Innovation Process at Omnichannel DCs Undergoing Shifts in Channel Mix

by

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Abstract

An increase in digital demand has forced a DC that previously fulfilled mostly wholesale orders to adjust its operational strategy and pursue innovation to address the shift in channel mix. This thesis aims to develop and propose an innovation framework that can be used to identify the areas in the DC that are constrained and what technologies can be used to tackle these constraints. The proposed process is based on external innovation methods identified through research and internal innovation methods present in the company today. Once developed, the proposed innovation process is evaluated through the application of a previous DC innovation to ensure viability. The proposed process is then applied to the DC today to recommend areas and technologies for innovation investment. It is concluded that the proposed process performs well when applied to a previous innovation and is therefore deemed as viable. When applied to the DC today, the process recommends an investment in the DC's footwear selection area using process and staffing optimization.

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Chapter 1
Project Introduction

1 Project Background

Research for this thesis was completed at "Neilos", a pseudonym for a retail company that sells athletic footwear, apparel, and equipment. Neilos is headquartered in North America and has several distribution centers across the United States that support its North American distribution network.

1.1 Omnichannel Distribution Centers

Distribution networks are used by companies in a variety of industries to flow goods from a producer or supplier to an end consumer. These networks consist of storage facilities, distribution centers, and transportation systems that support the movement of goods until they reach the end consumer. Depending on the size of the company and goods for sale, distribution networks vary in both structure and size, [1].

This thesis will focus specifically on the distribution center (DC) within the distribution network. DCs are specialized warehouses that handle order fulfillment and other value-added services (VAS). They not only store finished goods, but also provide selecting, packing, and shipping functionalities, [2]. If a DC fulfills orders from multiple distribution channels, this DC is "omnichannel".

Sections 1.1.1, 1.1.2, and 1.1.3 below further describe the specific DC analyzed in this thesis, the channels and product engines it serves, and its overall layout.

1.1.1 NADC Background

North America Distribution Center (NADC) is Neilos's largest DC in the world. It is in the mid-south United States along with several other DCs that operate together as the central node of Neilos's distribution network. Today, NADC has a footprint of roughly three million square feet and 35 miles of conveyer. Conveyer transit times therefore become a main contributor to the building's average order-to-ship time.

Until 2020, this was the main node of Neilos's North American distribution network with nearly all finished goods from overseas passing through NADC and the other DCs in the mid-south area. As discussed in Section 1.2, the COVID-19 pandemic has caused in a shift in marketplace trends that have changed Neilos's distribution network strategy. The mid-south's central node remains crucial to order fulfillment as new regionalized nodes have been added to the network to address local digital demand. This thesis will be based on NADC as the largest omnichannel DC in the central node of Neilos's network.

1.1.2 Sales Channels and Product Engines

NADC is an omnichannel DC and serves all Neilos's distribution channels. The percentage of each channel that is processed by the DC each month is called the channel mix. Relevant channels are described in Table 1 below.

Table 1: Neilos's Distribution Channels

Channel	Shorthand	Description
Digital	Digital	Order by individual consumer online; fulfillment direct-to-consumer; e-commerce
Wholesale Partners	WP	Order for wholesalers of Neilos products
Neilos Stores	NS	Order for Neilos-owned stores

NADC also fulfills orders from all three of Neilos's product engines: footwear, apparel, and equipment. As described in Section 1.1.3, each product engine and channel are treated differently as they are processed through the DC.

1.1.3 DC Layout and Process Flow

Figure 1 shows a general overview of NADC's layout. The layout of this DC is not linear as depicted. At a high level, pallets of product arrive at the receiving area of the DC and are placed into storage either in pallets or individual cases. When an order is placed, it is selected from the selecting area which is periodically replenished from the storage area. Once an order has been selected, it is then sent for packaging and shipping.

Figure 1: NADC General Layout

Depending on the product engine and channel, orders will travel through the distribution center in different ways. Apparel and equipment have one area for every step through the DC from receiving to shipping. Thus, both product engines are said to move through the DC in one flow. Footwear has multiple areas for multiple steps in the process from receiving to shipping; namely, storage, selection, and packaging. Therefore, depending on footwear order's channel, an order can move through the DC in different paths. This process is more complex when compared to apparel and equipment. This is because NADC processes mostly footwear orders.

One property of an order that also affects its flow path through the DC is whether it is a "repack" or "full case" order. This is an assumed constant % split by channel. When an order is made of items that are shipped in the same case they were received in, this is called a "full case" order. All full case orders are multiple units of the same SKU in its received quantity, also known as the units per case (UPC). When an order is made of items that are shipped in a different case than they were received in, this is called a "repack" order. All single item orders and all orders of multiple different SKUs are classified as repack orders. Repack orders have a different UPC than the received case UPC.

Table 2 shows the assumed constant % split between full case and repack orders for all channels served at the DC from lowest to highest full case %. The numbers in this table show the percentage of total orders from each channel that are fulfilled by the full case or repack process.

Table 2: Full Case and Repack % by Channel

Channel	Full Case %	Repack %
Digital	0	100
NS	40	60
WP	80	20

On one extreme, all digital orders are repack orders. This intuitively makes sense as individual consumers are very unlikely to order enough of the same SKU that they would receive a full case. On the other end, WP orders are mostly full case orders. The NS channel between these two extremes all involve a mix of full case and repack orders.

Another factor that affects an order's DC flow path is the number of units per order. When processing at the DC, a single order is classified as an order of only one unit. All orders with more than one unit are classified as a multiple unit order. Digital is the only channel at the DC that serves both single and multiple unit orders. Most digital orders are footwear single orders. To serve this specific demand, the Digital Packaging Value Added Service (DPVAS) area was created at NADC; this area only serves digital footwear single orders. At DPVAS, these digital footwear single orders are packaged either manually or automatically by packaging machines. All other orders travel to another area for packaging.

Lastly, another factor that affects how an order flows through the DC is if value added service (VAS) is required. VAS includes activities such as hanging clothes or removing and adding price tags. All orders requiring VAS will pass through an area of the DC where VAS is performed: VAS, Apparel VAS, or DPVAS. Most VAS is performed on repack orders with a very small percentage of full case VAS processed at the DC. The percentage of repack orders requiring VAS is assumed to be constant by product engine and channel. A constant full case VAS percentage is assumed for all channels. Chapter 4 of Wallach's (LGO '18) thesis, describes the entire DC process and can be reviewed for a deeper explanation of the flow paths for all channels and product engines [3].

1.2 Recent Marketplace Trends

The business environment in which companies are operating has been shifting. This shift has been further accelerated by the COVID-19 pandemic. The following sections highlight some of the changes and challenges that Neilos faces today at the DC level due to these recent marketplace trends.

1.2.1 Digital Demand

Before 2020, Neilos served most of its customers through its marketplace partners (WP) and branded storefronts (NS). It was beginning to see consistent growth in its digital channel when the COVID-19 pandemic hit. Once stores closed and consumers moved to online shopping, e-commerce across the globe saw growth two to five times faster than before the pandemic, [4]. NADC was designed and built to service large wholesale orders in full cases and was not equipped to handle this level of digital repack demand.

Investments were made over the last two years to expand Neilos's distribution network through the addition of regional nodes to service local digital demand. With this expansion, NADC remains essential to digital fulfillment with most digital orders forecasted to be fulfilled from the mid-south node through the end of 2023. Figure 2 shows the forecasted digital demand in North America in units through the end of 2024.

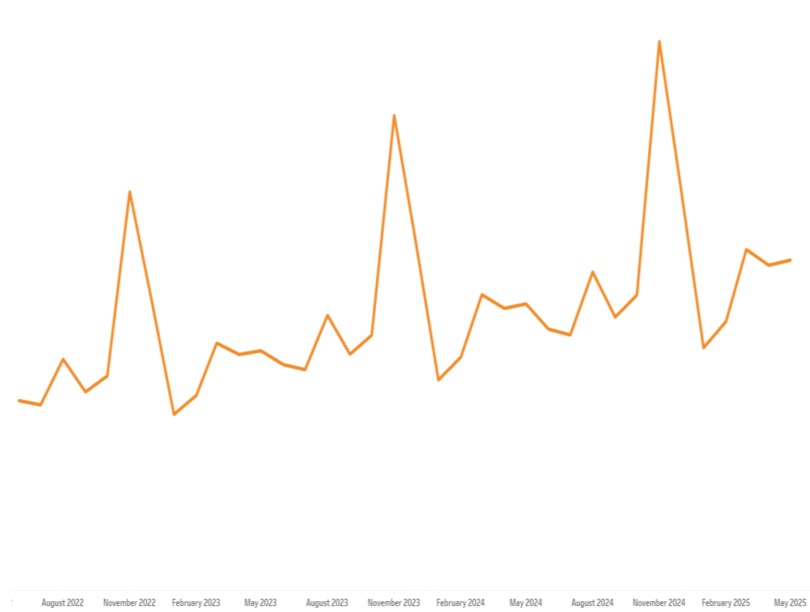

Figure 2: Digital Demand Forecast for Mid-South Node

Peaks during the back-to-school season can be seen in July to August and peaks during the holiday season can be seen in November to December. With this continued growth in digital demand, NADC will look to update its processes and potentially its design to better service e-commerce, and thus repack, orders.

1.2.2 Labor Market

As the United States recovers economically post-pandemic, the demand for labor has exceeded supply. Companies across multiple different industries are facing larger attrition rates coupled with increased competition for labor. The transportation and logistics sector has been particularly hard hit, with the impact of worker-retention challenges and rising labor costs being felt across the entire value chain. High demand for workers causes the cost of labor to increase accordingly. Transport and warehousing labor wages have increased four times faster than before the pandemic. Despite these wage increases, operations roles are still having difficulty hiring and retaining frontline workers, while also seeing increase absenteeism, [5].

With these challenges now facing NADC, the DC will look for ways to decrease its labor reliance to dampen shocks felt by further changes in the market.

1.2.3 Product Fulfillment

The pandemic not only caused e-commerce growth across industries, but also increased both customer expectations around speed and convenience of fulfillment and fulfillment cost, [6]. Sections 1.2.3.1 and 1.2.3.2 discuss this in more detail.

1.2.3.1 Delivery Speed

In the retail industry, the race to shorten order to delivery cycle time is the single greatest influence on the shape of future omnichannel supply chains. Research shows that when delivery times are too long, almost half of omnichannel consumers will shop elsewhere. It has also been found that 90% of US online shopper expect two- to three-day shipping but largely remain unwilling to pay for speed, [6].

Amazon continues to be a catalyst across the retail industry setting a high bar for direct-to-consumer delivery with select markets offering one-day delivery since 2019, [6]. To keep up with competition such as Amazon and meet modern consumer expectations, Neilos will look to ensure orders are processed through its DCs as fast as possible.

1.2.3.2 Fulfillment Cost

The UPC for digital orders is much lower than that of a traditional wholesale order. Therefore, costs on a per unit basis for digital product fulfillment are higher relative to non-digital orders. As channel mix shifts towards more digital orders, Neilos will look to reduce costs where applicable.

1.2.4 Sustainability

Sustainability has become an increased focus across many industries to meet climate goals. Neilos has launched their sustainability campaign where they have pledged to reach zero carbon emissions and zero waste. They have focused on efforts such as using sustainable materials for manufacturing, refurbishing products, and recycling products. To meet these sustainability goals, Neilos will continue to look for opportunities in its DC environment to improve.

1.3 Problem Statement

As Neilos's omnichannel DCs adapt to the marketplace shifts described in Section 1.2, they must strategically invest in the right innovations in the right places. Therefore, the problem statement of this thesis is to propose an end-to-end process for innovation within the four walls of Neilos's omnichannel DCs that will recommend the correct innovation to address the current business environment trends (i.e., growing digital demand, labor reliance, sustainability, etc.).

1.3.1 Project Hypothesis and Goals

The hypothesis of this thesis project is if innovation selection and deployment can be driven by corporate business strategy, then the correct investments will be made that target the right areas in the DC and are the most beneficial to achieving that business strategy.

Project goals involve proposing an innovation process from ideation to deployment and developing supporting tools to drive innovation selection decisions within the process. The proposed process must be aligned with Neilos's culture and must be scalable to other DCs across the North American distribution network.

1.4 Project Approach

Neilos's distribution network is comprised of many DCs that are all designed and built-in different ways to support different fulfillment functions. This thesis will focus its analysis on NADC, the largest and most complex DC in the North American distribution network. It is assumed that if the process works for NADC, it can be scaled to other DCs in the network.

The first step in the project approach is to develop a proposed innovation process that can be evaluated and applied at the DC level. This proposed process will be created from Neilos's current innovation processes, innovation processes used in industry and academia, and Neilos's culture to ensure maximum adoption. Once the process is created, it will be evaluated using a past successful innovation project at NADC to ensure that it works and can recommend the same innovation. Lastly, if the process evaluation is successful, the process will be applied to NADC today to recommend the next innovation this DC should pursue. Conclusions and recommendations for further work will be provided at the end of the analysis.

Chapter 2
Innovation Framework Proposal

2 Introduction

This chapter will cover the creation process of the proposed framework for innovation at omnichannel DCs. The innovation process will leverage internal and external best practices to develop an end-to-end solution that will not only work for NADC but also will be scalable to other aspects of Neilos's business. These internal and external sources will be further discussed in Sections 2.1 and 2.2. Section 2.3 will discuss the five phases of the proposed innovation process in depth, namely, the plan, identify, evaluate, select, and deploy phases. Finally, Section 2.4 will summarize lessons learned during the creation process and next steps.

2.1 Internal Innovation Processes

Internal innovation processes are processes that currently exist or have existed in the past at Neilos. To begin this analysis, there were two key aspects that were important to understand before the innovation process could be developed. It was first important to understand how the company was structured to ensure that the proposed process would be adopted. For example, if a highly structured process was developed for a company that was extremely flexible, it would lower the chance of adoption and impact. Secondly, it was important to understand what innovation processes were already in place at Neilos and if they could be leveraged for the purpose of this project.

2.1.1 Company Structure

Neilos's company structure is analyzed from an organizational and cultural perspective in the following sections. This analysis was performed by the author to better understand how to maximize adoption at this specific company. If this work were to be completed at a different company, it is recommended that this analysis is recreated.

