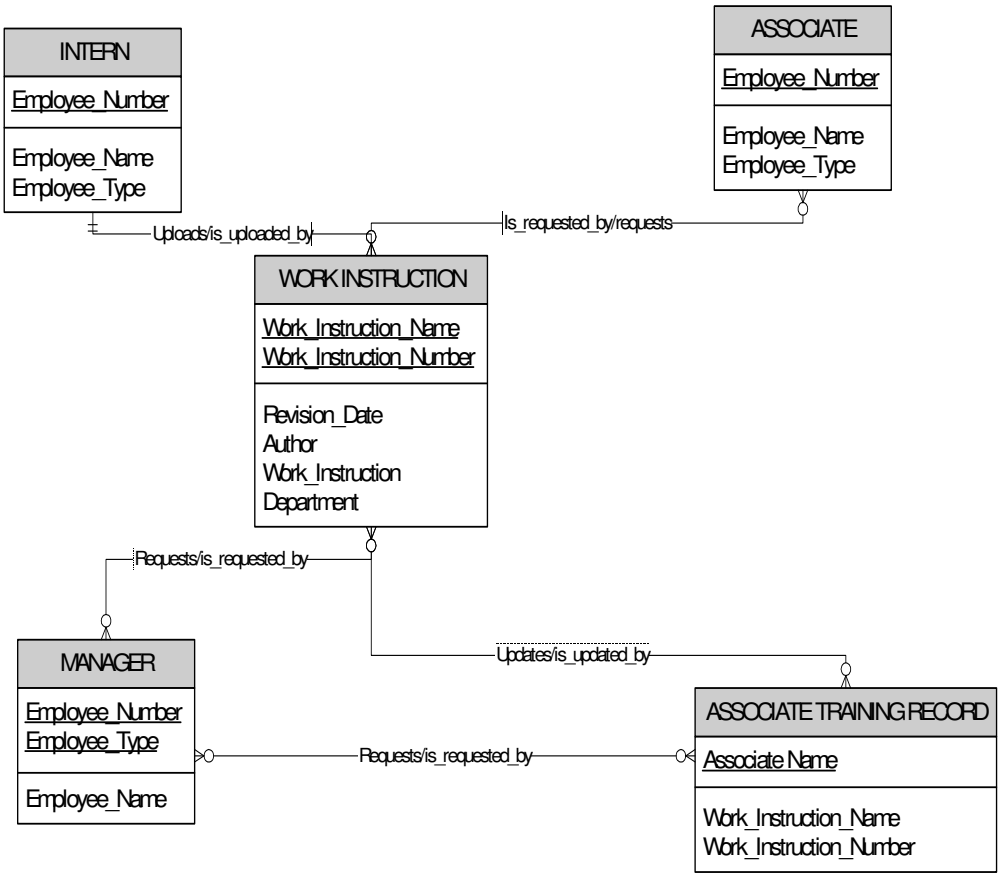


Figure 6. Database Interaction

vii. Implementation

At this point, the team needed to determine the best way for associates on the line to access the database and work instructions. Since associates move around the trailer to complete their processes, placing hard copies of the documents at a single location was not feasible. Therefore, the team decided that a line-side computer, as shown in Figure 7, allowing employees to access the information would be the best option. This enabled employees to use the database to view a work instruction as they were completing the process instead of having to walk back and forth to read laminated process sheets. In addition, the line-side network eliminated the managers' current responsibility of printing the work instructions and posting them line-side. Because processes can change frequently, reducing the amount of hard copies made the process more environmentally friendly while granting managers more time to complete more meaningful tasks.

Figure 7. Line-Side Computer for Associate Use

Each manager using the system received one-on-one training from one or both members of the team. This allowed the team members to teach the manager the specific tasks that he or she would be performing on site and more easily answer any questions that he or she had. Furthermore, the team was able to go into greater depth in the system so that the managers would be able to assist employees using the system on the line. In addition to one-on-one sessions, multiple progress meetings were held to explain updates to the system and any new features added. These meeting were also used to collect feedback from managers on how to improve the system.

Associates on the line also needed to be trained on how to use their portion of the database. Once the computer was setup on the line, the department received a group training session on the system. This allowed associates to ask more questions specific to the part of the database and system that they would actually be using. In addition, one-on-one training from managers was available if the on-line process did not match the documented process.

viii. Sustainment Plan

Ensuring that work instructions are kept up-to-date is key to Boatmate Trailer's continued improvement in both training and quality. During the creation of work instructions, team members worked to involve associates in each step of the process. Doing this gave associates a sense of responsibility in keeping the

new work instructions and database system up-to-date. The team hoped that the associate's involvement and awareness of the project would translate into associates being more likely to report a changed process or an obsolete document.

