

Accelerating the Onboarding of a New Factory Partner

By:

Amanda Rikki Lurie

B.S. Earth and Environmental Engineering
Columbia University, 2009

Submitted to the MIT Sloan School of Management and the Institute for Data,
Systems, and Society in partial Fulfillment of the Requirements for the Degrees of
Master of Business Administration
and
Master of Science in Engineering Systems

In conjunction with the Leaders for Global Operations Program at the
Massachusetts Institute of Technology
June 2016

©2016 Amanda Rikki Lurie. All rights reserved.

The author hereby grants MIT permission to reproduce and to distribute publicly copies
of this thesis document in whole or in part in any medium now known or hereafter
created.

Signature of Author _____

Signature redacted

MIT Sloan School of Management
MIT Institute for Data, Systems, and Society
May 6, 2016

Certified by _____

Signature redacted

Dr. Stanley Gershwin
Senior Research Scientist, MIT Department of Mechanical Engineering
Thesis Supervisor

Certified by _____

Signature redacted

Dr. Stephen Graves
Professor of Management Science, MIT Sloan School of Management
Thesis Supervisor

Accepted by _____

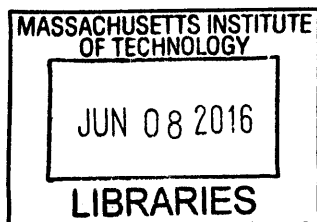
Signature redacted

John N. Tsitsiklis
Clarence J. Lebel Professor of Electrical Engineering
Engineering IDSS Graduate Officer

Accepted by _____

Signature redacted

Maura Herson
Director of MBA Program, MIT Sloan School of Management



ARCHIVES

This page has been intentionally left blank

Accelerating the Onboarding of a New Factory Partner

By:

Amanda Rikki Lurie

Submitted to the MIT Sloan School of Management and the Institute for Data, Systems, and Society on May 6, 2016 in partial Fulfillment of the Requirements for the Degrees of Master of Business Administration and Master of Science in Engineering Systems

Abstract

Nike established the Advanced Manufacturing team to create a future of manufacturing that will be able to better meet growing customer expectations, battle rising costs of production, and unlock new design capabilities. While new methods of manufacturing are groundbreaking for Nike, there is currently no standard operating procedure on how to properly integrate these new methods into footwear manufacturing. Nike would like to better understand the current process and identify ways to increase the ease of deployment to ensure profitability and improved speed to market. To do this, the research explored the current state of bringing onboard a new factory partner to the factory network, investigated metrics through which to evaluate inefficiencies, and provided suggestions for process improvements to create a more efficient future state. Future state projections show significant decrease in factory setup time. Preliminary implementation of the suggestions shows encouraging results in decreasing cost and increasing speed to market. While results are currently theoretical, this research provides a baseline framework to identify waste and develop process improvements to more efficiently onboard a new factory partner.

Dr. Stanley Gershwin
Senior Research Scientist, MIT Department of Mechanical Engineering
Thesis Supervisor

Dr. Stephen Graves
Professor of Management Science, MIT Sloan School of Management
Thesis Supervisor

This page has been intentionally left blank

Table of Contents

- Abstract 3
- Acknowledgements 5
- List of Figures..... 8
- 1.0 Introduction 9
 - 1.1 Nike, Inc. Company Background 9
 - 1.2 Nike Footwear Manufacturing Background 10
 - 1.3 Nike Footwear Advanced Manufacturing Background 10
 - 1.4 Problem Statement 13
 - 1.5 Project Goals 13
- 2.0 Project Methodology 14
 - 2.1 Overview 14
 - 2.2 General Approach 14
 - 2.2.1 Understand Current Process 14
 - 2.2.2 Identify Metrics for Success 14
 - 2.2.3 Develop Process Improvements 15
 - 2.3 Data Collection Limitations 15
- 3.0 Literature Review 16
 - 3.1 Process Documentation and Mapping 16
 - 3.2 Lean Process Improvement Methods 17
 - 3.3 Factory Startup Discussion 19
 - 3.3.1 Equipment Planning 20
 - 3.3.2 Automation Implementation 21
 - 3.3.3 Labor and Training 21
 - 3.3.4 Implementing Change 23
- 4.0 The Current State 24
 - 4.1 Work Stream Methodology 24
 - 4.2 Factory Operations 25
 - 4.2.1 Training 26
 - 4.2.2 Product Choice 27
 - 4.2.3 Factory Location 28
 - 4.3 Legacy Equipment Ordering 29
 - 4.3.1 Phase 1 29

Acknowledgements

I would like to first thank Nike for its support of my project and the Leaders for Global Operations (LGO) program. Being part of the cutting edge, innovative Advanced Manufacturing and New Factory Partnerships teams was an amazing learning opportunity. A very special thanks to Nguyen Webster, my project supervisor, and Bill Rogers and Michael Newton, my project sponsors. Without your support, guidance, and mentorship, this project would not have been possible. And thank you to my fellow Nike LGOs and Sloanies, Clara Voigt, Blair Holbrook, Andrew Gabris, and Katy Shaw for being my workout partners, sounding boards, and friends during our time at Nike.

Thank you to the Leaders for Global Operations (LGO) Program for its support of this work. I would also like to thank my advisors at MIT, Professor Stephen Graves and Professor Stanley Gershwin, for their time, advice, and assistance through the project.

Thank you to my Lambdies and LGBros. The last two years have been a whirlwind experience of laughter, learning, and memories. I can't wait to see the amazing things that the Lambdas achieve.

And to my 371 Amsterdam Ladies, you are my second family. Thank you for your endless support, encouragement, and wit. I am so happy to have all of you in my life.

Finally, and most importantly, I would like to thank my family. My mom and dad for their continuous support throughout my entire academic journey, and each of my siblings, Tobie, Pesy, Adam, and Becky for the love and guidance you have given me through the years. And to Aunt Harriet and Uncle Chuck, thank you for your much needed on-the-ground encouragement during my internship. You have all given me the confidence, skills, and work ethic to be successful.

This thesis is dedicated to the memory of my Opie, who passed away during my time at LGO. His wanderlust, passion for helping others, and love of laughter will inspire me forever.

4.3.2 Phase 2 and Phase 3.....	31
4.3.3 Pre-Production	31
4.4 Novel Equipment Ordering.....	31
4.5 Material Ordering.....	32
5.0 Identifying Waste.....	33
5.1 Rework.....	33
5.2 Wait Time.....	35
5.3 Handoffs.....	37
5.4. Summary Statistics of Current State.....	39
6.0 Kaizen Methodology.....	41
6.1 Background.....	41
6.2 Process.....	42
6.3 Findings	42
6.3.1 Current State.....	42
6.3.2 Problem Areas	43
6.3.3 Root Cause Analysis.....	43
7.0 Future State Discussion	49
7.1 Suggestions for Improvement: Internal.....	49
7.2 Suggestions for Improvement: External.....	50
7.3 Future State Predictions	53
8.0 Conclusion.....	55
8.1 Areas for Future Research.....	55
8.2 Final Notes.....	56
Appendix 1	57
Appendix 2	58
Appendix 3	61
References.....	62

List of Figures

FIGURE 1: RISING LABOR COSTS ACROSS ASIA: 12
FIGURE 2: THE SEVEN TYPES OF WASTE 19
FIGURE 3: FACTORY PLANNING BUILDING BLOCKS 21
FIGURE 4: REWORK 34
FIGURE 5: WAITING TIME 36
FIGURE 6: HANDOFFS 38
FIGURE 7: SAMPLE ISHIKOWA DIAGRAM 44

1.0 Introduction

The purpose of this thesis is to better understand and document the current process of deploying new methods of manufacturing to Nike, Inc. (Nike) footwear factories while identifying ways to ease deployment, and ultimately, create a new, more efficient process to ensure profitability and improved speed to market. This research was conducted in conjunction with the Advanced Manufacturing team within Nike.

1.1 Nike, Inc. Company Background

Since its creation in 1964 as Blue Ribbon Sports, Nike has grown to a company with 30.6 billion dollars in revenue (Nike, 2015). Nike is the world leader in three main athletic product categories: footwear, apparel, and equipment. Known as its trademark product around the world, Nike footwear represents 18.3 billion dollars of revenue for the company. Apparel revenue is about half the amount of footwear, totaling 8.6 billion dollars, while equipment totals 1.6 billion dollars (Nike, 2015). This thesis will focus on the footwear part of the business.

Nike produced more than 530 million pairs of shoes in 2015 across six different global markets: North America, Western Europe, Central & Eastern Europe, Greater China, Japan, and the Emerging Markets; in eight different sport categories: running, basketball, football (soccer), Men's training, Women's training, action sports, sportswear, and golf (Nike, 2015). Nike sells its products to retail accounts, through Nike-owned retail stores and Internet websites, and through a mix of independent distributors and licensees throughout the world. Nike follows a retail cycle of four selling seasons – spring, summer, fall, and holiday. The planning and design of a new style of shoe begins more than a year in advance of its planned market date and can sometimes begin up to two years early.

1.2 Nike Footwear Manufacturing Background

Like many of its competitors, Nike manufactures its products by independent contract manufacturers. Nearly all Nike footwear and apparel products are produced outside of the United States, while equipment products are produced both in the United States and abroad. Nike is supplied by approximately 146 footwear factories located in 14 countries. 96% of those factories are located in three countries: Vietnam, China, and Indonesia. The remaining 4% of footwear factories are located in Argentina, Brazil, India, and Mexico; these factories manufacture footwear primarily for sale within those countries. While there are a lot of footwear factories, five of the factories each accounted for greater than 10% of footwear production, and all together, accounted for approximately 69% of footwear production in 2015. The main materials used in Nike footwear are natural and synthetic rubber, plastic compounds, foam cushioning materials, nylon, leather, canvas, and polyurethane films used to make Nike Air-Sole cushioning components. The contract manufacturers are wholly responsible for the procurement of the raw materials and for the management of the suppliers of the materials (Nike, 2015). While the manufacturing operations are run by the contract manufacturer, Nike does have local offices in close proximity to the factories to manage the process and provide guidance if needed.

