Accelerating the Integration of Low-Volume, High-Mix Production Organizations

by

Priya Chacko

B.S. Biomedical Engineering with Honors, The University of Texas at Austin (2015)
B.A. Plan II with Honors, The University of Texas at Austin (2016)

Submitted to the MIT Sloan School of Management and the Department of Mechanical Engineering in partial fulfillment of the requirements for the degrees of

Master of Business Administration
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Author ………
MIT Sloan School of Management
Department of Mechanical Engineering
May 10, 2024

Certified by ……
Jung-Hoon Chun, Thesis Supervisor
Professor of Mechanical Engineering

Certified by ……
Yanchong Karen Zheng, Thesis Supervisor
Associate Professor of Operations Management

Accepted by ……
Nicolas Hadjiconstantinou
Chair, Mechanical Engineering, Committee on Graduate Students

Accepted by ……
Maura Herson
Assistant Dean, MBA Program, MIT Sloan School of Management

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Abstract

In private equity, the buy-and-build strategy may be used to perform horizontal acquisitions of targets that operate in the same industry and interact with similar customers and suppliers. This strategy increases the buyer's market share in the field, diversifies its customer base, provides opportunities for the realization of synergies, and may even add new capabilities to its offerings. The consolidated platform company can then achieve a value that is significantly higher compared to that of the individual portfolio companies alone. This increased value from the combination of portfolio companies, however, is dependent on their successful integration into the platform company.

This research investigates the unique challenges of aligning and integrating two independent production organizations that operate in the low-volume, high-mix (LVHM) metal fabrication sector. The research strategy used in this thesis begins with defining objectives and establishing the initial states of the portfolio companies. Then, a gap analysis and strategic benchmarking are performed to identify integration opportunities. Finally, proposals to accelerate integration in operations are provided: the first proposes increasing automation in production data management, and the second proposes a method to allocate indirect costs and better understand total costs during billing in the quote creation process.

Though time and resource constraints prevented the proposed recommendations from being implemented during this research period, these recommendations have the potential for substantial positive impact on both platform and portfolio company operations. While the proposals are tailored to the organizations studied in this research, the broader concepts on which they are based suggest wider applicability to similar LVHM production environments. This thesis offers a framework for organizations to assess their initial and goal states, define objectives, and develop strategies to accelerate integration.

Dr. Jung-Hoon Chun, Thesis Advisor
Title: Professor of Mechanical Engineering

Dr. Yanchong Karen Zheng, Thesis Advisor
Title: Associate Professor of Operations Management

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This thesis would not have been possible without the guidance and support of many parties.

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To my project sponsor, Brian Yoder, thank you for trusting me with this research opportunity. Thank you for your patience as I learned a new industry, for your flexibility in providing the freedom for me to explore within the platform, and for your guidance throughout my project. Your leadership taught me many lessons that I plan to carry forward into my career. I hope this research has a positive impact and proves to be useful, especially as Weller continues to grow. I am proud to have been the second employee of Weller Metalworks, and I am excited to see what lies ahead for the team.

To the teams at Laser Precision and Muthig Industries, thank you for welcoming me to the Midwest and into your companies. You both have built extraordinary organizations, and I feel very lucky to have been part of your next chapter. I am thankful for our time together, and I hope our paths will cross at some point in the future.

To my thesis advisors, Jung-Hoon Chun and Karen Zheng, thank you both for the guidance provided throughout my internship. From helping me narrow the scope of this project to teaching me about production costs, you both played key roles in shaping my learnings from this experience. Thank you for posing challenging questions, providing helpful advice, reviewing my data analyses, guiding me to conclusions, and supporting me through each stage of this research.

To my friends, thank y'all for the catch-up phone calls, care packages, postcards, and visits during this chapter of my life. I appreciate each and every gesture more than you know. Thanks for keeping me grounded and connected to a community for which I am beyond thankful.

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To my partner, Mason, thank you for reminding me what is truly important and for pushing me to rise to the challenges throughout my time in graduate school.

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Chapter 1. Introduction

1.1 Project Origin and Context

LFM Capital, a Nashville-based private equity company that invests in small and medium-sized manufacturing businesses, developed a new platform company focused on best-in-class machining and metal fabrication. Specifically, the platform is built around low-volume, high-mix (LVHM) contract manufacturing environments that primarily rely on make-to-order manufacturing strategies and, in which businesses produce a wide variety of custom products at low quantities. The LVHM platform came to be named Weller Metalworks, and its focus is on acquiring individual businesses in this manufacturing space and converting these fragmented organizations into a consolidated company that leverages synergies in order to drive growth and achieve operational excellence. With such a goal in mind, there exists a need for an integration playbook to guide the integration of acquisitions for this platform and to ensure that this process is well-managed, consistent, and successful by providing a roadmap for navigating the complexities of merging distinct entities into a consolidated, unified business. This research details the development of this framework based on the opportunities for alignment with the goal of accelerating the integration of the current portfolio companies.

The goal of Weller Metalworks is to acquire and integrate five or more businesses to provide customers with products of all stages, from prototype to end-of-life, in order to capitalize on the greater margin potential of these highly customized parts. At the start of this research in June 2023, there was only one company, Muthig Industries (also referred to as Muthig), that had been acquired in the LVHM platform, but another company, Laser Precision, was actively in the closing process at that time. The first company, Muthig Industries, closed in late May 2023, and the second company, Laser Precision, eventually closed on July 14, 2023. These two companies act as locations from which Weller Metalworks operates, and the organizational structure of Weller Metalworks during the time of this research can be seen in Figure 1-1.

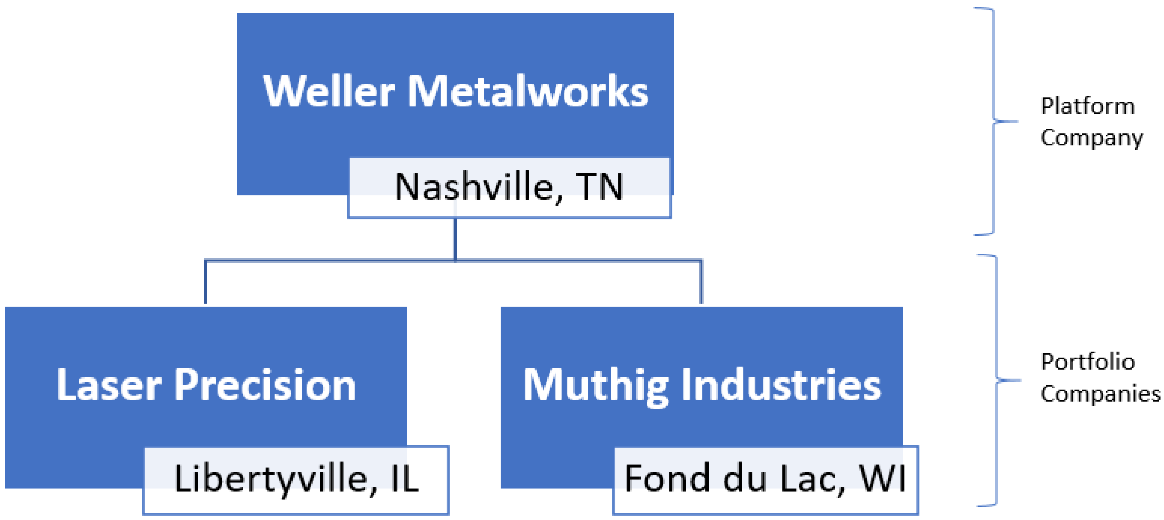

Figure 1-1. Organizational Structure of Weller Metalworks

Laser Precision and Muthig Industries comprise the initial acquisitions in the LVHM platform: as such, in the context of this research, they serve as case studies of different stages in the integration process and establish milestones in the integration timeline for the playbook. The integration strategies discussed in this thesis focus on the operations of these two companies.

1.2 Project Motivation

The motivation for this research is to develop a comprehensive framework that can be used in subsequent acquisitions to enable seamless consolidation and integration into the platform company, and this thesis documents how this framework applies to the current portfolio companies. Integrating companies that have been independently owned and operated for decades poses significant challenges, not only in terms of production processes but also in regard to unique operating systems, company cultures, and organizational structures. This is especially true in the low-volume, high-mix environments that are subject to a high degree of variability in the customer demand signal, production schedule, and manufacturing process. The goal, therefore, of this research is to consider these various layers of complexity, peeling each one back to find best practices, opportunities for improvement, and potential for realignment, and to achieve market competitiveness through operational excellence and sustained growth.

1.3 Project Methodology

The methodology for this research incorporates both a bottom-up and top-down approach to develop a deeper understanding of the individual businesses themselves as well as the methods by which they can best collaborate and operate as a consolidated company. This requires an evaluation of each of the acquisitions to inform strategic benchmarking and to gain further knowledge about their respective systems, processes, and cultures – all of which is information that factors into the creation of strategies for integration. Simultaneously, the platform company's goals and priorities were assessed to focus the integration efforts on specific areas and help shape the overall integration framework. Both perspectives are necessary to achieve a successful integration, driving growth and cohesion amongst the businesses in the LVHM portfolio.

1.3.1 Bottom-Up Approach

For this research project, the bottom-up approach seeks to evaluate the individual components of the whole by building a foundation of knowledge for each of the portfolio companies within the LVHM platform. This exploratory methodology involves surveying the operations, assessing the processes, and analyzing the systems on which the business relies. This starts with first gathering data at the local level to lay the initial framework and then building upon that framework to examine specific areas of interest. This foundation will be further developed by interviewing the subject matter experts and gathering input from the technical leaders at each site to identify local best practices, which will subsequently inform how these standards may be applied broadly to the LVHM platform. This internal benchmarking will allow the platform to capitalize on each company's strengths while proactively identifying and mitigating any potential integration risks specific to each business. By focusing on the individual businesses, the bottom-up approach provides insights into how the integration playbook can be created in such a way that considers each of the complex and unique ecosystems present.

1.3.2 Top-Down Approach

Conversely, the top-down approach views the integration of each acquisition through the perspective of the LVHM platform as a whole. This includes first establishing the high-level business priorities for the overall platform company and then building the integration strategy around those ideas. This strategy will trickle down from the platform company level to the interactions between portfolio companies and even further to each company's functional areas and business processes. This approach enforces consistent alignment in each integration and facilitates coordination among the various acquisitions. The long-term goals for the platform company and the strategy for how to achieve those goals govern the integration of each acquisition by prioritizing the efforts that best align with and add the most value to the platform overall. By creating the integration strategy from the perspective of consolidated portfolio company rather than that of the individual acquired businesses, the top-down approach identifies how to build connections and leverage synergies among the portfolio to achieve the overall platform goals.

1.4 Thesis Overview

This thesis is organized into four primary sections: Introduction and Background, Research and Integration Overview, Integration Investigation, and Recommendations and Conclusions. The Introduction and Background section includes this introduction (Chapter 1); a summary of the industry, platform company, and each portfolio company (Chapter 2); and a review of academic literature related to the thesis topic (Chapter 3). The Research and Integration Overview section describes the research strategy and data sources used in this thesis (Chapter 4), and it explores the objectives of both the platform company as well as those of the portfolio companies (Chapter 5). The Integration Investigation section first establishes the initial state of each site (Chapter 6), outlines the key integration considerations for select functional areas (Chapter 7), and details two operations processes as case studies in integration strategy – operational data management (Chapter 8) and quote creation (Chapter 9). The final section, Recommendations and Conclusions, suggests potential opportunities for operational improvements throughout the platform (Chapter 10) and summarizes the findings from this research (Chapter 11).

Chapter 2. Background

This chapter first provides an overview of the machining and fabrication industries as context for the manufacturing environments in which this research was conducted. Then, more specific background information is provided on the low-volume, high-mix platform, Weller Metalworks, as well as its two locations, Laser Precision in Libertyville, Illinois and Muthig Industries in Fond du Lac, Wisconsin. The information on each location's history and operations sets the scene for this research, informs the bottom-up approach to integration, and guides how the integration framework was developed.

2.1 Industry Overview

This project focused on the integration of two companies in the metal fabrication and machining industries, which are classified collectively by the U.S. Bureau of Economic Analysis (BEA) as the fabricated metal product manufacturing subsector of the manufacturing sector. These industries manufacture fabricated metal products by transforming raw material metal into intermediate or end-products. This type of manufacturing includes cutting, bending, machining, forging, stamping, and/or forming to shape metal pieces as well as welding and assembling to join pieces together as needed [1]. According to the BEA, in 2022, the total value of fabricated metal products used in the United States was over $700 billion, and the industries with the most use (by dollar value) of these products were construction, motor vehicles, and machinery, as shown in Figure 2-1 [2].

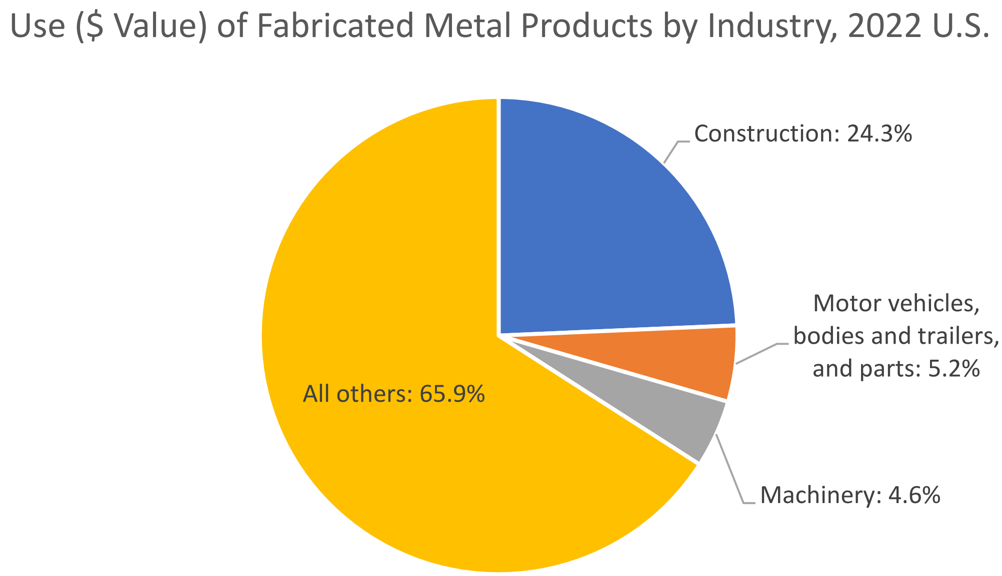

Figure 2-1. Use ($ Value) of Fabricated Metal Products by Industry, 2022 U.S.

Over the last six years, both the manufacturing sector as well as the fabricated metal products subsector have experienced growth in the United States. The annual gross output[1] for the U.S. manufacturing sector grew at a compound annual growth rate (CAGR) of 4.84% from 2017 to 2022, as shown in Figure 2-2 [3], and in this same period, the annual gross output for the subsector of fabricated metal products grew at a CAGR of 4.42%, as shown in Figure 2-3 [3]. Figure 2-2 shows that the manufacturing sector experienced some decline in output in 2019 and 2020 due to the COVID-19 pandemic and its impact on the overall economy, but the industry rebounded in the subsequent years.

[1] Gross output is defined as a measurement of an industry's sales, inclusive of sales to end-users and sales to other industries; this also refers to the total value in the end-to-end supply chain for the industry [3].

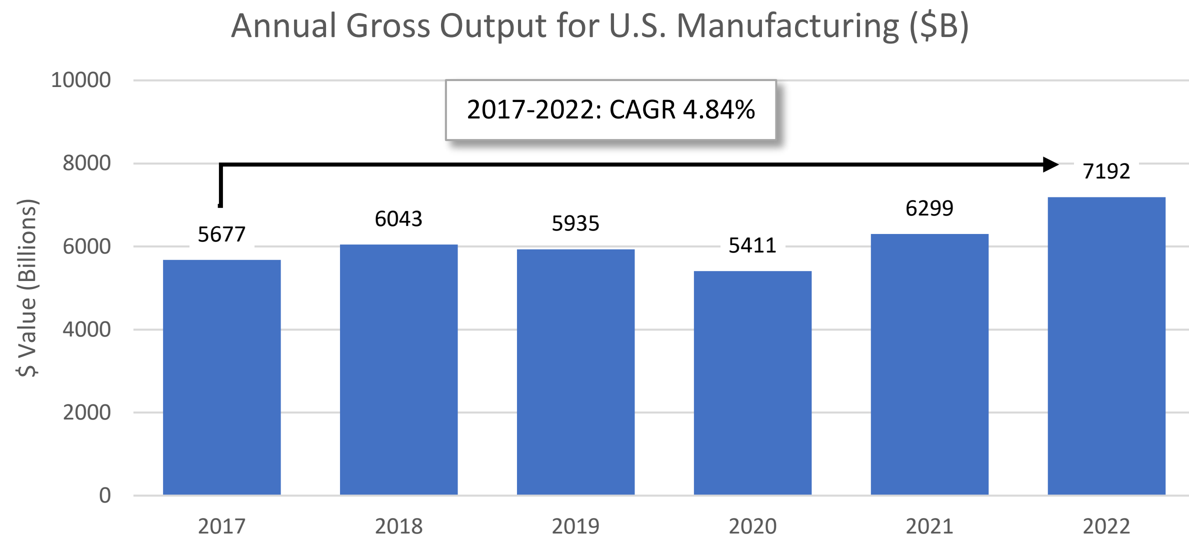

Figure 2-2. Annual Gross Output for U.S. Manufacturing ($ Billions) [3]

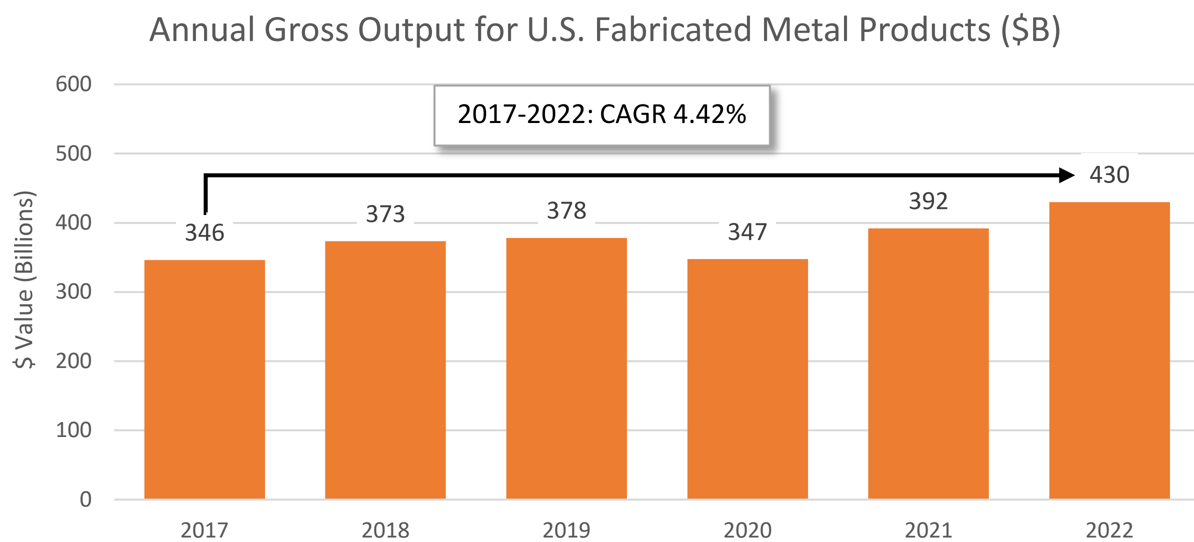

Figure 2-3. Annual Gross Output for U.S. Fabricated Metal Products ($ Billions) [3]

The post-COVID-19 resumption of large original equipment manufacturers (OEMs), coupled with an overall increase in demand from end-markets, have led the North American fabricated metal product market to be forecasted to grow in the coming years: in 2023, the value of this market was around $430 billion [3], and it is projected to grow at a CAGR of more than 4% over the next 5 years, continuing the current trend [4]. These OEMs have largely chosen to outsource their product manufacturing in order to save on the high fixed investment costs related to production and to instead dedicate resources toward their core competencies [5]. As such, the growth in these markets is unlikely to be captured by a single major player as the metal fabrication and machining industry is highly fragmented, with more than 60,000 suppliers in the space in the United States alone [6]. These suppliers, typically operating as contract manufacturers (CM), offer OEMs a variety of services at degrees of capability that typically differ based on the requirements of the end markets served, such as product tolerances or finishing standards.

In the low-volume, high-mix portion of this industry, the complexity of products renders the production process quite difficult to standardize. Highly complex fabricated and/or machined parts typically undergo many different production operations, each of which requires unique machine setups and additional labor. For example, a painted metal plate with tapped holes and multiple bends may go through at least five production steps – laser cutting, deburring, machining, forming, and painting – and at each of these steps, an operator is required to set up the equipment (laser cutter, brake press, vertical mill, etc.) with the necessary tools or fixtures to perform that operation. The manufacturing operations that are required depend on the type of part produced, so when there is a wide variety of product types, there are significantly more machine changeovers required. This large number of operations, tools, and changeovers makes it very difficult to standardize work in this high-mix production environment. These additional machine setups lead to an increased cost of labor, and that, combined with high raw material costs due to fluctuations in commodity pricing, can substantially drive up the cost to manufacture these complex products. As a result, the companies in these low-volume, high-mix production environments seek solutions to increase process efficiency, leverage automation, and drive continuous improvement as means to reduce costs in the production process.