Steps have also been taken to ensure that the database will continue to be used after its initial implementation. To aid in any maintenance or questions, team members created an instruction manual, as shown in Figure 8. The document includes details on how each part of the database is intended to work as well as any maintenance that might be necessary.

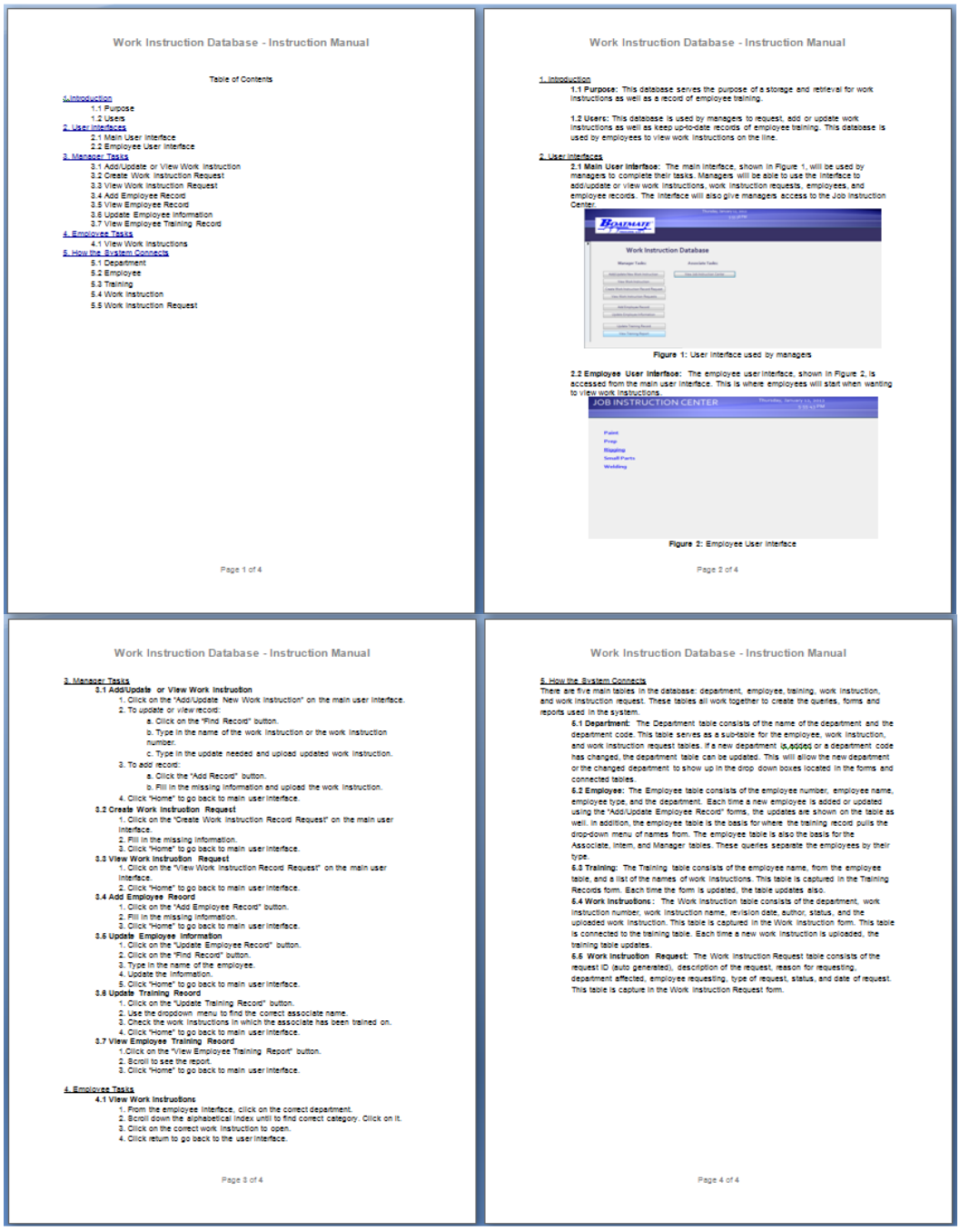


Figure 8. Instruction Manual for Work Instruction Database

5. Industrial Engineering Tools Used

The team utilized the following industrial engineering tools throughout the duration of the project.

i. Information System

Microsoft Access was used to create an information system for Boatmate Trailers. To create a database, the team learned what the company needed, determined how the associates and managers would interact with the system, created a prototype system, and updated the system upon further requests. First, the team members identified what was needed in the new system. Since there was no standardized way to store and retrieve work instruction information, a storage and request system for work instructions was the top priority. The team also found that the lack of a training system was causing quality problems and lower productivity. Thus, the second priority for the system was to have a training record for each employee and process.

