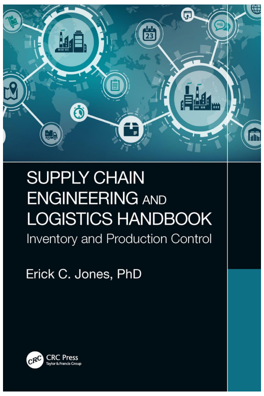

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Inventory and Production Control
Erick C. Jones

Using Six Sigma to Evaluate Automatic Identification Technologies to Optimize Broken-Case Warehousing Operations

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21

Using Six Sigma to Evaluate Automatic Identification Technologies to Optimize Broken-Case Warehousing Operations

Christopher A. Chung and Erick C. Jones

The continuous exploration of what is required the processes that impact system performance over sub-optimizing parts of a system leads to true innovation success.

Erick C. Jones

21.1 Introduction

This project was conducted by a team of professors and students from the University of Texas in Arlington as well as Tecnológico de Monterrey, Campus Querétaro. The Principal Investigator was Dr. Erick C. Jones, an Industrial and Manufacturing Engineering Professor at the University of Texas at Arlington as well as the Director of RAID labs. This project was also supported by Dr. Beatriz Murrieta, an Industrial Engineering Professor at Tecnológico de Monterrey, Campus Querétaro as well as the Department Chair. Support and project input was also given by Dr. Vettrivel Gnaneswaran, the Assistant Director of the RAID labs.

The project leads for this investigation include Jose Sanchez Gonzalez, Mackenzie Dacres, and Rayanne Macnee. Jose Sanchez Gonzalez is a Graduate MSIE Student at the University of Texas at Arlington. Mackenzie Dacres is an Industrial Engineering Undergraduate Student at the University of Texas. Rayanne Macnee is a Nursing Undergraduate Student. Support was also given by Walter Muflur and Cynthia Vinueza-Garcia, both Undergraduate Industrial Engineering Students at the University of Texas at Arlington.

21.1.1 Radio Frequency Identification and Auto ID Lab

The Radio Frequency Identification and Auto ID (RAID) Labs were established in 2011 by the Principal Investigator Dr. Erick Jones. The vision of the lab is that everything will be tracked wirelessly in 10 years. The mission of the lab is to provide integrated solutions in logistics and other data-driven environments through automatic data capture, real-world prototypes, and analysis. It is the goal of the RAID Lab to support the marriage of industries supply chain needs for automation identification technology with academia's theoretical applications. The purpose of the facility is to support project initiatives such as radio frequency identification (RFID), logistics, manufacturing, and information technology. The RAID Lab has had six major projects fully funded within the 1 year it has been established and has five more upcoming.

21.1.2 The National Science Foundation—International Research Experiences for Students (IRES)

The National Science Foundation (NSF) is an independent federal agency that was established in 1950 by Congress. It has an annual budget of $6.9 billion, all of which goes towards the progression of science, national health, prosperity, and welfare. That $6.9 billion currently funds approximately 20% of all federally supported basic research. The International Research Experience for Students Program is funded to support the development of worldwide research and interaction. It seeks to increase students' comfort level when working with people from different cultures by exposing them to the technological, cultural, economic, and socio-political aspects of Mexican society. The outcomes are as follows: an increase in research skills, cultural awareness, and a student's abilities in research methods and problem-solving skills.

21.2 Background

21.2.1 Company Background

Research was conducted at a large food product distribution center in Latin America. Problem Statement is as follows:

The information associated with a stretch wrapped full pallet License Plate Number (LPN) is lost when a "full" pallet has to be broken or taken apart to fulfill orders with individual cases on that pallet. The cases associated with the full pallet do not have the information such as lot, expiration date, or other relevant information that was included with the original LPN. This is causing customer returns of cases that are approximated at 15% of the outbound volume. It is expected that the volume of "broken" pallet case picking will be increasing in the near future with which the current methods may lead increase labor hours, high turnover, and lower worker productivity.

21.3 Research Objective

21.3.1 Research Question

In developing a research objective, the team narrowed the focus of the project down to three specific research questions. These questions include the following: Can RFID impact the number of outbound cases without LPN information? Can engineering work process redesign (EWPR) impact the incident ratio (IR)? And can RFID and EWPR impact the proposed future labor hours? We will explore these questions through the course of this chapter.

21.3.2 Relationship to Business Problem

These research questions are closely tied to the business problem faced by employees at Company XYZ's. By investigating RFID technologies, we will gain insights to the "broken pallet" case picking process and will be able to evaluate the impacts of pallet LPN information transfer to cases as well as future workflow and workstation redesign for increased worker optimization and improved safety conditions if RFID is implemented and if broken pallet case volume increases.