One such solution that many fabrication and machining organizations are targeting is the digitalization of manufacturing, brought about by Industry 4.0 [7]. This has taken many forms depending on the needs of the production environment and can include anything from introducing collaborative robots in welding operations to increasing connectedness and automated data transfer in the workorder scheduling operation. Both examples highlight means by which corporations aim to reduce manual labor required to run complex production operations. In general, by fully automating or even semi-automating production processes, manufacturers can save on costs by reducing both the time and the labor required for those operations, which is particularly important in an environment in which labor availability can be a significant challenge [8].

In a similar manner, increasing the connectedness of the manufacturing floor with the other areas of the business, such as sales, product design, and supply chain functions, improves the efficiency of the overall production system. Digital manufacturing is the necessary bridge between product lifecycle management and the various operations of a production floor that allows data to be shared throughout the organization [9]. This increased visibility drives efficiency improvements throughout the end-to-end production process, from raw material purchasing to production quality to shipping logistics. Integrating these various systems breaks down the silos of traditional manufacturing organizations and accelerates cross-functional collaboration. By having access to data, especially real-time data, both production individuals and management personnel alike can better understand the status of work orders, the quality of production processes, and the current state of operations as a whole. Ultimately, the digitalization of manufacturing and the increased system connectedness that comes with it results in more accurate forecasting, optimized production scheduling, improved capacity utilization, increased on-time delivery, and reduced costs of poor quality [7].

In addition to this heightened focus on digitalization, there has also been a strong reshoring effort in the U.S. manufacturing industry in recent years. Reshoring refers to bringing manufacturing that was once offshored or moved overseas back to the United States. Previously, the differences between the United States and other countries in the value of currency, the regulations regarding labor and the environment, and both the availability and proximity of raw material resources allowed for a reduction of costs for U.S. companies that made globalization and offshoring attractive in the 1980s [10]. This trend continued for some time but was recently disrupted by several factors: international wage inflation, increased transportation costs, higher import tariffs, heightened geopolitical conflicts, and, most recently, the COVID-19 pandemic. These disruptive agents have accelerated the trend toward reshoring, especially in the manufacturing industry.

Manufacturing, in particular, was significantly impacted by the COVID-19 pandemic as all aspects of supply chains were disrupted and non-essential domestic production was halted. During this time, the U.S. manufacturing output declined by 43% from the fourth quarter of 2019 to the second quarter of 2020 – the largest decline since World War II [11]. For the supply chains behind these stalled manufacturing organizations, the pandemic exposed vulnerabilities, such as the heavy dependence on certain countries for goods as well as the negative consequences of reduced inventory policies, and it brought about extreme shocks to both supply and demand that highlighted the need for more flexible, diverse, and resilient supply chain systems [7]. The manufacturing industry is now rebounding from these disruptions and their subsequent bullwhip effects, and one primary focus seems to be the domestication of once-offshored supply chains. In a survey of CEOs around the United States regarding the reshoring trend, it was found that 72% of survey participants planned to fully reshore operations within three years, and 74% of respondents said that the events of the last three years, such as the COVID-19 pandemic disruptions, amplified tension and conflicts in the geopolitical landscape, and increased need for greater supply chain transparency and resiliency, influenced their decisions to reshore [12]. According to this same survey, the top three types of operations that are being considered for reshoring are design and engineering, component manufacturing, and assembly [12] – all of which are significant aspects of fabricated metal product manufacturing in the low-volume, high-mix space, thereby creating great opportunity for domestic suppliers in this industry.

2.2 Platform Company Overview – Weller Metalworks

Weller Metalworks is the portfolio company name of the low-volume, high-mix platform created by the private equity firm, LFM Capital. This platform aims to meet customer needs for the full product lifecycle of highly complex parts. The company offers support for prototyping at the start of the product cycle, developing the tools necessary to create the part, executing pilot builds as production begins, completing full production runs as the product is in the height of its use, and producing parts for service when the product phases out of use (refer to product lifecycle section of Chapter 3 Literature Review for additional details). These complex parts have many features and are difficult to manufacture as they often require multiple production operations, time-consuming machine setups, and additional labor – all of which make it hard to scale to higher volume production. As such, Weller Metalworks focuses on lower volume production opportunities in order to satisfy customers with these particular needs.

The leading markets currently served by the LVHM platform are construction, transportation, marine, industrial, and agriculture. Many of the products supplied by Weller Metalworks to these industries are customer-facing, and because of the stringent customer requirements in these fields, a high degree of adherence to quality throughout the production process is critical. This adds a level of complexity to production: mistakes are not only costly in terms of scrap value, but they can also negatively affect the relationship with the customer. In this type of production environment, winning work from customers is heavily based on the quoted cost for the work as well as the quality and timeliness of the work delivered. These are key factors that must be considered in order to continue receiving orders from existing customers and winning business from new customers. Weller Metalwork's two locations, Muthig Industries and Laser Precision, excel in their production capabilities and commitment to quality and on-time delivery.

2.3 Portfolio Company Overview – Muthig Industries in Fond du Lac, WI

In 1965, after 25 years of experience as a Journeyman Tool and Die Maker, Ray Muthig founded Muthig Tool & Die in the basement of his home. In 1977, Muthig Tool & Die purchased Midwest Stamping, thereby adding metal stamping capabilities to their Tool and Die offering, and as the business grew, the company expanded into a new facility. Muthig's product capabilities continued to grow with the purchases of a laser cutter in 2007 as well as mills and lathes in 2009. With these capital expenditures, Muthig Industries was able to offer the following capabilities to its customers: tool and die, metal stamping, laser cutting, and production machining. These four services are now the four primary divisions of Muthig Industries, and the historical percentage of sales for each division can be seen in Figure 2-4.

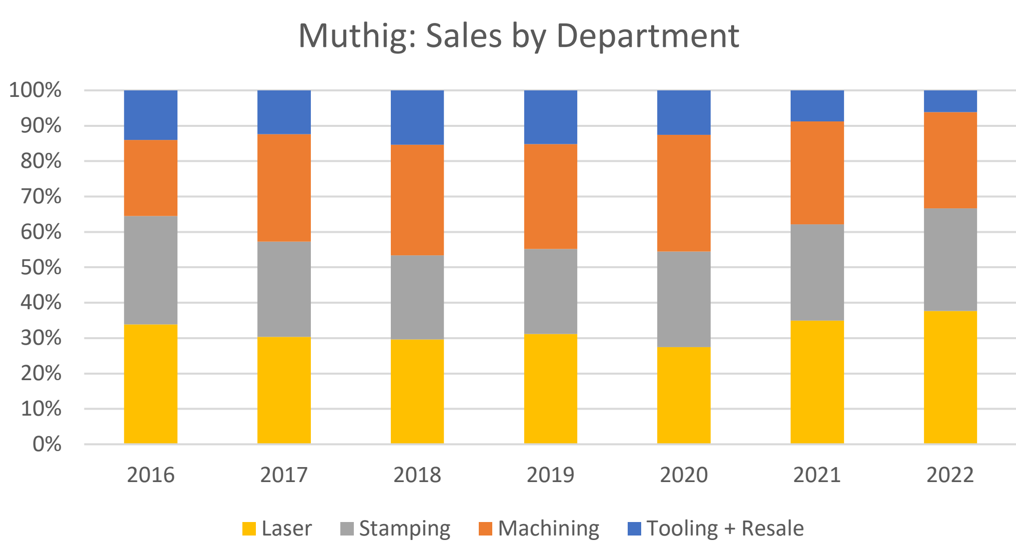

Figure 2-4. Muthig: Sales by Department (Normalized to 2016)

With such a wide range of capabilities, Muthig Industries has positioned itself in the market as a strong supplier in the LVHM fabricated metal product space. Specifically, the top three end markets served are agriculture, marine, and construction as shown in Figure 2-5. The company has experienced an increase in sales over the last 7 years, and on average, Muthig produces roughly 2200 unique stock keeping units (SKUs) each year for approximately 125 customers as shown in Figure 2-6. The company's diverse capabilities and consistent growth over time made it an attractive acquisition target for the Weller Metalworks platform.

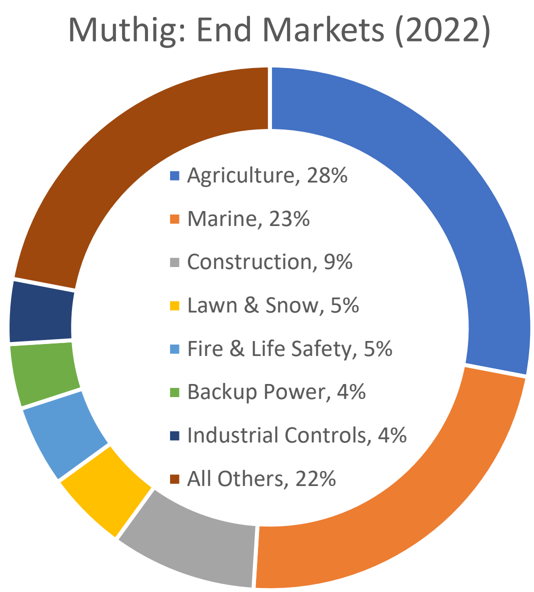

Figure 2-5. Muthig: End Markets (2022)

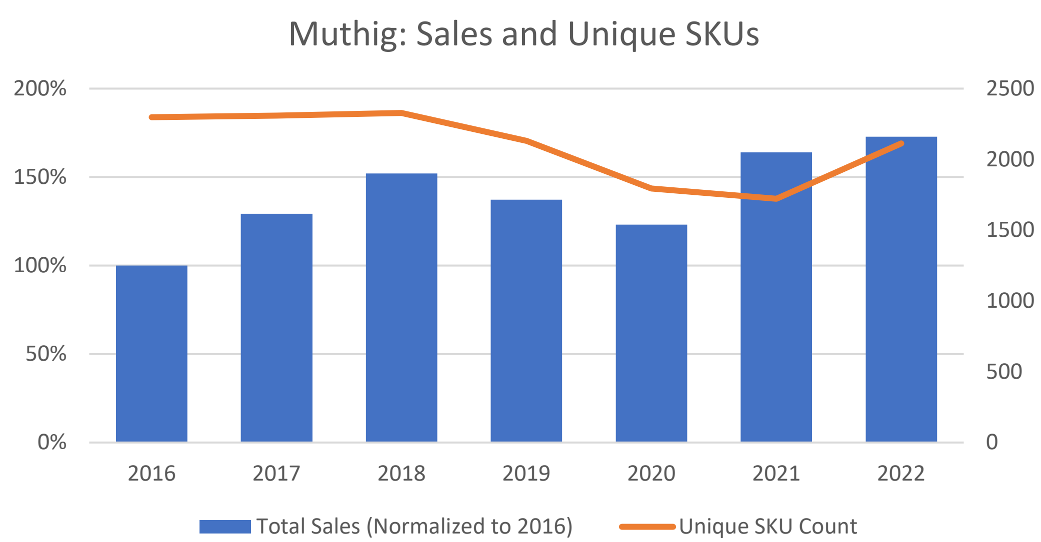

Figure 2-6. Muthig: Sales and Unique SKUs

To provide an example of the types of products produced by Muthig, a few images of sample parts that showcase the organization's production capabilities can be seen in Figure 2-7 and Figure 2-8. Figure

2-7 contains multiple products to emphasize the variety of sizes and complexity of parts produced, and Figure 2-8 displays two different views of the same product to highlight various features that required multiple operations in the production process, including laser cutting, press brake, horizontal mill, welding, and stamping.

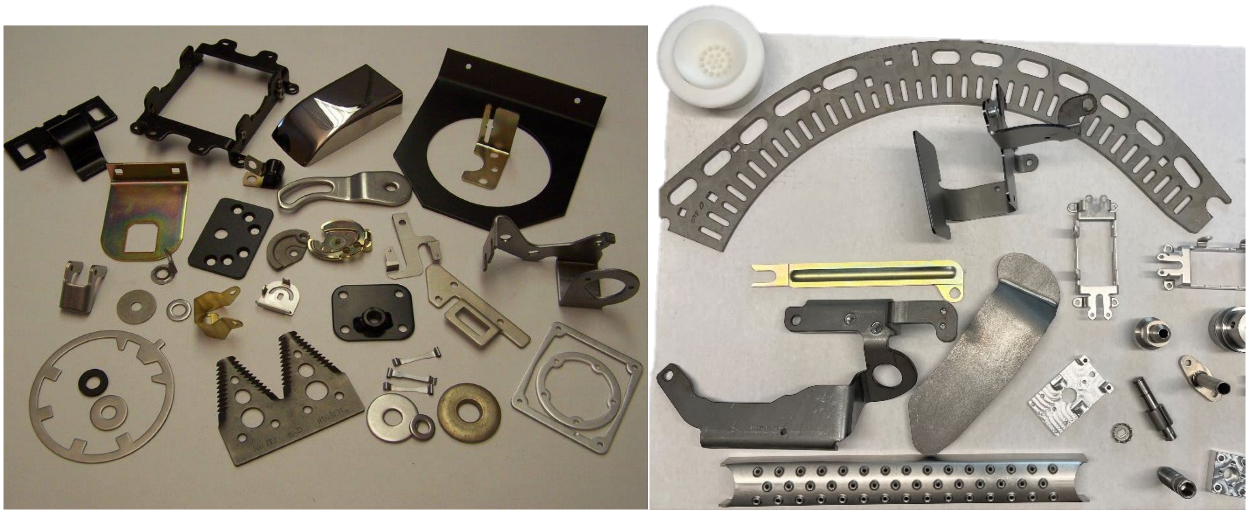

Figure 2-7. Sample products made by Muthig Industries

Figure 2-8. Sample product requiring multiple operations

2.4 Portfolio Company Overview – Laser Precision in Libertyville, IL

Laser Precision was founded in 1994 by Jeff Adams. When the business first started, it solely offered laser cutting services to other metal fabrication companies, but it has since grown to offer its own fabrication services as a contract manufacturer for OEMs. Now, in addition to laser cutting, the company is also capable of forming, welding, machining, assembly, finishing, and powder coating. These capabilities have allowed Laser Precision to serve a few different end markets, with the top 3 in 2022 being resource industries, energy and transportation, and construction industries as shown in Figure 2-9. The resource industries end market primarily refers to mining and heavy construction equipment; the energy and transportation end market serves oil and gas, marine, rail, and industrial segments; and the construction industries end market refers to infrastructure, forestry, and building construction.

Over the years, Laser Precision has become a leading metal fabrication supplier, experiencing growth in both sales as well as the unique number of SKUs provided: as of 2022, Laser Precision delivered over 7300 unique SKUs to 88 customers as shown in Figure 2-10. Some of these SKUs are displayed in Figure 2-11; these samples exemplify the variety of products that Laser Precision is capable of manufacturing, and while all of these products required multiple production operations, the yellow and black ones demonstrate one additional operation in particular – the powder coating finish, which is completed in-house in their 7-stage powder coating operation. The company's achievements as an award-winning supplier are even more impressive with such a large number of unique products to manufacture, and as a result, Weller Metalworks was eager for the organization to join the platform.

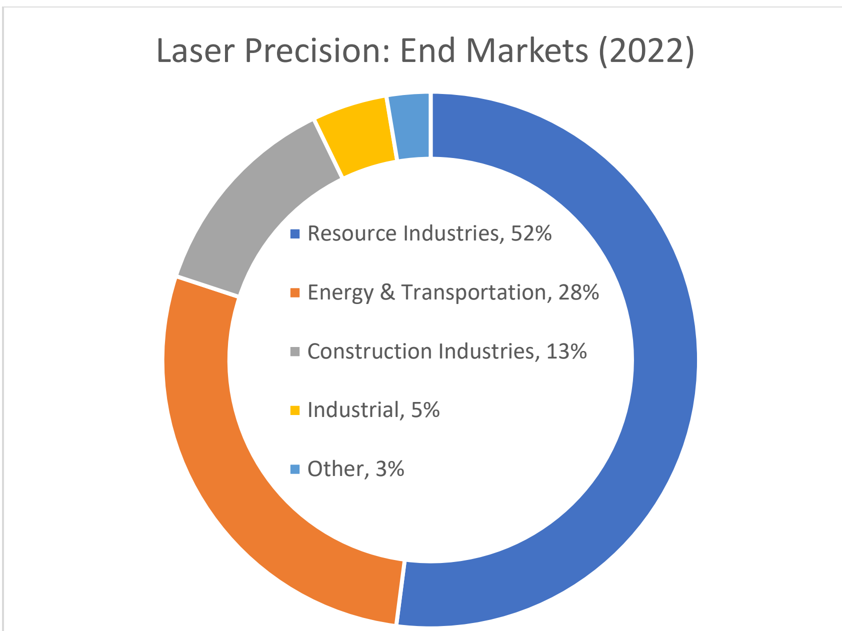

Figure 2-9. Laser Precision: End Markets (2022)

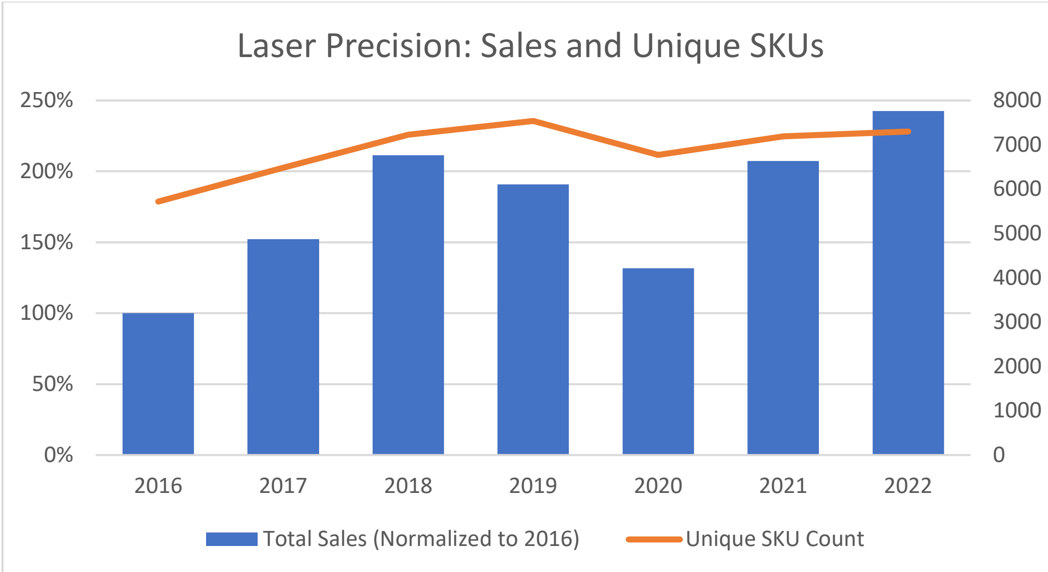

Figure 2-10. Laser Precision: Sales and Unique SKUs (Normalized to 2016)

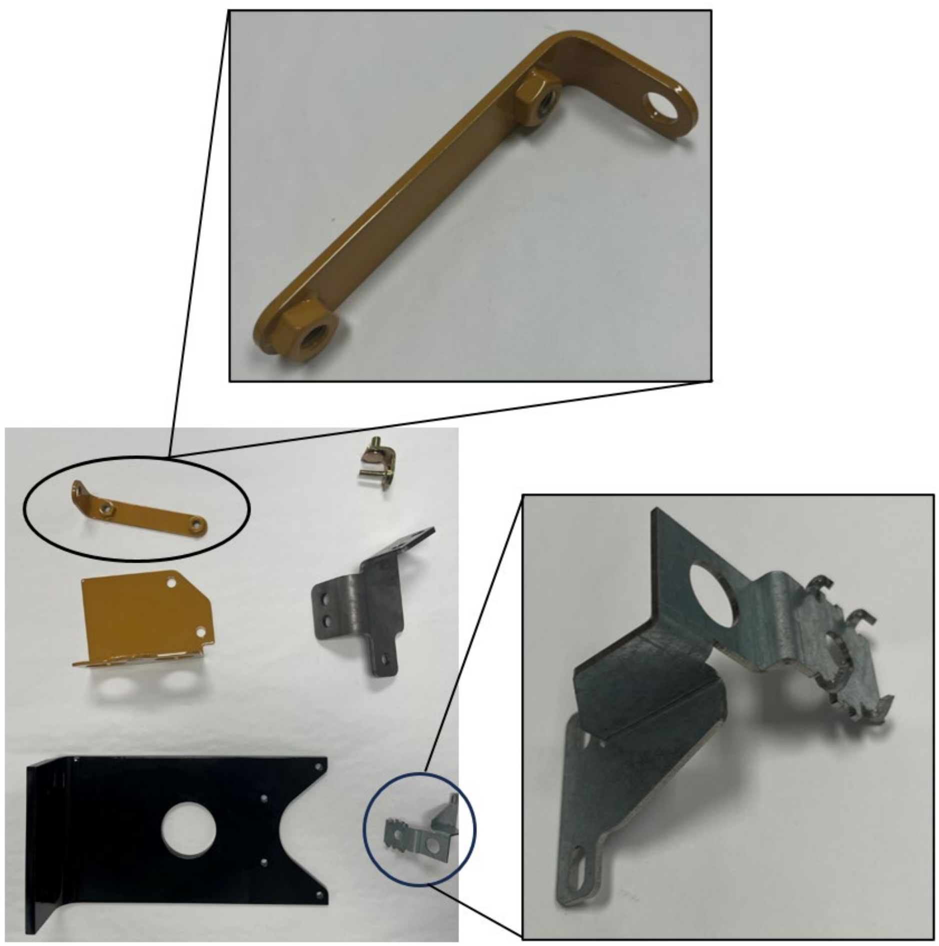

Figure 2-11. Sample products made by Laser Precision

Laser Precision has achieved success by focusing on quality and on-time delivery: specifically, in 2022, they achieved over 99.9% on-time delivery and a quality measure of 84 defective parts per million (PPM), which signifies a defect rate of only 0.0084% for the entire year [13]. The Laser Precision team attributes this high-level of performance to their robust production data management system, named Synchronized Sourcing. This system's foundation is built on the concepts of vendor alignment, in which a vendor's capabilities and performance are aligned with the needs of the customer, and strategic sourcing, in which a vendor's capacity and core competencies are factored into the sourcing decisions. Synchronized Sourcing takes this alignment of the end-to-end value stream one step further – the customer requirements dictate the vendor's performance in every facet of the supply creation and create an entire ecosystem that governs the vendor's operations [14]. As a vendor, Laser Precision prioritizes meeting the needs of its customers and configures all aspects of its operations to do so. As OEMs consolidate their vendor base to decrease costs and increase the ease of vendor management, the remaining vendors must take on the displaced demand from the OEM, which has grown in both volume and product complexity. In order to remain competitive, these small- and medium-sized manufacturers, like Laser Precision, must evolve and find mechanisms to manage this additional demand, given its direct impact on their growth [15]. Laser Precision achieved this evolution through its digital transformation, which centered around the implementation of Synchronized Sourcing.