Next, the team determined what each user would need the system to accomplish. Managers would use the database to request new or updated work instructions as well as track employee training. On the other hand, associates would only need the database to look up work instructions on the line. Therefore, the team decided that only managers needed full access to the database. Thus, managers would have the capability to add/update employees, add/update work instructions, request the creation of a new work instruction, and update/view training records while employees would be given access to only the part of the database that allowed them to view the needed work instructions.

Once the team had finished determining the requirements of the database, they designed the new system. The database was then tested by different managers to determine the usability of the system. One area of improvement was to create a user interface for employees to make it easier for them to find a certain work instruction. Originally, all work instructions were on a long form making it time consuming to look for the correct process. Therefore, the team decided to change the form to have an alphabetical index of different parts of the trailer. Once the employee clicked on the category, they would be taken to a screen with only a few work instructions, which drastically reduced the time spent searching for the correct one.

ii. Engineering Economics

Using the concepts of engineering economics, the team completed an economic analysis to justify the project's benefits to Boatmate Trailers. While many of the values were estimated, the analysis still provided the company with an idea of when their investment would start earning a profit. In order to do this, the team had to determine the cost of each allocated resource, consider what would be necessary to sustain the new system, and analyze the current system.

iii. Project Management

Since no firm requirements or deadlines had been set, the team managed the project by establishing goals with deadlines at the beginning of the project. The first goal the team set was to complete the work instructions for the rigging area by the end of the fall semester. This objective entailed many small tasks, so the team used these activities to create intermediate goals. For example, creating a user friendly format for the work instructions within the first two weeks of the project was the first intermediate goal set. Without this intermediate goal, the team would not be able to create the work instructions later. Thus, by creating small, intermediate objectives the team was able to break the larger, final goal into smaller parts making the project more focused.

iv. Quality Control

Due to the process variations on different assembly lines, there were discrepancies on trailers of the same make and model. Many of these differences were attributed to varying placement of components such as decals and stickers; however, others were more serious quality issues. For example, installing a fender

using the wrong process will produce scratches in the paint thus making the trailer susceptible to rust. By standardizing all processes and retraining associates, Boatmate was able to consistently provide a higher quality product to their customers. If deviations did occur, the process document was to be checked and further steps were to be taken to resolve the issue.

v. Standardization

As the overarching concept of the project, standardization came into play in almost everything the team accomplished. From standardizing each individual value-added activity to standardizing the format and location of the work instructions, many steps were taken to ensure that the approved processes were in place throughout the rigging department. This alleviated many day-to-day issues by bringing all associates and managers onto the same page. Furthermore, as one of the building blocks of continuous improvement, standardization aided Boatmate Trailers in their overall strategy.

vi. Value Chain Analysis

By performing value chain analysis, the team made sure the correct product was coming into and leaving a station. In some instances, an associate would struggle to correct a component that had been processed in a previous department or station. The first area was then notified of the defect and corrective action was put into place by that area's supervisor. In other cases, several tasks needed to be completed before another activity could take place. Thus, various checks and references were added to the work instructions to ensure processes were completed in the correct order.

6. Evaluation and Recommendations

Due to the success of the project in the rigging department, the team recommended that it be extended to Boatmate Trailer's four other departments. Before moving forward with the expansion, the team found some areas that could be improved upon as well as some features that could be added. Since Boatmate has several processes that rarely happen (less than once a month), the team needed to coordinate better with production scheduling to ensure one or both teammates were available to observe them. In order to reduce work instruction creation time, the team would also like to simultaneously take notes and pictures of each process. While this would be more time consuming on the front-end, it would ease the translation as well as clear up some of the questions the author had while writing the document. Due to the complexity of several of Boatmate Trailer's processes, the team would also like to implement the use of video in the work instruction documents. These videos could also be used for steps that were difficult to capture in photographs, required extra safety measures, or were key to form, fit, or function.

Boatmate Trailers, LLC then determined that the project would be extended to the paint, prep, welding, and small parts departments. The team then continued the project taking into account the previous recommendations. For example, video was used to help explain how to assemble upright boards—a process that only *one* manager knew how to do at the time. In addition, to the documents, the team also took other steps to help Boatmate improve their processes and overall product. These activities included reliability studies on the band saw and new automatic bending machine, standardizing visual management tools for the rigging department, and creating a plant layout for the proposed, new facility.

7. Conclusion

By working closely with managers and associates and using Industrial Engineering tools, the team was able to document current processes and create a database that met the company's needs. The work instructions created helped Boatmate Trailers to reduce variation in the quality of their products, decrease cycle times, and improve new associate training. In addition, the information system gave the company a way to store these work instructions and keep track of each employee's training. While there are still improvements to be made, this project has helped Boatmate Trailers, LLC to improve upon their current processes.

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