Research Hypothesis:

In conducting our research, we developed three test metrics. These metrics are listed as follows:

Test Metrics:

1. The number of outbound cases without LPN information (NCLPN)
2. The incident ratio
3. The projected number of future labor hours (PNLH).

In addition to three test metrics, three hypotheses were created.

Null Hypothesis:

(H_{01}): RFID technologies do NOT reduce the NCLPN Alternative Hypothesis (H_a): RFID technologies do reduce NCLPN.

(H_{02}): RFID technologies and EWPR do NOT reduce the IR.

(H_{03}): RFID technologies and EWPR do NOT reduce the PNLH.

The Rejection Criteria:

H_{01} is that if the NCLPN can be reduced by 10% then we cannot reject the H_{01}.

H_{02} is that if the IR can be reduced by 10% then we cannot reject the H_{02}.

H_{03} is that if the PNLH can be reduced by 10% then we cannot reject the $H_{03.}$

21.3.3 Research Methodology

We will employ design for Six Sigma research approach (DFSS-R), developed by Jones (2006). DFSS-R is a research methodology focused on reducing variability, removing defects, and getting rid of wastes from processes, products, and transactions. The approach utilizes quality tools and optimization techniques with effective cost justification (Figure 21.1).

The design for Six Sigma research-based approach contains seven different levels, where the problem defined needs to be measurable followed by the definition of metrics.

Research Methodology with Steps:

This section describes the different actions that need to be done under each specific phase.

Figure 21.2 outlines the seven phases of DFSS-R methodology and the corresponding steps with each phase. In the first stage "Plan", we define and measure the problem. In the second stage "Predict", we measure, analyze, design, and identify. In this project, the last phase "Perform" which uses Optimize and Verify was not utilized due to time constraints.

Table 21.1 elaborates specifically on the tools the team utilized for this project. Specific tools are listed, and examples of these strategies are provided in Figures 21.3–21.5. Figure 21.3 provides an example of a sample flow chart and how it might be utilized to solve a problem. Figure 21.4 displays the organizational structure of a fishbone diagram. Figure 21.5 illustrates how by using Pareto analysis, one can identify 20% of the causes to 80% of the problem. These tools were all utilized through the course of the project to come to our conclusions.

The team also conducted through data collection through plant visits, interviews, and observations. Listed below is a summary of the various plant visits as well as the major accomplishments for each visit.

21.3.4 Research Approach

As mentioned before, the research approach used by the team was the DFSS-R methodology. We utilized the Define, Measure, Analyze, Design, and Identify phases. In the Define phase, we identified the company business problem and narrowed the scope of the research project. Utilizing the results of the previous phase, now we will identify the metrics for the business problem statements in the Measure phase. Using the results of the previous phase, we analyzed the impacts of the current operations on the

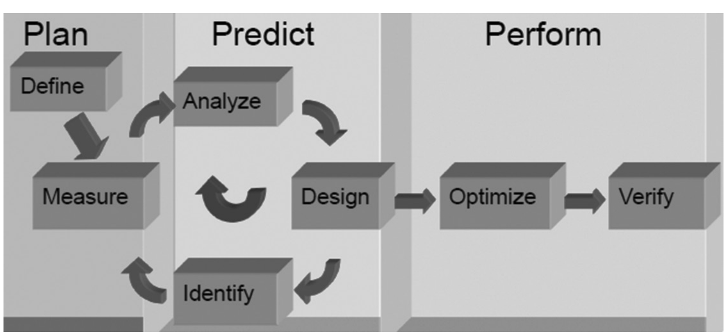

FIGURE 21.1 DFSS-R research methodology. (Jones 2006.)

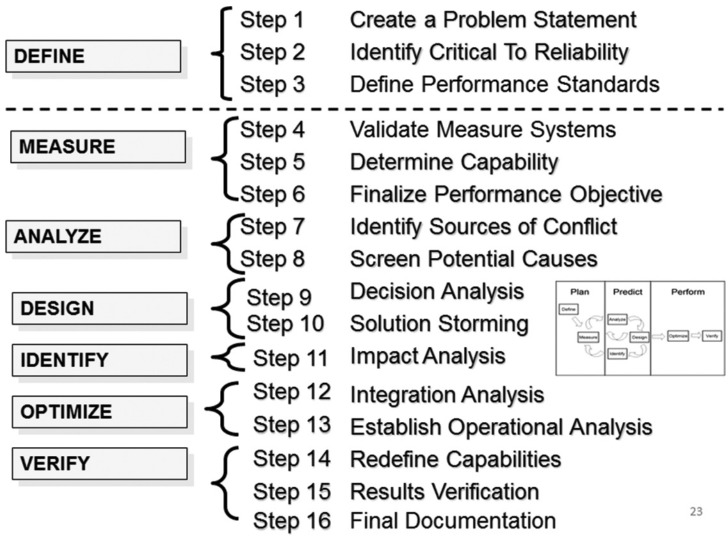

FIGURE 21.2 Phases of DFSS-R.