Laser Precision's Synchronized Sourcing operating model synchronizes the various components of its supply, such as raw material inventory, labor availability, machine utilization, and transportation requirements, with its customer needs and demand signals. Variations in those demand signals – drop-in or hot orders, changes to order quantities, and order cancellations – were once unmanageable and unpredictable aspects of demand volatility that led to unexpected inventory depletions, disrupted build schedules, delayed production operations, and additional personnel involvement. Now, however, with Synchronized Sourcing, Laser Precision can accept these demand fluctuations and update its operations accordingly and automatically [14]. Its digital ecosystem pulls in the customer demand signal, processes it according to a set of pre-determined rules, flags any exceptions to these rules, and pushes the demand data through the system to update the production schedule as needed – all of which is completed automatically and frequently through electronic data interchange (EDI). Synchronized Sourcing and its use of EDI allows “electronic technology to do what it does best: collecting and organizing disparate data elements regarding demand and tailoring a process that assures customer requirements are met and expectations are exceeded” [14], thus providing Laser Precision the agility and flexibility to excel in the low-volume, high-mix production realm.

Chapter 3. Literature Review

This chapter provides a review of academic literature and other sources related to the key topics of this research in the intersection of low-volume, high-mix production and private equity. First, it covers the concepts of product lifecycle and make-to-order manufacturing to provide context for the Weller Metalworks investment thesis. Then, the private equity strategy of buy-and-build is reviewed to understand LFM Capital's approach. Finally, lean manufacturing, Industry 4.0, and strategic benchmarking are reviewed as they relate to identifying areas for operational improvements and platform alignment in integration.

3.1 Product Lifecycle

The product lifecycle (PLC) represents the full life of a product and typically contains four major stages – introduction, growth, maturity, and decline. The PLC is usually used in the context of a product's life in a market and is depicted by a bell-shaped curve to represent the unit sales over time (Figure 3-1) [16]. In the introduction stage, the product first enters the market and begins capturing some initial market share. In the next phase, sales grow more significantly as there is greater market acceptance, but sales eventually reach their peak when the product is in the maturity stage of its lifecycle. In this stage, a product reaches its market saturation, and sales begin to decline as fewer new customers are reached [17]. Finally, in the decline stage, the market moves away from the product, and as a result, sales are reduced until the product eventually reaches its end of life [16].

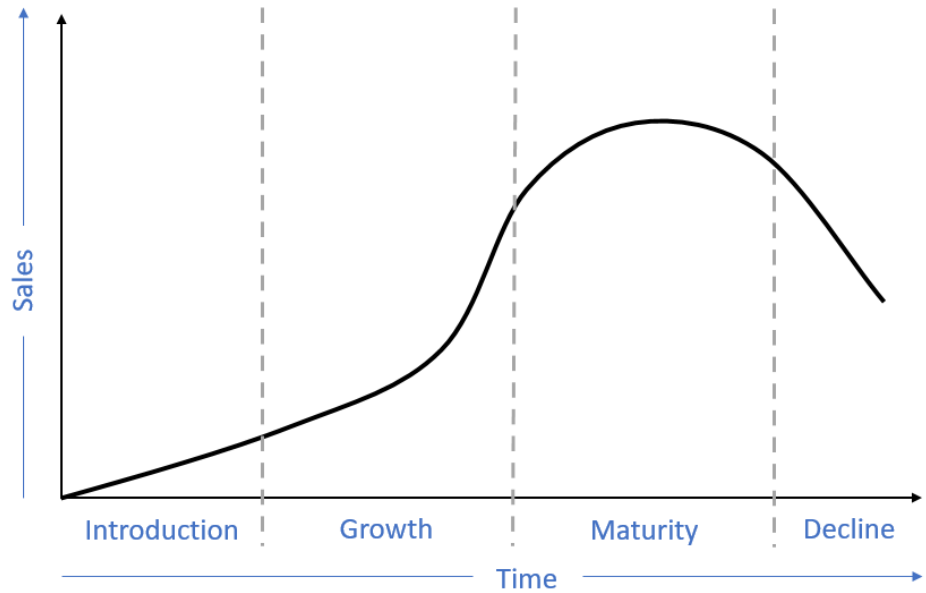

Figure 3-1. Product Lifecycle

The idea of the PLC can also be applied to manufacturing environments, but instead of measuring the product sales, the production volume is measured. In this context, the introduction stage reflects the creation of a prototype product that is produced in very low volumes as production processes are refined. In the growth stage, the manufacturer increases production volume as it seeks to build greater efficiencies into the production process [18]. The maturity stage is when the product is produced at its full volume, and the manufacturer’s focus is on delivering the product at the highest level of service and quality to the customer while achieving the lowest possible cost in production. Finally, the decline stage in manufacturing is a balance between scaling down production to match the decrease in demand and ensuring there are products or components available if service is necessary as the product nears end of life.

Figure 3-2 overlays the manufacturing product lifecycle, from prototype to full-volume production to end of life, on a plot of the increasing production volume (left y-axis) and decreasing overall margin (right y-axis). This chart illustrates the idea that as products are more complex in nature and ordered in lower volumes, they have higher margin potential than those that are less complex and ordered in higher volumes. This is due to the additional machine setups, labor, and overall resources that are required to produce low-volume products compared to the single setup and long run for high-volume production. This idea is the basis of the Weller Metalworks investment thesis for low-volume, high-mix metal products, and both Laser Precision and Muthig Industries operate in the green highlighted space in Figure 3-2 [19].

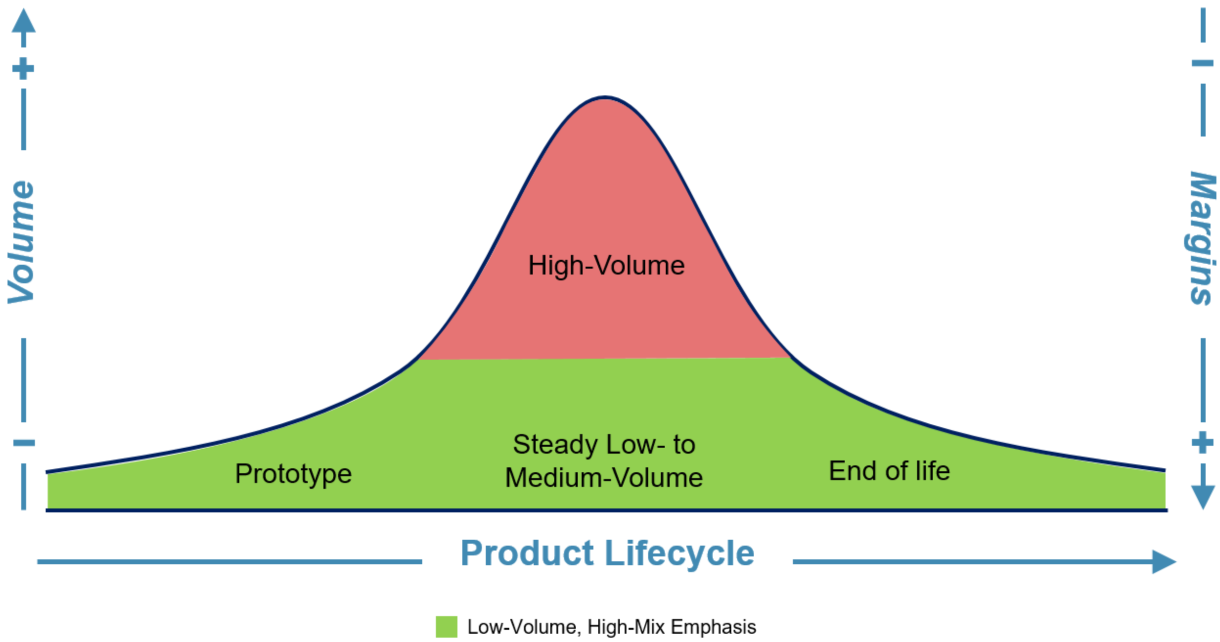

Figure 3-2. LVHM Product Lifecycle

3.2 Make-to-Order Manufacturing

There are two primary types of manufacturing: make-to-stock (MTS) and make-to-order (MTO). In make-to-stock manufacturing, a company manufactures products based on sales forecasts before receiving the customer's order; when the order does arrive, it is fulfilled from the products in stock. Industries that employ MTS manufacturing are typically those characterized by high-volume production and constant demand, such as the automotive, food, or chemicals industry. Because there is less fluctuations in these environments, organizations that employ MTS manufacturing are able to achieve more stable production planning, reduced stockout risk, and more efficient allocation of resources. In make-to-order manufacturing, on the other hand, a company only begins the manufacturing process when the customer's order is received, and "each order typically requires different amounts of processing work on the work centers of the firm, the use of a different number and/or different sequence of work centers" [20]. Benefits of this type of manufacturing are reduced inventory costs, increased flexibility, and reduced risk of overproduction [21]. In general, make-to-order manufacturing is the dominant strategy used in low-volume, high-mix production environments because there is a greater need for product customization based on changing customer requirements.

Because each product is customized to meet customer's specifications, it is not possible to pre-manufacture and stock products in the make-to-order environment [22]. Instead, the customer's order is the start of the process. Upon receiving the order, the company must decide whether to prepare a quote, and, if they decide to create the quote, how much they will charge for the product. In this estimation and quoting process, the company must account for the manufacturing costs so that the profit from the job can be considered. At this stage, the company faces a tradeoff between spending a lot of time and effort to ensure the pricing is competitive or providing a quick estimate at a higher price point to build in some buffer [20]. In the contract manufacturing environment, companies compete on price, quality, delivery time, technical expertise, and reliability, so each company must balance these factors when issuing competitive quotes. As such, submitting a quote that is priced too high can lead to work not being won, but submitting a quote that is priced too low may not provide enough profit for the business. This highlights how important quoting accuracy and efficiency is in the make-to-order production environment [20].

3.3 Private Equity Strategy: Buy-and-Build

In private equity, the buy-and-build strategy has been referred to by a number of names – strategic rollup, consolidation play, or leveraged build-up [23]– but the basic idea remains the same: "after an initial buyout-type purchase of a company (so-called ‘platform’), the private equity firm completes one or more… add-on acquisitions” [24]. “Typically, the buy-and-build strategy is structured as a horizontal acquisition strategy where the acquisition target is in the same sector, operates on an equal level of the value chain, or interacts with very similar if not identical suppliers and customers” [24]. The ultimate goal of this strategy is to receive an exit multiple at the time of sale that is much higher for the consolidated platform versus what would be offered for the individual portfolio companies [23].

The method by which this goal is achieved depends on one of the four strategic directions employed: consolidation, build-up, missing link, or roll-up. In the consolidation approach, the acquisitions tend to focus on vertical or horizontal integrations. The build-up strategy involves many acquisitions in a highly fragmented industry to create a larger, single player in the market. The missing link approach is characterized by an add-on acquisition filling a gap in the product portfolio, geographic presence, or market, and the roll-up strategy is motivated by implementing the platform’s business model on all acquired portfolio companies [24]. Not only do these four strategic directions characterize the various options for the buy-and-build strategy, but this strategy can also be developed in terms of its tactics for growth. There are four primary avenues for growth that define mergers and acquisitions: market penetration, market development, product development, and diversification [24]. In market penetration, the buyer aims to grow by finding new customers or increasing current sales using the existing product portfolio. In market development, this existing product portfolio is sold to new markets and customers. In product extension or development, new products are created to claim more of the existing market. In diversification buy-and-build strategies, both new products and new markets are targeted [25]. The figure below, called the Ansoff Matrix, illustrates the different options for these growth strategies (Figure 3-3, adapted from Ansoff 1956) [25].

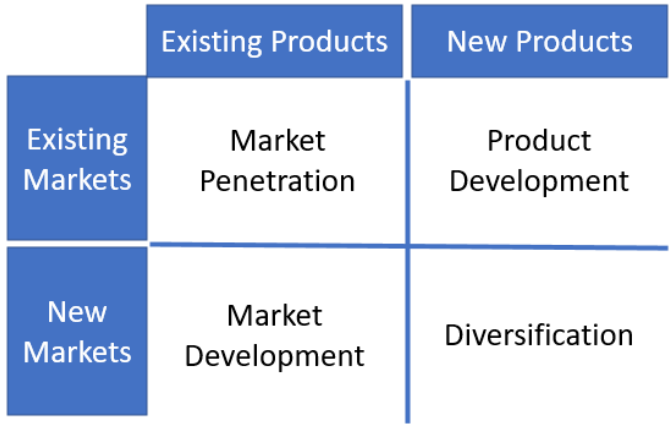

Figure 3-3. Ansoff Matrix

In addition to growth in the market and/or product offerings, other drivers of value creation in these buy-and-build strategies are operational improvements and the realization of synergies. Operational improvements may generate value through top-line (revenue) and bottom-line (net profit) methods: for instance, an increase in the effectiveness of the sales team would lead to higher top-line, and a reduction in costs due to the implementation of lean processes would lead to a higher bottom-line [26]. Depending on the needs of the site, there are many types of operational improvements that may be implemented, but generally, these occur at the site level, whereas synergies can be achieved across the platform due to its size and multi-site nature. As defined by Salter and Weinhold in the Harvard Business Review (1978), synergies are the benefits achieved when companies successfully exchange their skills and resources [27], and this added value, these economies of scope, can be quantified "as the difference between the value of the combined entity compared to the added values of the separate companies prior to the transaction" [24]. Ultimately, these synergies can lead to a return on the platform company that is greater than the sum of its individual and distinct parts, the portfolio companies, thereby enabling the platform company to achieve its goal of exiting at a much higher multiple [24].

By combining multiple organizations and consolidating them to operate as one entity, there are many different types of synergies that may be realized, such as those in the realms of business, market, finance, and management. Business synergies impact all functional areas of a business and are typically achieved from economies of scale, economies of scope, and multi-plant economies. In all three of these areas, there are efficiency gains that lead to a reduction of costs, an increase in flexibility, better allocation of resources, and a diversification of risk. Market synergies result from the increase in market power and market expansion: as the platform acquires multiple players in the market, it grows in size, captures market share, and can benefit from cross-selling to the larger customer base. Additionally, with this size increase, the platform may now be able to exercise substantial influence on prices, both to customers as well as from suppliers, in the market [24]. The financial and management synergies that may be achieved are typically seen at the platform level, for the leadership team of the platform can set the strategy in both of these areas to trickle down to the portfolio companies. While these four types of synergies have been positive and value-add, it is also important to consider that there may be some dis-synergies in the acquisitions and subsequent integrations; theoretically, however, the positive synergies realized should far outweigh the impact of these dis-synergies and integration costs. Figure 3-4, reproduced from Hoffmann, displays how the buy-and-build strategy and its realization of synergies impacts the overall value of the platform entity [24].

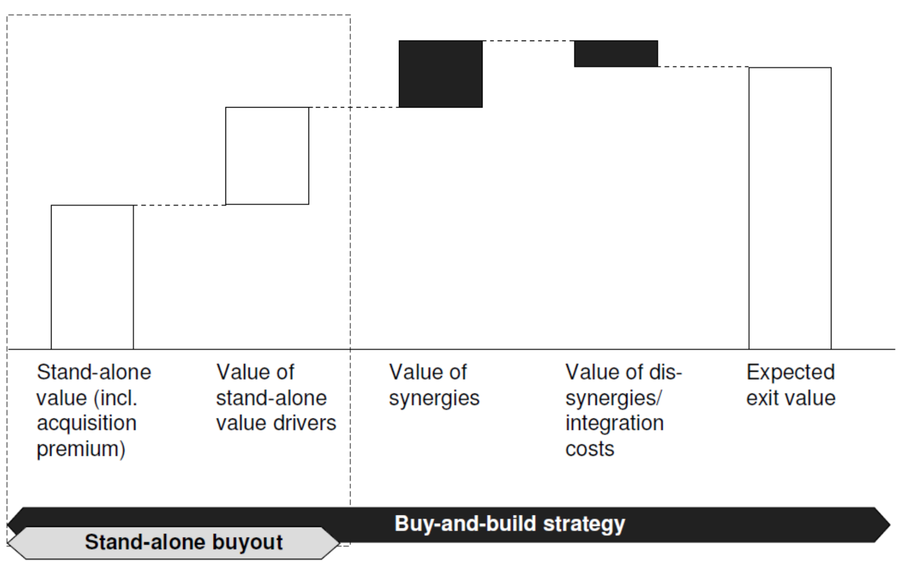

Figure 3-4. Value Created from Buy-and-Build Strategy with Synergies

3.4 Lean Manufacturing

Lean manufacturing originated in Japan with Taiichi Ohno's development of the Toyota Production System, which is based on the total elimination of waste [28]. Waste can be defined as any "entity that consumes resources but does not add value from a customer's perspective," [29] and Ohno created seven categories to classify waste: transportation, inventory, motion, waiting, overproduction, overprocessing, and defects. The definitions for each of these types of lean wastes, as written by Vinodh, are seen in Table 3-1 [29].

Table 3-1. The 7 Lean Wastes

Lean Waste	Lean Waste Definition
Transportation	Unnecessary or unproductive movements of materials or subassemblies
Inventory	Unnecessary stocking of items that may be in raw material, work in process, or finished goods
Motion	Unwanted movement of workers
Waiting	Delay for several entities (may be material, tooling, tool, instructions)
Overproduction	Producing more than what the customer has asked for
Overprocessing	Unnecessary or inappropriate processing
Defects	Nonconformities

The goal of eliminating waste is to create flow, thereby improving efficiency, reducing costs, improving operations, and increasing margins. Ohno proposed various tools for process improvement as means by which waste could be eliminated, and one such tool used in this research was process mapping [29]. A process map is a graphical tool used to visualize the sequence of steps in the process, and by documenting the process, organizations can more easily identify various forms of inefficiencies and waste throughout the process. The process maps created for Muthig Industries and Laser Precision can be found in Chapter 5. Initial State. These process maps were used to develop a qualitative, high-level understanding of how information, material, and product flow through each site. Mapping the process helps not only to highlight potential wastes but also to visualize the organization's flow – one of the five lean principles, the others being define customer value, identify the value stream, create a pull system, and pursue perfection through continuous improvement [30]. All five principles of lean manufacturing are achieved, in part, through the elimination of waste.

While these five lean principles are effective in Toyota's high-volume, low-mix manufacturing of the automotive industry, there are some difficulties in their application to low-volume, high-mix manufacturing. In LVHM production environments, there is much greater variability in the product types, machine setups required, cycle times, customer demand, order quantities, and requested delivery dates [31]. With all of this variability, creating a standard, whether that be process flow or instructions, poses quite a challenge as there is not one standard process that applies to all products. Because not all five lean principles applied in the context of this research, this thesis focused on the ones that are the most relevant and applicable to the production environments of Muthig Industries and Laser Precision.

3.5 Industry 4.0

The fourth industrial revolution, referred to as Industry 4.0 (i4.0), revolves around digitalization and smart systems [32]. Digitalization, defined by Kagermann, is "the networking of people and things and the convergence of the real and virtual worlds that is enabled by information and communication technology (ICT)" [33]. When applied to the production environment, the digital technologies of Industry 4.0 create smart manufacturing systems by "(1) empowering physical resources in production, (2) utilizing virtual and dynamic assets over the internet to expand system capabilities, (3) supporting data-driven decision making at all domains and levels of businesses, or (4) reconfiguring systems to adapt changes and uncertainties in dynamic environments" [34]. By connecting the pre-production, production, and post-production systems, there is end-to-end information sharing and integration across the supply chain [35].

This interconnectedness is enabled by information and communication technology and described in three pillars: horizontal interconnection, vertical interconnection, and end-to-end engineering.

Horizontal interconnection is described as the digital interconnection throughout the supply chain between a company and its suppliers or customers. Vertical interconnection refers to the connectedness within an organization among the various functional groups of the company. End-to-end engineering ties the whole product lifecycle together, from product development and prototyping to end of life [36]. These three pillars of ICT are particularly beneficial for LVHM production environments because their high-mix nature is susceptible to frequent fluctuations in customer demands and requirements. Now, with ICT, these fluctuations can be automatically processed and incorporated via smart, self-optimizing production systems, and they no longer cause the same level of disruption to production operations, work order scheduling, and material resource planning that they once did.