2.1.1.1 Cultural

Neilos has their own version of Toyota's Production System called Lean System (LS). There are three key LS principles that drive the culture at Neilos: be simple, flexible, and scalable. Being simple and flexible leads to a DC culture that has flexible work processes and generally prioritizes manual labour over automation. Neilos highly values its associates in its DC labor workforce; a strong business case is needed to invest in automation when a manual solution is available. The main learnings the author concluded while studying this organizational culture with respect to the innovation process are:

(1) Neilos is used to using flexible work processes; therefore, the proposed innovation process will not be adopted if it is too structured.

(2) LS principles must be incorporated into the proposed innovation process to support Neilos's culture.

(3) Neilos's culture is sometimes hesitant to invest in automation because the technology is not perceived to be simple and flexible. The proposed innovation process must include a quantitative method for recommending automation when it is truly justified and recommending alternative solutions when it is not.

2.1.1.2 Organizational

Neilos is divided into four main geographies (geos): North America, Europe, Asia Pacific, and China. Each geo acts almost as a separate company within Neilos. Geos are challenged with sharing lessons learned between each other and often differ in overall strategy and network design. To unite the geos, there is a fifth branch, Neilos Global, that is based at their headquarters (HQ). This division is responsible for overall business strategy. It also aims to standardize processes and create tools that can be used across all geos; however, they are challenged with geo adoption.

Both geo and global teams are structured in matrix organizations. Generally, there are many benefits to matrix organizations such as flexibility between departments, open communication, increased employee engagement and morale. There are also challenges such as lack of clarity around roles and responsibilities, competing priorities between teams, and slower decision making due to an increase in stakeholders, [8]. Neilos sees both these advantages and disadvantages which must be considered when developing an innovation process for its omnichannel DCs.

At the DC level, the LS teams have buy-in from senior leaders which results in a strong presence of the LS principles (be simple, flexible, and scalable). At the HQ level, global teams are responsible for large project funding and therefore, project prioritization.

The main learnings the author concluded while studying this organizational structure with respect to the innovation process are:

(1) Increased communication is needed between global and geo teams. Global teams need to more frequently share their business strategy and tools with the geo teams. Geo teams need to share their operational pain points with the global teams, so global tools are created that address the right problems. The proposed innovation process must facilitate this communication and help to break silos.
(2) Geo teams at the DC level are most focused on day-to-day operations. The proposed innovation process must encourage a longer-term focus tied to business strategies.
(3) Innovation processes are currently not standardized across the company. The proposed innovation process must be scalable to other areas in the organization and must aim to standardize where possible.
(4) LS principles must be incorporated into the proposed innovation process to support the political structure at the DC.
(5) Global teams at HQ need to be incentivized to make large investments at the DC level. The proposed innovation process must include business case development guidelines for geo teams at the DCs to use to ensure success when requesting project approval.

2.1.2 Existing Innovation Processes

Upon interviewing teams at the omnichannel DCs, four types of existing innovation were identified.

(1) Top-down
(2) Bottom-up
(3) Inside-out
(4) Outside-In

All four of these innovation types have been used at the DC level with no recommendation for one over the other. Overall, DC innovations today come mostly from top-down and inside-out methods.

Top-down innovation is defined as projects that originate from HQ to the DC. Bottom-up innovation is defined as projects that originate from operations and associates on the DC floor to the DC engineering teams. These projects can often be classified as continuous improvement activities. Inside-out innovation is defined as projects that originate from the DC engineering teams identifying opportunities for improvement and contacting appropriate vendors that can provide solutions that the team has identified are best suited to address the constraints. Finally, outside-in innovation is defined as projects that originate from vendors reaching out to the DC teams to implement their products where applicable. Innovation that is either bottom-up or inside-out was identified as preferrable as it aligned with LS continuous improvement principles and targeted the areas with the most opportunity in the DC.

In general, it was noted that the DCs were skilled at executing innovation projects once they were defined but required a standard process for identifying where and what to target when innovating. There was one DC innovation program that was initiated before the COVID-19 pandemic that aimed to focus DC innovation in identified target areas. It was called the North American Supply Chain Innovation Program and was put on hold once the pandemic started. The steps of this program were: explore, evaluate, confirm, and scale. The goal was to first explore different opportunities for innovation within the DC, evaluate which options were most viable, execute pilot programs to confirm innovation performance, and finally, scale to other DCs in the network. This structure was considered as a starting point when developing the innovation process.

2.1.3 Internal Innovation Takeaways

To summarize, key takeaways from the internal innovation processes described in Sections 2.2.1 and 2.2.2 that must be added to the proposed innovation process are:

(1) Incorporate LS principles of simplicity, flexibility, and scalability into all steps of the process.
(2) Include long-term focus for innovation and connection back to business strategy developed at HQ.
(3) Include a quantitative method for recommending automation when it is truly justified and recommending alternative solutions when it is not. This should also prioritize bottom-up and inside-out innovation.

(4) Include standardized guidelines for business case development.

(5) Scale process to other areas in the organization and standardize where possible.

2.2 External Innovation Processes

External innovation processes are processes that are currently used outside of Neilos in different companies or industries. Best practices from academia and industry were analyzed before developing the final proposed innovation process. Sections 2.2.1 and 2.2.2 present the details of this analysis.

2.2.1 Academic Resources

The Harvard Business Review published an article titled "You Need an Innovation Strategy" that produced key insights into what makes innovation programs successful, [9]. Author G. Pisano argues that failure to build and maintain the capacity to innovate is most often due to a failure to articulate an innovation strategy that aligns innovation efforts with the overall business strategy of the company. Without this strategy, companies struggle to weigh the trade-offs of various practices, to design a coherent innovation system that fits their competition needs over time, and to align different parts of the organization with shared priorities. To address these challenges, the article suggests that a company's innovation strategy must address how innovation will create value for customers and the company and what types of innovation should be explored. It also notes that only senior leaders can set an innovation strategy as innovation cuts across functions, and they must recognize that this strategy requires continual experimentation and adaption.

There are several challenges with innovation noted in this article that Neilos faces on a day-to-day basis such as aligning different parts of their organization and weighing the trade-offs between different innovation options. The proposed innovation process should therefore include a strategy and planning step that aims to identify goals for innovation that tie back to business strategy. This should be developed at the HQ level and communicated to the DCs.

Author A. Mariello in the MIT Sloan Management Review proposes a process for successful innovation that involves five stages, [10]. The first stage is idea generation and mobilization. In this stage, ideas are generated and then mobilized wherein the idea travels to a different physical or logical location to be moved along. The second stage is advocacy and screening. This stage weighs an idea's pros and cons through a transparent and standardized evaluation process. The third stage is experimentation. This stage tests the sustainability of ideas for a particular organization at a particular time in a particular environment. This can also be described as piloting an idea on a smaller scale before rolling it out to an entire organization or portfolio of customers. The fourth stage is commercialization where the organization looks to its customers to verify that the innovation solves their problems and then should analyze the costs and benefits of rolling out the innovation. The final stage is diffusion and implementation. This involves gaining final acceptance of an innovation and setting up the structures, maintenance, and resources needed to produce it, [10].

This source states that innovation should begin with an idea generation and mobilization stage. They imply that the strategy of the company is understood before this phase is executed, which aligns with the previous article. A key takeaway for the proposed innovation process is the standardization of the idea screening phase. This validates the quantification of the decision to automate discussed in Section 2.1.1.1.

2.2.2 Industry Resources

There is no one correct innovation process that is used across all companies in every industry. Some companies offer general innovation essentials to be used when crafting your own framework. McKinsey has presented one such example with their eight essentials of innovation that are generally present if a company has a successful innovation program and culture. These items are aspire, choose, discover, evolve, accelerate, scale, extend, and mobilize. The first four items are strategic and creative in nature. They aim to set a vision or strategy for innovation, to choose the right innovation to fit the strategy, to uncover actionable and differentiated insights, and to evolve their business models over time. The next four items deal with how to deliver and organize innovation repeatedly. They aim to remove bureaucratic barriers and encourage cross-functional collaboration, to consider maximum scale of an idea, to leverage external resources, and to reward innovative behavior, [11]. Key takeaways from the eight essentials framework are:

(1) Innovation should be tied to business strategy and company vision.
(2) Innovation processes are fluid and subject to change over time. Companies must be willing to evolve to support this.

(3) To achieve innovative thinking, organization changes may be necessary to promote collaboration, learning, and experimentation, not because any one structure is not able to support innovation, [11].

Many companies have innovation processes though they may instead be defined as a capital projects process or a product development process. All these methods can be used to develop a new capability to improve customer experience and increase company value.

One example of a capital projects process is from ExxonMobil, one of the largest oil and gas companies in the world. Their process involves five stages and is used to globally manage their capital investments across Upstream, Downstream, and Chemical businesses. The stages of their process are plan, select, define, execute, and operate. The plan phase involves identifying opportunities to achieve a business goal tied to business strategy. The select phase evaluates multiple options to address this opportunity and ends with the selection of a winning idea and standardized business case development. The define phase begins the front-end engineering and execution planning for the decided concept. Full funding is awarded to the project after this phase with leadership approval at a level that corresponds to the size of the project. The execute phase involves activities such as detailed engineering, construction management, and procurement. Finally, the operate phase aims to start-up successfully, handover to operations, and evaluate performance of new asset, [12]. Some key takeaways from this process involve:

(1) Identify the area for investment and then evaluate multiple solutions to address this area.
(2) Standardized business case development and financial approval should directly relate to the size of the project.
(3) Project does not end with start-up. There is a post start-up evaluation of performance that ties back to metrics in the original business case.

One example of a product development process is at Shopify, a multinational e-commerce company that provides a platform for online stores and retail point-of-sale systems. Their process involves seven stages and is used to bring an original product idea to market. The stages of their process are idea generation, market research, planning, prototyping, sourcing, costing, and commercialization. The first and second phases involves brainstorming potential product ideas and performing market research to ensure demand is present. The third phase of planning is to layout schedule and budget before proceeding with prototyping or commercialization. The fourth phase of prototyping involves experimenting with several versions of the product until a minimum viable product is developed for testing. The fifth and sixth phases involve engaging vendors and putting final costs to your product. The seventh and final stage includes launching the product to the market, [13].

When comparing the product development process above to innovation within a DC, it is important to note that the customer will not be directly using the innovation but will instead be benefitting from the innovation through the form of faster delivery, increased sustainability, or lower cost. Therefore, some key applicable takeaways from this process above include:

(1) Idea generation and market research can equate to understanding where opportunities are in the DC and what options are available to address them.
(2) Develop an execution plan including budget and schedule before executing a project.
(3) Evaluate different solutions and vendors before committing to one solution/vendor.

2.2.3 External Innovation Takeaways

There is not one innovation process in industry that works for every company, but instead, general behaviors can be seen across companies with successful innovation programs. Some processes, such as capital project management and product development, act as types of innovation processes within their respective companies. Generally, for large companies, innovation excellence in industry is often built in a multiyear effort that touches all parts of the organization, [11].

To summarize, key takeaways from the external innovation processes that must be added to the proposed innovation process are:

(1) Tie innovation to company strategy and vision. Strategy should be understood before idea generation phases can take place.
(2) Identify the specific area for investment and then evaluate multiple solutions and vendors to address this.
(3) Relate size of project to standardized business case development and financial approval. Include execution plan with early schedule and budget when developing business case.

(4) Evaluate innovation after deployment to ensure performance is as defined in the original business case.

(5) Be willing to evolve over a multiyear timeframe to support fluidity and change of innovation processes over time.

2.3 Proposed Innovation Process

Key takeaways from conducting research on internal and external innovation processes are presented in Table 3 below along with a proposed solution for how to implement these learnings into the proposed innovation process.

Table 3: Internal and External Innovation Process Takeaways with Action Plan

Takeaway	Innovation Process Type	Action Plan
Incorporate LS principles of simplicity, flexibility, and scalability into all steps of the process.	Internal	Do not exceed five total steps in the process. Do not include too many or too specific required paperwork.
Include long-term focus for innovation and connection back to business strategy developed at HQ.	Internal	Have the first step in the process as a strategy identification step. Encourage team to develop an innovation portfolio using this process.
Include a quantitative method for recommending automation when it is truly justified and recommending alternative solutions when it is not. This should also prioritize bottom-up and inside-out innovation.	Internal	Evaluate financial cost and benefit of each potential innovation. Consider temporary vs. permanent problems. Invest in process improvement before automation. Identify areas for improvement first, then propose solutions (bottom-up and inside-out).
Include standardized guidelines for business case development.	Internal	Standardize business case based on project size.

Scale process to other areas in the organization and standardize where possible.	Internal	This is a next step to build on the proposed process.
Tie innovation to company strategy and vision. Strategy should be understood before idea generation phases can take place.	External	Have the first step in the process as a strategy identification step.
Identify specific area for investment and then evaluate multiple solutions/vendors.	External	Identify opportunities/areas for investment in the DC tied to company strategy as a second step.
Relate size of project to standardized business case development and financial approval. Include execution plan with early schedule and budget when developing business case.	External	Standardize business case based on project size.
Evaluate innovation after deployment to ensure performance is as defined in the original business case.	External	Include pilot plan and evaluation of performance relative to original business case as a final step.
Be willing to evolve over a multiyear timeframe to support fluidity and change of innovation processes over time.	External	This is the next step to build on the proposed process.

To summarize above, the proposed process should be a maximum of five steps, should start with a business strategy identification step, should aim to identify areas for improvement before brainstorming solutions, should include standardized business case development, and should evaluate performance of innovation after installation. Incorporating all these learnings, the proposed innovation process is shown in Figure 3 below.

Figure 3: Proposed Innovation Process for Omnichannel DCs

The proposed innovation plan has five steps: plan, identify, evaluate, select, deploy. This process puts an emphasis on the front end of the innovation process as this is something the DCs had identified that they were challenged with. There is a backwards arrow between select and deploy that represents the connection between the performance evaluation and the original business case. Sections 2.3.1, 2.3.2, 2.3.3, 2.3.4, and 2.3.5 discuss each of the five proposed steps in more detail.

2.3.1 Plan

This first step was created to ensure that business strategy was considered when beginning an innovation project. This thesis will focus on one of the many business goals that has been top of mind since the beginning of the COVID-19 pandemic: shift in channel mix at omnichannel DCs due to growth in digital demand. After several interviews with both DC and HQ teams, addressing capacity challenges caused by digital demand growth has been a highly focused goal and is seen as a top priority within the four walls of the DC. Innovation is required to address the current capacity gaps and was required to address capacity gaps since 2020.