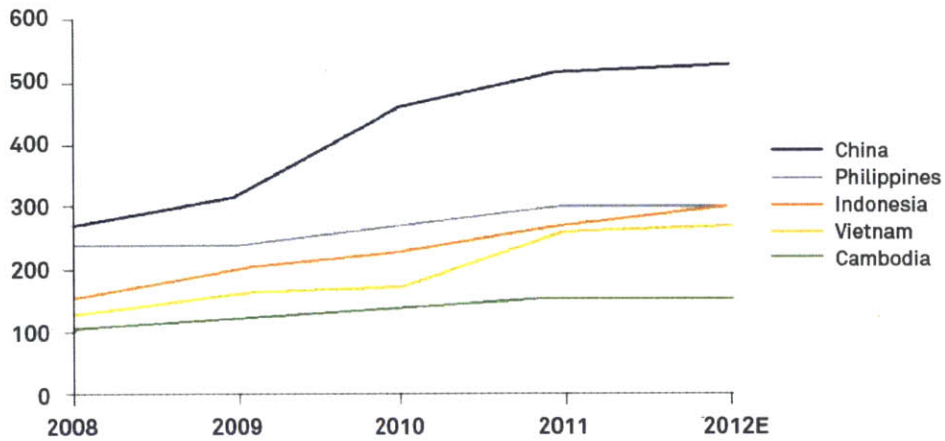
1.3 Nike Footwear Advanced Manufacturing Background

To maintain a competitive advantage over its competition and to stay the industry leader in footwear, Nike established the Advanced Manufacturing team to create a future of manufacturing that makes the best use of materials, technology, and people. The Advanced Manufacturing team was created in April 2014 as part of the Manufacturing Revolution group. The Advanced Manufacturing team is committed to changing the way that Nike produces footwear through the development and implementation of innovative methods of manufacturing.

By developing these new methods of manufacturing, Nike will be able to solve three main challenges it's encountering with its current manufacturing network:

- 1) **Customer Expectations are Changing:** Consumers are pushing for more customization and a more specialized product as it puts them "back in the center of attention of the footwear producer." Customization allows for "direct, one-to-one contact" where the consumer is "greeted, inquired, scanned, measured, questioned, supported, and assisted in their purchase experience, transforming a simple necessity act, into a ritual that makes the consumer feel that what the company is trying to do is not simply trying to sell an item, but learning more about his or her desires and expectations." While Nike's current manufacturing capabilities are able to meet the present customer expectations of "buying a good pushed by a need," the projected increased growth of customization will certainly overwhelm the manufacturing system. Current manufacturing systems would not accommodate the types of customization that Nike Design projects for the future. The new methods of manufacturing that are to be deployed are designed with these needs in mind (Boër, C. R., and Sergio Dulio, 2007, pg 27).
- 2) **Production Costs are Rising:** As mentioned in section 1.2, virtually all of Nike footwear production is conducted in Asia. Contract manufacturers benefited from the low cost of labor, materials, and other required inputs with manufacturing in Asia. When Nike moved production to Asia more than twenty years ago, labor was plentiful and cheap, but current trends indicate that the labor arbitrage will not continue forever in Asian manufacturing. Wages are steadily rising in each of Nike's main footwear manufacturing countries:

Figure 1: Rising Labor Costs Across Asia (Macquarie Research, 2013):



As these costs continue to rise as projected, the current methods of manufacturing will not be sufficient. The Advanced Manufacturing strategy aims to remedy this problem.

- 3) **Technology is Evolving:** While the current methods of manufacturing have led Nike down a successful path, they are outdated. Remarkably, the methods of manufacturing across the footwear industry remain similar to those used by town cobblers nearly 200 years ago. While other industries quickly update and innovate manufacturing methods, footwear production is still very antiquated. Nike aims to change this, looking to modernize the manufacturing practices and machinery like other industries have done. This same innovation is necessary in footwear manufacturing.

The Advanced Manufacturing group is composed of four teams: Digital Product Creation (DPC), Operations (Ops), Ecosystem (Eco), and New Factory Partnerships (NFP). DPC is tasked with increasing visibility and transparency into the order, production, and distribution process through digital tools and processes. The Ops team is responsible for the demand planning and project management for all of Advanced Manufacturing, ensuring that all of the groups are aligned on the overall goals of the group and Nike, in general. The Eco team works to develop an intelligent supply chain to procure the necessary equipment, materials, and other items that will be needed within the factory.

The NFP team is responsible for all operations and activities that occur within the four factory walls to manufacture the footwear. This thesis will focus on the work done by the NFP team, but will feature interactions and processes that were done with the other teams within Advanced Manufacturing.

1.4 Problem Statement

Because these new methods of manufacturing are groundbreaking for Nike and the industry as a whole, there is currently no standard process on how to implement new manufacturing techniques into footwear manufacturing. The NFP team within Advanced Manufacturing worked through this process since its inception, working to incorporate new technologies into Nike's manufacturing. As the pioneer of these new methods, the NFP team perceives that the process is not proceeding efficiently: the process is encountering trial and error, non-value added work, and rework at times. These inefficiencies lead to an uncertain and longer than ideal factory-planning process.

1.5 Project Goals

Nike's perception is that the process to deploy new methods of manufacturing is flawed. This research aims to expand Nike's competitive advantage by developing a streamlined startup process to fix the process for onboarding new factory partners. When attempting to create a better process, the new process should meet specific goals. They are as follows:

- 1) **Reduced Cost:** By eliminating waste and unnecessary steps in the process, Nike will be able to utilize fewer resources and lower relative headcount.
- 2) **Improved Speed to Market:** By decreasing the number of process steps, Nike will be able to get footwear to market much quicker.
- 3) **Gates and Dates:** Stakeholders in the process will be aware of the necessary deadlines and tests to be successful in deploying new methods of manufacturing.
- 4) **Ownership of Responsibilities:** A clearer distinction of responsibilities across the stakeholders.

5) Keep the Craft: The new process cannot in any way affect the look, feel, and quality of Nike footwear.

2.0 Project Methodology

The purpose of this chapter is to briefly outline the methodology used for the project, as well as limitations that were encountered during the data collection process.

2.1 Overview

This research aimed to first understand the current process in use by the NFP team at Nike to deploy new methods of manufacturing. Generally, this research was done by conducting interviews to gather data from current stakeholders. Subsequently, a set of metrics is developed to identify areas of opportunity to improve the process, and ultimately provide recommendations to create a better process.

2.2 General Approach

2.2.1 Understand Current Process

The first step in learning about potential process improvements is to understand the current process. To document the steps and activities, process mapping is utilized. Process mapping is an important tool to understand process time, stakeholders involved, and interdependencies between steps. By creating a visual tool to map out the process, stakeholders are better able to identify waste. In addition, those that are adding to each step can answer questions and provide clarification for others (Cobb, 2006). Finally, a key to understanding the process is learning not only about what was done in each step, but the reasoning and decision-making behind each step.

2.2.2 Identify Metrics for Success

After the process was mapped, it is critical to determine a way to measure inefficiencies within the process. Once inefficiencies can be measured, the steps that require the most process changes become more obvious. Three metrics are selected to measure waste within the process.

2.2.3 Develop Process Improvements

Based on the three metrics, process steps with the most inefficiency are identified. A 5-why root cause analysis is conducted to determine the root cause of the worst bottlenecks and problem areas. Based on these root causes, various solutions are proposed to remedy the challenges within the process. These solutions include overall changes in strategy, as well as changes in the step-by-step processes.

2.3 Data Collection Limitations

Data for this project was collected primarily through qualitative methods. As the various steps in the process were not tracked in real time, stakeholder memory and documents are heavily relied upon. Data was generally collected through multiple pathways: interviewing stakeholders, attending team meetings, shadowing employees, analyzing documents, and visiting Nike factories. If stakeholders had differing opinions on a process step, stakeholders collaborated and agreed upon the answer that is detailed in this thesis.

3.0 Literature Review

This literature review is not intended to be exhaustive. This section provides an overview of the background research that was done to better understand onsite activities at Nike. The literature informs the decisions and recommendations that will be given.

3.1 Process Documentation and Mapping

Detailing and using process maps is not a new concept, and many individuals have developed ideas on the best way to do so. Frank Gilbreth is the first to be credited with introducing the idea of the process map in his search for the “one best way” to complete a task. In his 1921 address to the American Society of Mechanical Engineers, he preached to the audience about the need to define a problem and break it down into smaller tasks in order to better understand it, and thus improve it. His initial work described four main parts of a task: the operations, the transportation, the inspection, and the storage/delay (Gilbreth, 1921). Following Gilbreth, in 1947, the Society of Mechanical Engineers established a set of symbols to better standardize process mapping (Graham, 2008). Since then, there has been much work to continue these early endeavors. For the purpose of this research, a sequential flow diagram will be discussed, as the order of operations was most important to Nike.

Sequential flow diagrams aim to “present the discrete steps in a process sequentially in the order in which tasks are accomplished (Colligan et. al, 2010).” In creating such a map, it is important to document the amount of time required for each step, as one of the main goals of this type of map is the timing associated with each and all of the tasks. It is also important to explain the reasons behind a step or decision to shed light into why specific tasks were conducted before or after others, and most importantly, if tasks should be moved around to create a more efficient process (Phillips & Simmonds, 2013). Finally, it is important to note the stakeholders that are necessary for each of the sequential steps. This is critical as it allows for the balancing of work across members of

a team and teams within a group. With the flow diagram, it becomes much easier to visualize the number and types of tasks that will be required at a given time (Anjard, 1999).

3.2 Lean Process Improvement Methods

In order to identify inefficiencies and wastes in the current process, principles from lean production are studied. The goals of lean are to eliminate wasteful processes, increase output, improve product quality, and shorten time to market and thus, overall cost (Karlsson and Ahlstrom, 1996). Ultimately, lean aims to remove any business process or task which does not create value for the customer (Womack and Jones, 1996). Astonishingly, according to the Lean Enterprise Research Center, only about 5% of process tasks actually add any value for the customer. To find areas for opportunity and improvements in a process, lean focuses on seven types of waste shown below in Figure 3 (Melton, 2005, pg 666). These lean metrics will be revisited in Chapter 5.