3.6 Strategic Benchmarking

Benchmarking is defined as the process of comparing the performance of an organization in key areas against those of other organizations, especially those that are high-performing, with the intention of learning how to improve and become more competitive in the field [37], [38], [39]. Strategic benchmarking, therefore, is benchmarking with the objective of "discover[ing] ideas for improvement that will trigger breakthrough changes and may be leveraged across the business to enhance an organization's competitive advantage" [38]. The benchmarking process begins with selecting the core competencies of interest and measuring these items to understand the current state. As a tool of continuous improvement, benchmarking requires constant re-evaluation, so it is essential to select the competencies that are most representative of the business's performance in order to ensure that resources are being dedicated to measuring the correct performance indicators [37]. After the key core competencies have been selected, measurements should be conducted and data should be collected to assess the current performance in those categories. Next, a gap analysis should be conducted to determine the differences between the performances of the organizations being compared, and finally, this analysis should result in recommendations for improvement [38].

In the context of this research, the acquisition and subsequent integration of multiple production organizations operating in the same fabricated metal product field under the Weller Metalworks platform provided a unique opportunity to remove the barriers of competition and allow two organizations to learn from one another. Strategic benchmarking was used to identify areas of opportunity in the platform: by comparing various competencies of both portfolio companies, best practices were shared, lessons were learned, and potential areas for improvement were found.

Chapter 4. Research Strategy and Data Sources

In this chapter, the research strategy and data sources used throughout this thesis are described. As mentioned in Section 1.3 Project Methodology of Chapter 1, this research relied on understanding two perspectives for integration – the top-down perspective of the platform company, Weller Metalworks, and the bottom-up perspective of the portfolio companies, Muthig Industries and Laser Precision. The top-down perspective was used to understand the goals of integration, and the bottom-up perspective was used to analyze the two portfolio companies and establish the initial state of each. The approach used to conduct this research as well as the data collected during the research process take these two perspectives into account.

4.1 Research Strategy

This research is intended to develop a comprehensive understanding of the portfolio companies, identify the challenges of integrating these unique business entities, and provide recommendations for current and future acquisitions and integrations to the Weller Metalworks platform. To accomplish this, the following five-step process was developed:

1. Establish the Objectives and Initial State
2. Perform Gap Analysis
3. Perform Strategic Benchmarking
4. Identify Integration Opportunities
5. Propose Recommendations for Integration

The process begins with establishing the objectives of integration and the initial state of each of the involved parties, which, in this case, are the portfolio companies. This is a critical first step to developing a framework for integration because it takes both the end goal and starting point into account, and the subsequent steps in this process develop the roadmap between these two states, as informed by the gap analysis. Next, strategic benchmarking is performed to understand the best practices of each location, and this naturally leads to identifying opportunities for integration. By performing strategic benchmarking, the performance of each company can be more deeply understood and attributed to a number of distinct factors, whether it be strategies for sales or processes for quality; how each company implements these factors can serve as lessons for the other organization. If one company has found a certain factor to be significant to its success, then it is worthwhile to share the lessons learned with its new sister company in hopes that this factor will provide comparable beneficial results there as well. As such, these areas can serve as opportunities for integration in that the portfolio companies can reach alignment on certain topics and begin to operate in the same manner. The final step in this process is to propose recommendations for integration. These recommendations are informed by the information learned from the preceding steps, and they focus on areas in which the most significant synergies can be achieved.

Due to time and resource constraints, this research concluded with recommendations for integration based on the two existing portfolio companies; however, if the research continued for an extended period and additional resources were allocated to the implementation of these recommendations, then additional steps could have been followed to evaluate the process of implementing the recommendations as well as the results of the implementation. It would be interesting to understand how well these recommendations are received, how easily they are implemented, and what impact the new systems and processes have on the platform company. Ideally, if Weller Metalworks acquired another portfolio company, this research could be assessed through the integration of the new portfolio company to understand how well these recommendations apply to future acquisitions.

4.2 Data Sources

The research strategy outlined in the preceding section requires data to produce the most informed recommendations for integration. The three primary data sources for this research are the business systems and documentation of the portfolio companies, the observations made while on-site at each location, and the company personnel themselves. These three data sources provided specific insights into the operations and processes by which each company functioned, and when compiled, this data created a more holistic view of the organizations. The business systems and documentation supplied both qualitative and quantitative information, my observations provided independent evaluation of current practices, and the company representatives helped shape a qualitative understanding of each business from the perspective of those who have worked there for many years.

Each portfolio company provided full access to its ERP system and business documentation. The ERP provided quantitative data regarding a number of different areas of the business, such as historical sales, customer orders, unique SKUs produced, total quantity of products shipped, and end-markets served. Much of this historical data was analyzed to develop the company profiles documented in Chapter 2. The ERP systems also tracked the production operations of each location as well as the performance of those operations – both of which fed into establishing the initial states of each portfolio company and performing strategic benchmarking. Both of these steps were also informed by financial performance of each company, both historical and projected, in the ERP; this quantitative information was analyzed to better understand the markets served as well as individual customer trends for each portfolio company. On the other hand, the documentation of each organization, such as their process flow charts and general business rules, supplied the qualitative side of the structure of each one's operations. Using both the quantitative and qualitative data available in the ERP and business documentation allowed us to gain a deeper understanding of the similarities and differences between the two portfolio companies.

Complementing this understanding were my own observations made while on-site at each company. These observational studies were conducted at both a macro- and micro-level: the production floor layouts and operations process flow diagrams found in Chapter 5 were created based on this data, and this data also served as inputs into each step in the research strategy process as they provided a distinct perspective from the ones gathered via the ERP system, business documentation, and company personnel. Although there is some inherent bias from the researcher's own experiences and knowledge of production entities, this perspective, compared to those who have owned and/or operated the portfolio company, is one of an independent party, not one of someone who is acutely familiar with the inner workings of the business. One area in which this independent perspective is particularly useful is in assessing opportunities for operational improvement, for the researcher is able to see opportunities in areas that may not be evident to those who are accustomed to certain processes, like those who have worked in the organization for an extended period of time.

The individuals who have been with each portfolio company for many years were another source of data for this research. Unlike my independent observations, they provided perspectives that had been based on years of knowledge of the company and its operations. The team members at each company explained their business processes, answered questions about various operations, and explained their own views of certain procedures. They detailed various sub-processes of their overall operations workflow, such as the quoting process at Muthig and the electronic data interchange process at Laser Precision, and described not only how these were constructed but also why these processes took a certain form. These interactions with the company personnel informed the bottom-up perspective for integration, and most importantly, with their guidance, we were better able to build a comprehensive understanding of each organization and identify areas in which the two portfolio companies could begin the integration efforts.

Chapter 5. Integration Objectives

The objective of the Weller Metalworks platform is to create one consolidated company through the acquisition and integration of multiple businesses in the metal fabrication and machining industry in order to provide solutions that meet customer needs for low-volume, high-mix production. These acquisition activities are guided by a set of goals for the Weller Metalworks platform as well as expectations from the private equity firm, LFM Capital. While LFM Capital has longer-term goals for the Weller Metalworks platform based on its initial investment thesis, the platform itself has concrete targets to achieve on an annual, or even quarterly, basis in order to ultimately accomplish some of these goals. These objectives are then translated down from the top levels to the portfolio companies, and from there, it is the responsibility of the site leaders at each location, with the support of the platform leader, to drive progress toward these goals. In addition to the platform level goals, the portfolio company leaders also must achieve certain targets for their own sites. This chapter provides a description of goals from both the top-down perspective, which represents those of the Weller Metalworks platform, and the bottom-up perspectives, which represents those of the portfolio companies, Laser Precision and Muthig Industries. While these two perspectives are in alignment in terms of their over-arching objectives, the ways by which these objectives are achieved differ.

5.1 Top-Down (Platform Company) Goals

The end-state goals of the Weller Metalworks platform are to increase the overall value of the company and to position itself in the market so that its sale, or exit, will provide a positive return on investment for all stakeholders. Accomplishing these two primary goals requires that the platform focuses on growth in terms of both revenue and earnings before interest, taxes, depreciation, and amortization (EBITDA), as well as on diversification of customers, end-markets, and geographies served. This can be achieved through several different levers, such as integration and add-on acquisitions, that serve as a means of operational improvement.

Integration, in this context, focuses on bringing multiple organizations together under one company in order to realize the synergies produced by sharing best practices among the sites, accelerating cross-site collaboration, and driving efficiencies across the platform. The high-level goal of integration is to leverage the various capabilities of each site in order to take advantage of the opportunities identified in both the platform and the investment theses: essentially, integration, when executed well, proves that the platform, as a whole, is more valuable than the individual pieces operating independently. It is worth noting that integration does not necessarily require that all operations will move to one location nor that all sites align on the various business systems used. For instance, it may not be in the best interest of the platform for its companies to immediately move to a standardized enterprise resource planning (ERP) system, but this may become required at a later stage to facilitate better collaboration. Integration, therefore, is not necessarily about standardization; instead, integration is a vehicle to build value and create a system by which these entities, such as Laser Precision and Muthig Industries, can seamlessly work together and support the needs of Weller Metalworks' customers as one unified contract manufacturer.

The most significant step changes in platform level growth for both revenue and EBITDA typically occur via add-on acquisitions. For instance, when Weller Metalworks only comprised one location, Muthig Industries, its revenue and EBITDA were equivalent to those of Muthig; however, when Weller completed the acquisition of Laser Precision, the platform increased its sales, finances, capabilities, and many other factors by adding those of Laser Precision to those of Muthig. Looking at these two metrics specifically, revenue and EBITDA are targeted in private equity because they are indicators of financial performance and value: increasing revenue reflects a company's ability to increase its sales, capture additional market share, and strengthen its customer base, whether through acquiring new customers or maintaining pre-existing ones; increasing EBITDA reflects the growth in the company's overall profitability. When potential add-on acquisitions are evaluated for the Weller platform, these two metrics serve as key inputs for assessing a target company's overall value, allow for comparison across the metal fabrication and machining industry, and aid in determining an appropriate acquisition multiple, the ratio of purchase price to that business's EBITDA.

Add-on acquisitions can impact not only revenue and EBITDA, but these acquisitions can also substantially alter the platform's concentration of customers, end-markets, and geographies. A high customer concentration, in which a small number of customers contribute a significant portion to a company's revenue, can lead to excessive dependence on one customer, decreased pricing power, and reduced potential for scalability and growth. Similarly, concentration in end-markets and geographies are also viewed negatively because these can leave a company vulnerable to market trends for a particular industry or overly dependent on a specific geographic region. Certain end-markets may suffer in economic downturns, be subject to industry-specific regulations, and be impacted by seasonality just as geographic areas can be devastated by natural disasters, political instability, and regional economic crises. Having a high concentration in any or all of these three areas is risky, but adding other companies that have different profiles in these matters can help diversify the platform.

Diversification, in general, is a strategy by which investments can be de-risked, and this concept applies not only to the goals for add-on acquisitions but also to how potential investors and acquirers consider the Weller Metalworks platform. At the time of sale, any potential buying parties will evaluate Weller Metalworks on many different criteria, including those listed above, to assess risk in any of those areas and to determine the overall value they are willing to pay for the business. The value selected is often referred to in terms of being a multiple of the company's EBITDA, exactly like the acquisition multiple but from the selling perspective instead of buying perspective. For businesses like Weller Metalworks, there are certain thresholds for EBITDA, customer concentration, level of integration, and

EBITDA to Revenue ratio, EBITDA margin, that result in a specific range of exit multiples, which is the total value paid for the consolidated platform at exit divided by the platform's consolidated EBITDA.

While the exit multiple reflects the valuation of the total platform at the time of exit, there are other metrics that are used to measure the performance of the invested funds. In private equity, the success of an investment is typically evaluated in terms of internal rate of return (IRR) or multiple on invested capital (MOIC). IRR estimates the profitability of an investment based on the annualized rate of return on the investment, and MOIC measures the relative value gained from the initial capital invested. When LFM Capital created its investment thesis for the Weller Metalworks platform, both IRR and MOIC projections were made under various exit conditions to understand the range of upside potential. Figure 5-1 illustrates how the EBITDA of the platform results in different MOICs for investors:

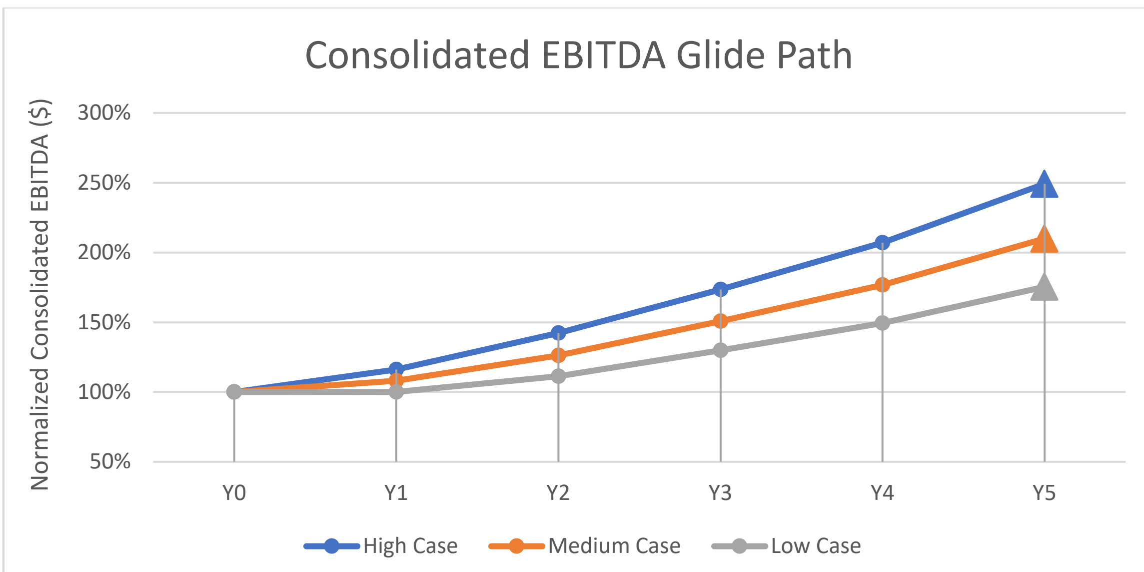

Figure 5-1. Multiple On Invested Capital (MOIC) Projections

Figure 5-1 illustrates three scenarios – High, Medium, and Low – for the multiple on invested capital that could be achieved given the platform's capital structure and exit multiple. Each of these three cases corresponds to a numerical value of the multiple, but they were generalized as "High," "Medium," and "Low" in order to conceal the true projected MOIC values. The x-axis represents the 5-year holding period for the platform, and the y-axis represents the consolidated EBITDA for the platform as a whole. Each of the glidepaths depicts the projected growth for the consolidated EBITDA over this 5-year hold, and the result, as seen in Year 5 and noted by the triangle markers, is three scenarios with varying MOICs based on the consolidated EBITDA the platform is able to achieve at the time of its sale. Even though the Weller Metalworks platform is still in quite a nascent state, it is important for the portfolio companies to understand this expectation in order to develop and implement strategies to meet these goals.

5.2 Bottom-Up (Portfolio Companies) Goals

Taking the platform-level goals into consideration, the leaders of the portfolio companies must shape the strategy of their sites to achieve site-level targets that tie into the overall platform objectives. As these high-level goals cascade down from the platform level, more specific actions can be developed to be taken at the portfolio company level. For example, one of the main objectives for the platform, as a whole, is to grow revenue by a target, so this percentage will be allocated among the platform's portfolio companies. Each portfolio company – Laser Precision and Muthig Industries, in this case – will have a target growth amount that will, if achieved, allow the platform to grow by the desired target in revenue for the given period. The revenue growth targets for the portfolio companies may be achieved through a variety of initiatives implemented at each location. These initiatives should be customized to fit the location specifically: while one company may pursue this growth through acquiring new customers or entering a new end-market, the other may achieve this growth by increasing prices on their products with pre-existing customers. Tailoring the strategies for growth to meet the needs of each individual site allows each portfolio company to optimize its approach based on its unique position in the market and account for nuances within its customer base.

In addition to the overarching platform-level targets, the portfolio companies are also expected to grow their business operations, advance integration, and continue implementing operational improvements. While this may seem like an obvious statement, it is worth noting that any portfolio company of the Weller Metalworks platform was acquired based on its ability to deliver certain results, and as such, it is necessary that those firms continue delivering those results to the platform. If these results were to decline, then additional strategies must be implemented to compensate for the loss of whatever value was originally projected at the time of acquisition. Both portfolio companies in the Weller Metalworks platform have been independently owned and operated for decades, so the leadership teams at each location are well aware of how to run a successful business. In fact, it is this operational excellence, as well as other desirable factors, that led to their acquisition by the Weller platform. The leaders of these sites are the subject matter experts of their respective operations, and they are expected to continue generating value through their business operations.

Now, as part of the Weller Metalworks platform, the portfolio companies must work together to advance integration and implement operational improvements. Integration, as discussed above in Section 5.1, can impact a wide variety of functions, operations, and business systems, and it is a critical piece to achieving the goals of Weller Metalworks. The portfolio companies, therefore, must determine how to best work together to achieve the full integration of the platform, and when new companies are acquired, these must also be brought into the collaboration process. Many of these integration objectives are set by the Weller leadership team, but how the objectives are achieved, such as sharing and standardizing best practices for certain processes, is the responsibility of the portfolio company leaders. This research documents some of the key considerations for integration for a small set of functional areas in Chapter 7. Operational improvements, which may also result from or contribute to integration efforts, can also be implemented at the level of the sites to accelerate collaboration among the portfolio companies. Recommendations for specific operational improvements for each site will be shared in Chapter 10.

Chapter 6. Initial State

This chapter outlines the initial state of the two portfolio companies, Muthig Industries and Laser Precision, observed at the time this research was conducted in order to identify areas in which integration synergies could potentially be achieved. As mentioned in Chapter 1, the acquisitions of both companies were completed in 2023, within 2 months of each other, and the overall Weller Metalworks profile changed significantly with each addition. Because these two organizations had not previously worked with other locations, much less worked together, there was no precedent for how the integration of these two entities should unfold. As such, the first step was to establish the current state of each portfolio company at the time of this research. Determining the initial state of these locations was necessary to highlight the similarities and differences and to understand the best path forward for their integration. This chapter contains two sections, one for each location, that detail each company's production operations and business processes from the lens of assessing their overall compatibility, collaboration potential, and ability to integrate under the Weller Metalworks platform.

6.1 Muthig Industries

The general information about Muthig Industries, such as its origin, historical sales, and industries or end-markets served, can be found in the Section 2.3 of Chapter 2. This subsection, instead, focuses on the company's manufacturing and business processes – both of which are relevant to the company's fundamental operations – in order to establish the initial state of the organization at the start of the integration process.

6.1.1 Production Operations

Muthig Industries operates out of a 35,000 sq foot facility in Fond du Lac, WI, and employs roughly 40 individuals, which designates it as a small enterprise. Its manufacturing operations are divided into four departments: Stamping, Laser, Production Machining, and Tooling. The layout of their production facility is organized by these four departments with some additional space reserved for functions that impact all production departments, such as sales, general administration, and quality and engineering. Figure 6-1 represents the site map for Muthig Industries:

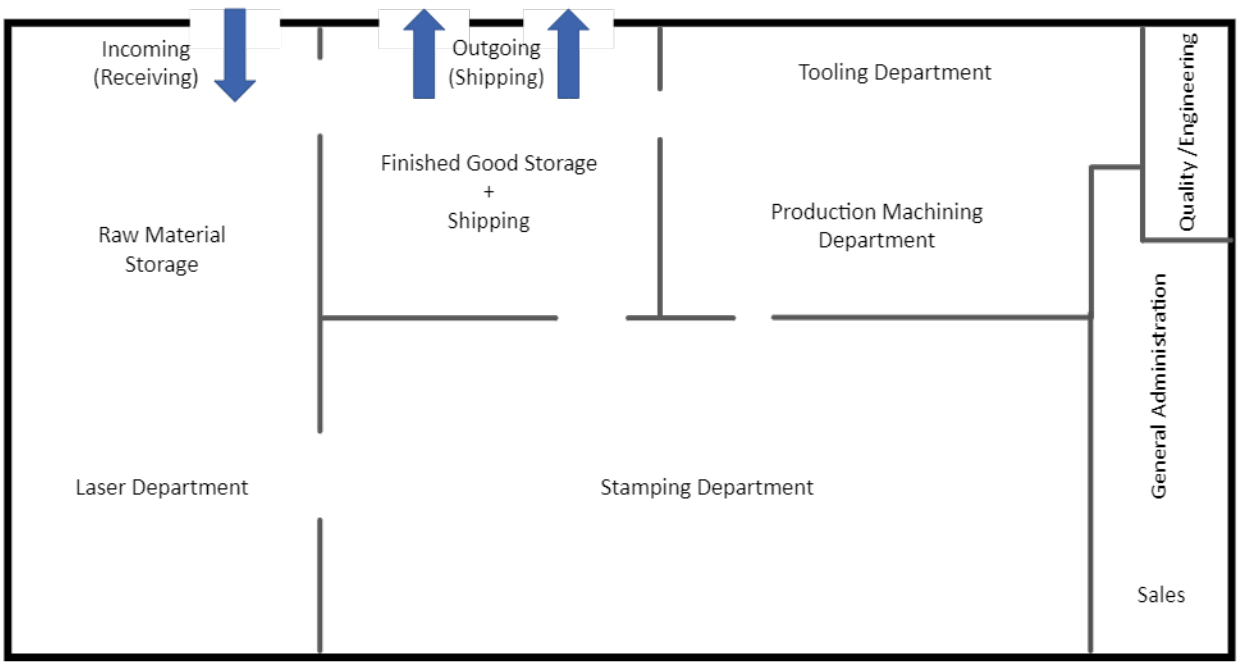

Figure 6-1. Muthig: Site Layout

Figure 6-1 is somewhat misleading in that it seems as if each department is independent from one another, except for the Production Machining and Tooling departments. While some departments are mostly self-contained and do not rely on other departments' operations, others are not that way. Certain work orders will pass through multiple departments and require operations that are performed in different areas. Muthig uses make-to-order manufacturing practices and completes work orders in batches, following a similar manufacturing system as a job shop. This is due to the high-mix, low-volume nature of the types of products manufactured by Muthig: because each product requires unique processes, it is quite difficult to establish a standardized flow through the production floor. For example, a stamping product may originate and end in the stamping department, but something that requires laser cutting may start in the Laser department then go to the deburring stations in the stamping department and then finish in the production machining area. As a result, the work orders travel among the four departments as required by the product specifications.