The global strategy that directly ties to digital demand growth at Neilos is their digital-first supply chain strategy. This strategy states that 100% of digital volumes must be sustainably delivered in four days or less and 50% of digital volumes (high-volume SKUs) sustainably delivered in 2 days or less with 99% delivery precision. NASC has developed a geo strategy to address this including but not limited to the expansion of their distribution network, evaluation of robotics and process automation at the DCs, and the development of processes and tools to improve operations management tasks.

For the DC environment specifically, to meet this global delivery goal, orders must be processed, especially digital orders, as quickly as possible through the DC. The DC goals that support current corporate strategy are to grow DC capacity (throughput and storage) and to consider robotics and process automation where applicable. Therefore, this thesis will emphasize a capacity growth strategy when analyzing case studies in Chapters 3 and 4.

As discussed in Section 1.2, it is important to note that there are multiple of changes in the current business environment in addition to digital demand growth that Neilos is addressing through their business strategies (e.g., sustainability, labor reliance reduction, etc.). This planning step can therefore be updated in the future to reflect a different business strategy or goal relative to current business priorities. There is also an option to have this step include multiple goals at once with different prioritizations. These recommendations will be further discussed in Chapter 5.

2.3.2 Identify

With strategy and goals known from the plan step, the second step of the proposed innovation process is to identify areas within the DC that have the greatest opportunity for improvement to support these goals. This step will always involve some analysis of the selected DC to understand how it operates and what areas could benefit most from innovation. For example, in the case studies completed for this thesis described in Chapters 3 and 4, capacity growth has been identified as the primary strategy, and therefore, a capacity analysis was completed on the selected DC, NADC, to identify the areas that have the largest capacity constraints. It is believed that innovation should be targeted in these areas to make the most progress towards business goals. It is important to note that if the strategy identified in the first step were to change, the selected analysis would have to be replaced by a more applicable analysis. For example, if the main strategy was to improve sustainability within the DC, an analysis of which areas in the DC produce the most waste would be a more appropriate option versus a capacity analysis.

2.3.3 Evaluate

The third step in the proposed innovation process is to evaluate different types of innovation to address constrained areas identified in the previous step. Four types of innovation were identified and prioritized from lowest to highest complexity in terms of implementation. To align with LS principles, if a constraint could be addressed by improving a current process or adding additional staffing, it was prioritized over investing in new technology. Figure 4 displays the prioritization of the four innovation types. Each type is further discussed in Sections 2.3.3.1, 2.3.3.2, 2.3.3.3, and 2.3.3.4.

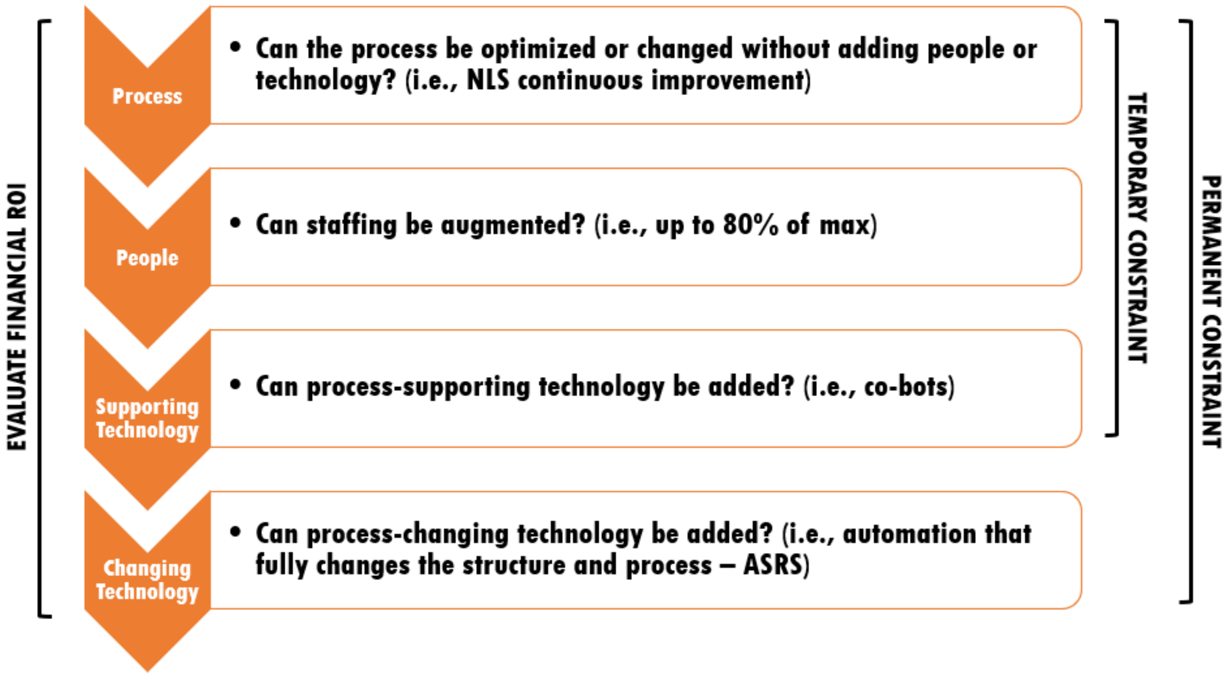

Figure 4: Prioritization of Innovation Type

Using this diagram, the user starts at the first step and evaluates the financial return on investment (ROI) of implementing this innovation type. If a constrained area can be unconstrained by this innovation type and implementing the innovation is financially beneficial, then the user should select this innovation type. On the right side of the diagram, it indicates what steps should be evaluated for both temporary and permanent constraints. A temporary constraint was classified as a constraint that was not recurring and was predicted to affect the DC only in the short-term. A permanent constraint was classified as a constraint that was recurring and was predicted to affect the DC in the short- and long-term. It was decided that for temporary constraint, process-changing technologies should not be considered unless the constraint is regularly recurring. Chapters 3 and 4 will perform the ROI analysis associated with these innovation types for two different case studies.

2.3.3.1 Process Changes

The first type of innovation involves making changes to the current process in an area. This innovation type asks if the process can be improved or changed without adding people or technology. From a financial perspective, this is the least expensive option when addressing a constrained area. Some examples of process changes when assessing DC capacity are balancing or changing the workload assigned to different areas (if there are multiple areas processing the same orders) or changing the flow of a product through the DC to a new processing area.

2.3.3.2 Staffing Changes

If there are no process changes available, the user can then look to increase or balance staffing within the DC. The staffing level should not be increased to 100% of the maximum staffing limit in a particular area. The limit to which staffing could be increased was recommended at 80% to allow for the flexibility to add more people if needed in temporary high demand scenarios. This innovation can be evaluated at the same time as a process-supporting technology solution. It may often be less desirable for many reasons to increase staffing within the DC. Some reasons could be financial while another could be related to increasing reliability on the labor workforce. Another method for "increasing" staffing is to get the existing staff to work additional hours at the DC. This was not evaluated as overtime hours were not a common occurrence in this DC and were deemed as a non-viable option. If this were to change, it is recommended that this analysis is included as part of this portion of the process.

2.3.3.3 Process-Supporting Technology

Process-supporting technologies are innovations that can be added to the existing process without changing the structure of what currently exists in the DC. One example of this type of innovation would be adding co-bots, or robotics that assist and work with humans to achieve a task, to a selecting area to assist associates with their current process. To easily evaluate this innovation, the process used in an area must be broken down into specific actions taken to progress an order through this area. Once individual actions are identified, technologies that can be added to support these actions can be identified and evaluated.

2.3.3.4 Process-Changing Technology

Process-changing technologies are innovations that require the process and structure of an area to undergo a major change. One example of this type of innovation would be adding an automated storage and retrieval system (ASRS) to a selecting area that is currently using manual processes to select items. This type of investment should not be made for temporary constraints in the DC unless they are recurring. The financial ROI would not justify an investment of this size for a constraint that is not inherently large and permanent. For both process-supporting and process-changing technologies it is important to note that the addition of these innovations would potentially result in the hiring of specialized personnel that can operate and maintain these technologies if training is too advanced for existing associates.

2.3.4 Select

Once the type of innovation has been evaluated and chosen, the details of the innovation must be further developed. This leads to the select step, the fourth step of the proposed innovation process. This step involves identifying and selecting potential vendors and developing a business case for the specific innovation project. Table 4 below shows an overview of the specific requirements necessary for each type of innovation to be approved. At Neilos, an A3 is a short one-page business case that defines the problem, target, and recommended solution with associated financials. A business case deck is a formalized presentation deck that is presented to HQ personnel and developed by the DC that includes more details around the schedule and execution of the project. The intake form is a more formalized version of the A3 that is used for projects approved at the HQ level.

Table 4: Vendor and Business Case Requirements by Innovation

Innovation Type	Approver	Business Case Type	Vendor Required?
Process	DC Leadership/LS	A3	Maybe
People	DC Leadership/LS	A3	No
Supporting Technologies	DC Leadership or HQ Leadership	A3 + Business Case Deck + Intake Form	Yes
Changing Technologies	DC Leadership or HQ Leadership	A3 + Business Case Deck + Intake Form	Yes

As the innovation increases in complexity and cost, there are more requirements necessary to approve the project and proceed with deployment. Sections 2.3.4.1 and 2.3.4.2 further discuss the specifics of both vendor selection and business case development.

2.3.4.1 Vendor Selection

Vendor identification and selection varies by company and is generally assisted by internal procurement or contracting departments. Starting first with vendor identification, HQ has currently developed a decision-making framework that acts as a database of preferred vendors used to assist the DCs during their innovation processes. It is recommended that this tool is used by the DC for future work as part of the proposed innovation process. Alternatively, vendors can be identified from manufacturing and warehousing tradeshows as well as through recommendations from other companies and industries.

When selecting a vendor, the company can either bid or single source the vendor. When bidding the work to a vendor, cost is usually the primary factor. During the bidding evaluation, multiple attributes must be taken into consideration. Some of these attributes may include cost, capability, safety record, piloting and deployment proposal, and past relationship with the company. It is recommended to create a matrix of attributes that the company values and wishes to evaluate when selecting a vendor for a particular innovation project. These attributes can be weighted based on project priorities. Once each vendor has a final score, the vendor with the highest score can be selected.

When single sourcing a vendor, schedule is often the primary factor. Single source contracts can leverage existing contracts with vendors at the DC level, or they can reach out to a specific vendor that has promised a particular timeline or who has specialty capabilities that are required to execute the innovation project.

2.3.4.2 Business Case Development

Business cases also varies by company. Within Neilos, depending on the size of the project, usually from a cost perspective, there are different requirements for business case development and approval. From Table 4 above, as the innovation becomes more technically complicated and more expensive, there is more information and justification required in the business case. The approver will also come from HQ instead of the DC level. Specifically, an A3 form is required for all projects. This defines the basic business case including problem statement, current condition, target condition, and resources required. For more complicated projects, a formalized business case in a presentation deck is required as well as a project intake form.

2.3.5 Deploy

The final step in the proposed innovation process is the deployment of the innovation once a vendor has been selected and a business case has been developed and approved. Actions within the deploy step include development and execution of a pilot project for the innovation and the final go or no-go assessment of the technology within the DC.

2.3.5.1 Piloting Plan Development

Research was conducted to gather what a successful pilot plan looks like. It was found that successful pilot plans include early engagement with the vendor and include the following details:

(1) Length of time: how long the pilot will last in the DC and who will be responsible for ensuring the schedule is met.

(2) Performance evaluation: how the pilot program will be evaluated as successful or not. This should tie back to the metrics identified in the original business case.

(3) Installation logistics: how the pilot will be executed. This could have a pilot in the DC or at an off-site location. It could also include temporary equipment installation.

(4) Cost: how much the pilot will cost.

Once these details have been defined and agreed upon with the vendor, the pilot plan can be executed. During the pilot, improvements should be made dynamically and applied during the pilot if required, [14].

2.3.5.2 Go or No-Go Assessment

When the length of time defined in the pilot plan is complete, a go or no-go assessment must be made. This decision should be based on whether the pilot met the expected performance metrics defined in the piloting plan. If expected performance is met, then operations handover activities can begin. Once fully installed, performance should be continually measured over the course of the innovation's lifetime.

2.4 Summary

The proposed innovation framework discussed in this chapter combines research from internal and external sources to create a process that adds structure and meshes well with the culture of Neilos. The proposed process has five steps: plan, identify, evaluate, select, and deploy. The plan phase aims to understand the short- and long-term corporate strategy of the company and what goals should be set at the DC level to achieve this broader strategy. The current strategy identified for Neilos is to increase network capacity. At the DC level, one goal to achieve this strategy is to increase throughput capacity. The identify phase prioritizes areas for innovation in the DC based on strategic goals. Given the goal to increase throughput capacity, a capacity model in Power BI was developed to assess which areas of the DC are the most constrained.

Next, the evaluate phase assesses four different types of innovation for the constrained area (process changes, staffing changes, process-supporting innovation, and process-changing innovation) and chooses the best option based on financial ROI to support the investment decision. Once the innovation type is chosen, the select phase selects a vendor and develops a business case for the innovation project. Finally, in the deploy phase, a pilot plan is created and executed with the vendor and a go or no-go decision is made.

To evaluate the effectiveness of this proposed innovation process, the following Chapter will take a successful past innovation project and take it through the process to see if the same recommendation for investment would be made.

Chapter 3
Innovation Framework Evaluation

3 Introduction

In this Chapter, the proposed innovation process discussed in Chapter 2 will be evaluated using a successful past innovation project executed at NADC. The goal of this exercise is to verify that the proposed innovation process is effective in choosing and executing the right innovation for the DC. As this past project was deemed successful, if the proposed innovation process can recommend the same or similar decisions as those that were taken at the time, it will be deemed as an effective tool for future application.

3.1 Case Study Background – Zipper

As discussed in Section 1.2.1, prior to 2020, NADC's main fulfillment channels were wholesale (WP, NS) and its main product engine was footwear. It had the capability of fulfilling digital single footwear orders mainly through its DPVAS area as mentioned in Section 1.1.3. Prior to 2020, this area in the DC was completely manual with associates packaging and performing VAS on individual footwear orders that arrived by conveyer from footwear selection. This area serviced minimal orders as most of the DC demand was wholesale. Once the COVID-19 pandemic hit and wholesale stores closed, all customers turned to the digital channel to purchase their products. There was not adequate infrastructure in place for this large volume of digital orders, primarily single footwear orders, to be processed effectively within NADC. DC teams had to think quickly and innovate to fulfill a shifting channel mix.