Figure 2: The Seven Types of Waste

Type of waste	Description	Within the process industry	Example symptom
1. Over production	<ul style="list-style-type: none"> Product made for no specific customer Development of a product, a process or a manufacturing facility for no additional value 	<ul style="list-style-type: none"> Large campaign—large batch and continuous large-scale manufacturing processes Development of alternative process routes which are not used or the development of processes which do not support the bottleneck Redesign of parts of the manufacturing facility which are 'standard', e.g., reactors 	<ul style="list-style-type: none"> The extent of warehouse space needed and used Development and production organization imbalance An ever changing process (tweaked) Large engineering costs/time associated with facility modifications
2. Waiting	<ul style="list-style-type: none"> As people, equipment or product waits to be processed it is not adding any value to the customer 	<ul style="list-style-type: none"> Storage tanks acting as product buffers in the manufacturing process—waiting to be processed by the next step Intermediate product which cannot leave site until lab tests and paperwork are complete 	<ul style="list-style-type: none"> The large amount of 'work in progress' held up in the manufacturing process—often seen on the balance sheet and as 'piles of inventory' around the site
3. Transport	<ul style="list-style-type: none"> Moving the product to several locations Whilst the product is in motion it is not being processed and therefore not adding value to the customer 	<ul style="list-style-type: none"> Raw materials are made in several locations and transported to one site where a bulk intermediate is made. This is then transported to another site for final product processing Packaging for customer use may be at a separate site 	<ul style="list-style-type: none"> Movement of pallets of intermediate product around a site or between sites Large warehousing and continual movement of intermediate material on and off site rather than final product
4. Inventory	<ul style="list-style-type: none"> Storage of products, intermediates, raw materials, and so on, all costs money 	<ul style="list-style-type: none"> Economically large batches of raw material are purchased for large campaigns and sit in the warehouse for extended periods Queued batches of intermediate material may require specific warehousing or segregation especially if the lab analysis is yet to be completed or confirmed 	<ul style="list-style-type: none"> Large buffer stocks within a manufacturing facility and also large warehousing on the site; financially seen as a huge use of working capital
5. Over processing	<ul style="list-style-type: none"> When a particular process step does not add value to the product 	<ul style="list-style-type: none"> A cautious approach to the design of unit operations can extend processing times and can include steps, such as hold or testing, which add no value The duplication of any steps related to the supply chain process, e.g., sampling, checking 	<ul style="list-style-type: none"> The reaction stage is typically complete within minutes yet we continue to process for hours or days We have in process controls which never show a failure The delay of documents to accompany finished product
6. Motion	<ul style="list-style-type: none"> The excessive movement of the people who operate the manufacturing facility is wasteful. Whilst they are in motion they cannot support the processing of the product Excessive movement of data, decisions and information 	<ul style="list-style-type: none"> People transporting samples or documentation People required to move work in progress to and from the warehouse People required to meet with other people to confirm key decisions in the supply chain process People entering key data into MRP systems 	<ul style="list-style-type: none"> Large teams of operators moving to and from the manufacturing unit but less activity actually within the unit Data entry being seen as a problem within MRP systems
7. Defects	<ul style="list-style-type: none"> Errors during the process—either requiring re-work or additional work 	<ul style="list-style-type: none"> Material out of specification; batch documentation incomplete Data and data entry errors General miscommunication 	<ul style="list-style-type: none"> Missed or late orders Excessive overtime Increased operating costs

While lean has typically been applied to processes on the manufacturing floor, it can be successfully implemented across the whole supply chain. Specifically, Panwar (2015) discusses that while new and unfamiliar to processes outside of the factory line, lean thinking can and should be implemented elsewhere. With a cross-functional approach that focuses on long-term benefits, lean can help to standardize processes, increase service levels, and ensure proper communication across teams. Panwar goes on to

encourage both upstream and downstream involvement: incorporating both supplier and customer feedback is incredibly important.

While information and data are often abundant in large corporations, lean methodology can help to alleviate issues with the exchange of said information (Karlsson, 1996). Through the use of visual management tools and clear definition of team metrics, information is more easily transferred. Visual management tools allow for open access and increase transparency across stakeholders while metrics make requests for information more predictable and acceptable. Both visual management tools and metrics that are developed should be clear and easy for all employees to understand. (Bevilacqua, 2015). Kovera (2014) writes that visual management tools are best when they provide both management and peers insight into progress against the predetermined metrics. She goes on to say that “the best leaders, best teams, and best organizations leverage visual management tools to create a culture of adaptability, trust, respect, and continual learning that ensures a safe workplace (pg 36).”

3.3 Factory Startup Discussion

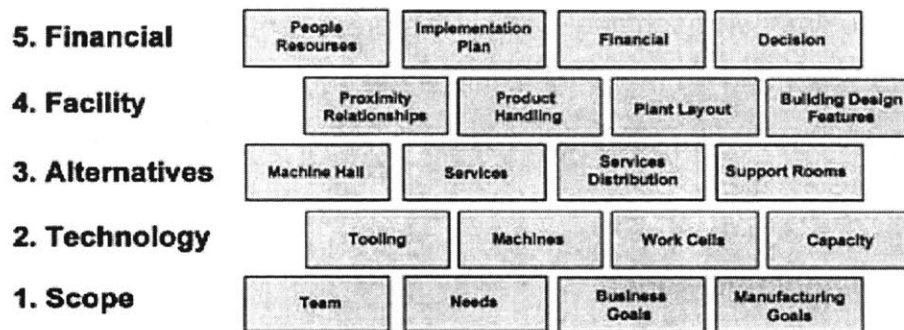
In establishing a new manufacturing environment or greenfield factory, there are many concerns that must be addressed for a successful factory startup. Most often, it is difficult to know how and where to start, but these decisions can have an incredible impact on future factory performance. What is agreed upon is the need for a “holistic” approach to factory planning. With this in mind, a factory startup can occur in two ways:

1. Production planning includes the design of the factory layout, including the machines, people, and processes.
2. Production planning happens in a more iterative process as the factory is being designed and built, adapting to the constraints that become apparent.

It is recommended that the design of the factory along with the planning of production happen in parallel to create a more adaptive process (Ackermann, 2013).

Arsenault (1998) believes the factory planning process is “objective and analogous to building a block wall (pg 2809).” It is necessary to follow a process that allows for the build up of steps for a successful factory launch; you cannot complete the steps at the top of the blocks before those on the bottom. Following this approach should reduce errors and delays.

Figure 3: Factory Planning Building Blocks



3.3.1 Equipment Planning

Equipment is most often described in literature as the first item to consider when planning for production. The following questions should start the equipment discussion (Lubash & Porter, 1997):

1. How many pieces of equipment are needed?
2. How many fixtures are needed?
3. What is the desired daily capacity of the line?
4. How many operators are needed on the line?
5. What strategies maximize the throughput?

Because a greenfield is a blank slate, the installation of new equipment and processes comes without historical benchmarks and data to compare performance. Armed with the answers to these questions, a model can be constructed to test how various machines would affect the line performance with little risk. Inputs into the model should include, but are not limited to: process flow, product demands, equipment set-up, equipment capacity, staffing levels, process times, equipment downtime, lot size, and rework.

Careful record keeping and documentation eliminates the worry that any data is left out of the model (Lubash & Porter, 1997).

It is important to set and communicate standards and project deliverables to all supplier partners from the beginning. The starting point for selecting equipment should be the “large machines or plant installations that will form the core of the project (Schmidt, 2011, pg 15).” This choice is mainly a financial one, but it is also important as it sets the equipment standards for the smaller machines. Setting this precedent from the start will make it easier for engineers working on the plant to install the equipment and balance the line when production is set to begin. (Schmidt, 2011).

3.3.2 Automation Implementation

There are also many important questions to consider when it comes to the factory’s automation system, including:

1. How far processes should be automated?
2. Whether all systems of the plant should be automated?

Establishing and planning for automation in stages is recommended: the initial factory will most likely not be fully automated, but knowing the future automation plans can help in selecting factory control systems. Such control systems should have the capacity to accommodate prospective automation technology. The way in which the plant will be operated is directly related to the automation system that is chosen (Schmidt, 2011). It is important to remember that a high rate of automation makes it far more difficult to remain adaptive, most notably in the case with a higher variety of products (Ackermann, 2013).

3.3.3 Labor and Training

Based on factory planning and equipment requirements, a labor force will need to be trained to staff the factory. Zheng (2014) discusses a framework to decide the best

employee for the job. There are three different parameters through which to measure a possible employee: learning ability, skill at the job, and attitude. There are eight types of potential employees for which you have to adapt the training strategies for:

1. Good learning ability, low skill, bad attitude
2. Good learning ability, low skill, good attitude
3. Good learning ability, high skill, bad attitude
4. Good learning ability, high skill, good attitude
5. Bad learning ability, low skill, bad attitude
6. Bad learning ability, low skill, good attitude
7. Bad learning ability, high skill, bad attitude
8. Bad learning ability, high skills, good attitude

He goes on to discuss the need for specific metrics during the training process to show progress for the future factory workers. Rather than a “see and do” method, tangible metrics and standard operating procedures will produce a successful training.

Lanzara and Patriotta (2007) describe another framework, this time for conducting the training process. They advocate for the creation of a “manufacturing community” in order to institutionalize the manufacturing methods to the new labor force (pg 641). It is a four-step process:

1. Making the workforce: “an intensive formal training program based on classroom lectures and practical exercises (Lanzara and Patriotta, 2007, pg 641).”
2. Making the plant: co-locate training and “involve the future workforce in the construction of the factory (Lanzara and Patriotta, 2007, pg 643).”
3. Making the product: the “repetitive act of assembling and disassembling (Lanzara and Patriotta, 2007, pg 649).”
4. Closing the box: the establishment of “institutionalized rules and the collective task of manufacturing (Lanzara and Patriotta, 2007, pg 645).”

Through these distinct stages of training, the greenfield training experience gives the workers a heightened sense of community and “collective appropriation (643).” The new

labor force recognizes that they are part of something new, developing and training in parallel with the factory, itself.

3.3.4 Implementing Change

While process improvements can bring more efficiency to an organization, implementing the changes can be even harder than determining what to improve in the first place. Tensions and frictions are certain to arise as stakeholders struggle with their changing roles and tasks. Poor commitment from top management is one of leading reasons that process improvements fail. Without this support, employees lack the motivation to adopt the improvements. Another obstacle to implementing process improvements is the wrong choice of tool. With hundreds of improvement tools, an organization must be clear about its methodology for tool-choice. Stakeholders also need to be shown exactly how these tools will be able to improve their tasks – leadership must detail with case studies and data to back up the claims (Tickle et al, 2014).

If the new process is to be accepted, it must become institutionalized across teams. The institutionalization happens in two phases: the creation of a template followed by enactment and reproduction of the template. The template can take the form of cognitive tools such as rules, procedures, visual management systems, project management applications, and so on. It is through this template that the standard operating procedures become clear to stakeholders. The template persuades stakeholders to adopt the common practices and provides a reference during the implementation of the change (Jensen et al, 2003). The implementation phase happens through inscription and delegation mechanisms. Inscription is the form of codifying the process and delegation ascribes action to stakeholders to complete the process (Lanzara and Patriotta, 2007).

4.0 The Current State

In order to develop a strategic plan for improvement, it is necessary to understand the current work process. This section provides an overview of the current state. The current state was defined as the state of the system from September 2014 thru September 2015. The current state research was very important because trying to improve the actions of others without truly understanding the current state of the processes and procedures of an organization is a recipe for failure. The current state map can be found in Appendix 1, laid out by work stream. Due to the proprietary nature of the work streams, summaries are provided in this chapter, but the details of the steps are not discussed. In addition, names are disguised as “Alpha,” “Beta,” etc.