TABLE 21.1

Tools Used within the DFSS-R Methodology

Define	Measure	Analyze	Design	Identify	Optimize	Verify
Interview process/ observations	Hypothesis testing	Fishbone	Scenarios	Cost-benefit analysis	Factorial design of experiments	Control plans
Language processing	Analysis of variance	Pareto analysis	Fractional factorials	Visual systems	Theory of constraints	TPM
Prioritization matrix	Quality function deployment	Process mapping	Data mining	5-S	Response surface methodology	Multiple response optimization
System map	Flowchart	Multi-vari chart	Blocking	TPM	Blocking	Visual systems
Stakeholder analysis	Measurement system analysis	Chi-square	Response surface methodology	Mistake-proofing	Data mining	SPC/APC
Thought process map	Graphical methods	Regression	Multiple response optimization	SPC/APC	Multiple response optimization	Mistake-proofing
Value stream mapping	Process behavior charts	Buffered tolerance limits	Theory of constraints	ROI analysis	Fractional factorials	Continuous improvement

metrics defined. We identified the problem and the metrics, and analyzed the metrics. Now we are going to identify how the RFID technology will impact the metrics. In the Identify phase, we evaluate the cost-benefit of the proposed scenario in the Design phase.

21.3.5 DFSS-R Steps and Description

The results of the Define state was the defining the business problem statements. The cases associated with the full pallet do not have the information such as lot, expiration date, or other relevant information that was included with the original LPN. This is causing customer returns of cases that is approximated at 15% of the outbound volume.

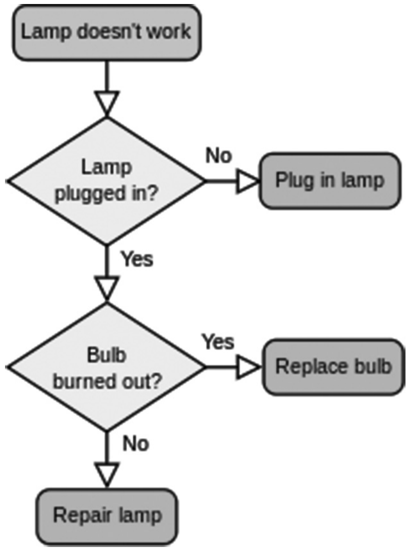

FIGURE 21.3 Sample flow chart.

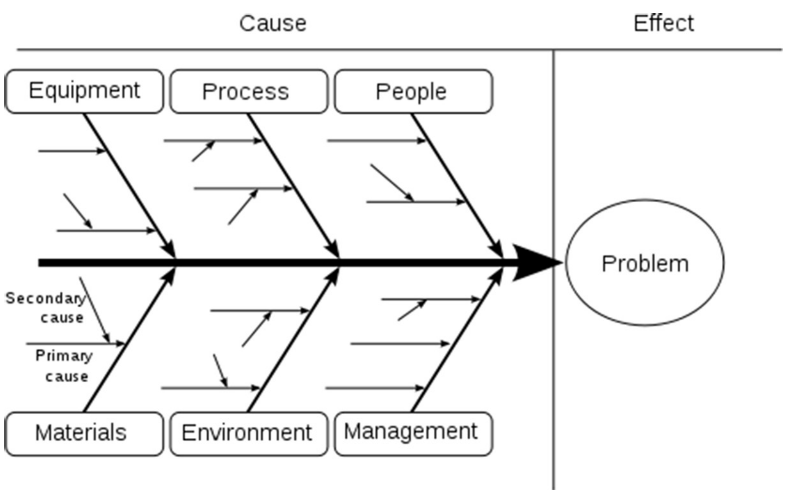

FIGURE 21.4 Sample fishbone diagram.

FIGURE 21.5 Pareto analysis.

After conducting the Measure phase, the team was able to determine the following metrics:

Metric No. 1: Number of outbound cases without LPN Information.

Metric No. 2: Incident ratio

Metric No. 3: Future number of labor hours (FNLH).

After determining the metrics, the team then began the Analyze phase of DFSS-R. The results of the Facility Layout Analysis were two floor-level conveyors travel to the outbound shipping transportation area. The pallets are staged in front of the conveyor so that they can be "broken" pallet case picked. Then, the workers unload the pallet onto floor conveyor where the pallets have a designated location.

This would indicate that fixed location designs are possible. However, integrating barcodes or additional RFID labels would require additional manpower needs as well as equipment for the operation. Based on the observation of material handling techniques used, worker productivity may be impacted by the calculation of incidence rate.