In the summer of 2021, NADC launched the Zipper project. This technology was a fully automated, high capacity, on-demand packaging machine that serviced single digital footwear orders. Zipper promoted right size packaging which improved sustainability through the DC. Its software system included an optimization platform to produce the best sized shipping box for each footwear order and integrated well with the DC's warehouse management system (WMS). It was rolled out to support the manual process in DPVAS. Both manual and automated processes package digital single footwear orders today. This innovation project is largely viewed as an extreme success at the DC level.

The following sections will assume that the year is 2020 and the DC team is assessing what innovation they should invest in to solve their digital capacity problem. The process will be applied and evaluated to assess what would be recommended if it had been used in the past.

3.2 Plan and Identify Analysis

Starting first with the plan phase, the corporate strategy remains the same in 2020 as it does in 2023: grow network capacity and implement network changes to grow digital business. As previously mentioned, at NADC at this time, capacity was lacking for digital demand due to lack of infrastructure to process digital orders. Understanding the main goal to grow capacity at the DC to support shifting demand, a capacity analysis was performed using a model that was developed as described in the following sections.

3.2.1 DC Capacity Analysis

As described in Section 1.1.3, NADC is a complex omnichannel DC with many different flow paths depending on the sales channel and product engine among other characteristics. A capacity model was developed to determine which areas of this DC were the most capacity constrained and to allow the user to make more-informed investment decisions. Application of this model is shown using the case studies further discussed in Chapters 3 and 4.

3.2.1.1 Available Tools and Data

There are two models that the DC uses that relate to capacity. All data related to these models is either sourced from Microsoft Excel or a SQL database. The first model measures capacity at the daily level with the user inputting several parameters (>15) to characterize the simulated daily demand. Some of these parameters include digital volume, non-digital volume, and % of digital single orders. Once parameters are entered, the model shows demand and capacity of each area in the DC and associated conveyers. This model is built with assumed capacities of each area based on average UPCs, machine capacities, and average units per hour (UPH). This model has been compared to actual performance in the DC and has been shown to be a relatively accurate representation of daily capacity when the parameters described above are entered correctly; however, to use this model, the user must be intimately familiar with the DC so they can update these parameters to simulate different demand scenarios. Due to its complexity, this model is only used for detailed analysis in one-off situations. There are only a handful of people at the DC who know how to use it correctly.

The second model measures total forecasted DC capacity at the monthly level with the user inputting forecasted monthly demand. The monthly demand forecast provided is broken out by channel and product engine. This model does not calculate capacity broken out by channel and product engine; it instead uses this demand forecast to calculate monthly capacity by full case or repack flow as described in Section 1.1.3. First, the model calculates the full case and repack monthly demand based on the forecasted monthly demand by channel entered in the model. Next, the model calculates the full case and repack capacity of each general area of the DC based on average UPC values, standard allowable minute (SAM) values, average historical staffing, historical area efficiencies, and average full case and repack % by channel. SAM values are the total minutes for an associate to complete one task in each area. SAM values can either be minutes per unit or minutes per case depending on the area in the DC; conversions using average UPC are used where applicable. The sum of the SAM values for each task in an area is equal to the total minutes for an associate to process a unit through that area. This can be converted to a UPH for the area. This UPH can then be multiplied by the total hours worked by associates in an area and the historical area efficiency to get the estimated monthly area capacity. As there are multiple parallel full case and repack areas in the DC, once the area capacity is calculated, it is added to either the total full case or total repack capacity.

As an example, it is described below how this model calculates the capacity of the DPVAS area as described in Section 3.1. To calculate the capacity of the DPVAS area, the model needs to account for both the area's manual packaging and the automatic packaging processes as the capacity of each adds together to calculate the capacity of the entire DPVAS area. Starting with the automatic packaging, the model takes the rated UPH of packaging machines in the area and multiplies it by a parameter in the model that defines the proportion of orders fulfilled by the automated vs. the manual process. This number is then multiplied by the monthly machine hours to get the capacity of the automated area in units per month. With the manual packaging, the model takes the proportion of orders fulfilled by the manual packaging vs. automated packaging and multiplies it by the SAM value of an associate to process a package, the average historical hours worked by associates in this area, and an average UPC. This calculation also shows the capacity in units per month. Both calculations added together give an estimate of the total units per month DPVAS can process in both its manual and automatic packaging operations. As DPVAS only processes repack orders, this capacity is classified as repack capacity in the model and is added to the total DC repack capacity.

Once both the full case demand and capacity and the repack demand and capacity are calculated, the minimum of demand and capacity for both full case and repack is added together to produce the total NADC monthly capacity expressed in units per month. It can be noted that in recent months, repack capacity is less than repack demand based on DC actual performance. This is due to an increase in digital demand and the DC's lack of infrastructure to support high levels of repack orders. The minimum of full case capacity and demand varies by month. The second model, though easier to use than the first model, has a high complexity with over 20 tabs of data in the spreadsheet. Historical values used in capacity calculations are not regularly updated and capacity is not broken out by channel or product engine. Also with this model, there is no way to identify a bottleneck in the DC as total full case and repack capacity is comprised of the addition of several different areas in the DC.

With both current models, there are minimal to no data visualizations that help to present the results of these capacity analyses and they are difficult to update without specialized knowledge. Capacity calculations using UPC parameters are not connected to the actual demand channel mix, but instead to average UPCs for the overall demand. Finally, in both models, it is difficult to identify a long-term bottleneck that should be the area of focus for investments as one is presented at the daily level and does not present the capacity per area in detail. For these reasons, a third capacity model was created with the primary goal to aid in investment decisions and with secondary goals to be user friendly, to improve data presentation, and to improve accuracy of capacity and demand calculations.

3.2.1.2 Software Platform Selection

To improve data visualizations for the model, selection of the modelling platform was narrowed down to Tableau and Microsoft Power BI. Both platforms are used in industry, with Tableau being the preferred platform for Neilos. Power BI is easier to learn and use for less experienced users, is cheaper, and is slower when handling large volumes of data. Tableau can handle large volumes of data quickly from a wider variety of data sources; however, it has a steeper learning curve and is often only used by experienced users or data analysts, [15].

Ultimately, the ease of use and flat learning curve of Power BI was what led to the decision to use the platform for this capacity model. It was also chosen due to its ability to create Sankey diagram visualizations much easier than Tableau. It was desired by the DC engineering team to have a Sankey diagram of the DC that could automatically update based on the channel mix of demand. Therefore, the capacity model of the DC was constructed as a Sankey diagram with demand flowing by channel and product engine through different areas of the DC.

The pros of using Power BI were as advertised. The platform had a flat learning curve and a user-friendly interface to generate data visualizations, especially Sankey diagrams. The visualizations, once created, were easy to update for beginner users and presented capacity and demand data in a simplified way compared to existing models. Despite these successes, there were several learnings during the model creation that lead the author to recommend reevaluating this model choice for this application. This is discussed further in Section 3.2.1.6.

3.2.1.3 Model Design

This model aimed to calculate demand and capacity at the monthly level within each area of the DC by channel and product engine to identify imbalances within specific areas. The first step in designing and building this model was to create the base visualization of the Sankey diagram. This involved identifying all areas and possible flows in the DC to model first by product engine and channel as discussed in Section 1.1.3. This involved multiple walkdowns of the DC and conversations with stakeholders at the DC in both operations and engineering teams. The Sankey visualization in Power BI requires a source, destination, and value. The source is where the flow originates, the destination is where the flow ends, and the value is the demand flow between the two. This structure was built in the model to depict all flows through the DC and the magnitude of demand moving between each area.

Once this structure was created, the demand value was calculated for each source and destination pairing to populate the Sankey visualization. Demand was calculated using demand formulas that were derived from the existing models used at the DC. These formulas are presented in Appendix

A for each source and destination pairing. There are several parameters in these demand formulas that needed to be referenced to complete the demand calculation. One group of parameters are channel and product engine dependent. These parameters include, but are not limited to, repack %, full case %, repack UPC, and full case UPC.

The other group of parameters are universal to every channel and product engine. These parameters include, but are not limited to, case storage %, unit select %, and INT 1 % of repack. Inventory types (INT) are used in the DC's WMS system to identify specific orders and how they should be fulfilled in the DC. Two of these parameters, storage and selection percentages, only apply to the footwear flows through the DC as apparel and equipment flows have no parallel paths. It is first assumed that footwear orders are sourced from either case storage, pallet storage, or the shave tower throw lines by a constant percentage. It is next assumed that footwear and is selected from either unit select, cart select, or select mod by a constant percentage. The remaining universal parameters are assumed to be constant depending on the month:

(1) INT 1 % of Repack – percentage of full case orders that travel directly from routing sorter to either the mixed sorter or the apparel sorter. Applicable for all product engines.
(2) INT 10 % of Singles – percentage of single orders that travel directly from routing sorter to DPVAS. Applicable for footwear only.
(3) Full Case VAS % - percentage of all full case orders that require VAS. Applicable for all product engines.
(4) Digital Singles % - percentage of digital footwear orders that are single orders. Applicable for footwear only.

These universal parameters are coded directly into the Power BI model and can be adjusted by the user based on a specific demand scenario. A final assumption made when calculating demand is that all demand fulfilled directly from the selecting area is replenished from storage areas over the course of the month. This assumption is valid and allows the model to flow consistently from the start of the DC to the end.

For example, to calculate demand between one of the footwear storage areas, case storage, and the routing sorter that routes cases after storage to a specific area for replenishment or shipping:

$$Value_{Case\ Storage\ \&\ Routing\ Sorter} = Monthly\ Footwear\ Demand \times Case\ Storage\ \%$$

From the equation above, as the model is looking at the path from case storage to the routing sorter, it pulls the monthly footwear demand entered by the user, discussed in the following section, and multiplies this by the case storage % parameter that is user adjustable.

Figure 5 shows the completed Sankey diagram for a specific demand forecast filtered by the footwear product engine. This data visualization can be filtered by product engine and/or channel and will update the demand flows as applicable. Each vertical bar represents an area, or source and destination, in the DC. The grey flows that connect different bars represent active paths in the DC. The width of each grey flow represents the volume of demand in units per month that flows between that specific source and destination bar. The visualization below is misleading in that it seems to show the flow that enters the DC is not equal to the flow that leaves the DC – this is a flaw of the modelling software – the demand into the DC equals the demand out of the DC in this model. The demand into an individual area in this model is also equal to the demand out of an individual area as no capacity constraints have been added.

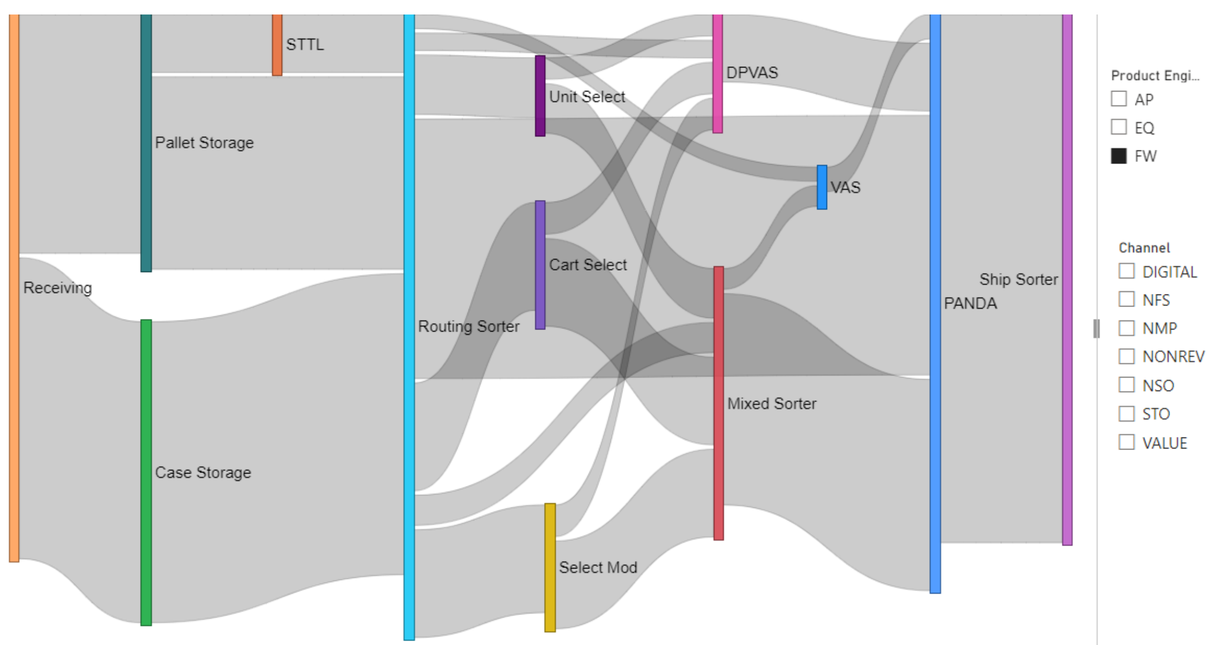

Figure 5: Sankey Diagram Filtered by Product Engine (Footwear)

As the model currently stands, demand is unconstrained. There are no capacity limits in the model that prevent demand from flowing to the next area. Therefore, adding the capacities of each area was the next step in model creation. This model did not support adding a capacity of the flow between two areas. Therefore, capacity of a given source and destination pairing was chosen to be based on destination as this would be the area receiving the flow's demand. To start, parameters needed to calculate the DC area capacities were identified and included in backend of the model. Some of these capacity parameters included the relevant SAM values, historical area efficiency, hours per shift, historical actual staffing per shift and maximum staffing per shift. Total actual working hours per month were calculated by multiplying hours per shift by historical actual staffing per shift by total days worked per month. Total maximum working hours were calculated in the same way as the maximum people per area.

Material handling equipment (MHE) capacity constraints were also added as capacity parameters in the model. These were known historical values from existing models that reflected the maximum UPH of an area related to the equipment in that area. This capacity limiting equipment could be conveyer, machinery, or robotics. Both operational and MHE capacity equations can be found in Appendix A for each destination. These formulas were derived from the existing models used at the DC. Both operational (based on staffing) and MHE capacity were calculated for each area in the model. The lower of the two was taken as the monthly capacity of that area.