4.1 Work Stream Methodology

To determine the critical path, research of the current process was conducted over a three-month period. The interviews, conversations, document gathering, and factory visits allowed stakeholders to detail the steps through which they completed tasks. During this process, stakeholders are asked to discuss the sequence of steps, the teams (both internal and external) that are involved in each process step, and the amount of time that each step takes. The following process was used when gathering information:

1. Overview of the project and goal of the research.
2. Explanation of the part of the current state that was to be discussed.
3. Explanation of the information that is needed to build a successful process map (see above paragraph).
4. Mapping of tasks, steps, information flow, and stakeholders.
5. Discussion of key metrics through which to measure the success of each step (To be detailed in Chapter 5).
6. Clarification and opportunity for the employee to correct or modify any of the process steps.
7. Schedule follow-up meeting if necessary.

Through this research, four work streams are defined: factory operations; legacy equipment for a pilot factory (later, referred to as a learning factory) and production factory; novel equipment for the production factory; and materials to be ordered for the learning factory and production factory.

4.2 Factory Operations

This work stream includes processes related to key decisions around product choice, factory location, and training of the new partner. Mapping the manufacturing steps to make footwear was conducted during the research and will be only briefly discussed due to proprietary concerns, though key learnings will be mentioned.

To teach the new partner how to make footwear, Nike established a learning factory line in location Alpha, separate from the production factory line, located in Beta. Nike also selected a current factory partner, Gamma, to supply components and general guidance throughout the learning process. Gamma was located in a third, separate location.

Gamma was selected based on four characteristics:

1. **Equipment Level:** how sophisticated and well maintained is the existing equipment in the Gamma factory.
2. **Capacity:** bandwidth availability to assist in training based on the physical factory size.
3. **Resources:** bandwidth availability to assist in training based on labor.
4. **Logistics:** how easy or hard would it be to travel to the Gamma factory.

As this research details what happens before full-scale production began, products were made in Alpha on the learning factory line. This factory line was integral in teaching stakeholders how footwear is currently manufactured and how they could potentially be better manufactured in the future with new methods of manufacturing. As it pertains to the learning factory line, this section will discuss how factory workers are trained, how

products are chosen for new methods of manufacturing, and how the location for a production factory is determined.

4.2.1 Training

Training on the learning factory line was a cross-functional task for Nike. While the NFP team was ultimately responsible for helping to teach the front line workers, the process requires assistance from many areas of Nike's business. As the learning process began, key stakeholders outside of Advanced Manufacturing traveled to Alpha to transfer their knowledge to the new factory partner. Most often, the stakeholders would visit for a week at a time and teach as much as possible within that amount of time; they would then go back to the Nike campus, returning if there was a request for additional training. It is important to note the teaching was done through a "watch as I do" methodology. For example, a machine expert would show those working on the learning factory line exactly how to use a specific machine or complete a certain stitch, expecting that the knowledge would be transferred.

The training process was crafted into three phases with added difficulties at each step:

1. Phase 1: Assembly of specific parts of the shoe
2. Phase 2: Assembly of all parts of shoe and full formation of the shoe
3. Phase 3: All of the above plus creation of the subcomponents of the shoe

Gamma was integral at each of these steps because it supplied the input materials and the knowledge on footwear production. As part of the training process, the new factory partner was required to make a certain number of shoes by a due date. When the quantity was reached and the NFP team was comfortable, the new factory partner could move onto the next phase of training. It was expected that the new factory partner would grade its own products to measure quality. Quality checks were done at the end when a shoe was finished, but were most often cosmetic checks, as the new factory partner did not have any lab equipment to test tolerances of a shoe onsite. Tolerance testing was done by the Nike team and often took weeks to complete. It is important to note that a

member of the NFP team was always on site throughout the training process. There was no one that was stationed permanently, but NFP was diligent about maintaining supervision over the new factory partner.

4.2.2 Product Choice

Product choices for the learning process and production process are extremely important and should not be approached lightly. Product choice was deliberated over a three-day period between two members of the NFP team. The team started this process by looking at three factors:

1. **New Technology Roadmap:** Nike creates a roadmap to plan out new technologies that could be incorporated into footwear over the next five to fifteen years. The NFP team examined which of these new technologies could be incorporated into the chosen product. NFP wanted to avoid teaching the new factory partner a possibly outdated manufacturing technology.
2. **Ease of Manufacturability:** By training the new factory partner on a product that was less complicated, the NFP team hoped that it could teach the partner the basics of shoe manufacturing before moving on to more advanced products. Manufacturability was mostly determined by the number of parts in the shoe and number of steps in the process to manufacture the shoe.
3. **Methods of Make:** The NFP team evaluated whether new methods of manufacturing could be incorporated into the production process of a specific model. Choosing a product that can only be manufactured by current manufacturing processes would not be a good choice for the new factory partner as it negates the whole goal of the project.

Using these factors as a lens through which to evaluate the full Nike product line, the NFP team settled on ten preliminary models for the new factory partner to manufacture. It is important to note that the models would not be redesigned to make them easier to manufacture. Taking those ten models and researching which models would most

compliment the skills of the Gamma factory, the NFP team narrowed the pool to five models. These five models were then presented to the Advanced Manufacturing leadership, who again narrowed the pool to three models:

1. Model X: a running shoe that is widely available, globally and one that the Gamma factory currently manufactures. The Gamma factory is the number one producer of Model X with extensive experience on its production.
2. Model Y: a less common shoe, but one that would allow the new factory partner to learn many different types of technologies on the roadmap, as well as investigate new methods of manufacturing. The Gamma factory has some, but not extensive experience making Model Y and there is also limited demand for the shoe, worldwide; it exists in a niche market.
3. Model Z: also a running shoe that is widely available, though less so than Model X. Assembling the shoe is quite complicated and it contains parts that are only made in one factory in the world. The new factory partner would not be able to take on the manufacturing of that part as it is proprietary. There is worry that this part could become a bottleneck in assembly. Gamma has experience with Model Z and it would also allow the new partner to gain new skills as it relates to the new technology roadmap.

NFP then presented these models to the Manufacturing leadership, who decided that Model X would be produced because of its simplicity and ubiquity as a Nike product.

4.2.3 Factory Location

The locations of both the learning factory (Alpha) and production factory (Beta) are two more critical decisions for this process. The learning factory was chosen as it was close to the new factory partner's headquarters and provided fairly easy access for Nike. The production factory was chosen based on a collaboration between the NFP team and the Ecosystem team. Various factors were considered: safety of factory location, available and existing footwear supplier network, and ease of travel to the factory for the partner

and Nike. It is important to note that Alpha and Beta were fairly far away from each other and were managed by different leadership. Also, Beta was chosen midway through the factory setup process; stakeholders were forced to make plans without full knowledge of where the factory would be.

4.3 Legacy Equipment Ordering

In order to implement new methods of manufacturing, the new factory partner needed to first master current manufacturing methods. To do this, the new partner would need to acquire machines used in factories that are currently making Nike footwear. Determining the types of machines, no less the exact machines was not an easy task. This work stream discusses how the NFP team decided on, ordered, and tracked the delivery of legacy equipment that would be necessary for both the learning stages and production stages.

4.3.1 Phase 1

Each product has a specification diagram called a Product Flow Chart (PFC) that details the steps and machines necessary to manufacture the product. A current factory partner in Asia creates the PFC as the shoe is being developed. With the PFC for Model X, the NFP team determined which equipment would be necessary for the assembly required in Phase 1. More often, though, the PFC is not detailed enough to know the exact type of equipment. For Phase 1, this was not a big problem as it was acceptable to find equipment that was close enough to the specifications because the new partner was simply getting familiar with the manufacturing process. About 80% of the equipment was ordered by the NFP team from internal manufacturing resources that had test equipment on site. The new factory partner then purchased the equipment from Nike to be used in the Alpha factory. The remaining 20% of equipment was purchased from outside vendors with the help of the Ecosystem team. The new partner then purchased this equipment from Nike to be used in the Alpha factory.

4.3.2 Phase 2 and Phase 3

In the second and third phases of the learning process, equipment ordering became far more complicated as specific rather than general equipment was necessary. For example, in Phase 1, it was acceptable to say the new partner would need a heat press that got to 50 degrees Celsius, but in Phase 2 and Phase 3, the specific brand, model, and SKU was necessary for the machine. Following the same methodology as above, about 20% of equipment could be acquired from internal manufacturing resources within Nike and then sold to the new factory partner. The remaining 80% of equipment proved to be difficult to obtain.

4.3.3 Pre-Production

In the pre-production phase of the learning process, equipment needs were very specific as the equipment was destined for the production facility. The product was already determined and most of the learning had already been done in the learning facility. Information needed for the production equipment was entered into a common spreadsheet, shared with NFP, the new factory partner, and the Eco team. The NFP team input the type of equipment, the factory partner would determine exactly which piece of equipment was required down to the SKU and the Eco team would then put the order through. This worked fairly well as each stakeholder was familiar with the process at this point. Similar to Phases 2 and 3, Nike had to purchase all of the equipment due to secrecy reasons, and the new factory partner would then purchase the equipment from Nike.

4.4 Novel Equipment Ordering

After ordering legacy equipment, the new factory partner had to focus attention on new types of equipment that would be part of the new method of manufacturing strategy. This equipment required a much more difficult decision process: unlike the legacy equipment, there was no current process to simply copy. To determine which equipment

would be modernized, the NFP team and the new factory partner took multiple joint trips to the manufacturing lines in Asia. On those same trips, the new factory partner visited the Manufacturing Modernization innovation centers where modernized equipment was already being integrated into existing facilities. To decide which steps to modernize, priorities were set through the ROI, the availability of equipment, the project schedule and timelines, and the business priority determined internally. After the steps were selected, the new partner had to decide which equipment would be developed internally versus which equipment would be procured from the Manufacturing Modernization. While this decision was made jointly between the NFP team and the new factory partner, there was little alignment between the Advanced Manufacturing goals and the Manufacturing Modernization goals. Because of this, the new factory partner had to reverse many of their decisions to develop new equipment. They later realized that Manufacturing Modernization had already done exactly what they were doing. These types of confusions led to a large amount of rework and lost time.

4.5 Material Ordering

Material ordering followed a very similar process to that of the legacy equipment ordering. The biggest difference was that in the early stages (Phase 1 and Phase 2) of the process, the Gamma factory was able to provide all the necessary material; Nike and new factory partner were able to rely very heavily on the knowledge of the Gamma factory leadership. While helpful throughout the beginning stages, this acted as a crutch for Phase 3 and the pre-production stages when material decisions had to be made. It was sometimes unclear who should be leading the material ordering: NFP, Eco, or the new factory partner. Similar to the pre-production equipment stage, stakeholders used a spreadsheet to coordinate the material ordering process.