In order to meet the needs of the LVHM production environment, each of the four departments contains a variety of equipment to perform different services. In the Metal Stamping department, Muthig offers mechanical presses that range from 20-ton to 220-ton as well as precision stamping presses that use computerized servo driven feeders. They can create many different types of stamped products as well as the dies that are used to produce those products, such as progressive dies, compound dies, trim dies, and draw dies. The Laser department includes both laser cutting and forming operations, which are completed by high precision lasers and 60-ton to 193-ton press brakes. In the Production Machining department, there are both horizontal and vertical machining centers as well as lathes that provide 3D/multi-axis machining capabilities. These are coupled with Renishaw probing systems that measure product features during the machining process to ensure that the finished product meets the required specifications. Finally, the Tooling department offers mills, lathes, and wire electrical discharge machining (EDM) that allow Muthig to create a wide range of custom tooling and fixtures to meet their customers' production tooling needs. These specialized pieces of equipment allow Muthig to advertise a broad offering of services and production capabilities in the LVHM metal fabrication space.

6.1.2 Business Processes

Reigning over these pieces of production equipment is the enterprise resource planning (ERP) system that Muthig uses to process quotes, schedule work orders, optimize capacity utilization, control inventory, and generally run their business. The ERP contains a quoting module that allows the Sales team to generate quotes directly in the system, automatically factoring in raw material pricing and cycle time adjustments. Muthig uses this module alongside their own proprietary quote calculator to ensure that they are pricing competitively while also achieving their desired profit margins. The quoting process differs by department in the amount of input provided by Muthig's quote calculator, but all quotes are ultimately entered into the ERP system to be converted into production orders when accepted by the customer.

The ERP then advances from order processing to scheduling, the process by which the work orders are scheduled for production. In this process, the ERP is particularly useful because it provides real-time visibility into the utilization and capacity of all machinery, thereby allowing the Muthig Operations leaders to schedule jobs accordingly. Muthig uses backwards scheduling, in which jobs are scheduled by first looking at their ship date and then understanding how long production will take to complete the order; this method of scheduling provides additional flexibility and allows them to meet last-minute changes or requests from the customer. While these requests require Muthig to manually update the system, the ERP will automatically recalculate the production start date, accounting for whatever operations were added to the original production process. This increased flexibility positions Muthig as a vendor who accommodates customer requests and can meet changing customer needs in an agile manner.

Figure 6-2 represents the process flow of business operations at Muthig Industries:

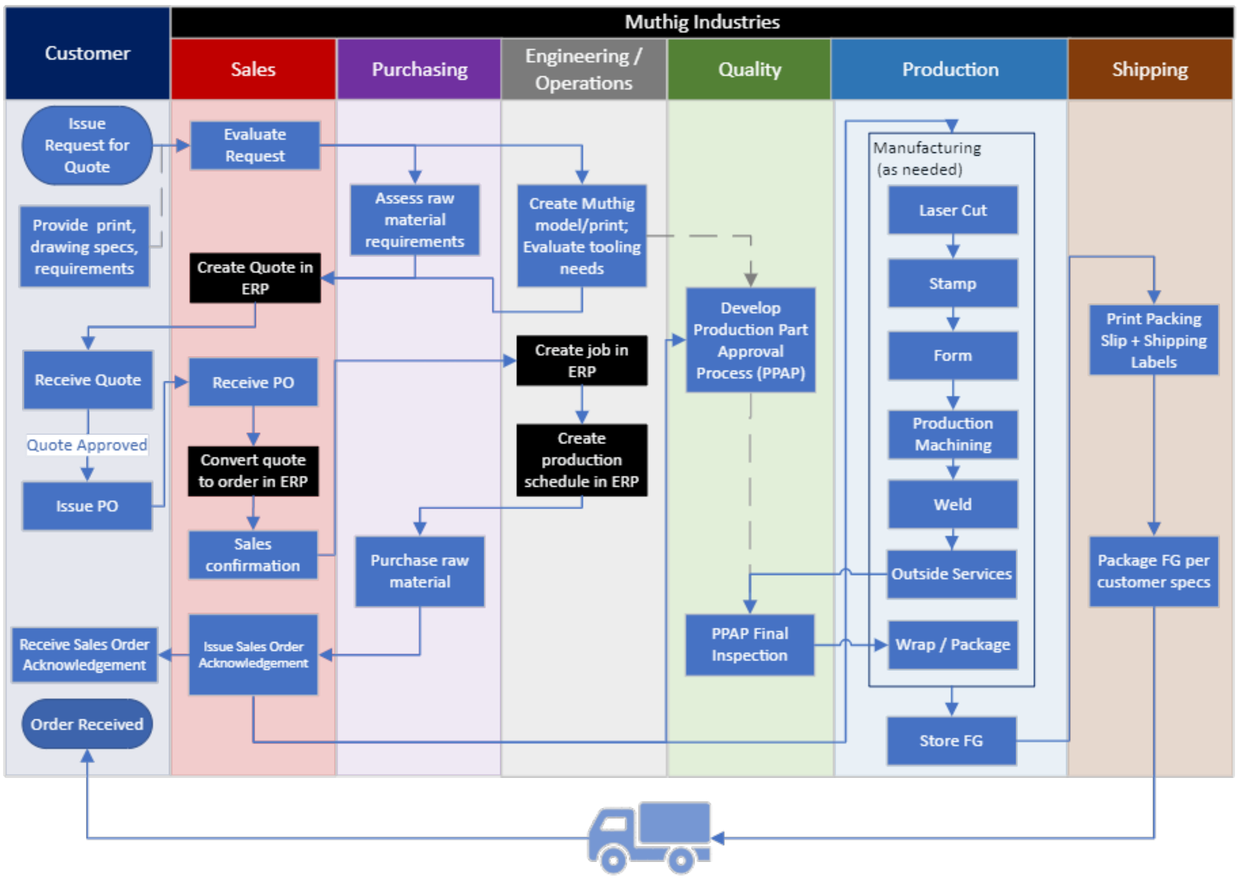

Figure 6-2. Muthig: Process Flow Diagram

Each of the columns in the swimlane diagram above represents different functional areas in Muthig's organization. There is some overlap in the personnel of each functional area – for instance, the Sales group includes Inside Sales personnel, who also help with the raw material purchasing and operations administrative tasks – but the tasks that are required of each functional group are quite separate from one another. Each box represents an action, and each action is positioned in the vertical swimlane for the functional area responsible for that action. The ovals in the customer column represent the start and end of the business process, and the grey dashed connecters, such as that between the "Create Muthig model/print; Evaluate tooling needs" and "Develop Production Part Approval Process (PPAP)," represent information from a source to an output. While the source of information does not necessarily lead to the next action, it does factor into that output action in some way. The black boxes represent the actions that are completed through Muthig's ERP system – details for which are provided in the paragraphs preceding Figure 6-2.

Muthig uses paper cover sheets to move an order from sales through the rest of the functional areas of the organization. Each type of order – repeat orders for active parts, orders for parts in-stock, new revision orders, new product orders, tooling orders, and engineering change orders – receives a different cover sheet, and the information on the cover sheet generally follows the process diagram as depicted in Figure 6-2. There are some exceptions in which certain functional areas are only involved on certain order types: for instance, for any new product order or revision update to an existing product, the Quality group is required to verify that the new print and inspection report are available to the production team. This is not required for parts that are already in-stock or those that do not have a revision change associated as those products already went through the quality process when they were first ordered or updated. The cover sheet process, in general, requires each functional area team member to complete his/her section and then submit the document to the next responsible party, thereby facilitating cross-functional communication and collaboration. For all orders, the cover sheet process guarantees that the sales pricing is accurate, the data has been entered into the ERP system, the order has been added to the production schedule, any necessary raw material inputs are purchased and/or available, the customer communication (sales order acknowledgement) has been issued, and all functional groups are informed of and approve of production.

6.2 Laser Precision

Just as is the case with Muthig Industries, the background information for Laser Precision can also be found in Section 2.4. The following subsections detail the production operations and business processes at Laser Precision. This organization is quite unique in that its ERP system is fully integrated into both production operations and business processes, which has been a key factor in their success as a contract manufacturer in the low-volume, high mix metal fabrication realm.

6.2.1 Production Operations

Laser Precision is a mid-sized enterprise that employs around 145 individuals and operates in Libertyville, IL, out of a 130,000 sq. foot facility – 125,000 of which are dedicated to manufacturing. Laser Precision's production floor is organized as shown in Figure 6-3:

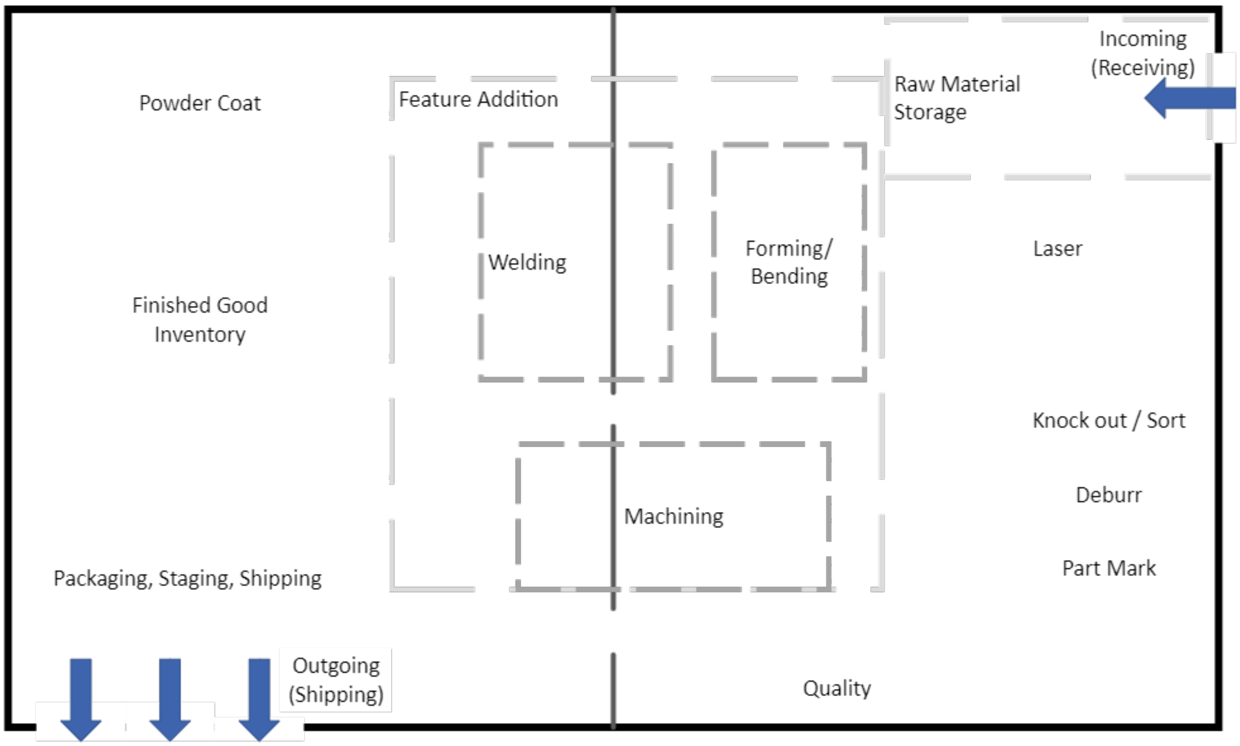

Figure 6-3. Laser Precision: Production Floor Layout

This site map only represents the production floor and does not include the front offices that are used by the management staff for sales, operations management, engineering, material procurement, and quality. Compared to Muthig's facility, Laser Precision has fewer walls between each of the operations groups, and this is by design: most of the products that Laser Precision manufactures follow a similar flow through the production floor, so an open floor plan allows for easy movement of orders between operations. Though Laser Precision still relies on make-to-order manufacturing in the low-volume, high-mix metal fabrication realm, its product routings, or order of operations, are consistent enough to create a general flow through the production floor rather than have work orders bounce back and forth between the different operations groupings. Because the manufacturing process for any product depends on the product features and requirements, operations will be added or removed to the work order as needed to meet these specifications. Most products start as raw material, move into the laser department for laser cutting, proceed to the knockout / sort area to be removed from the laser cut sheets, pass through the deburr and part mark operations, and then move to different areas based on whichever features are required. Figure 6-4 depicts the process flows of different products progressing through the manufacturing shop floor.

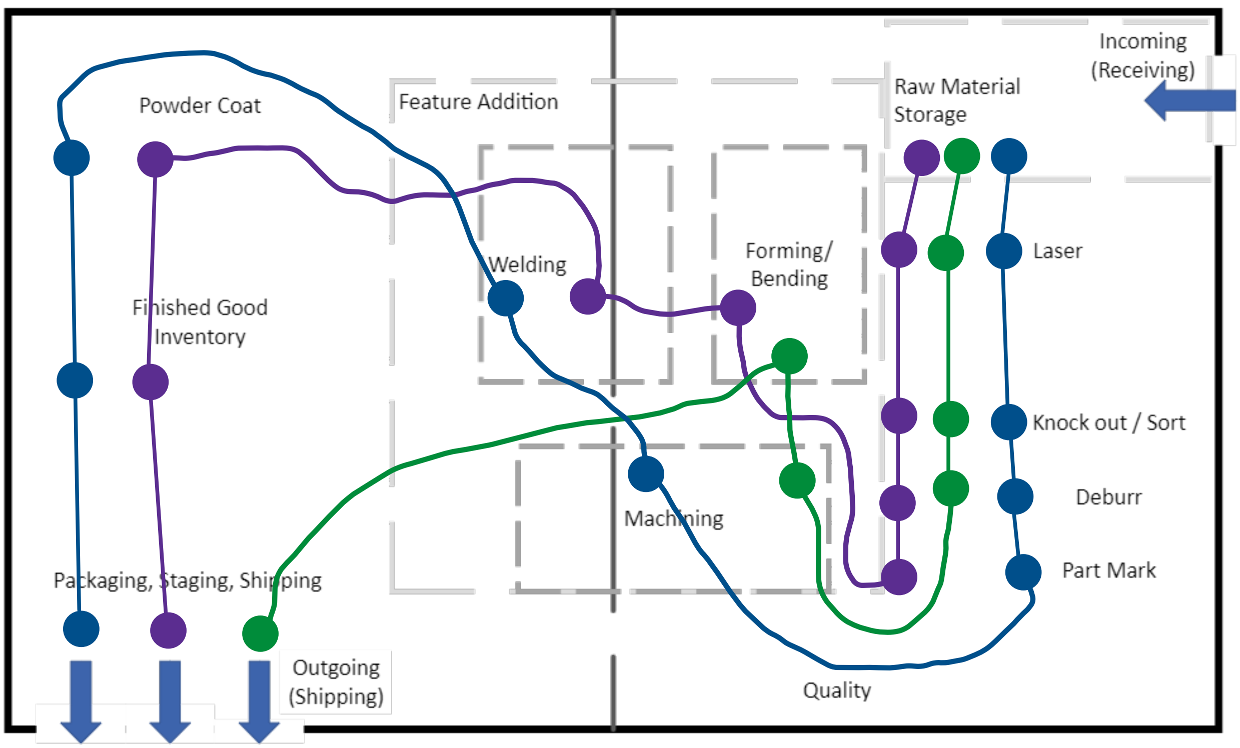

Figure 6-4. Laser Precision: Production Flow Examples

In this example, there are three products – purple, green, and blue – and each one's progression through the manufacturing process is represented by lines of the same colors. The circles in the diagram represent operations that are required to produce the product per the customer's specifications. As mentioned above, the beginning process is the same for all three products, from raw material to deburr. At that point, the paths diverge as each product goes to its respective required operations. The blue product, for example, must first go through part marking before undergoing the machining, welding, and powder coating operations; after the production operations are complete, it can be put to stock in the finished good inventory and then ultimately shipped. Contrastingly, the green product does not require part marking, so it will go straight from deburr to machining. After that, it will go to forming before being packaged and prepared for shipping. The green product may have been an urgent order as it did not get stored in the finished good inventory and instead went straight from production to packaging, staging, and shipping. Finally, the purple product followed the same path as the blue product at the start of its operations, but after part marking, the purple product went through forming and welding rather than the path of machining and welding that the blue product took. Despite the differences in the initial stages of their routings, the final operations of the blue and purple products are the same, however, as both products progressed from powder coating to finished good inventory to packaging, staging, and shipping. These three sample products illustrate that even though these products require different operations at different stages, there is an overall flow and standardization of the movement of orders that can be achieved in the Laser Precision production environment due to the type of products that Laser Precision manufactures. This standardized flow is depicted in Figure 6-5 by the high-level process flow as well as by the red arrows drawn on the production floor map in Figure 6-6.

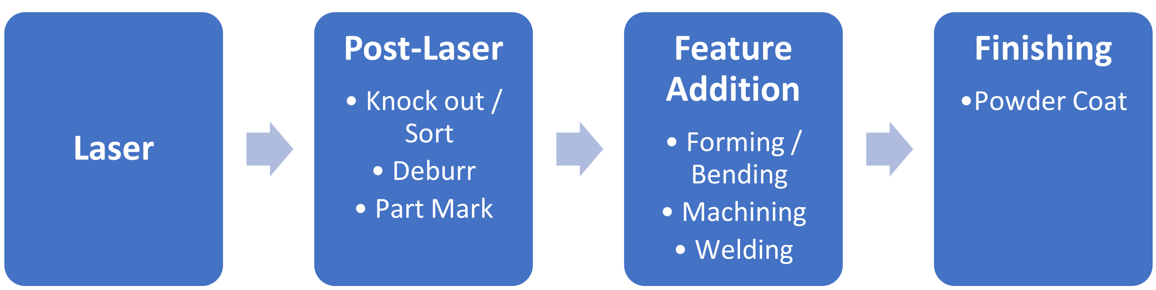

Figure 6-5. Laser Precision: Production Process Flow Diagram

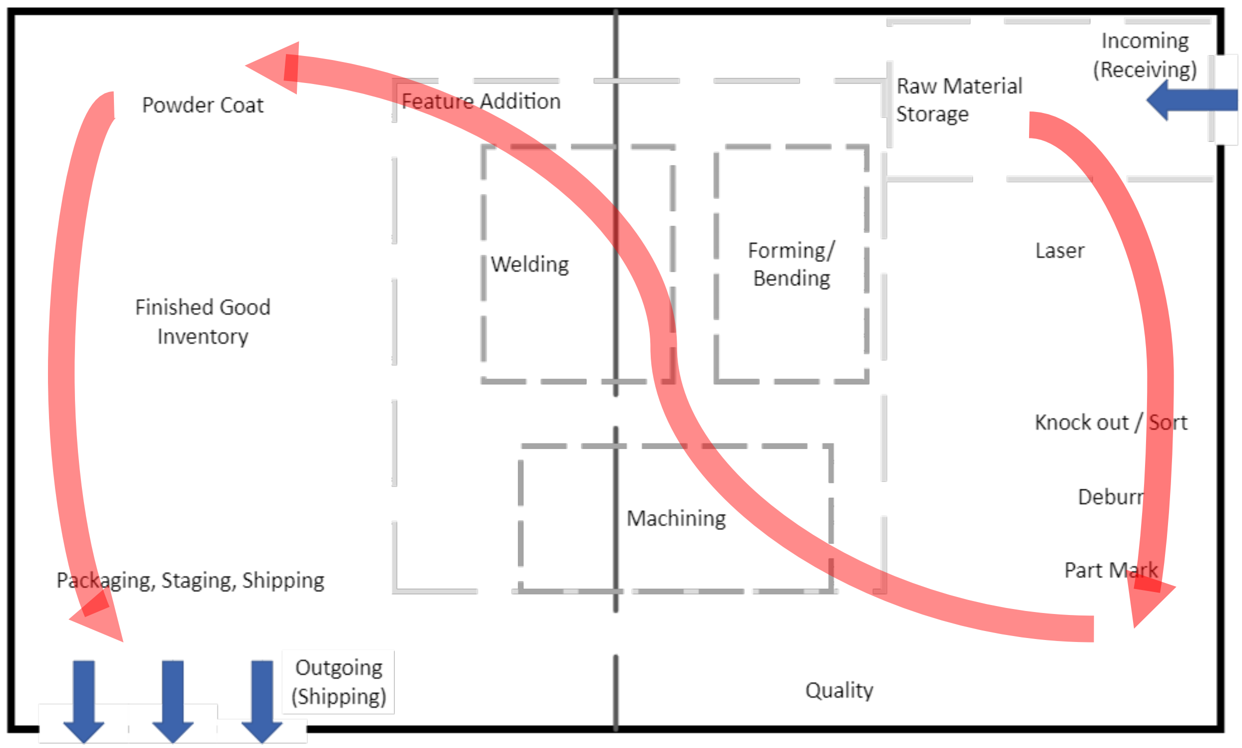

Figure 6-6. Laser Precision: Production Floor Layout with Overall Process Flow

As illustrated by the production floor diagram, Laser Precision offers metal fabrication services for laser cutting, forming, machining, welding, assembly, and finishing. The laser cutting is accomplished by laser cutters that are connected to material towers as well as loading and unloading tables, which allow the whole operation to be fully automated. The material towers load the laser cutting tables with the required sheets, the laser cutters detect the sheet and begin the cutting operation, and when completed, the cut sheet is moved to an unloading table. Laser Precision's forming services feature press brakes that can achieve a forming pressure of up to 170 tons for products up to 9 ft in length. In terms of machining, Laser Precision uses lathes, drill presses, and vertical machining centers to offer high-precision milling, drilling, turning, multi-axis machining, beveling, and tapping. The welding group offers both manual welding as well as welding assisted by collaborative robots (co-bots); the equipment used in this department is as follows: manual arc welding stations, spot welding machines, stud welding guns, MIG and TIG welding machines, a robotic welder, and welding co-bots. Finally, the assembly and finishing groups offer custom services to meet specific customer needs: in fact, Laser Precision built its own 7-stage powder coating operation in-house so that it could meet customer specifications regarding product finish, such as dual coat, gel coat, and military certified chemical agent resistant coating (CARC). This machinery, in conjunction with having its production floor organized in such a way that allows for a more standardized flow than is typical of LVHM production environments, has allowed Laser Precision to optimize its production operations for a wide variety of metal fabrication services.