For example, using the same source and destination pairing as above, the calculation below shows an example of how both operational and MHE capacity would be calculated for the case storage to routing sorter flow:

$$Operational\ Value_{Case\ Storage\ \&\ Routing\ Sorter} = N/A$$

$$MHE\ Value_{Case\ Storage\ \&\ Routing\ Sorter} = Machine\ Hours * Efficiency * Units\ per\ Hour$$

In this equation, the routing sorter is first identified as the destination. Therefore, routing sorter capacity equations are used to calculate the capacity of this area. The routing sorter is a machine that has no people that affect its capacity. Therefore, its operational capacity does not exist. For its MHE capacity, the total hours it works is multiplied by the machine efficiency and the rated units per hour that it can process. Since the MHE capacity is the only capacity available for this area, this is the routing sorter's capacity. If operational capacity was a non-zero number, then the lower of the two numbers would be taken as the area capacity.

Now that the capacity calculations were added to the model, a table visualization was created to show both the demand and capacity of each area at NADC with the calculated difference between the two. Demand for an area was calculated by summing all the demands of every flow into a specific destination. The capacity was calculated as described in the example above. Section 3.2.1.5 discusses how both the demand and capacity numbers of each area were validated in the model before use.

Ideally, the capacity constraints would be added to the Sankey Diagram visualization at each area. Some logic could be used to determine if the total demand was able to pass through a specific node in the visualization given its capacity. Unfortunately, this model visualization did not support the addition of capacity constraints at each area. Therefore, it was determined that an additional calculation would need to be performed to identify a new demand flow value to be used in the Sankey diagram: the lower of demand or capacity of a given area.

It was noted that if the capacity of an area was less than the demand of that area, then the model would need to subtract demand flowing out of an area. This would require logic that will decide what channel and product engine to subtract from. This prioritization of channel and product engine was not easily defined or modelled. Based on the complexity of modelling the capacity and "demand subtraction" logic in the Sankey Diagram in Power BI, these were not included in the visualization. Instead, a table visualization was created that displayed total demand and capacity of each area in the DC. Figure 6 shows a screenshot of this table visualization from the model with masked data.

Capacity_Indicator	Demand Value	Monthly Capacity	Difference
SelectMod	[redacted]6.63	[redacted]9.03	[redacted]7.60
UnitSelect	[redacted]3.32	[redacted]4.78	[redacted]8.54
CartSelect	[redacted]6.63	[redacted]0.45	[redacted]6.18
APVAS	[redacted]6.09	[redacted]3.84	[redacted]7.75
ValueAddService	[redacted]4.15	[redacted]8.69	[redacted]4.54
CaseStorage	[redacted]0.72	[redacted]8.12	[redacted]7.40
ApparelSorter	[redacted]5.83	[redacted]4.17	[redacted]8.34
Zone71Selecting	[redacted]8.90	[redacted]1.64	[redacted]2.74
DigitalPVAS	[redacted]1.80	[redacted]6.58	[redacted]4.78
PalletStorage	[redacted]6.28	[redacted]6.31	[redacted]0.03
MixedSorter	[redacted]4.52	[redacted]1.59	[redacted]7.07
APCaseStorage	[redacted]4.00	[redacted]7.81	[redacted]3.81
ShaveTowerTL	[redacted]8.33	[redacted]3.40	[redacted]5.07

Figure 6: Capacity Table Visualization

The difference column shows the difference between demand and capacity in units. If highlighted red, the area is under capacity. If highlighted green, the area is over capacity. The demand presented in this table is unconstrained demand; therefore, capacity deficiency displayed in this table shows all potential bottlenecks in the DC assuming each area is hit with its maximum demand.

The capacity modelling complexities discussed above feed into recommendations for future work in DC capacity modelling further discussed in Section 3.2.1.6. With this final table visualization added, the model was fully constructed and ready for user input.

3.2.1.4 Model Inputs and Outputs

While using the model, the user must input five main parameters. The first two main variables to be updated are the monthly demand by product engine and channel and the days per month that each shift works. The demand itself is provided monthly by planners at HQ and the days worked per month is obtained from analytics teams at the DC.

The remaining three main parameters that must be regularly updated in the model were INT 1% of Repack, INT 10% of Singles, and Digital Singles %. These parameters, previously discussed in Section 3.2.1.3, change month over month. For example, over the holiday season, there are higher volumes of digital singles as more customers are purchasing a single pair of shoes as a gift.

After updating the model for a specific monthly demand scenario, data visualizations in Power BI show the demand flow through the DC by product engine and channel, the capacity vs. demand at each area of the DC, and the characteristics of the demand.

These results can be used to determine which areas of the DC are under capacity and require innovation to improve their capacity throughput. Section 3.2.2 applies this model to the DC for this case study.

3.2.1.5 Model Validation

To validate that the model was producing the correct values, the results were compared to outputs from both models discussed in Section 3.2.1.1. It was found that the demand and capacity calculations in the model produced values that aligned with both existing models at the DC. The difference between the two stemmed from using an average UPC value in existing models and a demand dependent UPC value in the new model. Using a UPC value that was demand dependent instead of an average, should result in a more accurate calculation of both demand and capacity in the DC. The results of this model were also compared to DC actual performance that was tracked in previous months. Adjustments were made to the efficiencies of each area based on this comparison. As a final check, multiple operations employees in the DC reviewed the model to confirm that the calculated values aligned with what they experienced on the floor of the DC.

3.2.1.6 Model Learnings

When building this model, there were several lessons learned for future work that are discussed in more detail in Chapter 5. The three main takeaways were:

(1) The Power BI platform is limited in its data processing and capacity modelling capabilities (adding capacity constraints). It is recommended to use either a different platform or to invest in a DC capacity modelling software.

(2) Logic associated with demand prioritization needs to be included in any future modelling. This will help determine what channel and product engine combination does not get processed by an area when it is under capacity.

(3) Future modelling should include other business priorities such as sustainability performance, storage capacity, and order to ship time through the distribution center. This can be combined into one large model or can be displayed across multiple models.

3.2.2 Identify Analysis Results

Both a short-term (2021) and long-term (2022) analysis was performed using the capacity model described above to determine if the bottlenecks were temporary or permanent. Three different monthly scenarios were analyzed to simulate the capacity at different points of the year. Both July and December were selected as the two peak seasons experienced by the DC: back to school and holiday. April was selected as the third month to simulate as it represented an average total demand for the DC. Table 5 shows the different parameters used for each of the three cases. Values in this table have been adjusted for data privacy.

Table 5: Zipper Capacity Analysis Parameters

	April (Average Month)	July (Back to School)	December (Holiday)
INT 1 % of Repack	20%	15%	10%
INT 10 % of Singles	25%	30%	35%
Digital Singles %	65%	70%	75%

A general trend shown is that as the months progress into the largest peak season in December, the number of digital single orders processed by the DC increases. As more digital singles are processed, the amount of repack orders sent directly to DPVAS (INT 10) increases and the number of repack orders sent directly to the mixed or apparel sorters (INT 1) decreases. Demand for each of these months was sourced from past long-term forecasts used in 2020. Using these forecasts instead of actuals simulates a more realistic picture of what decisions the process would have recommended at the time.

3.2.2.1 Short-Term Capacity Outlook

Figure 7 shows the model results from the short-term capacity analysis run for April, July, and December of 2021.

Figure 7: Zipper Short-Term Capacity Analysis Results

In the graphs above, green bars show a positive difference between capacity and demand of a specific area in the DC. If the bar is red, this means there is a negative difference between capacity and demand and therefore, a capacity constraint in that area. Both back to school and holiday peak seasons show bottlenecks for DPVAS in 2021. The DC does not experience any capacity issues in an average month such as April based on these results.

3.2.2.2 Long-Term Capacity Outlook

Figure 8 shows the model results from the long-term capacity analysis run for April, July, and December of 2022.

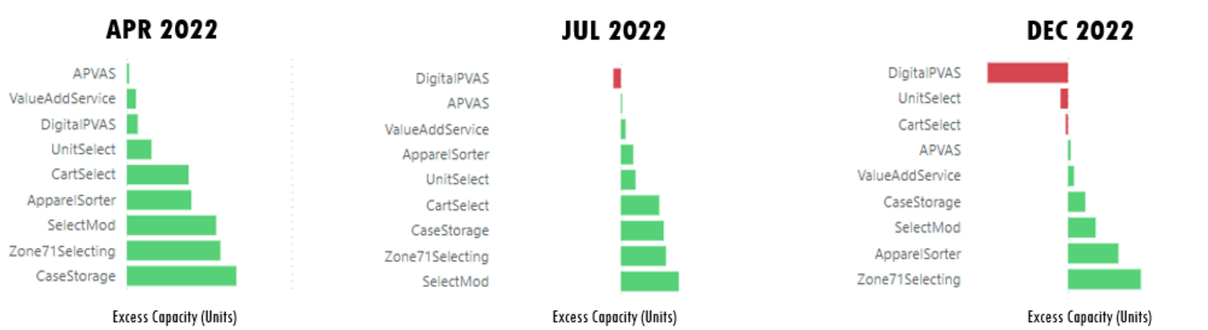

Figure 8: Zipper Long-Term Capacity Analysis Results

Again, both back to school and holiday peak seasons show bottlenecks for DPVAS in 2022. These bottlenecks have grown relative to the short-term capacity analysis. During the holiday season, it is also noted that two of the three footwear selecting areas, unit select, and cart select, are also under capacity. The DC continues to not experience capacity issues in an average month such as April.

3.2.3 Investment Area Recommendation

From the results above, it can be determined that DPVAS is a recurring temporary bottleneck for NADC in both back to school and holiday seasons. Therefore, investment should be made at DPVAS to address this capacity constraint especially as demand continues to shift towards the digital channel. This investment decision is consistent with the actual decision to invest in DPVAS that was made in 2020.

Though footwear selecting presents capacity constraints in December 2022, DPVAS should be prioritized over investment in the footwear selecting areas due to its constraints in both peak seasons and the increased magnitude of its capacity deficiency.

3.3 Evaluate Analysis

With DPVAS selected as the area in the DC where innovation should be focused, an analysis of the four different innovation types was performed on DPVAS. This analysis is described below in Sections 3.3.1, 3.3.2, and 3.3.3. For all financial loss calculations, a $50/unit underage cost is assumed for a unit that is not fulfilled in that month. With this, it is assumed that customers will cancel orders that are delayed and/or not fulfilled in the month they were ordered, and that company reputation will also decrease. This assumption was validated by the NASC division in Neilos that uses the same cost metric for other analyses they complete. This number is the average cost of a single order at NADC and would be the result of refunds associated with lack of on-time fulfillment. It is noted that this is a higher estimate of financial loss as some customers would have their orders fulfilled the next month and would not cancel. However, it was decided to estimate this cost as a worst case to add contingency when calculating if an innovation would solve the capacity constraint.

3.3.1 Process and Staffing Changes

Currently in DPVAS, there are limited process changes that can be made to the current process without adding people or technology. The only viable change involves balancing workload by sending DPVAS orders to another area to be packaged. To relieve pressure on the DPVAS area, footwear digital single orders can be processed by the mixed sorter instead. Upon investigation, this solution would negatively affect conveyer capacity in the DC around the mixed sorter to process the volume of packages needed to eliminate DPVAS capacity constraints. Therefore, it is recommended to analyze staffing changes to see if this is a viable option.

Table 6 below shows the current and augmented staffing changes with masked data that could be made in the DPVAS area.

Table 6: DPVAS Staffing Analysis

Metric	Current Staffing	Augmented Staffing
Utilization	60%	80%
Capacity Deficit	41% of demand	30% of demand

Current utilization in the DPVAS area is 60% which means that an additional 20% of people can be added to the area before hitting the recommended maximum staffing. Investing in this staff augmentation would cost the DC a significant amount of money and would only recoup ~10% of the capacity deficit in the area. Though significant savings could be captured from this innovation type, a large bottleneck still exists at DPVAS resulting in a financial loss that is still more than double the savings captured by adding more staff. Therefore, it is recommended to move to the next analysis using process-supporting technology.

3.3.2 Process-Supporting Technology

Beginning with the evaluation of process-supporting technology, the DPVAS process can be broken down into five individual steps shown in Table 7 below.

Table 7: DPVAS Processing Steps

DPVAS Step	Current Process
Product retrieval	Product is brought to athlete
Box sizing and retrieval	Product is scanned and box size is read from screen
Product packaging	Shipping box is assembled, and product is placed
Label printing and application	Label is printed when box is scanned, placed on box by associate
Box transportation to shipping	Conveyer is next to athlete

In the first step of product retrieval, associates receive totes of product by conveyer to their packaging stations. Next, the product is removed from the tote, scanned by the associate, a shipping label is automatically printed, and a box size is recommended on their computer screen. The associate then takes the recommended box size from a shelf next to their station and assembles it. Boxes used for digital orders are flattened preassembled boxes that can be pushed into a 3D shape by the associate. Once the box is assembled and the product is placed inside, the associate takes the printed label and applies it to the box in the designated area. A filler material is required when packaging this footwear as the shoes are already in their own shoe boxes before being placed in a shipping box. Lastly, boxes are placed on an outgoing conveyer by the associate to send to shipping.

This process already uses process-supporting technologies such as conveyer for transport, barcode scanning for order identification, and automatic shipping label printing. Box assembly has the highest potential for improvement with automation; however, since boxes are preassembled and do not require tape assembly, there are not many changes that could be added to drastically improve packaging performance. Therefore, it is recommended to evaluate process-changing technology instead.

3.3.3 Process-Changing Technology

For the process-changing technology evaluation, the requirements of the new technology were first listed as follows:

(1) Supports single digital footwear orders (highest volume in DPVAS during peak seasons).

(2) Allows for smooth product retrieval and shipping from the DPVAS area.

(3) Chooses the right size box depending on the product.

(4) Packages the product more efficiently than a human.

(5) Prints and applies labels more efficiently than a human.

Based on the requirements above, the main technological option available is using an automated packaging machine. Estimates for this technology are in the range of $1-2 million dollars but have the machine processing capacity to fix the bottleneck in DPVAS and recoup the lost sales from units not processed. This solution will also result in shipping savings from reducing the size of the shipping box on average. It is important to note that this technology will require an update to the current WMS system, additional conveyer to retrieve product and/or send to shipping, and associate training. Further evaluate analysis would have been completed at the time of this project to prove that the DPVAS area's bottleneck would be eliminated by using an automated packaging machine. The new UPH could be found using machine specifications and the capacity could be directly calculated. This specific analysis was not included in this thesis as it had already been completed by Neilos.