5.0 Identifying Waste

In order to find inefficiencies in the current state, the process must be measured in some way. This section discusses the metrics through which to do so. Metrics are a key component to a successful process improvement as they provide an agreed upon way to measure. While it can be difficult to decide on the exact metrics to show success or failure in a process, this is an important step in the journey to improvement for an organization. On the manufacturing floor, metrics might seem more obvious as it relates to productivity and factory output. But, when it comes to factory planning and the work done before production, metrics can sometimes be unclear. To remedy this, Fabrizio and Tapping apply lean methodology to the wastes often seen in an office environment. They arrive at these 7 deadly wastes:

1. Rework
2. Waiting
3. Unnecessary Motion
4. Over processing
5. Equipment downtime
6. Inventory/Storage
7. Inspection (Fabrizio and Tapping, 2006)

While it would have been preferable to investigate all seven of the wastes, due to time constraints and availability of stakeholders, only three of the wastes could be calculated for the steps in the process. The three metrics are: rework, wait time, and over-processing. These three were chosen as they were straightforward to measure and could be applied to all the documented steps. Also, from the preliminary qualitative research, stakeholders consistently voiced concerns about rework, having to wait on other stakeholders, and the number of handoffs that occurred throughout the process.

5.1 Rework

Fabrizio and Tapping detail rework as “all the time spent redoing, correcting, or reworking a job (Fabrizio and Tapping, 2006, pg 10).” They go on to say that tasks and

projects should be performed correctly – the first time. This type of waste results in loss of valuable time, materials, equipment, and people-hours. An example of this is an incorrect entry of a piece of data or order requirement into an excel document. While this error seems benign, it can lead to production delays, late or incorrect deliveries, and even overtime costs.

After mapping out the current state, rework time is investigated (See Figure 4 below). Each process step is defined as a distinct task that had a beginning and ending as identified by stakeholders who were interviewed. Total time is the amount of time from when a stakeholder began the task to when it was completed. Rework time is the amount of time that the stakeholder spent correcting errors or redoing work throughout that task. Methods for calculating rework time include: time stamps on spreadsheets and documents, email conversation timelines, and recorded changes to other official forms. Names and details of tasks are removed. Steps are not in sequential order.

Figure 4: Rework

Process Step	Rework time (weeks)	Total time (weeks)	% Rework Time
1	1	3	33%
2	2	4	50%
3	18	36	50%
4	5	10	50%
5	5	12	42%
6	1.5	4	38%
7	2	6	33%
8	2.5	8	31%
9	3	10	30%
10	1.5	5	30%
11	0.5	2	25%
12	1	4	25%

13	2	8	25%
14	1	4	25%
15	5	20	25%
16	1	4	25%
17	8	44	18%
18	0.5	3	17%
19	4	24	17%
20	3	20	15%
21	0.5	4	13%
22	1.5	12	13%
23	0	4	0%
24	0	5	0%

5.2 Wait Time

Fabrizio and Tapping detail wait time as “idle time causing work to stop. It means that people and operations are idle.” The act of waiting for anything in a process – “people, paper, machines, or information” – is a form of waste (Fabrizio and Tapping, 2006, pg 11). Often wait time is easily eliminated by simple process improvements that allow for better exchange of information. An example of wait time is: Team A needs a specific piece of data from Team B to place an equipment order. Unfortunately, until Team B supplies that piece of data, Team A cannot proceed with the order. Time is a resource that stakeholders can never recover. It is incredibly important to get rid of process wait time whenever possible.

After mapping out the current state, wait time is also documented in a similar fashion to rework (See Figure 5 below). Total time is the amount of time from when a stakeholder began the task to when it was completed. Wait time was more difficult to calculate than

rework time: it was calculated based on the delays that were communicated by stakeholders. The same process steps are found below with their associated wait times.

Figure 5: Waiting Time

Step Number	Waiting Time (weeks)	Total time (weeks)	% Waiting Time
1	1	3	33%
2	1	4	25%
3	11	36	31%
4	4	10	40%
5	2	12	17%
6	1	4	25%
7	2	6	33%
8	3	8	38%
9	1	10	10%
10	1	5	20%
11	0	2	0%
12	2	4	50%
13	4	8	50%
14	1	4	25%
15	4	20	20%
16	1	4	25%
17	14	44	32%
18	1	3	33%
19	8	24	33%
20	5	20	25%
21	1	4	25%
22	3	12	25%
23	1	4	25%
24	2	5	40%

5.3 Handoffs

Handoffs are a great measure of over-processing during a task or project. In this process, a handoff is defined as an exchange of an item or piece of information between individuals or teams of stakeholders. Fabrizio and Tapping discuss how “putting work or effort into something a customer doesn’t want or ask for is waste.” Over-processing does not add value for the customer, and the customer will not pay for it (Fabrizio and Tapping, 2006, pg 12). As handoffs increase, so too does the non-value added work. Confusion on objectives and requirements increase the likelihood of over-processing, as stakeholders have to go back and forth to arrive at a final product. Fabrizio and Tapping believe that over-processing can be eliminated if goals are communicated properly across teams.

After mapping out the current state, the number of handoffs is also documented in a similar fashion to rework and wait time (See Figure 6 below). The same process steps are found below with their associated number of handoffs. While a low number of handoffs is desired, handoffs are inevitable. To address this issue, stakeholders were asked what the ideal number of handoffs would be if the process was at its most efficient. Those numbers can be found in the third column.

Figure 6: Handoffs

Step Number	# of Handoffs	Desired # of Handoffs
1	8	5
2	8	4
3	10	6
4	11	6
5	6	4
6	6	5
7	10	7
8	11	6
9	3	3
10	4	3
11	4	3
12	3	3
13	5	4
14	8	7
15	13	8
16	6	4
17	10	7
18	4	3
19	15	9
20	11	8
21	5	4
22	4	4
23	4	3
24	3	3

5.4. Summary Statistics of Current State

While the current state steps are proprietary to Nike, providing insight into the complexity of the process is important. Key statistics in the current state process map:

- Duration of Process: 1 year (September 2014 to September 2015)
- Total work time (value-add + non value-add): 256 person-weeks

A person-week is defined as the amount of time that a person works over the unit of time of a week.

- Value-add time: 112.5 person-weeks
- Non-value-add time: 143.5 person-weeks
- Number of Tasks: 166
- Number of Teams involved: 10
- Number of Decision-Points: 43

A decision-point is a point at which a member of the team had to make a decision about how to proceed in the process.

- Number of Trips to Asia: 7

This page has been intentionally left blank

6.0 Kaizen Methodology

In this chapter, the Kaizen methods of continuous improvement are discussed. With the above metrics of rework, wait-time, and handoffs to signal areas that needed improvement, Kaizen was used as a means to improve the process.

6.1 Background

The word Kaizen in Japanese is written with two kanji characters: one meaning, “to change” and the other meaning, “for the better.” While the origins of the word Kaizen are not completely known, the term has roots as far back as 1644 in China with a similar meaning of improvement. When Fredrick Taylor and Frank Gilbreth began to popularize standardization and process improvement, the Japanese adopted Kaizen as the word to properly summarize their methods of improvement.

The Kaizen way of life includes fives main steps for process improvement:

1. Identify the Problem
2. Establish a Goal
3. Identify a Better Means
4. Propose and Evaluate the Method
5. Implement Improvement

It is incredibly important for employees to take part in the Kaizen process, as they must feel empowered to better methods they know and practice so well (Kato and Smalley, 2011).

To implement Kaizen in the NFP factory onboarding process, members of the Advanced Manufacturing team took part in a Kaizen event to provide suggestions and tangible ways to improve. The new factory partner was also consulted.

6.2 Process

The agenda for the Kaizen event is as follows:

1. **Current State:** Stakeholders were guided through the current state work-streams and encouraged to provide feedback.
2. **Problem Areas:** In this case, a problem area is defined as a task that slows down the onboarding process and was difficult for team members to complete. Problem areas that were identified based on the aforementioned metrics were discussed with stakeholders. Participants were encouraged to bring up any other problem areas from their qualitative experience. The problem areas that were seen from the metrics matched those from the stakeholders. The top three problem areas were chosen as the main topic for the Kaizen event.
3. **Root cause analysis:** Using lean methods, such as the 5-Whys and Fishbone diagrams, root causes were identified for each of the bottlenecks.
4. **Solution/Implementation:** Stakeholders provided possible solutions and implementation ideas to solve the root cause problems.

6.3 Findings

6.3.1 Current State

A standard Kaizen event would have stakeholders define the current state during the event as the first part of the day. But, to save time, this was done prior to the event through interviews and other documentation as mentioned above. Also detailed above, four work streams were defined for the current state: factory operations; legacy equipment for the learning factory and production factory; novel equipment for the production factory; and materials to be ordered for the learning factory and production factory.

6.3.2 Problem Areas

Based on the three metrics and discussion with the stakeholders, four problem areas were identified by targeting which tasks had the most rework, wait time, and handoffs associated with them:

- **Product Choice:** The process to choose the particular product to be manufactured in the Alpha and Beta factories.
- **Communication Across Teams:** How various teams and stakeholders did and did not communicate across silos to accomplish tasks.
- **Equipment and Material Ordering Process:** The lack of standard operating procedures to order equipment and material.
- **Reporting Mechanisms:** How were various stakeholders updated about progress?

Because reporting mechanisms was deemed to be very similar to the communication problem area, the first three bullets were investigated for this research and in the Kaizen.

6.3.3 Root Cause Analysis

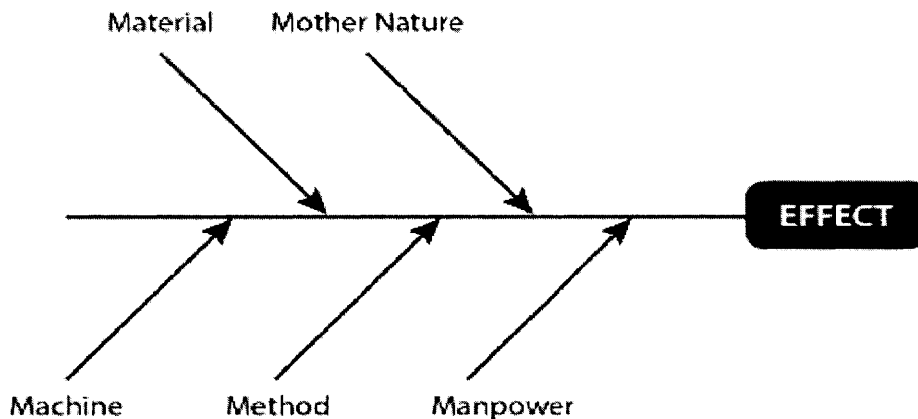
The first method that can be used for root cause analysis is the Ishikawa diagram. This model allows stakeholders to identify the causes and effects of a problem through graphical form. This diagram breaks the causes of the problem into five categories, known as the “5 Ms”:

1. **Material:** This includes all items that are consumable by the project such as raw materials, paper, water, electricity, etc.
2. **Method:** This deals with processes, flow of information, R&D, procedures to make decisions, etc.
3. **Mother Nature:** This is everything related to the environment around the work place.
4. **Machine:** This refers to the manufacturing equipment necessary for the process.