6.2.2 Business Processes

The overarching operating system at Laser Precision is a custom ERP that governs all aspects of their business. This production data management system automatically pulls in almost all its customer demand signals via electronic data interchange, updates orders as changes are made by the customer, and uses backwards scheduling to create a prioritized schedule based on the ship date for the work orders that are then processed on the shop floor. There are built-in business rules that govern this system; for example, one such business rule ensures that any changes made within a certain time window from the ship date trigger an exception that must then be reviewed. If the change can be accommodated (if there is enough raw material, equipment / personnel capacity, etc.), then the change is approved and accepted, and the update feeds straight into the schedule, which is then automatically reprioritized in the system. If the change cannot be accommodated, then additional discussions with the customer are required to determine how to handle the change request. The schedule of orders determines both when and how much raw material is needed, which then allows the team to ensure it is available for production. The raw material and production schedule are then inputs that allow Laser Precision to optimize metal sheet utilization in the laser cutting process by creating the nested layouts for whatever is due per the schedule as well as by pulling in additional parts that fit on the nested layout and have the same material requirements. The ERP system calculates how long each of the next manufacturing process steps should take, as projected by the routing developed during the quoting process, and the work order flows through the production floor accordingly so that it is ready by the given ship date. This unique ERP system provides Laser Precision with agility and flexibility to update their production processes as needed.

Figure 6-7 illustrates the swimlane diagram of process flow for Laser Precision. The ovals in the customer column represent the beginning and end of the process, and the other boxes represent all the remaining activities that are completed throughout manufacturing. Each column of a different color represents a functional group; the grey arrows with dashed lines connect information inputs to subsequent activities; and the black-colored boxes highlight activities that are conducted within the ERP.

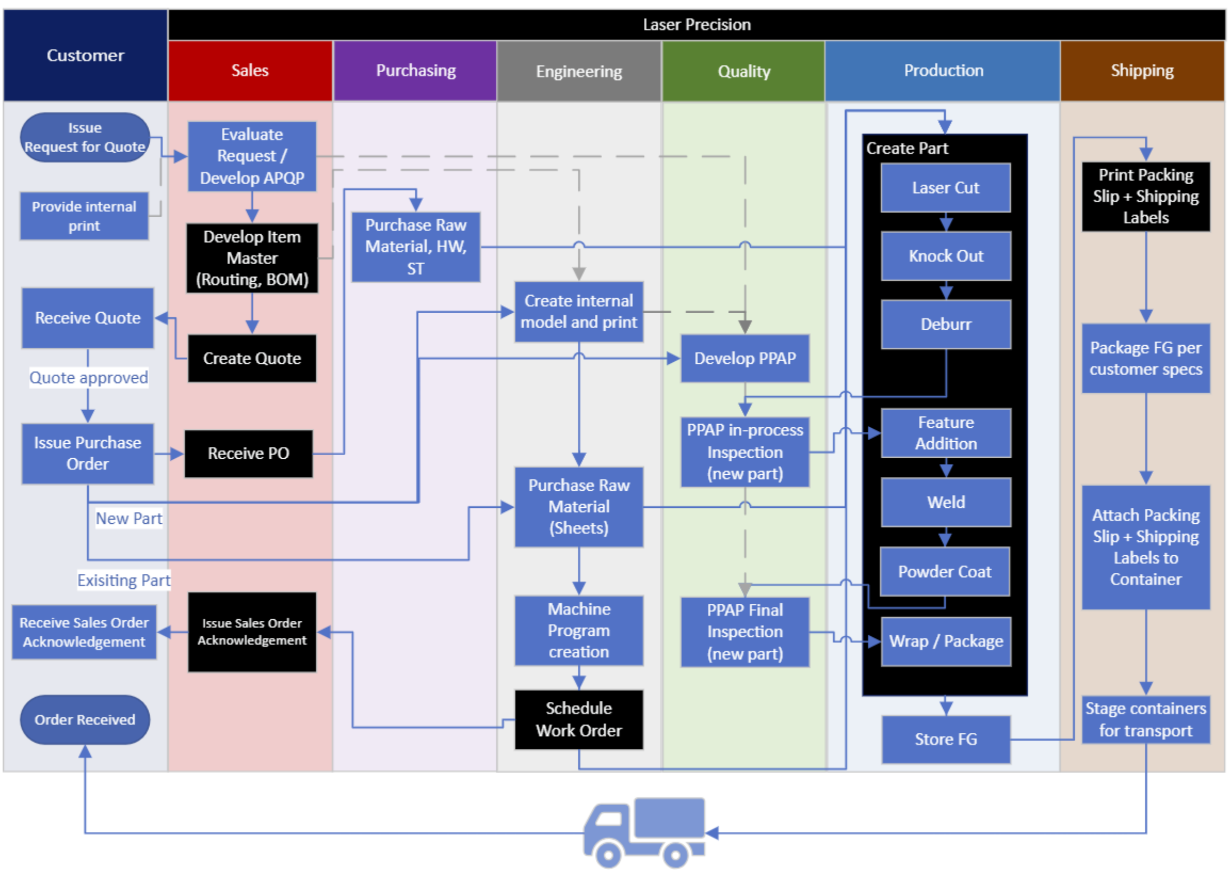

Figure 6-7. Laser Precision: Process Flow Diagram

This swinlane diagram documents the high-level process of how an order moves through Laser Precision's production from sales to shipping, but it does not illustrate how each of the functions interact with the ERP behind the scenes to enable the ERP to perform as the brains of production. For instance, the purchasing group uses the ERP's material resource planning (MRP) module to determine the raw material inventory levels, which account for how much of the current inventory is allocated to future production. If raw material is needed, the ERP will alert the purchasing team by flagging certain orders to indicate that there is not sufficient material to create these products. This then allows the purchasing team to place orders with its raw material suppliers for these products. In a similar manner, the engineering and production groups rely on the ERP to progress orders through the manufacturing process. The engineering team independently creates the machine programs and then imports the layouts for the laser cutting machines to the ERP to start the production process, which is entirely governed by the dispatch list.

The dispatch list, created by the ERP, is the list of prioritized orders for each operation in the production process. As customers submit changes to existing orders or drop in new orders, the ERP verifies whether these changes are feasible, and if approved by the Laser Precision team, the ERP processes these changes to update the dispatch list accordingly. A product's routing, which defines the route the product must take through various operations in the manufacturing process, identifies which operations will be required, and these products are scheduled on work orders that are added to the overall production schedule in the ERP. This schedule is then broken down into each of the operations groups, and each operations team references the ERP's dispatch list to understand which work orders should take priority. For example, when the laser cutting operation is completed, the work order disappears from the laser dispatch list and advances to the next operation's dispatch list. The operations team to receive this order will then work on it immediately after the current job only if it is mandated by the dispatch list as top priority; if it is not a priority, then other more pressing work orders will be completed first. The ERP not only tracks all of this movement of work orders on the shop floor, but it continuously updates and re-prioritizes the dispatch lists for each of the operations groups to ensure that products are completed on time. The Laser Precision operating system eliminates much of the manual work that would be required to process the ever-changing customer demand signals, and it allows the organization to focus, instead, on operational excellence and quality.

Chapter 7. Key Integration Considerations for Functional Areas

When determining the strategy for integration of two distinct entities, it is important to consider how each company is organized. Each of the two portfolio companies, Muthig Industries and Laser Precision, has specific functional areas that perform certain business operations. To understand how these companies can work together in these business operations, the similarities and differences between their functional areas should be investigated, and their ability to achieve alignment in these operations should be assessed. This chapter compares the two organizations at a high level and explores some key considerations for the integration of two functional areas, Human Resources (HR) and External Relationships, which have been selected as examples due to their potential for consolidation and synergy achievement. Because Muthig and Laser Precision operate quite similarly as contract manufacturers in LVHM metal fabrication, it was believed that their HR and External Relationships functions would also be very similar in capacity and scope, and as such, these two functional areas were chosen as the starting points for driving alignment between the portfolio companies. These strategies were further developed and detailed in the integration playbook, and this chapter captures those ideas for these two functional areas in a summarized form. While these examples do not provide a comprehensive comparison of the portfolio companies, they do establish the process by which strategic benchmarking was performed and opportunities for integration were identified.

7.1 High-Level Comparison of Portfolio Companies

As a small business with less than 50 employees, Muthig Industries operates quite differently than Laser Precision, which employs more than 120 employees as a medium-sized manufacturing organization. These two portfolio companies are not only different in the size of their workforce but also their scale of production: as noted in Chapter 2, Laser Precision produced almost 3.5 times as many unique products as Muthig Industries in 2022. As a much larger shop in terms of the number of products produced as well as in terms of physical space, Laser Precision has more resources allocated to its various production departments as well as the front-office functions. With a larger workforce and more machinery than Muthig, Laser Precision has greater production capacity, and subsequently, it also has greater raw material needs to capitalize on its full production capacity. Muthig Industries, on the other hand, has a much smaller workforce, which allows it to be more flexible in its working hours for its employees as well as in their ability to meet rapidly changing customer needs. As a smaller team, many of Muthig's employees are responsible for more than one activity or business operation, which keeps the business running in a lean manner.

The production and business processes for the two portfolio companies are similar in some ways and different in others. Both organization's processes start with quoting and creating the digital version of the product along with its routing in the ERP system, and the routing is used in both shops as the guide for which operations the product must undergo in the production process. The ERP system supports production operations by creating the production schedule based on backwards scheduling, calculating shop capacity, managing inventory levels, and tracking products through the production processes as defined by its routing. While both organizations rely on make-to-order manufacturing strategies, the processes differ in the types of products that each shop manufactures: Muthig's products are equally split among the Laser, Production Machining, and Stamping departments, whereas almost all of Laser Precision's products start with Laser operations and then progress through the rest of the shop. This difference is key to allowing Laser Precision to have a more standardized production process flow whereas Muthig relies more heavily on batch processing of work orders. The increased standardization has also allowed Laser Precision to move to a more automated system by which pre-production data is processed and fed into the production operations. Standardization is difficult in the high-mix, low-volume production realm, but achieving it can lead to increased operational efficiencies.

7.2 Functional Areas

With a better understanding of some of the fundamental similarities and differences between the two portfolio companies, a deeper investigation into the functional areas of each organization was conducted. Not only did this inform the strategic benchmarking of the two locations, but it also allowed for the identification of functional areas in which integration synergies could be achieved. The following sections, Section 7.2.1 and Section 7.2.2, outline some of the key considerations for integration at the functional level, and the two functional areas selected – Human Resources and External Relationships – serve as examples of how integration strategies were evaluated.

7.2.1 Human Resources

Human Resources is a function that impacts all other areas of the business as it defines how an organization interacts with its employees. This department is responsible not only for hiring employees, managing the workforce, and issuing employee benefits but also for creating, maintaining, and enforcing workplace standards. When viewed in the context of integration, it was important to first understand what HR standards, processes, and documentation were in place at each of the portfolio companies in order to then develop a strategy for alignment and integration. Understanding the similarities and differences between the policies, as well as their rationales, led to meaningful discussions among the HR leaders of each organization about how integration of the portfolio companies into the platform company should be achieved.

One of the first items examined in this process was each site's employee handbook. The handbook contained the policies of each location, such as the start and end times of a shift, the procedures for notifying the management of absences, and the schedule for the holidays. Each organization's handbook was developed based on its unique practices, and as such, the two portfolio companies had significant differences between its policies. For instance, as a much larger organization, Laser Precision clearly outlined the times of each shift in order to create a standard to which all employees would adhere;

contrastingly, Muthig Industries, whose size is roughly one-third that of Laser Precision, was able to allow for flexible shifts for its employees, with no defined start nor end times. While this difference between when employees were expected to work may not seem significant, it is, in fact, integral to the way that each business operates, and trying to simply have one organization take on the policies of the other would undo that. At the current stage of the platform company, it did not seem necessary to choose one policy or the other; instead, it was determined that each location could, for the time being, continue its respective stance regarding the hours of its workforce. This would allow each location to enforce policies based on what worked for its specific size and unique culture, while still making progress toward moving to a more consolidated state in the future by understanding the rationale behind these policies. In a similar manner, the other various guidelines listed in the handbook were analyzed, compared, and discussed in order to best understand how to achieve alignment between the two sites.

7.2.2 External Relationships

One functional area that seemed to be ripe for achieving integration synergies was the platform's External Relationships. Though the "External Relationships" function is not a typical term in most business organizations, in the context of this research, it is used to refer to both ends of the supply chain cycle – the supply side as well as the demand side. Because both Muthig Industries and Laser Precision operated in the metal fabrication and machining industry, as well as in the low-volume, high-mix production space, the two organization were operating in parallel ways: they both required similar raw materials, performed similar operations upon these items, and delivered somewhat similar products to their customers. As such, the successful collaboration and consolidation of these two portfolio companies into the Weller Metalworks platform company could lead to the realization of economies of scale, economies of scope, and overall increased resiliency on both ends of the supply chain cycle.

On the supply side, the integration of the two portfolio companies could result in economies of scale that would allow for increased buying power and advantageous pricing due to volume discounts.

Additionally, the access to each other's suppliers would also increase overall supply resiliency as each organization could now benefit from the other one's network. Both Muthig Industries and Laser Precision require metal as a raw material to feed their production. As a single buyer, either organization has less buying power than if they were to combine this need. By combining their raw material demands and using the same supplier, the two companies would be able to reduce their per-unit transaction costs and purchase the steel at better rates. Similarly, if either of the organizations had a particularly good relationship with a raw material or sheet metal supplier, then the other organization could benefit from the pre-existing goodwill and also receive preferential treatment. By having multiple suppliers on which the organizations can rely, they can also decrease the risk of potential supply disruptions and increase the flexibility of their supply chain. The two portfolio companies could also achieve economies of scale by sharing in the raw material transportation costs, optimizing routes for shipment, and increasing visibility into each other's inventory levels. While this area could not be fully investigated during the period in which this research was conducted, it is recommended that it be further evaluated as a first step towards achieving some integration synergies on the supply side.

On the demand side, integration would allow the platform as a whole to cross-sell its services to a broader customer base, thereby achieving both economies of scope and economies of scale in its marketing, distribution, and selling opportunities. Muthig Industries and Laser Precision have different product capabilities, but with their acquisition into the Weller Metalworks platform, each organization can offer the other portfolio company's services to its customers, thereby creating a much broader service offering and achieving economies of scope. For instance, prior to joining Weller Metalworks, Laser Precision was unable to meet customer needs for any product that required stamping operations as Laser Precision does not have the machinery nor the expertise in that area, but now, with Muthig Industries as a sister company under the Weller Metalworks platform, Laser Precision has stamping capabilities at its disposal. By bringing the two portfolio companies together, the customers of both organizations now combine into one customer base, to which these new capabilities may be offered. Similarly, because the marketing and sales efforts for each organization can now be combined, economies of scale can be achieved in pooling resources and reducing costs in these areas. This is also true for the platform's distribution options: as a larger entity, the platform has greater negotiating power and can create better deals with logistics providers, share transportation services, and lower costs for the two portfolio companies. In order to manage these external relationships, it is recommended that the Weller Metalworks platform use a customer relationship management (CRM) tool to document each customer's needs as well as to track the success of acquiring new customers. This item would contain valuable data about services in which each customer is interested, whether additional customer needs could be met from additional portfolio companies, and the impact of the collaboration of the portfolio companies – the last of which would serve as a proxy for the success of the platform's integration itself.

Ultimately, due to the nascent nature of the platform company at this stage, complete alignment could not be achieved for the portfolio companies because there had not been sufficient time to understand how the platform should operate as one. At the time this research was conducted, the two portfolio companies were still operating as independent entities, just as each one had done for the entirety of their existence before joining the Weller Metalworks platform. Attempting to consolidate their policies or instate one platform-level policy was neither an easy nor a beneficial task. Forcing one to conform to the other would result in some form of loss for the conforming party, and selecting one policy for the whole platform would not work because the new platform-wide policy would inevitably favor either one organization or the other. Because these two groups would be working together for the foreseeable future, there was care taken to ensure that neither felt as if they had been disadvantaged in the integration process.

The objective of the strategic benchmarking of the portfolio companies was to better understand each organization, learn from its best practices, and identify areas in which alignment between the two companies could be achieved. As mentioned in Chapter 5, the ultimate goal of integration was to build value and create a system by which the portfolio companies could collaborate to support customer needs as one united platform. There were some best practices that could be learned from the portfolio companies, but as a whole, there was no single set of policies that could be instated for both groups to adhere to. Each organization's various functional areas were assessed for alignment potential, and the integration playbook was developed around these ideas to document the recommendations on how to achieve such alignment. While some functional areas were more easily integrated than others, the functional area that seemed to be most viable for integration was operations because the two portfolio companies operated in the same industry, using many similar processes. As such, we took a deeper examination of their operations and focused recommendations for integration in this domain.

Chapter 8. Integration Case Study: Data Management

This chapter documents a case study of one area within operations – the management of production-related data. When developing a more comprehensive understanding of the two portfolio companies from the bottom-up perspective, it was found that this is an area in which Laser Precision has excelled, and the system that they created around this idea of data management, referred to as Synchronized Sourcing, has allowed them to achieve outstanding quality and on-time delivery performance. From the top-down perspective, the goals of the Weller platform are for the portfolio companies to continue their growth, so Laser Precision's best practices in this domain should be shared across the platform and applied to processes at Muthig Industries in order to enable that growth, achieve alignment, and promote integration between the two portfolio companies. The current processes for data management are outlined to establish the initial state of both locations, and then, the proposal for integration as well as its theoretical impact are described.

8.1 Current Process

While Muthig Industries and Laser Precision are both in the low-volume, high-mix metal fabrication space, the two companies operate quite differently in terms of how they manage and process data. Laser Precision handles its production data in an almost entirely automated fashion. Their Synchronized Sourcing system relies on EDI, a process by which businesses complete transactions electronically by digitally exchanging information such as sales orders, forecasts, change requests, invoices, and shipping confirmations. The EDI system automatically pulls in customer demand data, translates this data into a compatible format, processes this information according to specific business rules, and pushes this translated data into Laser Precision's production system. This is the most automated format of data processing as it requires very little human intervention to perform the actual data entry, though there is some required to review exceptions to the established business rules. Because not all customers run EDI systems, Laser Precision must also accommodate some more manual work that is submitted via email or customer portals. In these cases, the sales team serves the function of translating the sales data into the production system, a time-consuming task that requires great attention to detail in order to avoid human error in the data entry process. The data submitted via the customer portal is considered slightly less manual than the email process because there is slightly less human involvement required as documents are uploaded to the portal in a more standardized format. These three groups of incoming data types and how each one is processed is depicted in Figure 8-1.

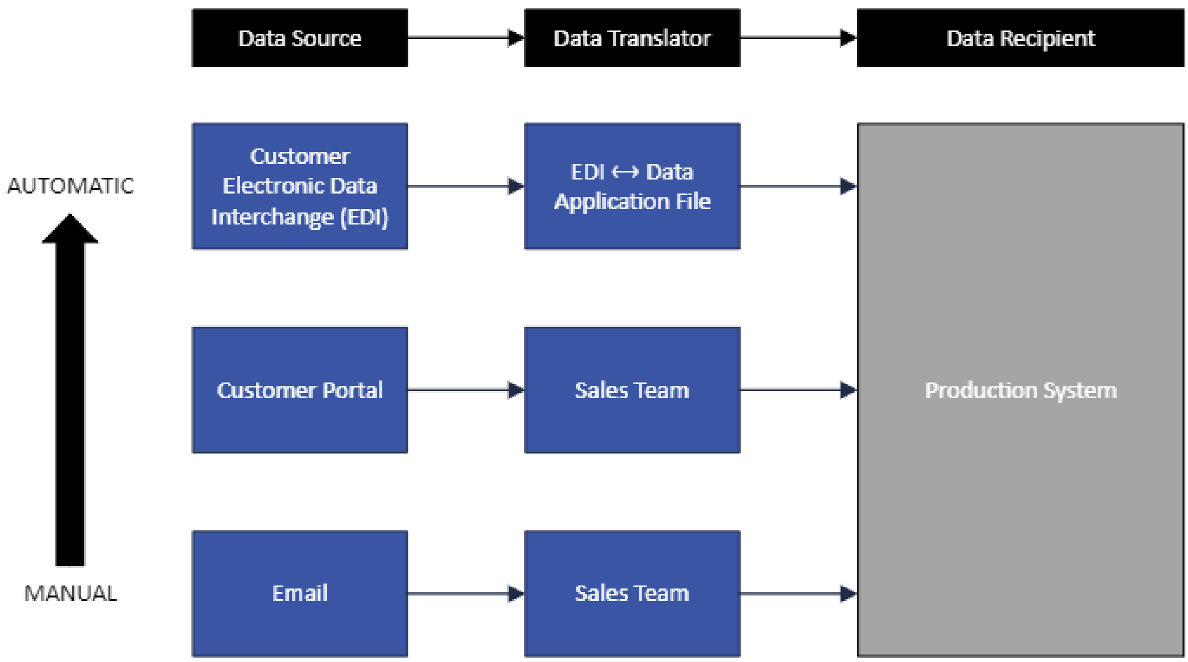

Figure 8-1. Data Transfer Process Flow Diagram

While all three types of incoming data sources are used, the majority of Laser Precision's production comes from the top option, the automated EDI-based system: for the past two years, an average of 90% of sales and 88% of unique SKUs were processed via EDI. This system is extremely beneficial in the production environment because it is able to automatically enter new orders, update existing orders, and reprioritize the active work order schedule; plus, it does so continuously throughout the day to ensure that it has the most up-to-date information. These prioritized dispatch lists are displayed in each department, and the supervisors of each operation ensure that the work is completed in the designated order. Laser Precision's EDI system automates order entry for both sales orders and forecasts and automatically updates the production dispatch list for each operation, thereby removing the burden of manual, time-consuming work and reducing the possibility for urgent work orders to be missed.