3.3.4 Innovation Type Recommendation

After evaluating all four innovation types to address the capacity constraints in both short-term and long-term peak seasons at DPVAS, a stop light summary diagram was generated and is presented in Table 8. Green means that capacity gain is fully recouped, estimated cost is low relative to other options, and the estimated gain/ROI is high relative to the other options. Red means that capacity gain is not recouped, estimated cost is high relative to other options, and the estimated gain/ROI is low relative to other options. Yellow means that it falls somewhere between the two other color options.

Table 8: Summary of Zipper Evaluate Analysis

Innovation Type	Description	Capacity Gain	Estimated Cost ($)	Estimated Gain/ROI ($)
Process	Reroute singles packaging to mixed sorter			
People	Increase staffing to 80% of max			
Process-Supporting Technology	N/A			
Process-Changing Technology	Automated packaging machines			

From this table, the process-changing solution is the only solution that can fully address the constraints in the DC and recoup all financial losses from unprocessed units of demand. Though this solution has the highest capital cost, it also has the highest ROI. In terms of space required in the DC, parts of DPVAS area (i.e., manual packaging) will need to be removed to make space for the new machines. Through removing this existing equipment for some of the manual packaging areas, the new machines will be able to fit in the DPVAS area. For these reasons, it is recommended to proceed with an investment in an automated packaging solution.

The proposed process recommended the same solution as the past DC engineering team when faced with the same challenge. However, the above analysis would help the team to form the beginnings of their business case to leadership for approval of investment in the technology.

3.4 Select and Deploy Analysis

For both the select and deploy analyses, as both the business case and pilot plan for this project are already created, it was evaluated if each document included all metrics as defined by the proposed process. For a project of this size, it is recommended by HQ processes that two project forms, the intake form and the A3, are completed to include with the business case for leadership approval. This project completed all three items and received business line approval for the project. When selecting an automated packaging vendor, they identified three vendors based on market research, tradeshows, and recommendations within the same industry. These three vendors were evaluated on cost, schedule, and capability where Zipper was ultimately selected. These actions for the select phase align with the proposed innovation process.

In the deploy phase, a pilot plan was developed that included all components as discussed in Section 2.3.5.1. Key metrics to evaluate in the pilot are displayed in Table 9.

Table 9: Zipper Pilot Performance Metrics

Metric	Target Condition Identified	Evaluated in Pilot	Business Case Metric
Labor Reduction	Yes	Yes	Yes
Cost	Yes	No	Yes
Machine Availability	Yes	Yes	No
Production Performance	Yes	Yes	No
Outbound Box Quality	Yes	Yes	No

As shown above, the pilot plan did not evaluate all metrics from the original business case and measured additional metrics in the pilot plan that were not included in the business case. It is recommended by the proposed innovation process in the future to keep consistent metrics across both the business case and pilot plan for clarity in performance improvement. Lastly, the pilot of Zipper was completed on time and within budget as compared with the plan.

3.5 Summary

In summary, the proposed process performed well when applied to a past successful innovation project such as Zipper. In the plan phase, the process allowed for the identification of corporate strategies and DC goals that demonstrated the Zipper investment was aligned with the North American supply chain network strategy to increase capacity and digital fulfillment capabilities. In the identify phase, the process's capacity analysis showed that DPVAS was the bottleneck for NADC in the short- and long-term peak seasons which also aligned with the investment of Zipper. Once DPVAS was identified as the constrained area in the DC, the evaluate phase in the process recommended the selection of a process-changing technology, specifically, an automated packaging machine. The select phase showed that Zipper's business case and vendor selection process aligned with the proposed innovation process. Lastly, in the deploy phase, it was identified that the Zipper pilot plan included all recommended metrics as per the proposed process. However, it is recommended that for future projects, there is a consistency between the performance metrics evaluated in the pilot and those presented in the business case.

The evaluation of the proposed innovation process using the past innovation project of Zipper at NADC was successful. The process recommended the correct technology type in the most constrained area of the DC based on strategic goals and it also allowed for clear business case development and piloting. Therefore, with this successful evaluation, Chapter 4 will now apply the process to NADC today to recommend an innovation for the DC teams to pursue.

Chapter 4
Innovation Framework Application

4 Introduction

The final analysis to complete using the proposed innovation process is to recommend an innovation that should be invested in at NADC today. This process application could be repeated to prioritize multiple different investments with different strategic goals. This will be further evaluated in Chapter 5.

As discussed in Section 1.1 and 1.2, NADC is large and complex distribution center that is omnichannel with most of its orders as footwear. Its layout is non-linear, and it relies on miles of conveyer to move orders back and forth across the building until they are shipped. It has been stated by several operators in the DC that their footwear selection processes are problematic. This was partially confirmed by the capacity analysis performed in Chapter 3. The next sections will aim to address these challenges at NADC and recommend an innovation to address the DC's constraints using the proposed innovation process.

4.1 Plan and Identify Analysis

The same strategic goals and plan phase will be used for this case study as the Zipper case study in Chapter 3. Increasing network capacity by increasing DC capacity has remained as the top priority since 2020. Again, the focus will be on throughput capacity evaluated using the capacity model that was developed and described in Section 3.2.1. Both a short-term (2022) and long-term (2023) analysis was performed to determine if the bottlenecks were temporary or permanent. Though this thesis was written in 2023, the analysis to determine how to address short-term bottlenecks at the DC was conducted in 2022. The same monthly scenarios were analyzed to simulate the capacity at different points of the year: April, July (back to school), and December (holiday). This analysis used the same parameters for each month as shown in Table 5.

Demand for each of these months was sourced from both past and current long-term forecasts depending on if the month had passed already.

4.1.1 Short-Term Capacity Outlook

Figure 9 shows the model results from the short-term capacity analysis run for April, July, and December of 2022.

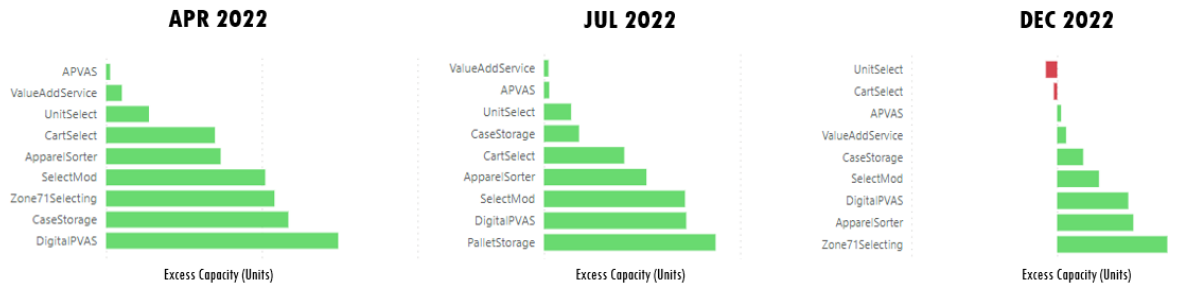

Figure 9: NADC Short-Term Capacity Analysis Results

In the graphs above, green bars show a positive difference between capacity and demand of a specific area in the DC. If the bar is red, this means there is a negative difference between capacity and demand and therefore, a capacity constraint in that area. These graphs show the same data as the long-term Zipper analysis with the exception that Zipper has been installed and DPVAS is no longer a bottleneck. In both April and July, NADC faces no capacity issues in the DC under these demand conditions. In the holiday peak season of December, two of the three footwear selecting areas, unit select, and cart select, have capacity constraints.

4.1.2 Long-Term Capacity Outlook

Figure 10 shows the model results from the long-term capacity analysis run for April, July, and December of 2023.

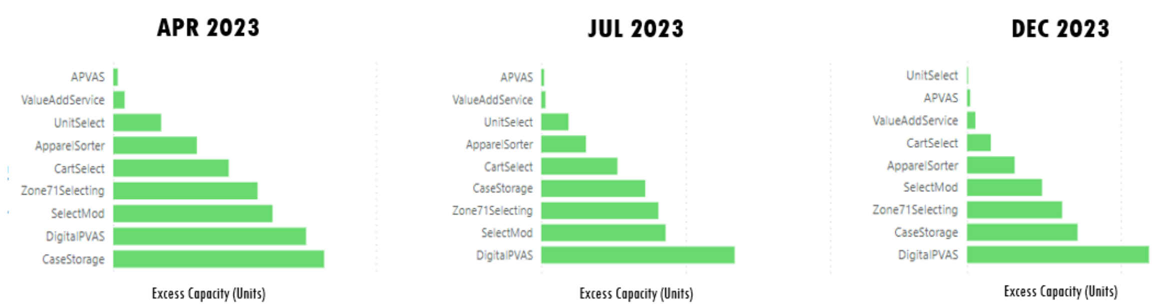

Figure 10: NADC Long-Term Capacity Analysis Results

These graphs show that in the long-term, there is no expected capacity constraints at the DC in the footwear selecting areas based on current forecasts. Therefore, it can be concluded that this is a temporary bottleneck. As the North American distribution network adds more regional nodes to service local digital demand, fulfillment of these orders shifts from NADC to these new nodes. Therefore, the trend shown above is expected in the long term.

4.1.3 Investment Area Recommendation

From the results above, it can be determined that both unit select and cart select are temporary bottlenecks for NADC in the short-term holiday season. Therefore, short-term investment should be made in these footwear selecting areas to address these capacity constraints. As this is a temporary bottleneck, process-changing technology should not be considered unless demand forecasts change, making this bottleneck either recurring or permanent.

4.2 Evaluate Analysis

With footwear selecting areas confirmed as the areas in the DC where innovation should be focused, an analysis of the four different innovation types was performed. This analysis is described below in Sections 4.2.1, 4.2.3, and 4.2.4. Though these areas have been shown to have temporary bottlenecks, the process-changing technology analysis was still performed to understand what potential options are available if demand forecasts were to change. For all financial calculations, a $50/unit cost is assumed for a unit that is not fulfilled in that month.

4.2.1 Process Changes

Starting first with process changes, as described in Section 1.1.3, the footwear selection process can be completed at any one of three available footwear selection areas: cart select, unit select, and select mod. Each selecting area is different in process and in size and has its own storage area for holding inventory. In both cart select and unit select areas, individual SKUs sit on shelves laid out in a large area over multiple floors. Associates push carts with totes on them and select designated items for each order before placing a finished tote on conveyer to travel to the next destination. Each SKU is only located in one location per floor. The only difference between these areas is the size of the selecting area. Unit select is much smaller than cart select. Select mod has modular square areas of shelving with SKUs on each module's shelves. Associates are assigned to specific modules and select items only from their modular areas of shelving. Once selected, they place items into a tote waiting near a conveyer belt within their modules. The tote is pushed onto the conveyer belt once the order has been fully selected. Inventory assignment to each of the three areas is most closely modelled as random. SKUs are not specifically assigned to one area. When a SKU runs out in an area, it is replenished if its demand is "high". There is no defined process for how SKUs are assigned to and removed from a selection area – if there is demand, a planner will put a SKU in whatever area has space. Some SKUs sit in footwear selection long after their demand has decreased.

Table 10 shows the current work split assumptions and operating parameters of the three footwear selection areas. Utilization in this table is defined as the proportion of current staffing compared to the maximum staffing allowable in a specific area. The UPH data per associate shown in the table below has been altered for confidentiality.

Table 10: Workload Split between Footwear Selection Areas

Area	Work Split Assumption	Utilization	UPH (minimum of Replen/Select)
Select Mod	40%	71%	60 (Select)
Cart Select	40%	87%	40 (Select)
Unit Select	20%	42%	35 (Select)

Both select mod and cart select are the two largest areas and select more orders than unit select which is physically smaller and less staffed. It can also be noted that cart select is already over-staffed with utilization 7% higher than the recommended 80%. Each area has a replenishment process where products are taken from storage and replenished at a desired location. Each area also has a selection process where products are selected from a desired location. The processing capacity of each area is shown in UPH and has been taken as the minimum of either the replenishment or selection process in each area. All areas above are limited by their selecting capacity and not their replenishing capacity. Select mod has the highest UPH of the three areas: it is approximately 20-25 UPH higher than unit select or cart select.

From the capacity analysis, in December of 2022, select mod has enough excess capacity to process the unprocessed units from both unit select and cart select. Therefore, allocating more work to select mod could alleviate capacity constraints altogether. However, this solution would involve enhanced forecast methods to improve DC planning. This improved planning would involve ensuring that the right inventory, and more of it, was placed in select mod to be selected by associates. To confirm feasibility of this solution, it is recommended that a storage space analysis is conducted at NADC to ensure there is no risk to adding more inventory to select mod.

With this valid solution, one should stop here while using the proposed innovation process. However, Sections 4.2.2, 4.2.3, and 4.2.4 will walk through the remaining innovation types in the evaluate steps to further show how the process could work if the solution above was not viable.

4.2.2 Staffing Changes

Looking at staffing next, it is possible to either augment staffing or reallocate staffing across the three areas. Table 11 shows the staffing augmentation analysis for all three areas of footwear selection over the 2022 Holiday season. The capacity deficit data (units and dollars) has been altered for confidentiality.

Table 11: Staffing Augmentation Analysis in NADC Footwear Selection

	Select Mod		Cart Select		Unit Select	
Metric	Current Staffing	Augmented Staffing	Current Staffing	Augmented Staffing	Current Staffing	Augmented Staffing
Utilization	71%	71%	87%	87%	42%	80%
Capacity Deficit	N/A	N/A	2% of demand	2% of demand	10% of demand	N/A

No additional staff were added to cart select as it was already over-staffed, and no additional staff were added to select mod as it was not capacity constrained. In unit select, to bring the capacity utilization to the recommended 80%, this would cost the DC money to add the additional staff and would debottleneck this area. In this case, the fixed cost per month of additional people is lower than the savings for this short-term temporary bottleneck. Therefore, augmenting the staff in unit select could be a good first step to addressing the capacity constraints at footwear selecting. However, it would not solve the issues in cart select. This leads to a secondary staffing analysis to reallocate some people from select mod to both cart select and unit select.