5. (Wo) Manpower: This includes all of the labor and human resources necessary for the project.

A fishbone/Ishikawa diagram looks like Figure 7 where each of the above causes of a particular problem are laid out. Additional branches are built off of the 5Ms to dive deeper to find the root cause.

Figure 7: Sample Ishikawa Diagram



In recent years, the 5 Ms have been expanded to the 8 Ms to include:

- Measurement: How is the particular process measured and how is success quantified?
- Management: How is the team run? What is the management style that is used?
- Maintenance: How are “budgets, costs, revenue, etc” are managed? (de Saeger, 2015)

The second method for determining the root cause to a problem is a 5-Why Analysis. By repeatedly asking the question “Why,” stakeholders are able to “peel away the layers of symptoms which can lead to the root case of a problem (Determine the Root Cause: 5 Whys, 2015).” It is a very quick way to dig into a problem and avoid getting caught up on the indicators of a problem rather than the cause of the problem. An example of such an analysis is given here:

Problem Statement: Customers are unhappy because they are being shipped products that don't meet their specifications.

1. Why are customers being shipped bad products?

Because manufacturing built the products to a specification that is different from what the customer and the sales person agreed to.

2. Why did manufacturing build the products to a different specification than that of sales?

Because the sales person expedites work on the shop floor by calling the head of manufacturing directly to begin work. An error happened when the specifications were being communicated or written down.

3. Why does the sales person call the head of manufacturing directly to start work instead of following the procedure established in the company?

Because the “start work” form requires the sales director’s approval before work can begin and slows the manufacturing process (or stops it when the director is out of the office).

4. Why does the form contain an approval for the sales director?

Because the sales director needs to be continually updated on sales for discussions with the CEO. (Determine the Root Cause: 5 Whys, 2015)

Often, a fishbone/Ishikawa diagram is created first to identify general causes of an issue. A 5-Why analysis can then subsequently be done to dig deeper to find the true root cause. Due to time constraints for the Advanced Manufacturing team, a 5-Why analysis was done during the Kaizen. Additionally, stakeholders felt strongly that they had identified the problem areas and could apply the 5-Why analysis without a fishbone/Ishikawa diagram.

The following 5-Why analyses were done for the three previously identified bottlenecks:

Problem Statement: The product mix and choice is not optimized for the new factory partner.

1. Why is the product mix not optimized for the Alpha and Beta factories?

Because the product decision was made very quickly.

2. Why was the product decision made very quickly?

Because there was no process or methodology through which to choose a product for a factory.

3. Why was there no process to choose a product?

Because there was no set of criteria to choose the product.

4. Why were the models not selected through a holistic set of criteria?

Because a holistic set of criteria does not exist.

Problem Statement: There is a lack of alignment and proper communication within Advanced Manufacturing.

1. Why is there no alignment?

Because each team is working towards their own interpretation of the mission.

2. Why are each of the groups working toward their own interpretation?

Because clear roles and responsibilities are not defined; milestones are not openly defined across teams.

3. Why are clear roles and responsibilities not defined?

Because there is no accountability.

4. Why is there no accountability?

Because there is a lack of process and program management tools.

Problem Statement: The equipment and material ordering process was too complicated.

Why path number 1:

Because there are too many steps in the process.

1. Why are there too many steps in the process?

Because roles and responsibilities for stakeholders are not clearly defined.

2. Why are roles and responsibilities not clearly defined?

Because there is no AGREED upon process.

3. Why is there no agreed upon process?

Because there is no clear ownership of the work that needs to be done.

4. Why is there no clear ownership?

Because there is a lack of process and program management tools.

Why path number 2:

Because there are too many people involved.

1. Why are there too many people involved?

Because there is a lack of one source of truth about best practices.

2. Why isn't there one source of knowledge amongst stakeholders?

Because we rely on tribal knowledge and factory expertise that is not our own.

3. Why do we rely on tribal knowledge?

Because there is very little documentation and standard practices.

From these exercises, the root causes to many of the inefficiencies in the process are:

1. Unclear accountability.
2. No metrics to measure the process.
3. Lack of transparency across the teams.
4. No standard processes and procedures.

This page has been intentionally left blank

7.0 Future State Discussion

Based on the above root cause analysis, various solutions are discussed next in this section. The solutions are divided into improvements that could be made internally by Nike and improvements that would require external collaboration with the new factory partner.

7.1 Suggestions for Improvement: Internal

Internal improvements can be made through a three-step process:

1. Document and standardize the current process.
2. Establish internal metrics for a successful factory startup.
3. Implement tools to improve project management techniques.

The first step in this process improvement is to document and standardize the current methods for onboarding a new factory partner and the requirements for setting up a new factory. There is a large reliance on tribal knowledge throughout the process, but stakeholders were unsure what the “truth” was and who was the expert. Put simply: “what is the agreed upon process stakeholders are supposed to be following?” To eliminate this problem with future factory startups, it is recommended that stakeholders continue to construct process maps to document their current steps. Stakeholders should have much more visibility into the dependencies and cross-functional requirements. In addition to documenting the process steps, roles and responsibilities of internal stakeholders should be documented and agreed upon. As evident by the amount of rework, stakeholders are often duplicating work because they simply didn’t know what task was to be completed by whom. Creating a clear process map and standard operating procedure along with expected responsibilities will make this clearer. A real-time indicator of what each stakeholder is doing that shows who is and is not providing the necessary inputs would be useful.

Second, internal metrics of success should be agreed upon and implemented. Because there were no metrics, it was difficult to track progress and declare success. As this was the first time that the process had been attempted, stakeholders were unsure if they were on the road to success. Common questions that were asked: “how long should this task take?”; “how many people are necessary for this process step?”; “how much money should we be spending to complete this?” These questions could have been easily answered had Nike set specific measurable goals. While it is understandable that stakeholders were unsure of what to expect for the inaugural process implementation, the metrics are absolutely necessary going forward.

Finally, project and visual management tools are a simple improvement to increase transparency across teams and accountability for stakeholders. Stakeholders had no insight into what others on the Advanced Manufacturing teams were supposed to be doing and what they were actually doing. This is because the Advanced Manufacturing project manager was not using any visible tool to track or show progress. There was no agreed upon process for ordering: “who is keeping track of the bigger picture?” Because of this, stakeholders were not held accountable for an incomplete or slow completion of a task. Even worse, stakeholders had little knowledge of what was expected of them for current and future tasks. Because of this, stakeholders were operating in a vacuum with blinders, focusing only on their tasks instead of understanding how their tasks relate to other stakeholders’.

7.2 Suggestions for Improvement: External

External improvements can be made through a three-step process:

1. Gather and codify expert knowledge of the footwear manufacturing process.
2. Establish external metrics for a successful factory startup.
3. Create a more stringent process to choose a factory location and product to be manufactured.

One of the biggest challenges for onboarding the new factory partner was the lack of standardized process and procedures. This applies not only to the steps necessary to set up the factory, but also to the actual footwear manufacturing process: the exact process to manufacture the chosen footwear model was unknown. To remedy this, it is necessary to codify the knowledge around manufacturing various models of footwear. For example, “what is the order of operations for manufacturing a particular model?”; “what equipment is necessary to manufacture a model?”; “what are the most difficult steps in the manufacturing process?”; “how should a shoe be measured on its quality?” A full list of knowledge gathering can be found in Appendix 2 as it relates to equipment, material and labor.

There were very few KPIs or metrics that were agreed upon between Nike and the new factory partner as mentioned above. There was a clear lack of alignment on the definition of success. Because of this, it was nearly impossible to declare that a task was a success. It is necessary to implement a training plan with agreed upon measures of success. For example, is success defined by the sheer number of pairs of footwear that is to be produced or by a specific number of quality pairs of footwear (A grade vs. B grade)? Furthermore, how is an A grade shoe different than a B grade (both measures of quality); this was not standardized for the new partner. Metrics were qualitative rather than quantitative. Also necessary in the training plan is a detailed description of the key skills to be mastered and tests to make sure these skills have been acquired. The new factory partner did not have any testing facilities on-site and this made the quality assurance process more of an ad-hoc process rather than a standardized one: products were tested at a Nike facility or at another facility, owned by the partner. An on-site product testing facility is incredibly important moving forward, as it will allow the new factory partner to find errors in manufacturing earlier and more often. These changes are required if Nike is to be sure that a new factory partner is learning how to manufacture footwear properly.

The final recommendation is to develop a standardized process to determine where to set up a footwear factory and which footwear model to manufacture, ensuring that the needs of all stakeholders are more accurately determined and met. The factory location was chosen much later than desired, causing delays in equipment and material ordering. Various stakeholders from the different Advanced Manufacturing teams noted that they had little input into the decision. In addition, the learning factory was not co-located with the production factory, leading to even more delays and loss of knowledge between the learning process and production process. Research points to the benefits of the collocation of future learning factories and production facilities to increase efficiency. Research done by the Production in the Innovation Economy (PIE) Commission suggests that gains from the collocation of manufacturing and innovation are real (Locke and Wellhausen, 2014). By collocating training programs and other activities, knowledge transfer and productivity is improved. Employees who will be working on the production facility benefit from the learnings that are gained during the innovation period and innovation experts gain insight into the production process.

While the factory location is incredibly important, the product that is produced in the factories is just as important. One stakeholder believed that the process to determine which product to produce was the result of a “narrow view on how to approach the way products are manufactured.” By creating a more comprehensive method and filter of evaluating model mix and how easily the model can be produced or manufactured will help in determining what is the best model to make when onboarding a new factory partner. A preliminary list of items to consider for a particular model in the decision process:

1. Volume produced and predicted sales per year
2. Labor skills required to manufacture
3. Equipment required to manufacture
4. Supply chain network required

5. Tariffs in place
6. Total cost

When considering these issues, involving as many potential stakeholders as possible is recommended. A common problem that was encountered during this research process was stakeholders not knowing about a decision that was made and subsequently, getting frustrated many steps after it was too late to change. By instituting an agreed-upon methodology to choose a product to be manufactured, production should be more streamlined with Nike and its new factory partner.