On the other hand, Muthig Industries, a smaller shop with a wider variety of product types (stamped products, tool & die products, etc.), uses an enterprise resource planning system for its order management and production scheduling, but otherwise, the shop processes run quite manually, especially in its order entry and sales forecasting. Customers submit a request for quote (RFQ) via email or customer-specific portals through which they exchange documents with their suppliers – the middle and bottom options in Figure 8-1. The Muthig sales team processes these requests by determining the product pricing and issuing the quote. If Muthig is awarded the work, the customer will release or submit a purchase order (PO), either directly via email, uploaded to a portal, or via an electronic data interchange system. Muthig also uses an EDI system like Laser Precision, but unlike the one at Laser Precision, Muthig's EDI is not automated, nor does it feed directly into their ERP. Muthig's EDI transmissions require significant manual labor to process: specifically, when data is submitted via their EDI system, the Inside Sales team must access the EDI portal, print the transmitted orders and/or forecasts, and then manually enter the information from the printouts into their ERP system.

When Muthig receives an order via one of the methods described above, the Inside Sales team will first download it and then use the downloaded purchase order to create a sales order in Muthig's ERP system to reflect the details of the purchase order in terms of PO number, part number, part description, material requirements, quantity ordered, date needed, and any other specifications requested. When generating the sales order, the Inside Sales representative will create the sales order in the system, verify that all of these details match whatever is currently in the ERP, and finally, submit this order to production for work order scheduling. Not only is this process extremely manual and time-consuming – entering the orders for one customer can take roughly 6 hours per week – but it can also be costly: some customers charge a fee of $500 per error for each error present in the documentation of the sales order acknowledgement, seen in Figure 6-2.

In terms of forecasting, Muthig typically looks at approximately the next 12 months for material resource planning and roughly the upcoming 3 months for production scheduling purposes; however, many of their customers provide them with substantially more information about their longer-term production needs. For the customers who submit forecasts, these forecasts typically range from 3 to 20 months, but, as mentioned, these long-range forecasts are only analyzed if a product requires specialized material with a long lead-time. While this data has the potential to aid in sales forecasting, material purchasing, and production planning, the process by which it can be entered into the system is too cumbersome: the problem, once again, is the manual entry of this information. Orders that are beyond a certain window are subject to change, or even cancellation, so entering these orders into the system can lead to repeated work when the orders are updated. Because there is no indication of which orders will be changed, there is no way to only enter static orders into the system and wait for the final updates for the changing orders. As such, the Muthig team has decided that the time spent entering and updating this information is better spent elsewhere, and the forecasts are, for the most part, not utilized.

8.2 Proposal for Integration

In order to increase alignment between Laser Precision and Muthig Industries and progress toward integration for the Weller Metalworks platform, we proposed advancing Muthig's data management processes to be more like the fully automated ones of Laser Precision. The motivation for integration in this realm was that implementing the system by which Laser Precision operates at Muthig would allow the two organizations to share work and cross-sell more easily in the future. In order to advance Muthig in this way, the majority of its business needs would need to be addressed by these changes. While most of Laser Precision's business relies on EDI transactions, the same cannot be said of that of Muthig

Industries: of Muthig's current customers, only one uses an EDI system. While implementing EDI at Muthig would meet the needs of that particular customer, the processes for the other customers would remain unchanged. As such, the proposal for integration focused not only on how to implement EDI for the EDI-enabled customer but also how to also utilize additional systems to achieve more automated data transfer for those who were not EDI-enabled.

At the time this research was conducted, Muthig had six customers who were viable candidates to use an automated entry tool due to the format of their sales and forecast data. One of these customers, who will be referred to as Customer 1, uses an electronic data interchange system, but its format at that time was quite different from the automated one seen at Laser Precision. Customer 1's EDI system was set up in such a way that required the Muthig Inside Sales team to access the data via a virtual computer, print the documents that have been transmitted, and manually enter the data into their ERP – all of which essentially negates the benefits of it being an EDI system. Customer 1 is also able to submit forecasts via their EDI system. We proposed updating the EDI system and implementing a data translator to allow for the direct import of Customer 1's sales and forecast data into Muthig's ERP system.

Updating Customer 1's EDI system to directly connect to Muthig's ERP rather than using the current virtual computer process would handle the sales order entry and forecast entry for that customer. For the other customers, though their sales orders are not currently in an importable format, their forecasts would be able to be imported into Muthig's ERP via an automated entry utility. Data analysis was performed on three areas based on the Muthig's sales data for these six customers from 2022: order quantity by customer, sales value (in dollars) by customer, and product volume by customer. Order quantity is the total quantity of products shipped; product volume is the total number of unique part numbers or products, not the quantity of those products. Table 3-1 summarizes the scope of the automated data entry system(s):

Table 8-1. Muthig: Impact (%) of Automated Data Entry Systems

Automated Entry Type	Order Quantity	Sales Value ($)	Product Volume
EDI	57%	24%	25%
Import Utility	15%	41%	34%
EDI + Import Utility	**72%**	**65%**	**60%**

Thus, based on the sales data from 2022, updating the EDI system to directly import data into the ERP would allow Muthig to have automated data entry of sales data for 24% of its total sales, 57% of products by total order quantity, and 25% of products by product number. If this is supplemented with the implementation of a data import utility that allows for automated input into the ERP, Muthig would also have automated data entry of forecasts for 72% of products by total quantity shipped, 65% of sales by dollar value, and 60% of products by product number.

8.3 Impact of Proposal for Integration

This project was not implemented during the time of this research, but theoretically, it would have a positive impact in many different areas for Muthig Industries.

First, it would reduce the possibility of human errors due to manual data entry as well as the fines that would result from those errors. Not only would this result in cost savings, but it would also solidify Muthig's reputation as a high-quality supplier with great attention to detail. In this market, a supplier's reliability, performance, and service are all key factors that influence customers, so it is important for Muthig to minimize the risk of making mistakes in their customer communications.

Second, by eliminating the bottleneck of the people-based, manual entry process, the new automated system would allow for greater scalability in that the team would be able to accommodate a larger volume of sales orders and forecasts from their customers. As mentioned in Chapter 5. Integration

Objectives, growth is one of the primary objectives of the platform company, so eliminating a manual, people-based process – a barrier to growth and scalability – would help achieve this.

Third, this proposal would also provide greater visibility into a much longer time horizon, which would not only enable more accurate material resource planning as well as sales forecasting, but it would also allow Muthig to better understand the demand trends of each customer. As the platform company grows, it will seek more detailed information about the forecasts for each of its locations to better understand the platform level revenue, and this project would provide that information for Muthig Industries. While Laser Precision already has this level of granularity into its future demand, Muthig does not, but automating data entry for both sales and forecasting would move Muthig closer to Laser Precision's depth of data. Greater visibility into a longer range of customer demand can be valuable in setting strategies to target particular customers, planning raw material, and scheduling future production work orders.

Fourth, EDI would allow Muthig to cross-sell to Laser Precision's EDI-enabled customers in a format with which they are already comfortable. While there would still be some manual data entry required for the less data-sophisticated customers, the ones that do use EDI would be able to continue using that system with Muthig. The customer would not feel the burden of having to adopt two separate manners of communicating with the Weller Metalwork's locations; instead, they would be able to use their same system to complete transactions between either Laser Precision or Muthig Industries. This would allow for a seamless transition of operating between the Weller Metalworks' locations, thereby achieving the goal of the platform to serve customers as one unified organization. This would be a significant step toward integration for the platform.

The fifth benefit of the automation of these processes is the reduction in the amount of time that employees, specifically the Insides Sales team members, have to spend on entering this data, thereby allowing them to work on other, more pressing matters. While the benefit of this additional time for the team cannot yet be quantified as the product of that time is unknown, the savings from reallocating this time resource has been calculated using simplified financial models. These models are simplified in that they only account for the cash flow resulting from nominal labor cost savings, and as such, these models only highlight the impact to the total cash flow for the Muthig Industries location of the Weller Metalworks platform. The total cash flows for Muthig are not included and assumptions on certain costs are used so as to not disclose confidential information. A 5-year projection period is used as this is an average hold period for a private equity portfolio of this nature, and the discount rate was selected to be 14.95% [40]. The following scenarios project cost savings given a few different parameters.

8.3.1 Scenarios of Projected Cost Savings

8.3.1.1 General Assumptions

The proposed EDI system upgrade was quoted by a provider in three parts: software cost, professional service cost, and annual maintenance cost. The software was quoted at $6,875 for one trading license, $11,000 for two licenses, and $14,000 for three licenses. This means that the second license has an incremental cost of $4,125, and the third has an incremental cost of $3,000. The professional service cost covers the installation and setup of the trading partners, and this was quoted to be between $8,000 and $10,000. This cost could be broken down into a one-time software installation fee of $2,950 plus the setup of the system for roughly 30 to 50 hours, billed at $165 per hour. To simplify, an average of 40 hours was used for the first license, so the professional service cost was calculated to be $9,550, and for any additional licenses, the provider estimated that the installation and setup would take roughly half the time, which resulted in a cost of $3,300. The annual maintenance cost was a flat fee of $1,375 to maintain the trading license. Therefore, the capital expenditures for this project vary from year to year: this project starts with $17,800 to install and setup the EDI system, then costs $1,375 in the following years for annual licensing, and can incur additional costs for licensing, installation, and setup when the next trading partner or training partners are added.

The Inside Sales team at Muthig estimated that manually entering data for Customer 1 using the current EDI process – printing from EDI transmission, manual entry into ERP – requires roughly six hours each week for the current number of part numbers. The amount of time attributed to this process divided by the current number of part numbers from Customer 1 provides the rate at which this process is completed in terms of time per part. According to the U.S. Bureau of Labor Statistics' Occupational Employment and Wage Estimates for the state of Wisconsin (May 2022), the average hourly wage for an individual in a sales or sales-related occupation is $23.52. This figure was used as an estimate for the Inside Sales team member's salary, so applying the current rate at Muthig for data entry of the Customer 1's EDI data cost the business $141.12 per week. Excluding the United States federal holidays, there are 50 working weeks in a year, so each year, this process costs $7,056. By eliminating this process, the Inside Sales team will no longer be required to dedicate 6 hours per week to manual data entry, thereby saving $7,056 for the year in labor costs. It is imperative, however, to also account for the costs of the EDI system software installation and implementation. The following scenarios build these costs into the financial models in order to find the potential cost savings at hand, and Table 8-2 summarizes their differences.

Table 8-2. Summary of Scenarios for Projected Cost Savings

Scenario	Number of Licenses	Trading Partners, Year Added	Type of Growth in Number of EDI Transacted Products	Scenario Title
1	1	Customer 1, Year 1	No Growth	1 License, No Growth
2	1	Customer 1, Year 1	X % Annually Total number of EDI products grows by X% each year.	1 License, Static Growth
3	2	Customer 1, Year 1 Customer 2, Year 3	X % Annually + Start 100 Products Customer 2 starts with 100 products in its first year, Year 3. Each customer experiences X% increase from its previous year.	2 Licenses, Static Growth + Starting Products (100)
4	3	Customer 1, Year 1 Customer 2, Year 3 Customer 3, Year 5	X % Annually + Start 100 Products Customers 2 and 3 start with 100 products in each's first year, and each customer experiences X% increase from its previous year.	3 Licenses, Static Growth + Starting Products (100)

8.3.1.2 Scenario 1: 1 License, No Growth

Scenario 1 reflects the base case for the impact of the implementation of the EDI system. There is only one license purchased in this scenario because Customer 1 is the only one who is EDI-enabled during the time of this research. In this scenario, the EDI system is implemented, but there is no growth in the number of part numbers ordered by Customer 1. This means that the amount of time that Muthig has allocated to Customer 1's orders per week remains constant at 6 hours per week throughout the 5-year projection period. By keeping the number of products constant, the cost of labor for this process also does not change. In Table 8-3, Year 0 reflects the initial investment in the EDI upgrade, and the subsequent years highlight how this investment impacts the cash flows. The row labeled "Projected Old Cost" reflects the labor costs incurred each year to perform the current process of manually printing and entering the information into Muthig's ERP system. The bottom row, highlighted in blue, is the cumulative net present value per year for the savings achieved in Scenario 1. In this scenario, the payback period for this investment based on the discounted cash flows is 4.29 years.

Table 8-3. Scenario 1. Cumulative Projected Cost Savings (NPV) by Year

Year	0	1	2	3	4	5
EDI Proposal Cost	$17,800	$1,375	$1,375	$1,375	$1,375	$1,375
Projected Old Cost		$7,056	$7,056	$7,056	$7,056	$7,056
Cost Saving	$(17,800)	$5,681	$5,681	$5,681	$5,681	$5,681
PV of Savings	$(17,800)	$4,942	$4,299	$3,740	$3,254	$2,831
NPV of Savings by Year	$(17,800)	$(12,858)	$(8,558)	$(4,818)	$(1,564)	$1,266

8.3.1.3 Scenario 2: 1 License, Static Growth

Scenario 2 reflects the case in which the number of part numbers that are transacted via EDI increase by the same static rate each year. The rate at which these part numbers are processed is applied to the new number of part numbers to calculate the updated cost of labor dedicated to this process. In the initial year, the same investment is made to implement the EDI system as in Scenario 1, but after Year 0, this model differs from Scenario 1 in that the following years feature a steady increase in the number of part numbers from Customer 1. This is why the first row of Table 8-4 that contains the cumulative present value for each year at a part number growth rate of 0% matches Scenario 1, but the other rows, which use an annual part number growth rate greater than 0%, are different. Based on historical data from Muthig, excluding the years that seem to be impacted by the COVID-19 pandemic, Customer 1 increased their number of part numbers at rates that ranged from 4% to 6% each year. Assuming this trend continues in the projected period, the payback period based on the discounted cash flows ranges from 3.63 years to 3.82 years, respectively.

Table 8-4. Scenario 2. Cumulative Projected Cost Savings (NPV) by Year

Annual PN Growth Rate	Cumulative Savings (NPV), % PN Growth by Years. Years: 0	1	2	3	4	5	Discounted Payback Period (years)
0%	$(17,800)	$(12,858)	$(8,558)	$(4,818)	$(1,564)	$1,266	4.29
1%	$(17,800)	$(12,796)	$(8,390)	$(4,509)	$(1,091)	$1,919	4.16
2%	$(17,800)	$(12,735)	$(8,220)	$(4,195)	$(608)	$2,588	4.04
3%	$(17,800)	$(12,674)	$(8,049)	$(3,878)	$(117)	$3,273	3.93
4%	$(17,800)	$(12,612)	$(7,877)	$(3,557)	$383	$3,976	3.82
5%	$(17,800)	$(12,551)	$(7,704)	$(3,232)	$893	$4,695	3.72
6%	$(17,800)	$(12,490)	$(7,530)	$(2,903)	$1,412	$5,432	3.63
7%	$(17,800)	$(12,428)	$(7,355)	$(2,569)	$1,940	$6,186	3.54
8%	$(17,800)	$(12,367)	$(7,179)	$(2,232)	$2,479	$6,959	3.45
9%	$(17,800)	$(12,305)	$(7,002)	$(1,891)	$3,026	$7,751	3.37
10%	$(17,800)	$(12,244)	$(6,823)	$(1,545)	$3,584	$8,561	3.29

8.3.1.4 Scenario 3: 2 Licenses, Static Growth + Starting Products (100)

The initial capital expenditure to setup the EDI system for Customer 1 occurs in Year 0, just as in the previous scenarios, but in Scenario 3, an additional trading partner, who will be referred to as Customer 2, is added in Year 3. While this event could happen at any time in the projected 5-year window, Year 3 was chosen as it provided enough time for Muthig Industries to grow comfortable with the EDI system and to complete any other requirements, such as quality certifications, that Customer 2 necessitates of its suppliers. To establish Customer 2 on the EDI system, additional capital expenditures are required to pay for the second trading license and for the installation and setup of the software. Because the EDI provider has already performed the installation and setup for Customer 1 at Muthig, implementing the second trading license for Customer 2 is estimated to take roughly half the time. This puts the professional service cost around $3,300, assuming the installation portion of the implementation takes 20 hours rather than 40 hours, and this, in addition to the cost of the second license of $4,125, brings the total additional cost to be $7,425, as shown in Table 8-5.

With the addition of Customer 2 in Year 3, the number of products increases in Year 3 by 100 to account for Customer 2's products as well as by the percentage growth to Customer 1's products. While starting with 100 products may seem like a large number of products, it was reasoned that an EDI enabled customer would likely have more products to transact than one that is not EDI enabled. Additionally, the partnership with Laser Precision and the combining of the customer base for the whole Weller Metalworks platform is also likely to bring in more business, especially EDI-enabled business, to Muthig Industries. For the first two years, all products transacted via EDI only come from Customer 1, but when Customer 2 is added in Year 3, the total number of products comes from both Customer 1 and Customer 2. After Year 3, the annual part number growth rate applies to the products from both customers. Once again, assuming an annual static growth rate of 4% to 6%, Table 8-5 shows that the discounted payback period for Scenario 3 is 4.14 years to 4.38 years.

Table 8-5. Scenario 3. Cumulative Projected Cost Savings (NPV) by Year

Cumulative Savings (NPV), % PN Growth by Years. Additional License in Year 3.

		Years						Discounted Payback Period (years)
		0	*1*	*2*	*3*	*4*	*5*	
Annual PN Growth Rate	0%	$(17,800)	$(12,858)	$(8,558)	$(8,290)	$(3,804)	$98	4.97
	1%	$(17,800)	$(12,796)	$(8,390)	$(7,981)	$(3,319)	$785	4.81
	2%	$(17,800)	$(12,735)	$(8,220)	$(7,668)	$(2,824)	$1,488	4.65
	3%	$(17,800)	$(12,674)	$(8,049)	$(7,350)	$(2,320)	$2,208	4.51
	4%	$(17,800)	$(12,612)	$(7,877)	$(7,029)	$(1,807)	$2,944	4.38
	5%	$(17,800)	$(12,551)	$(7,704)	$(6,704)	$(1,285)	$3,698	4.26
	6%	$(17,800)	$(12,490)	$(7,530)	$(6,375)	$(754)	$4,470	4.14
	7%	$(17,800)	$(12,428)	$(7,355)	$(6,041)	$(213)	$5,260	4.04
	8%	$(17,800)	$(12,367)	$(7,179)	$(5,704)	$337	$6,068	3.94
	9%	$(17,800)	$(12,305)	$(7,002)	$(5,363)	$897	$6,895	3.85
	10%	$(17,800)	$(12,244)	$(6,823)	$(5,017)	$1,467	$7,741	3.77

8.3.1.5 Scenario 4: 3 Licenses, Static Growth + Starting Products (100)

Scenario 4 builds on Scenario 3 by adding an additional trading partner, named Customer 3, in Year 5 under the same conditions as Customer 2's introduction in Year 3. Just like the second trading partner's introduction, this added trading partner will require additional capital expenditures for the trading license and software installation and setup. In this case, it is assumed that the third trading partner's software installation and setup costs are equal to those incurred for the second trading partner, so the total cost to bring Customer 3 into the EDI system is $6,300 – incremental cost of $3,000 for the third license plus $3,300 in professional services expense.

In Scenario 4, we assumed that each of the new customers, Customer 2 and Customer 3, start with 100 products in each of their respective first years. The annual part number growth rate, then, is applied to all three customers each year, so Customer 2's number of products grows at the same rate as Customer 1 starting in Year 3 whereas Customer 3 only contributes 100 products in Year 5. In this scenario, at the historical 4% to 6% growth rates, the payback period in terms of the cumulative discounted cash flow would range from 4.24 to 4.67 years, as shown in Table 8-6.

Table 8-6. Scenario 4. Cumulative Projected Cost Savings (NPV) by Year

Cumulative Savings (NPV), % PN Growth by Years. Additional License in Year 3, Year 5.