Table 12 below shows the staffing reallocation analysis for all three areas of footwear selection. These reallocations were obtained by moving people from select mod until both cart select and unit select no longer experienced capacity deficits.

Table 12: Staffing Reallocation Analysis in NADC Footwear Selection

Area	Staffing Change	New Utilization	Capacity Deficit
Select Mod	-20	64%	N/A
Cart Select	+4	88%	N/A
Unit Select	+16	47%	N/A

This analysis shows that by decreasing the staffing in select mod and moving these people to both unit select and cart select, the capacity constraints could be addressed. This would involve increasing the utilization in cart select by 1%, which is not ideal but is feasible. Like the process analysis above, though this solution is viable, it would be highly dependent on forecast accuracy and would likely involve used enhanced forecasting methods compared to what is used today. It is however aligned with current inventory planning practices and thus may require less change than the process change solution.

4.2.3 Process-Supporting Technology

Both the unit select and cart select areas use very similar processes when selecting footwear units. They can be broken out into their replenishment (replen) and selection processes as shown in Table 13.

Table 13: NADC Footwear Selection Processing Steps

Step	Current Process	Potential Supporting Tech	Expected Cost	Expected Gain
Replen	1. Product arrives on conveyer in shipping box 2. Add multiple shipping boxes of product to a cart and take each shipping box to specific location for replen	- Automated conveyer directly to replen area - Robotics to move replen inventory to designated area	Added conveyer to cart select and unit select; potential loss of storage space due to restructuring	Replen UPH/efficiency increases
Select	1. Locate and scan product 2. Select product and add to tote (on cart or individual) 4. Send tote on conveyer	- Co-bots (i.e., Locus)	Robots as a service (likely), software integration, training	Selecting UPH/efficiency increases

As the replenishment process is not a bottleneck for both areas, no investment is needed right now. In selecting, a technology that could be used and has been used by other DCs in the network is co-bot technology. This technology involves using both robotics and people together to complete a task. Specifically for selecting tasks, robots can travel to selecting locations and wait to be filled by an associate. Once they have the desired product, they transport the products to a conveyer area to be moved to packaging. These robots assist associates with selecting processes by shortening travel times and increasing efficiency. Given the layout of both cart select and unit select, associates do not face large travel times within in the area which is the main selling point of this technology. The cost of the co-bot solution would be more expensive than optimizing the current processes and staffing. Therefore, it is not recommended to invest in this solution to address capacity constraints. Co-bots could be used as a solution for a different strategic goal such as decreasing reliance on the labor workforce. It is recommended to perform a more in-depth analysis if the initial strategy were to change.

4.2.4 Process-Changing Technology

Investing in process changing technology is not recommended in this scenario as the footwear selection bottleneck is temporary based on current demand forecasts. This section will discuss two options for this type of innovation if demand forecasts were to change and NADC continued to fulfill large portions of digital footwear orders.

The first option is often discussed amongst employees of the DC as a desired state that would align with LS's "one-flow" principles. This solution would involve consolidating all three footwear selection areas into one large selection area. Due to the non-linear layout of NADC and the lack of option to shut down temporarily, this is a very complicated investment that would require multiple small steps and a near-perfect execution plan. To test if this solution is viable, two key assumptions were made. The first is that all average staffing numbers were added to one selecting area. This assumes no total increase or decrease in staffing across footwear selecting. The second assumption is that overall efficiency of the area would increase by 15% due to a less complicated workflow. It was next decided that if NADC were to choose one selection area to grow, it would be select mod as it is the most efficient of the three areas. Table 14 shows the results of this analysis. The actual capacity deficit data (units and dollars) has been altered for confidentiality.

Table 14: Single Footwear Selecting Area Analysis Results

Metric	Multiple Select Areas	Single Select Area
Efficiency	41%	56%
Selecting Capacity Deficit	12% of demand	N/A

The results above show that when adding the additional staff from unit select and cart select to select mod assuming this area was large enough to support the increase in staffing and thus increasing efficiency, the single select mod selecting area can process all units with additional capacity available. This investment is viable, though complicated, and should be reevaluated in the future if demand forecasts change. Having one footwear selection area also removes the need for workload and staffing allocations between three different areas.

The second process-changing technology to evaluate is goods-to-person selection. One example of this type of innovation is ASRS. There are several execution challenges that face the DC team when considering ASRS at NADC, namely, the entire roof would need to be raised to support the system. Research completed in 2019-2020 at the same DC stated that implementation of ASRS could decrease processing time in storage and retrieval by 67% and total DC processing time by 37% with a return on investment projected to be 4 to 5 years, [16]. At the time this research was completed, the outlook for digital growth for this DC was much higher as no new nodes were projected to be added to the North American network to support this demand. Therefore, it is expected that the new ROI for ASRS in the DC today will be lower. Goods to person technology has been shown to be one of the most efficient ways to retrieve and select in many different industries. Therefore, it is recommended to consider this technology when a permanent bottleneck is expected or when constructing a new node in the network.

4.2.5 Innovation Type Recommendation

After evaluating all four innovation types to address the capacity constraints in both short-term and long-term peak seasons at NADC, a stop light summary diagram was generated and is presented in Table 15. Green means that capacity gain is fully recouped, estimated cost is low relative to other options, and the estimated gain/ROI is high relative to the other options. Red means that capacity gain is not recouped, estimated cost is high relative to other options, and the estimated gain/ROI is low relative to other options. Yellow means that it falls somewhere between the two other color options. In this graph, a labor reliance metric was added to better understand how these technologies would decrease reliance in the workforce.

Table 15: Summary of NADC Evaluate Analysis

Innovation Type	Description	Capacity Gain	Labor Reliance	Estimated Cost ($)	Estimated Gain/ROI ($)
Process	Optimize workload assignment				
People	Reallocate staffing				
Process-Supporting Technology	Automated conveyer for replen				
	Co-bots for selecting				
Process-Changing Technology	Single selecting area				
	Goods to person				

Based on the table above, it is recommended to implement process and people optimizations to address capacity constraints in the footwear selecting area of NADC. It is also recommended to consider slowly implementing a single selection area solution for footwear if capacity constraints are expected to persist over a longer period. Co-bot and goods-to-person solutions are not recommended with the current demand outlook but can be reevaluated if forecasts are expected to change or if recommended by a different strategy.

4.3 Select and Deploy Analysis

Starting with the select phase, when implementing a process or people solution, there is no vendor requirement. A business case including metrics such as throughput actuals, financial savings, and labor hours is required. Final approvals would stay at the DC level. When implementing the single selection area solution, this will need to be executed in smaller projects over a longer period. Some vendor requirements would include conveyer, structural/civil, and demolition. Existing contracts should be leveraged where possible. Finally, a business case including the A3, and project intake forms should be developed with metrics such as throughput actuals, financial savings, and efficiency increases. This would require final approval at the HQ level.

In the deploy phase, for process and people solutions, the timeline of the pilot would be approximately one month. If this month was successful, the pilot could be extended over a longer period, or the change could be fully implemented. The cost of the pilot would largely involve labor cost for implementing a process change or adding new people. It is recommended that the pilot be executed in the DC itself to show how the innovation performs in real conditions for the best feedback. Finally, the metrics stated in the business case should also be measured in the pilot. Specifically, throughput actuals before and after the change, financial savings, and labor hours. For the single selection area solution, the pilot would need to be also broken into smaller chunks of time likely one to two months each. Cost estimates would involve all infrastructure changes required plus additional labor hours if applicable. It is recommended to pilot these changes in the DC where it is possible to simulate real DC conditions. Finally, metrics measured in the pilot should align with what was presented and approved in the business cases.

4.4 Summary

Understanding how a company's strategic goals are prioritized and achieved at the DC level is crucial for innovating in the most impactful areas. The innovation process above was applied with a DC capacity growth goal which could change in the future. Once the strategic goal was identified, the innovation process showed that NADC has two of their three footwear selection areas, unit select and cart select, under capacity for the short-term peak season. This outlook improves in the long-term as more digital demand moves to other nodes in the network. It was found that this temporary bottleneck could be addressed using innovations such as process and people optimization in the DC. Specifically, this involves the reallocation of orders to select mod or the reallocation of people to unit select and cart select from select mod. Though these solutions are effective, they do require enhanced forecasting methods to ensure viability. In the long term, it is recommended to reevaluate the single selection area solution to address capacity constraints should they persist. This solution removes the need for work assignment to selecting areas and aligns with LS principles. Finally, in implementing any of these solutions, vendor selection is potentially required, and a business case should be developed with metrics such as throughput capacity, financial savings, efficiency increases, and labor hours defined. It is recommended that the pilot plan evaluates metrics defined in the business case and takes place in the DC over a one-to-two-month period.

In summary, the proposed process was successful in quantitatively identifying the bottlenecks that were experienced by the operations and engineering teams at NADC. Final conclusions, lessons learned, and next steps in improving this work are presented in the following chapter.

Chapter 5
Conclusions and Recommendations

5 Introduction

Chapter 3 and Chapter 4's case studies have shown that the proposed innovation process developed in this thesis adds structure to fostering innovation at the DC level. This process is loosely structured and only five steps long to mesh well with the structure and culture of Neilos. During the development and application of this process, there were several lessons learned and recommendations for future work that will be captured in the following sections of this Chapter.

5.1 DC Innovation Process Conclusions

The original goal of this thesis was to propose an end-to-end process for innovation within the four walls of Neilos's omnichannel DCs that will recommend the best innovation to address the current business environment trends. The hypothesis associated with this goal was that if innovation selection and deployment could be driven by corporate business strategy, then the good investments would be made that target the right areas in the DC and are the most beneficial to achieving that business strategy. The research and development of the proposed innovation process as discussed in Sections 2.1 and 2.2 and the application of the proposed process in Chapters 3 and 4 supports this hypothesis and this main project goal. Adding a planning step to identify business strategies at the beginning of the process was truly what drove the outcome of the following process steps. By connecting innovation to business strategy, the process allowed the DC team to:

(1) Add structure to their current processes for innovation.

(2) Focus on the why, where, and how of an innovation before executing.

(3) Improve geo/global silos.

(4) Create short-term and long-term DC investment plans.

(5) Create standardized business cases with metrics that connect to pilot plans.

The Zipper case study evaluation further supports that this process will recommend the best innovation for the business strategy selected. The NADC case study application showed that innovation can be thought of in a broad sense and innovative solutions that support business strategy do not always involve the addition of new technologies.

This process is truly a starting point for the DC team to continue developing their innovation strategies and has many additions that could be made to further enhance it. These recommendations for future work are discussed in Section 5.2.

5.2 Recommendations for Future Work

Despite the success of this process, there were many lessons learned and recommendations that were captured through the course of this project. It is broadly recommended to continue to iterate on this process and to take a full project from idea conception to handover through it to further understand what gaps exist and how they can be improved. The following sections highlight five main recommendations that should be considered when further applying this process at the DC in the future.

5.2.1 Team Communication

As discussed in Section 2.1.1, the structure at Neilos plays a huge role in its innovation processes and what projects are pursued. Currently, HQ and DC teams are siloed and do not communicate often when assessing innovation at the DC level. This results in the HQ teams not receiving feedback from the DC on what tools and/or processes that would be most effective and the DC teams not receiving feedback from HQ on what business strategies should be executed and what new tools they could use to improve performance. Therefore, it is first recommended to increase communication between both the geo and global teams in these locations to ensure that the right innovations are executed in the right locations at the right times.

The proposed innovation process aims to highlight where connections between the teams are most crucial; specifically in the plan and select phases. At the beginning of an innovation project, it should be very clear what the goal of the innovation is for both teams. Also, when creating the business case for approval, it should be clear what metrics are being evaluated, the projected costs, and who is approving the go or no-go decision. It is therefore recommended that both teams increase their communication when applying these phases of the innovation process for optimal results. Outside of the scope of this project, it is recommended to further investigate how communication could be improved between both teams without fundamentally changing the organizational structure of the company.

5.2.2 Strategic Goals and the Plan Phase

Adding a planning and goal setting phase to the proposed process not only helps to focus the intent of the innovation but also completely defines what innovation is recommended in the following phases. Over the course of this project, the plan phase has only focused on one strategic goal: increase DC throughput capacity. The case study in Chapter 4 shows that in the long-term, DC throughput capacity does not present any issues; however, there are still many opportunities for innovation at the DC level and beyond. Some such goals may include improving sustainability practices, reducing shipping times to customers, and reducing labor reliance.

As discussed in Section 1.2, there are many different priorities outside of throughput capacity growth such as sustainability, labor reliance, and storage capacity. Therefore, it is recommended to update the plan phase to include the evaluation of multiple prioritized goals where applicable to capture the complexity of the different challenges faced at the DC and corporate levels of the company. This recommendation will also require changes to the identify phase as different analyses will be needed to identify the best areas for investment based on the goals determined in the plan phase.

5.2.3 Capital Plan Development

Based on long-term strategic priorities and updates to the plan phase as discussed in the previous section, it is recommended that the proposed innovation process is used as the basis for the development of a capital plan at the company. A capital plan is defined as a list of investments that are scheduled for development and execution with associated timelines over the next three to five years. Right now, the company does not look this far into the future at the DC level which causes some confusion and lack of focus when pursuing innovations. By having a capital plan that is adjusted as needed in the long-term, DC teams can better budget their resources and concentrate on the most important innovations for the DC.

It is recommended that this plan is developed at the DC level and provided to HQ for approval. Currently, capital budgeting is not based on specific projects as they do not know what will be pursued in the short- and long-term. Therefore, this plan should also feed into the budget for DC capital investments to make more informed yearly budgets.

5.2.4 Capacity Modelling

This project focuses and relies highly on DC capacity modelling. Though this modelling will not always be applicable to the proposed innovation process based on the goals identified in the plan phase, it is recommended to continue building capacity models to further understand how the DC is performing on a daily and monthly basis. Through the development of the capacity model used in this project, there are several recommendations for improved modelling:

(1) Consider using different modelling software than Power BI.

(2) Build a model with the ability to constrain demand based on DC bottlenecks.

(3) Include a simple user interface with dynamic parameters that update the model in real time.

(4) Redo time studies and update SAM values for each area of the DC.

(5) Understand how demand is prioritized in the DC and use this to improve capacity/demand estimates.