7.3 Future State Predictions

Based on the recommendations that were laid out above, a future state is presented. This can be found in Appendix 3. Similarly to the current state steps, the future state steps are proprietary to Nike. Summary statistics are provided in this chapter, but the details of the steps are not discussed. Key statistics in the future state process map:

- Duration of Process: 9 months
- Number of Tasks: 76
- Number of Teams involved: 10
- Number of Decision-Points: 10
- Number of Trips to Asia: 4

Based on the projected decrease in duration of the process of 25%, a similar decrease in work-time (overall and non-value add) is expected. One of the biggest challenges of the project was being able to prove and determine if the recommendations would indeed lead to an improved process as it can only be tested when a new partner is chosen. It is important to note, though, that many of the process improvements have been subsequently implemented as new products have been introduced to the Beta factory. Based on these implementations, the recommendations do appear to be sound and are leading the team to more efficient processes.

This page has been intentionally left blank

8.0 Conclusion

The previous sections explained the ability of an organization to onboard a new factory partner by exploring the current state of the onboarding process, investigating metrics through which to evaluate inefficiencies, and providing suggestions for process improvements to create a more efficient future state. The current state was examined with three metrics: handoffs, wait time, and rework. From these metrics, areas of opportunity were identified and then investigated with a root cause analysis. The root cause analysis showed four main causes for many of the process inefficiencies: uncertain accountability, absence of performance standards to measure the process, lack of transparency across stakeholders, and nonexistence of standard operating procedures. Based on the discovery of these root causes, recommendations were made for both internal and external improvements. Preliminary implementation of the suggestions when applied to a new product in the Beta factory show encouraging results in decreasing cost and increasing speed to market.

8.1 Areas for Future Research

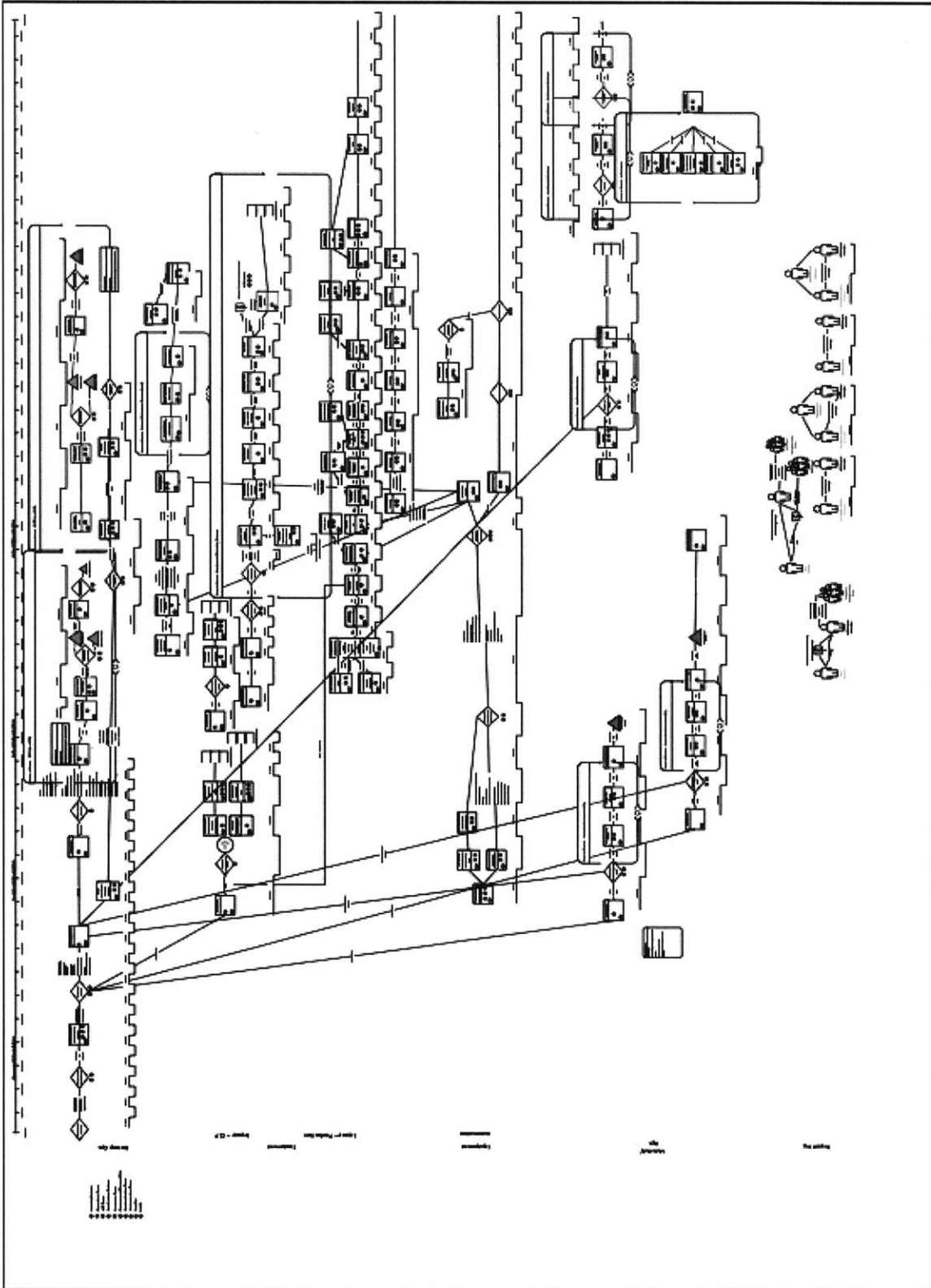
While this research provides a good baseline to begin improvements to the factory onboarding process for Nike, there are future areas of research that could amplify process efficiency. There was not enough time to examine all different types of wastes in the lean methodology, but this would be a great initiative to examine to find even more areas of opportunity. Also, this research only examined the processes that went into learning and pre-production. It is essential to continue mapping the production process, documenting areas of waste, and improving the process as it relates to full-scale production. Though this research was conducted in conjunction with the new factory partner, further input and process improvements from the partner's perspective would benefit the research and provide more opportunities for implementation.

8.2 Final Notes

The mission to bring on a new factory partner while attempting to modernize footwear manufacturing is a huge feat that should be commended. Nike is an incredibly successful company that has succeeded for quite a long time on manufacturing processes that some would call outdated. Throughout this research, the passion and rigor of Nike employees was evident. The openness to improve is apparent as many of the above recommendations have already been implemented or are in the process of implementation. One of the greatest lessons learned from this project is that changing a highly prosperous company is exceptionally hard. By focusing on process efficiency and increasing alignment across teams, Nike will be one step closer to changing the way the footwear industry manufactures its products.

Appendix 1

Current State of Onboarding A Factory Partner



Appendix 2

Manufacturing Process Guide

Equipment questions:

1. Manufacturing Step
2. Equipment Name
3. Necessary Tooling
4. Vendor Name
5. Model Number
6. Features
7. Country of Origin
8. Expected Lead Time
9. Expected Cost
10. Purchaser
11. Sources
12. Pictures

- Did you copy the line layout / process from another factory? How did you design the line layout and processes?
- How much Inventory of backup equipment and parts is necessary?

Material questions

1. Manufacturing Step
2. Material Input
3. Quantity/Amount required
4. Vendor Name
5. Model number/specs
6. Features
7. Country of Origin
8. Expected Lead Time
9. Cost
10. Purchaser
11. Sources
12. Pictures

- Did you develop any local suppliers?
- What are your primary sources of production materials?

Labor Questions

1. Direct Labor

- a. How many people work on the line? What are their titles and functions?
- b. Do you have a process map or detailed step map to describe all the activities of the workers?
- c. Please provide us with the titles and job responsibilities of all direct factory workers who are working on the floor. Did you create a skills matrix when recruiting? Please share.
- d. What/where are the quality checks for the indirect labor?
- e. Are there standard operating procedures for the work? Please share.
- f. Did you create a training plan by position and worker responsibility? Also, please share any other training material on Nike Code of Conduct (CoC) / Code Leadership Standards (CLS) and cultural training as well.
- g. Please rank and describe the hardest parts of the process to train for? How long did it take to train for each of these? How do you test proficiency?
- h. How long did you train the factory workers before they were ready for production? (Please provide an estimate of training duration by each manufacturing step)
- i. What was the turnover in the first year of operation? Have you been successfully able to lower it? If yes, how?
- j. How do you incentivize direct labor for production? Are there any specific rewards / incentives embedded in your day-to-day operations for a. workers staying with Nike factory for a period of time, b. completing their task within a target amount of time or c. producing Grade A shoes?
- k. Are there any programs (such as higher wages/incentives, healthcare, savings schemes, education, food subsidy, skill development opportunities, work-life balance) that the factory has experimented with and it has resulted in higher productivity and / or lower turnover?
- l. Do you face any short-fall of workers with desired skills? If yes, how have you found a solution? (generous over-overtime, production leveling etc.)
- m. How do you source the trainers/staff the school?

2. Indirect Labor

- a. How many people work not on the line, but for the factory? What are their titles and functions?
- b. Please provide us with the titles and job responsibilities of all indirect factory workers who are working for the factory. Did you create a skills matrix when recruiting? Please share.