The flowchart was also analyzed, and it demonstrates that the current operation of integrating automation for transferring LPN information from pallets to cases will require new operating procedures. This future state analysis will impact several areas of the current flowchart. These areas include managing forklift traffic, staging pallets to be picked, labeling operation, and staging operation. In addition, worker procedures need to be analyzed for excessive exertion, and better ergonomic postures must be considered.

The results of the fishbone diagram are that the current LPN is linked only to the pallet label. The information from this LPN would have to be linked at the case level. This is due to the fact that the conveyor scanner does not determine non-LPN information for broken-case pallets. However, the conveyor scanner may be able to use RFID LPNs in the future with strategic location. The current barcodes on the cases can only be used for the final end customer and are not being manipulated for distribution center use. Possible manipulation of this system may be a solution. Lastly, the current employee working capability may contribute to the overall work productivity. Educating employee on proper working postures may also impact worker productivity and overall distribution center efficiency.

The results of the Pareto Analysis confirm that the biggest impact for lost LPN information would come from a variety of solutions. Company XYZ's should consider linking the LPN to the cases, utilizing the conveyor scanner to automate manual counts on the conveyor, evaluating the manipulation of the customer's barcode to connect supply chain information, and modifying working postures, and lifting techniques employed by the workers may be modified to impact work productivity.

After thorough analysis, the team moved into the Design phase where we came up with three different scenarios: Scenario 1: Passive Gen 2 RFID System (RFID), Scenario 2: EWPR, and Scenario 3: Passive Gen 2 RFID System and EWPR (REWPR).

Scenario 1: Passive Gen 2 RFID System (RFID)

In this picture, we can see the first scenario where the employee is attaching the passive RFID levels to the cases. These labels contain LPN information that will help keep track of the cases. Fixed or handheld readers are used by the employees to write, read, and verify the information in the Virtual Memory System (VMS).

Scenario 2: Engineering Work Process Redesign

In the second option, we will redesign some of the process based on improving worker productivity. It will imply the change of the conveyor's height. As a result of the adjustments, the employee work methods will be affected with the goal to optimize the worker movements with training with minimal facility upgrades.

Scenario 3: Passive Gen 2 RFID System and EWPR (REWPR)

The implementation of RFID Gen 2 System and the EWPR.

These changes will impact the way the employees load the cases on the conveyor belts. In addition, the organization will be able to keep track of the cases that are shipped from the distribution center

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Summary: Consider using RFID for case-level LPN tracking; consider facility changes for higher worker productivity: Scenarios—passive Gen 2 RFID System, EWPR, and passive Gen 2 RFID System and EWPR.

Identify: In this phase, we evaluate the cost-benefits of the proposed scenarios in the Design phase. This will be done through the calculation of the return of investment as well as the payback period.

21.4 Results

We created three different scenarios in the Identify phase of DFSS-R phase.

Scenario 1 involves the implementation of a Passive Gen 2 RFID System (RFID). This would call for a large initial investment. With this scenario, every employee would be provided a barcode (RF) scanner. There is, however, an estimated investment rate of 31.4% with an estimated payback period of 0.43 years.

Scenario 2 involves the implementation of an EWPR. This scenario would call for an initial investment and would involve providing braces to increase the conveyor height. It is estimated that there will be an estimated savings return of 29.3% with a payback period estimated at 1.27 years.

Scenario 3 involves both the implantation of a Passive Gen 2 RFID System and EWPR (RfEWPR). This would call for an initial investment rate of 31.4% and a payback period of 0.44 years.

21.5 Discussion

21.5.1 Rejection of Hypothesis

In addition, we also rejected all three of our null hypothesizes. We found that RFID technologies do reduce the number of outbound cases without LPN information. We also found that RFID technologies and EWPR do reduce the IR. Lastly, we also found that RFID technologies and EWPR reduce the PNLH.

21.5.2 Limitation

The results and recommendations calculated during this project may not be accurate because of a variety of limitations we encountered. These limitations include the fact that the team was only able to observe operation for a limited time period given the duration of the research project. In addition, the team used mostly observations and limitation for the analysis. Also, a small sample set was used in all data collection. In order to validate results and give a serious evaluation, more data collection is needed. Lastly, it is recommended that the last phase of DFSS-R including steps optimize and verify is performed to insure that the technologies recommended are tested and are the proper solution for the given environment.

21.5.3 Conclusion

In conclusion, we are grateful to the National Science Foundation for the opportunity to be a part of this NSF-IRES in Mexico UT Arlington program. Because of their funding, we had the opportunity to enhance our Spanish language skills and experience the Mexican culture.

We also appreciate the opportunity for working with a research team and learning a scientific research approach using RFID and logistics technologies.

Acknowledgments

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