The first recommendation is to consider using a different modelling platform than Power BI. Power BI allowed for the quick construction of a Sankey diagram which was a powerful visual tool to model DC flows; however, it lacked multiple functionalities such as building capacity constraints, using dynamic parameterization, and performing analysis within the model. If this software is used in the future, it is recommended that all data is pre-processed before it is brought into the model to avoid the restrictions within Power BI itself. A case could be made to invest in capacity modelling software that is specialized for DC and warehouse modelling. This investment should be evaluated and highly considered to assist in the capacity planning, staffing optimizations, and investment decisions.

The second recommendation is to include capacity constraints in the model. Though the Sankey diagram was a great visual tool to understand how product flows through the DC, it lacked the ability to include capacity constraints at each area thus modelling unconstrained demand. It would be great to include these constraints to more accurately model how product flows through the DC.

The third recommendation is to invest in modelling that has a simple user interface so that many different people can use the model. With the current models in use, only DC teams with an expert knowledge of DC operations and analytics can update the models. The Power BI model built for this project aimed to simplify the user interface to make capacity modelling more accessible to the broader DC teams. This strategy should be kept for all future modelling improvements. In addition, it is recommended to pursue modelling that can support dynamic parameters for users to adjust that update the model in real time. With the Power BI model, the user must update the spreadsheet that feeds the model and then refresh the model to update the results. It would save time and would result in a more intuitive interface if parameters such as staffing numbers could be adjusted with a slider in the model itself.

The fourth recommendation is to redo the time studies that generated the SAM values used in the Power BI capacity model and current capacity models. These values have not been updated since the implementation of Zipper and should be retaken to ensure that the capacity values generated by capacity modelling are accurate. For the Power BI model, efficiency values were adjusted if there was a large discrepancy found between the calculated capacity and what was processed by a given area.

The final recommendation is to identify the prioritization of demand in the DC and include it in the model. When capacity is less than demand, it is unclear which channels and product engines are prioritized for processing and which channels and product engines do not progress past a specific area. To improve accuracy of DC product flows, this logic should be included in all future capacity modelling efforts.

5.2.5 Business Case Development and Piloting

It was identified in both case studies that standardized business cases should be developed and used for all future innovation projects. It is recommended to develop formalized templates for business case development that are selected depending on project size and cost. In these templates, approvers should be clearly identified, and metrics should be standardized. Having these standardized business cases with known metrics will decrease time spent on business case development and increase the chances of approval when approving at the HQ level by having a familiar format for senior managers to review.

Piloting performance metrics should always be tied back to the metrics identified in the business case. This will improve the ease of the go or no-go decision as it is clear when a project is under performing. Finally, it is recommended to pilot innovation projects in the DC where it is possible to better simulate real conditions.

5.3 Summary

In summary, this project identified an innovation process that can work for this specific company and can be adjusted for other areas of the business and other companies to best fit desired goals. The process performed well when used on a past innovation project and recommended investment in an area of the DC today that anecdotally has been the main problem area experienced by operators in the short- and long-term. Through its development, there are several recommendations for future work to improve the process. These specifically include improving communication between the DC and HQ, updating the plan phase to reflect multiple strategic goals, developing a capital plan for the DC, investing in improved capacity modelling, and standardizing business cases and pilot plans.

Appendix A

Demand Equation for Power BI Capacity Model by Source and Destination

N.B. Model parameters are shown in blue font.

Source	Destination	Demand Equation
Receiving	Case Storage	$Monthly\ FW\ Demand * Case\ Storage\ \%$
Receiving	Pallet Storage	$Monthly\ FW\ Demand * Pallet\ Storage\ \%$
Receiving	Apparel Storage	$Monthly\ AP\ \&\ EQ\ Demand$
Case Storage	Routing Sorter	$Monthly\ FW\ Demand * Case\ Storage\ \%$
Pallet Storage	Routing Sorter	$Monthly\ FW\ Demand * Pallet\ Storage\ \%$
Pallet Storage	STTL	$Monthly\ FW\ Demand * STTL\ \%$
STTL	Routing Sorter	$Monthly\ FW\ Demand * STTL\ \%$
Apparel Storage	Routing Sorter	$Monthly\ AP\ \&\ EQ\ Demand$
Routing Sorter	Unit Select	$Monthly\ FW\ Demand * Unit\ Select\ \%$
Routing Sorter	Cart Select	$Monthly\ FW\ Demand * Cart\ Select\ \%$
Routing Sorter	Select Mod	$Monthly\ FW\ Demand * Select\ Mod\ \%$
Routing Sorter	Apparel Selecting	$Monthly\ AP\ \&\ EQ\ Selecting\ Demand$
Routing Sorter	DPVAS	$Monthly\ Digital\ FW\ Demand * Digital\ Singles\ \% * INT\ 10\%\ of\ Singles$
Routing Sorter	VAS	$Monthly\ Total\ Demand * Full\ Case\ \% * Full\ Case\ VAS\ \%$
Routing Sorter	PANDA	$Monthly\ Total\ Demand * Full\ Case\ \% * (1 - Full\ Case\ VAS\ \%)$
Routing Sorter	Apparel Sorter	$Monthly\ AP\ \&\ EQ\ Demand * Repack\ \% - Monthly\ AP\ \&\ EQ\ Selecting\ Demand$
Routing Sorter	Mixed Sorter	$Monthly\ FW\ Demand * Repack\ \% - Monthly\ FW\ Selecting\ Demand - Monthly\ Digital\ FW\ Demand * Digital\ Singles\ \% * INT\ 10\%\ of\ Singles$

Apparel Selecting	Apparel Sorter	$Monthly\ AP\ \&\ EQ\ Selecting\ Demand$
Apparel Selecting	Mixed Sorter	$Monthly\ AP\ \&\ EQ\ Selecting\ Demand$
Unit Select	DPVAS	$Monthly\ Digital\ FW\ Selecting\ Demand * Digital\ Singles\ \% * Unit\ Select\ \% * (1 - Singles\ to\ the\ Sorter\ \%)$
Unit Select	Mixed Sorter	$Monthly\ Digital\ FW\ Selecting\ Demand * \big(Digital\ Singles\ \% * Unit\ Select\ \% * Singles\ to\ the\ Sorter\ \% + Unit\ Select\ \% * (1 - Digital\ Singles\ \%)\big) + Monthly\ Non\ Digital\ FW\ Selecting\ Demand * Unit\ Select\ \%$
Cart Select	DPVAS	$Monthly\ Digital\ FW\ Selecting\ Demand * Digital\ Singles\ \% * Cart\ Select\ \% * (1 - Singles\ to\ the\ Sorter\ \%)$
Cart Select	Mixed Sorter	$Monthly\ Digital\ FW\ Selecting\ Demand * \big(Digital\ Singles\ \% * Cart\ Select\ \% * Singles\ to\ the\ Sorter\ \% + Cart\ Select\ \% * (1 - Digital\ Singles\ \%)\big) + Monthly\ Non\ Digital\ FW\ Selecting\ Demand * Cart\ Select\ \%$
Select Mod	DPVAS	$Monthly\ Digital\ FW\ Selecting\ Demand * Digital\ Singles\ \% * Select\ Mod\ \% * (1 - Singles\ to\ the\ Sorter\ \%)$
Select Mod	Mixed Sorter	$Monthly\ Digital\ FW\ Selecting\ Demand * \big(Digital\ Singles\ \% * Select\ Mod\ \% * Singles\ to\ the\ Sorter\ \% + Select\ Mod\ \% * (1 - Digital\ Singles\ \%)\big) + Monthly\ Non\ Digital\ FW\ Selecting\ Demand * Select\ Mod\%$

DPVAS	PANDA	$Monthly\ Digital\ FW\ Selecting\ Demand * Digital\ Singles\ \% * (1 - Singles\ to\ the\ Sorter\ \%) + Monthly\ Digital\ FW\ Demand * Digital\ Singles\ \% * INT\ 10\%\ of\ Singles$
Apparel Sorter	Apparel VAS	$Monthly\ AP\ \&\ EQ\ Demand * Repack\ \% * VAS\ \%$
Apparel Sorter	PANDA	$Monthly\ AP\ \&\ EQ\ Demand * Repack\ \% * (1 - VAS\ \%)$
Mixed Sorter	VAS	$Monthly\ FW\ Demand * Repack\ \% - Monthly\ Non\ Digital\ FW\ Selecting\ Demand * (1 - VAS\%) - Monthly\ Digital\ FW\ Demand * Digital\ Singles\ \% * INT\ 10\%\ of\ Singles + Monthly\ Digital\ FW\ Selecting\ Demand * Digital\ Singles\ \% * Singles\ to\ the\ Sorter\ \% + Monthly\ Digital\ FW\ Selecting\ Demand * (1 - Digital\ Singles\ \%)$
Mixed Sorter	PANDA	$Monthly\ FW Demand * Repack\ \% - Monthly\ Non\ Digital\ FW\ Selecting\ Demand * VAS\% - Monthly\ Digital\ FW\ Demand * Digital\ Singles\ \% * INT\ 10\%\ of\ Singles + Monthly\ Digital\ FW\ Selecting\ Demand * Digital\ Singles\ \% * Singles\ to\ the\ Sorter\ \% + Monthly\ Digital\ FW\ Selecting\ Demand * (1 - Digital\ Singles\ \%)$
Apparel VAS	PANDA	$Monthly\ AP\ \&\ EQ\ Demand * Repack\ \% * VAS\ \%$

VAS	PANDA	$Monthly\ Total\ Demand * (Full\ Case\ \% * Full\ Case\ VAS\ \% + Repack\ \%) - Monthly\ Non\ Digital\ FW\ Selecting\ Demand * (VAS\ \% - 1) - Monthly\ Digital\ FW\ Demand * Digital\ Singles\ \% * INT\ 10\ \%\ of\ Singles + Monthly\ Digital\ FW\ Selecting\ Demand * \left(Digital\ Singles\ \% * Singles\ to\ the\ Sorter\ \% + (1 - Digital\ Singles\ \%)\right) - Monthly\ AP\ \&\ EQ\ Demand * Repack\ \% * VAS\ \%$
PANDA	Shipping	$Monthly\ Demand$

Operational Capacity Equation for Power BI Capacity Model by Destination

N.B. Model parameters are shown in blue font. All parameters have different values depending on the destination area. Also, staffing actual hours are the actual historical hours worked in a specific destination.

Destination	Ops Capacity Equation
Pallet Storage	$Staffing\ Actual\ Hours * \%\ Time\ Spent\ on\ Retreival * Efficiency * Units\ per\ Hour$
Case Storage	$Staffing\ Actual\ Hours * \%\ Time\ Spent\ on\ Retreival * Efficiency * Units\ Per\ Hour$
STTL	$Staffing\ Actuals\ Hours * Cases\ per\ Hour * Full\ Case\ UPC * Efficiency$
Routing Sorter	N/A
Cart Select	$Staffing\ Actual\ Hours * Selecting\ \%\ of\ Max\ Capacity * Efficiency * Units\ Per\ Hour$
Unit Select	$Staffing\ Actual\ Hours * Selecting\ \%\ of\ Max\ Capacity * Efficiency * Units\ Per\ Hour$
Select Mod	$Staffing\ Actual\ Hours * Selecting\ \%\ of\ Max\ Capacity * Efficiency * Units\ per\ Hour$
Mixed Sorter	$Staffing\ Actual\ Hours * Efficiency * Units\ per\ Hour)$

DPVAS	$Staffing\ Actual\ Hours * Efficiency * Units\ per\ Hour + Packsize\ Hours * Packsize\ Units\ per\ Hour * Number\ of\ Packsize\ Machines$
VAS	$Staffing\ Actual\ Hours * Efficiency * Units\ per\ Hour$
PANDA	N/A
Apparel Storage	$Staffing\ Actual\ Hours * Efficiency * \frac{Cases\ per\ Hour}{Full\ Case\ UPC}$
Apparel Selecting	$Staffing\ Actual\ Hours * Efficiency * Units\ Per\ Hour$
Apparel Sorter	$Staffing\ Actual\ Hours * Efficiency * Units\ per\ Hour)$
Apparel VAS	$Staffing\ Actual\ Hours * Efficiency * Units\ per\ Hour)$
Shipping	$Staffing\ Actual\ Hours * Efficiency * \frac{Cases\ per\ Hour}{Full\ Case\ \% * Full\ Case\ UPC + Repack\ \% * Repack\ UPC}$

<u>MHE Capacity Equation for Power BI Capacity Model by Destination</u>

N.B. Model parameters are shown in blue font. All parameters have different values depending on the destination area. Machine hours are associated with the lower capacity of a machine itself (i.e., routing sorter) or associated conveyer in the area).

Destination	MHE Capacity Equation
Case Storage	N/A
Pallet Storage	N/A
STTL	N/A
Routing Sorter	$Machine\ Hours * Efficiency * \frac{Cases\ per\ Hour}{Full\ Case\ UPC}$
Cart Select	$Machine\ Hours * Efficiency * \frac{Cases\ per\ Hour}{Repack\ UPC}$

Unit Select	$Machine\ Hours * Efficiency * \frac{Cases\ per\ Hour}{Repack\ UPC}$
Select Mod	$Machine\ Hours * Efficiency * \frac{Cases\ per\ Hour}{Repack\ UPC}$
Mixed Sorter	$Machine\ Hours * Efficiency * \frac{Cases\ per\ Hour}{Repack\ UPC}$
DPVAS	$Machine\ Hours * Efficiency * \frac{Cases\ per\ Hour}{Repack\ UPC}$
VAS	$Machine\ Hours * Efficiency * \frac{Cases\ per\ Hour}{(Full\ Case\ \% * Full\ Case\ UPC + Repack\ \% * Repack\ UPC)}$
PANDA	$Machine\ Hours * Efficiency * \frac{Cases\ per\ Hour}{(Full\ Case\ \% * Full\ Case\ UPC + Repack\ \% * Repack\ UPC)}$
Apparel Storage	N/A
Apparel Selecting	$Machine\ Hours * Efficiency * \frac{Cases\ per\ Hour}{Repack\ UPC}$
Apparel Sorter	$Machine\ Hours * Efficiency * \frac{Cases\ per\ Hour}{Repack\ UPC}$
Apparel VAS	$Machine\ Hours * Efficiency * \frac{Cases\ per\ Hour}{Repack\ UPC}$
Shipping	$Machine\ Hours * Efficiency * \frac{Cases\ per\ Hour}{(Full\ Case\ \% * Full\ Case\ UPC + Repack\ \% * Repack\ UPC)}$

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