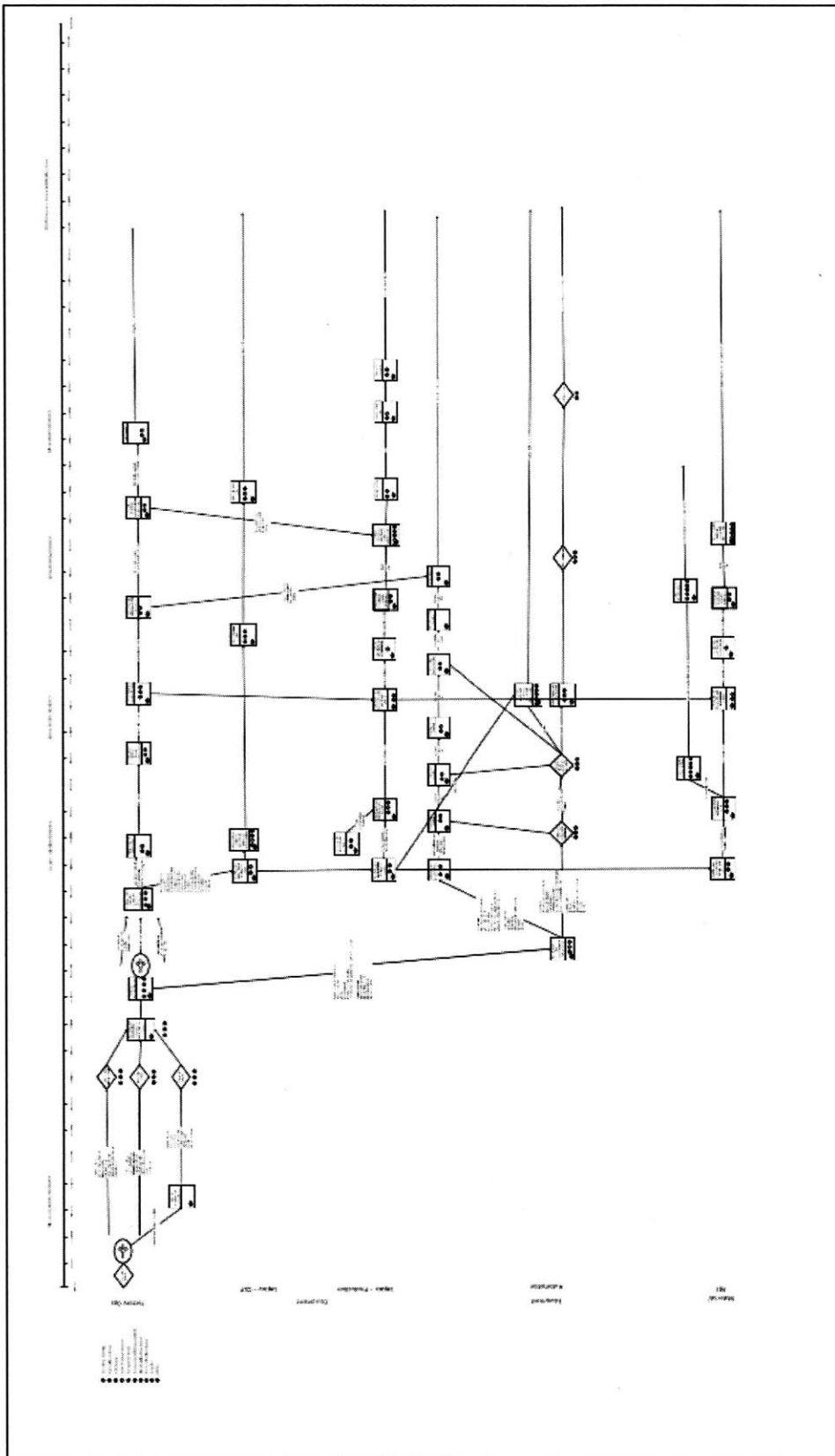
- c. What/where are the quality checks for the indirect labor?
- d. Are there standard operating procedures for the work? Please share.
- e. Did you create a training plan by position and worker responsibility? Also, please share any other training material on Nike Code of Conduct (CoC) / Code Leadership Standards (CLS) and cultural training as well.
- f. Are there required tests to take on the job?
- g. Please rank and describe the hardest parts of the process to train for? How long did it take to train for each of these? How do you test proficiency?
- h. How long did you train the indirect labor before they were ready for production? (Please provide an estimate of training duration by each position)
- i. What was the turnover in the first year of operation? Have you been successfully able to lower it? If yes, how?
- j. How do you incentivize direct labor for production? Are there any specific rewards / incentives embedded in your day-to-day operations for a. workers staying with Nike factory for a period of time, b. completing their task within a target amount of time or c. producing Grade A shoes?
- k. Are there any programs (such as higher wages/incentives, healthcare, savings schemes, education, food subsidy, skill development opportunities, work-life balance) that the factory has experimented with and it has resulted in higher productivity and / or lower turnover?
- l. Do you face any short-fall of workers with desired skills? If yes, how have you found a solution? (generous over-overtime, production leveling etc.)
- m. How do you source the trainers/staff the school for indirect labor?

3. General Production Questions

- a. How many production lines did you have in your first season of production?
- b. Describe your change out process for lines? How long does it take?
- c. Describe challenges with setting up new machines and lines? Anything specific to this shoe?
- d. Detail production volume for the first 6 months? First 12 months?
- e. Standard time per shoe? Per operations? Per manufacturing step? All baseline information.
- f. Please provide the manual for all process steps? How is this conveyed to workers?
- g. Please share your QA plans with us? How do you measure progress? How do you set goals?

Appendix 3

Future State of Onboarding A Factory Partner



References

- Ackermann, Jörg, Frank Börner, Hendrik Hopf, Sebastian Horbach, and Egon Müller. "Approaches for Planning and Operation of Adaptable Factories." *International Journal of Production Research* 51, no. 15 (August 1, 2013): 4618–29. doi:10.1080/00207543.2013.783243.
- Arsenault, D. *How to Design and Build a Turnkey Injection Molding Facility*. Vol. 44. Brookfield Center: Soc Plastics Engineers, 1998: 2808-2812
- Anjard, R. P. *Process Mapping: A Special Tool for Management and Technical Professionals*. Edina: Surface Mount Technology Assoc, 1999.
- Bevilacqua, Maurizio, Filippo Emanuele Ciarapica, and Claudia Paciarotti. "Implementing Lean Information Management: The Case Study of an Automotive Company." *Production Planning & Control* 26, no. 10 (July 27, 2015): 753–68. doi:10.1080/09537287.2014.975167.
- Boër, Claudio Roberto, and Sergio Dulio. *Mass Customization and Footwear: Myth, Salvation or Reality?: A Comprehensive Analysis of the Adoption of the Mass Customization Paradigm in Footwear, from the Perspective of the EUROShoE (Extended User Oriented Shoe Enterprise) Research Project*. Springer Science & Business Media, 2007.
- Cobb, Charles G. *Enterprise Process Mapping: Integrating Systems for Compliance and Business Excellence*. ASQ Quality Press, 2005.
- Colligan, Lacey, Janet E. Anderson, Henry W. W. Potts, and Jonathan Berman. "Does the Process Map Influence the Outcome of Quality Improvement Work? A Comparison of a Sequential Flow Diagram and a Hierarchical Task Analysis Diagram." *BMC Health Services Research* 10 (January 7, 2010): 7. doi:10.1186/1472-6963-10-7.
- "Determine The Root Cause: 5 Whys." Accessed December 5, 2015. <http://www.isixsigma.com/tools-templates/cause-effect/determine-root-cause-5-whys/>.
- Fabrizio, Thomas, and Don Tapping. *5S for the Office: Organizing the Workplace to Eliminate Waste*. Productivity Press, 2006.
- Gilbreth, Frank B. "Process Maps." *American Society of Mechanical Engineers*, 1921.
- Graham, B. B. "The Roots of the Business Process Mapping." *BPTrends*, 2008.
- Hamel, Mark R. *Kaizen Event Fieldbook: Foundation, Framework, and Standard Work for Effective Events*. Society of Manufacturing Engineers, 2010.

- Karlsson, Christer, and Pär Vahlström. "Assessing Changes towards Lean Production." *International Journal of Operations & Production Management* 16, no. 2 (1996): 24–41.
- Kato, Isao, and Art Smalley. *Toyota Kaizen Methods: Six Steps to Improvement*. CRC Press, 2013.
- Kovera, Rhonda. "Key Visual Management Strategies." *Occupational Health & Safety (Waco, Tex.)* 83, no. 2 (February 2014): 36–37.
- Lanzara, Giovan Francesco, and Gerardo Patriotta. "The Institutionalization of Knowledge in an Automotive Factory: Templates, Inscriptions, and the Problem of Durability." *Organization Studies* 28, no. 5 (May 2007): 635–60. doi:10.1177/0170840607068309.
- Locke, R. M., and R. L. Wellhausen, eds. *Production in the Innovation Economy*. Cambridge: Mit Press, 2014.
- Lubash, J., and A. Porter. "Greenfield Planning Using Innovative Analytical Tools." In *Advanced Semiconductor Manufacturing Conference and Workshop, 1997. IEEE/SEMI*, 162–65, 1997.
- Melton, T. "The Benefits of Lean Manufacturing - What Lean Thinking Has to Offer the Process Industries." *Chemical Engineering Research & Design* 83, no. A6 (June 2005): 662–73.
- Nelson, Eugene C., Paul B. Batalden, and Marjorie M. Godfrey. *Quality By Design: A Clinical Microsystems Approach*. John Wiley & Sons, 2011.
- Nike, Inc.(2015). Annual Report on Form 10-k.
- Phillips J and Simmonds L. "Change management tools Part 1: Using Fishbone Analysis to Investigate Problems. *Nursing Times*; 109: 15: 18-20, 2013.
- Rahani, A. R., and Muhammad al-Ashraf. "Production Flow Analysis through Value Stream Mapping: A Lean Manufacturing Process Case Study." *Procedia Engineering, International Symposium on Robotics and Intelligent Sensors 2012 (IRIS 2012)*, 41 (2012): 1727–34.
- S. Bødker, J. M. Carroll. "Annett, J., Duncan, K.D., Stammers, R.B., and Gray, M.J., 1971, Task Analysis, Training Information Number 6, HMSO, London. Ballim, A. and Wilks, Y., 1991, Beliefs, Stereotypes and Dynamic Modeling. In," n.d.
- Schmidt, H. "2 - Determining Equipment and Process Needs and How These Affect Food Factory Design." In *Hygienic Design of Food Factories*, edited by J. Holah and H. L. M.

Lelieveld, 12–34. Woodhead Publishing Series in Food Science, Technology and Nutrition. Woodhead Publishing, 2011.

Skevi, Afroditi, Hadrien Szigeti, Stefano Perini, Manuel Oliveira, Marco Taisch, and Dimitris Kiritsis. "Current Skills Gap in Manufacturing: Towards a New Skills Framework for Factories of the Future." Edited by B. Grabot, B. Vallespir, S. Gomes, A. Bouras, and D. Kiritsis. *Advances in Production Management Systems: Innovative and Knowledge-Based Production Management in a Global-Local World, Pt 1* 438 (2014): 175–83.

Tickle, Matthew, Dotun Adebajo, Robin Mann, and Francis Ojadi. "Business Improvement Tools and Techniques: A Comparison across Sectors and Industries." *International Journal of Production Research* 53, no. 2 (January 17, 2015): 354–70.

"Use of Process Mapping in Service Improvement." *Nursing Times*, April 26, 2013.
<http://global.factiva.com/redirect/default.aspx?P=sa&an=NURTIM0020130426e94q00009&cat=a&ep=ASE>.

Womack, James P., and Daniel T. Jones. *Lean Thinking: Banish Waste And Create Wealth In Your Corporation*. Simon and Schuster, 2013.

Zheng, Huizhen. "Analysis of Staff Training Needs at Xiahua Factory Based on OTP Mode." Edited by X. Huang and M. Cheng. *Proceedings of the 2014 International Conference on Economic Management and Social Science* 13 (2014): 133–37.