		Years						Discounted Payback Period (years)
		0	***1***	***2***	***3***	***4***	***5***	
Annual PN Growth Rate	**0%**	$(17,800)	$(12,858)	$(8,558)	$(8,290)	$(3,804)	$(1,969)	6.07
	1%	$(17,800)	$(12,796)	$(8,390)	$(7,981)	(3,319)	$(1,282)	5.63
	2%	$(17,800)	$(12,735)	$(8,220)	$(7,668)	(2,824)	$(579)	5.26
	3%	$(17,800)	$(12,674)	$(8,049)	$(7,350)	(2,320)	$140	4.94
	4%	$(17,800)	$(12,612)	$(7,877)	$(7,029)	(1,807)	$877	4.67
	5%	$(17,800)	$(12,551)	$(7,704)	$(6,704)	(1,285)	$1,631	4.44
	6%	$(17,800)	$(12,490)	$(7,530)	$(6,375)	$(754)	$2,403	4.24
	7%	$(17,800)	$(12,428)	$(7,355)	$(6,041)	$(213)	$3,193	4.06
	8%	$(17,800)	$(12,367)	$(7,179)	$(5,704)	$337	$4,001	3.91
	9%	$(17,800)	$(12,305)	$(7,002)	$(5,363)	$897	$4,828	3.77
	10%	$(17,800)	$(12,244)	$(6,823)	$(5,017)	$1,467	$5,674	3.65

8.3.2 EDI Proposal Conclusions

As previously mentioned, it is difficult to estimate the true value of the labor savings because it is not known how this labor will be applied. This is why only the labor costs, rather than any potential other benefits from the project, were used in the calculations. While these scenarios are focused on the implementation of the EDI System, additional calculations could be made for the implementation of the Sales Import Utility; however, the amount of time dedicated to the customers that would be transferred to this process is not known, so it was not possible to perform equivalent calculations for that part of the proposal at the time of this research.

The four scenarios illustrate that many variables – the number of part numbers for each participating customer, the year at which each customer joins, the growth to each customer's number of products – impact the model. The annual growth percentage for the number of products is an important factor as a greater number of products requires more labor for manual entry, which generates higher costs in terms of the amount of time dedicated to that process; the implementation of the automated data system for these cases, therefore, leads to a shorter payback period. Given the various assumptions made for each scenario, the proposal has a discounted payback period sometime in the third or fourth year, from 3.63 years to 4.67 years, based on the savings in labor costs. The payback period metric was selected as it felt like a simple way to indicate return on investment (ROI). Because this proposal was created for an organization that is quite cost conscious, we felt that it was important to describe the impact of this project in understandable and relatable terms. Even more important than the payback period, though, are the intangibles – eliminating barriers to growth and scalability at Muthig; increasing alignment with Laser Precision; transforming a people-dependent, manual processes to one that is system-based and automated; increasing visibility into the forecast to allow for better planning of material, inventory, and production; and, most significant of all, advancing integration for the Weller platform.

Chapter 9. Integration Case Study: Quote Creation

This chapter documents a case study of another area within operations, the very start of the process – quote creation. While this may not seem as though it is relevant to operations, the quote creation process starts all of production operations in the make-to-order manufacturing environment. Quoting is critical to both Laser Precision and Muthig Industries as it is the process by which the team determines how much to bill a customer, what operations belong in the production routing, and which resources are required. The two locations follow similar processes in the creation of a quote, and because this process is essential to both locations of Weller Metalworks, it appears to be a prime candidate for alignment and integration. Chapter 9 begins with the current process of quote creation; then, it describes the proposal for introducing burden rates into the process as a means to increase visibility into production costs. Finally, the potential impact of this proposal in the context of integration is discussed.

9.1 Current Process

The quoting process in place at the time of this research for both Laser Precision and Muthig Industries is quite similar at a high level. First, a customer contacts a portfolio company and requests a quote for some products, which is referred to as a "request for quote" (RFQ). It is then the responsibility of the sales team to create the quote that will be returned to the customer. The process by which the sales representative creates the quote is similar at both Weller Metalworks locations. At Laser Precision, the sales representative builds the quote in their custom ERP system, and part of this quote building process includes creating the product routing and bill of materials (BOM). The product routing contains the production operations required to create the product (laser cutting, deburring, welding, etc.), and the bill of materials describes the raw materials, components, and/or sub-assemblies that are used for the product. If new raw material or hardware is required, it is at this time in the process that the sales representative will be required to create that new item in the ERP system and then add it to the product's

BOM. The quoting module in Laser Precision's ERP system calculates the raw material usage based on the given geometry of a laser cut product as well as the cost of any hardware component usage. The total amount of time to create the product is calculated, and the sales team then bases the quote on the raw material price and the bill rates of the operations listed in the routing. Any additional markup is added at the end to generate a certain percentage of profit for manufacturing the product. The final quote is provided to the customer for the requested product at different quantity breaks, with higher quantities having a lower price per part. Figure 9-1 contains the high-level flow chart for the quoting process at Laser Precision.

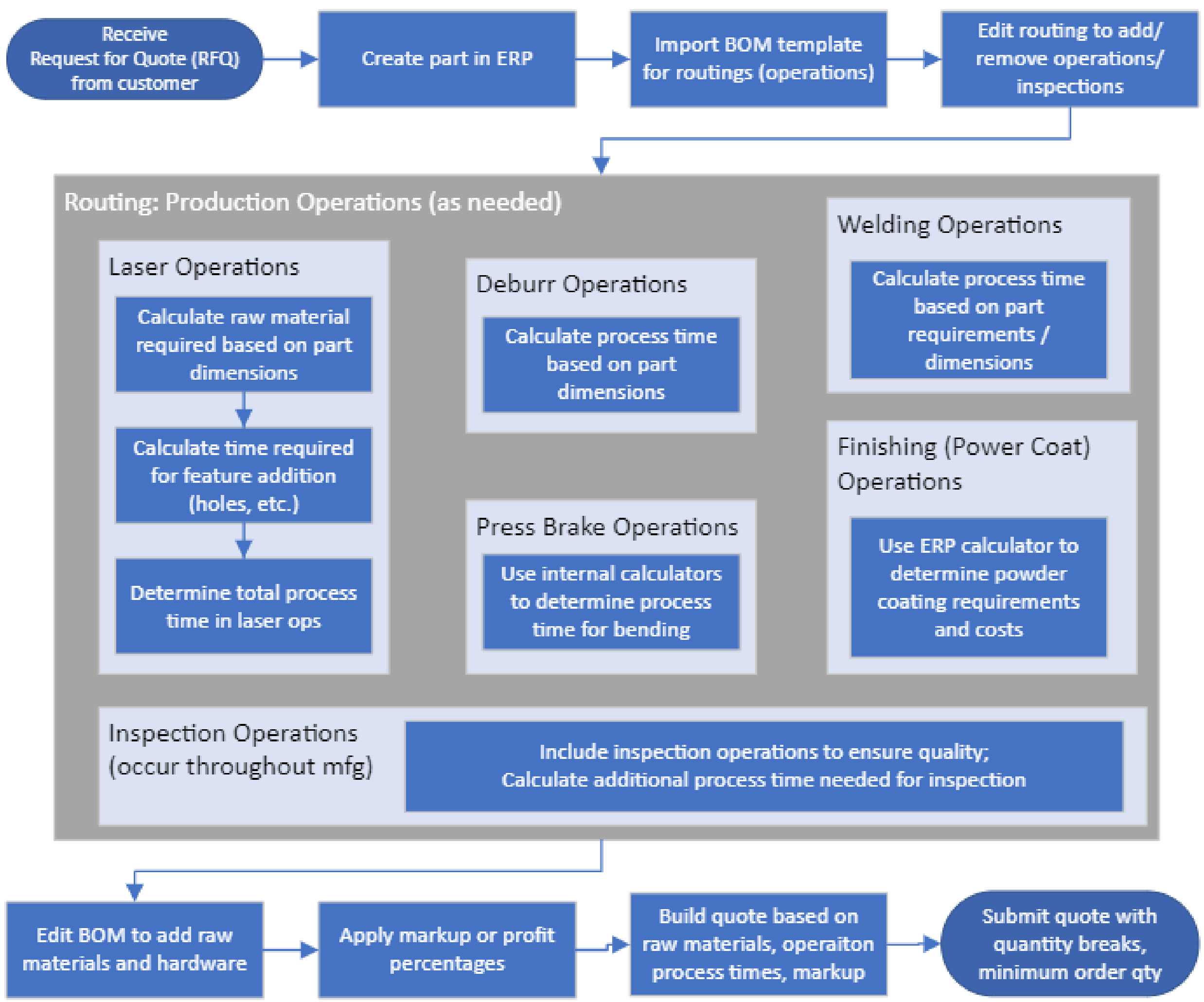

Figure 9-1. Laser Precision: Quoting Process Flow Diagram

Similarly, at Muthig Industries, after the customer requests a quote for a certain product, the Muthig sales team works on the development of the quote. Instead of exclusively using the quoting module in their ERP, the Muthig team primarily relies on their proprietary quote calculators, hosted in Excel workbooks, to calculate the price. These calculators determine the amount of time required by each operation to manufacture the product based on the product's geometry and features, and this information is entered into the ERP's quoting system. Each manufacturing operation has a set bill rate, so the time per operation is multiplied by the operation's bill rate to determine the total amount billed for the production. Then, any additional charges, such as for outside services, such as special plating or finishing, are included, and a certain amount of markup is added to generate a profit on the product. The total quote for the product is based on the raw material used, the amount billed for production, any additional services required, and some markup percentage. The calculator is used to determine the quote for different quantities, and if ordering in larger quantities, the customer will receive a discount on the price per part. Figure 9-2 displays the high-level flowchart of the quoting process at Muthig Industries.

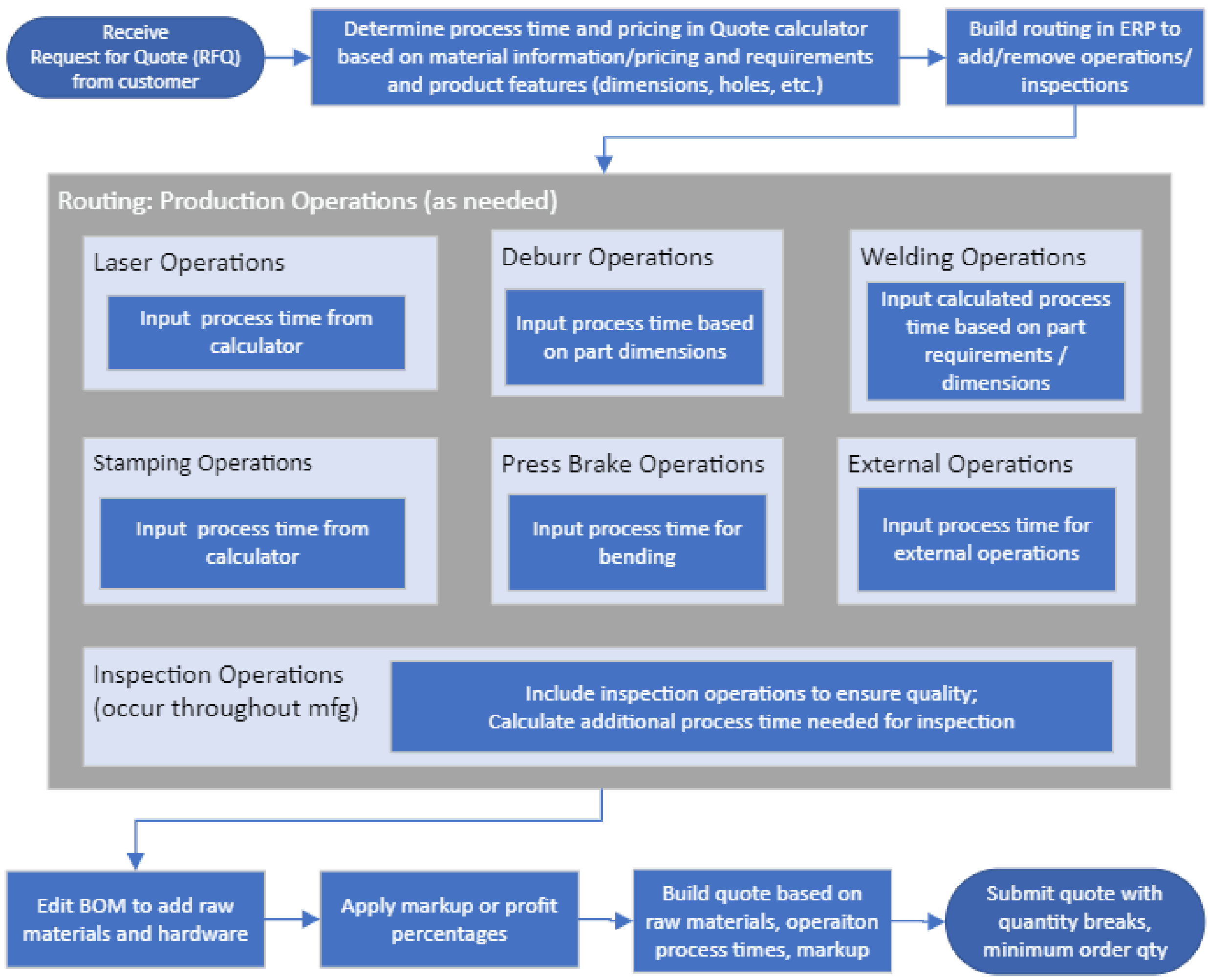

Figure 9-2. Muthig: Quoting Process Flow Diagram

Currently, both companies face challenges in the quote creation process. In many cases, potential customers will submit RFQs for a large packet of products – sometimes with the intention of contracting the portfolio company to manufacture these items; other times with the intention of merely understanding market pricing – in either case, regardless of the potential customer's intentions, the sales team must create quotes consistently, quickly, and competitively. Though there are differences in each company's bill rates and costs, the goal is for the platform to be following the same process and achieving similar profit margins. This is especially necessary in the low-mix, high-volume manufacturing environment because the amount of profit captured for this type of work can vary significantly. It is critical that the same quote creation process is followed so that the quotes produced are consistent; if each salesperson quoted differently, then there would be unwanted variation in pricing and, subsequently, profit. This is currently the case both at the portfolio company level as well as at the platform level: at the time of this research, there were contrasting aspects of the quoting process at the platform level between Laser Precision and Muthig Industries as well as at the portfolio company level between the various sales team members at each location. At the platform level, the differences in quoting between the two locations are due, in part, to differences in costs incurred by each organization, in the level of visibility each one has into those costs, in the standard rates established with recurring customers, and in material costs. At the portfolio company level, the differences between the salespeople may be attributed to how each person learned to quote, the additional margin deemed appropriate, as well as any institutional or tribal knowledge that has been incorporated over time. These differences, though understandable, are significant barriers to integration and collaboration between the portfolio companies.

Another challenge with the current quoting process is the amount of time required to generate quotes. Each RFQ requires time consuming manual data entry and calculations for both organizations, and as the number of products (and RFQs for those products) increase, so does the amount of time required to process that data. Each salesperson only has a certain number of working hours, so the more time spent generating quotes and responding to RFQs, the less time can be spent on business development. As the platform aims to grow its customer base and increase sales across both portfolio companies, the business development responsibility of the sales function becomes more critical, but responding to RFQs is still necessary to maintain current sales and business operations. This need is only further amplified as the platform grows: as additional customers are introduced, more RFQs are submitted, and the burden of the sales teams to split their time between completing quotes and generating new business is heightened. Therefore, the platform is eager to find solutions that allow the sales team to standardize their quoting processes, codify any tribal knowledge, increase visibility into the costs of operations, and increase the efficiency of quoting to allow for more time spent in business development.

9.2 Proposal for Integration

In order to align both Laser Precision and Muthig Industries in the quoting process, the Weller Metalworks leadership chose to implement a software that accelerates and standardizes quote creation. Users of this software upload the digital part file to the online platform, and the software analyzes the part and calculates the price based on the product features, material requirements, and any additional factors set by the company. The sales team can adjust the pricing via a number of different levers, but the general formula for pricing remains consistent. The software was intended to help meet the following goals across the Weller Metalworks platform:

1. Standardize the quoting process across the platform
2. Increase consistency of quotes between different sales team members
3. Reduce time spent in the quoting process
4. Increase volume of quotes processed
5. Increase visibility into product pricing, costs, and profits

During the time of this research, only the Muthig Industries team began the implementation of this automated quoting software, so this proposal will focus on Muthig rather than Laser Precision. In the first stage of the implementation, the new software accessed and imported the data from Muthig's ERP system, such as the bill rates for all operations, but because Muthig team had not updated their ERP data in many years, it was not clear whether this data should continue to be used moving forward or if it should be updated to reflect current rates. While the historical data used as inputs for bill rates allowed Muthig to be profitable as a whole, they did not have the data to understand the earnings nor costs of each production operation. This lack of data made it difficult to determine the current true cost for a product, and subsequently, it was not possible to determine the amount of profit generated at the product level. Because the new quoting software addressed the first four platform goals, listed above, the research proposal instead focused on costing.

9.2.1 Cost Accounting Methodologies: Traditional Costing versus Activity-Based Costing

The goal state is for the Muthig team to create better avenues to access and analyze their data so that they could, in fact, determine their true costs via a costing system. In traditional costing, there is one plantwide overhead rate that is determined by allocating the total overhead cost to one activity, whether that be machine hours or labor hours, for example. The primary flaw in the traditional system is that applying all overhead to one activity base would be inaccurate, especially in the high-mix, low-volume production environment in which Muthig operates; specifically, it would lead to cross-subsidization in which high-volume and/or low-complexity products are overcosted whereas low-volume and/or high-complexity products are undercosted. When calculating the cost driver rate for allocating overhead, it should not be based on actual or budgeted output but instead on capacity. The alternative to this traditional system is to implement an activity-based costing system. In activity-based costing (ABC) systems, there are many activities over which indirect costs can be allocated, and the multiple overhead allocation rates – one for each type of activity or cost pool – allow for visibility into the different types of costs in effect. ABC systems also allow for the allocation of period costs, costs that are not related to production, such as marketing expenses or selling, general and administrative (SG&A) expenses, which is important to understand in assessing how resources are costed. Therefore, the activity-based costing system seems to be a better fit to allow Muthig to understand how its various activities, both production-related and non-production related, contribute to its costs.

Because it was not possible to implement a full costing system during the research period, we proposed a method by which the true costs of production could be more accurately estimated without the full costing system: by introducing historical burden rates, which account for indirect costs, for three categories (General or Administrative, Machine, and Labor), the Muthig team should have better visibility into the costs of production.

9.2.2 Cost of Production

In manufacturing, the cost of the product includes any direct and indirect costs that are affiliated with the production of that product. Direct costs account for the costs that are directly related to a cost object or product, such as raw materials used, labor required to complete production operations, and any materials that are consumed by equipment in the manufacturing process. Indirect costs, on the other hand, account for all the other expenses incurred to operate the business, and because these costs are not directly traced to cost objects, they must be allocated.

While raw material and direct labor are easily measured, determining the exact values for some of the other cost groups is a difficult task. How much of a building's utilities bill should be allocated to an operation or a product? How should the front office staff's salaries be allocated per product? These questions are difficult to answer without having more detailed information about the consumption levels (time, resources, energy, etc.) and capacity of operations required for a given product, and creating recordkeeping systems to document this information at the level of detail necessary would be expensive and nearly impossible. Given Muthig's data, it was not feasible to measure such items at the level of granularity that would be needed to find the exact value. As such, determining these values is simplified and made easier by aggregating some of these costs into larger pools and selecting a cost basis for allocation. This was the method by which the burden rates for each operation were determined. In this context, "burden" is used as a general term to refer to the overhead costs of an operation.

9.2.3 Bill Rates and Burden Rates

Muthig, like many small job shops, provides quotes based on bill rates that are assigned to specific operations. A product will be quoted based on the bill rate for two phases of production – setup and run.

The total amount billed, Z, can be obtained by summing the amount billed for the setup and the amount biller for the run. The amount billed for the setup is calculated by multiplying the setup time by the setup bill rate, and the amount billed for the run is calculated by multiplying the run time by the run bill rate. The run time is calculated as the cycle time per part multiplied by the quantity of parts produced.

Because Muthig is a profitable business overall, it is known that the bill rates are greater than the total cost of manufacturing its products; however, the exact difference between the specific product cost and the amount billed is not currently known because the total cost of the product is unknown. Muthig also does not know what the cost breakdown is for each operation or each step in the production process. This is an issue that many job shops face: while they are able to cover their expenses each month, they do not have visibility into the true costs of their products. The goal of determining the true cost of the product was not feasible because the data was not available and there were no costing systems for this in place, so the next best alternative that would at least get closer to true costs was to determine the burden of each operation. While this would not provide the exact total cost of the product, it would provide a better approximation by capturing a portion of that cost. Burden, in addition to the direct costs incurred, would provide a much closer approximation of true costs than the system currently in use. By including burden rate in the quoting process, the Muthig team would have a better understanding of how each production operation contributed to the indirect costs incurred, and they would have additional flexibility in adjusting bill rates to ensure they were pricing competitively while still covering the indirect costs of production.

9.2.3.1 Proposed Calculation of Burden Amount

The first step in determining the burden rates for each operation was to classify all expenses listed in the 2022 Income Statement as direct or indirect. As an indirect cost, burden accounts for expenses such as employee health insurance, allocated utilities, allocated taxes, and other general or administrative expenses. Muthig classifies its information based on its four primary departments – Tooling and Resale, Stamping, Production Machining, and Laser – so the financial data was already split into these groups.

After determining which expenses could be classified as burden, the expenses were categorized into three groups: General, Labor, and Machine. General Burden refers to the indirect costs that are not associated with specific operations nor machines; instead, it includes the indirect costs that are widely associated with running the business as a whole, such as administrative salaries, facility maintenance fees, and other general expenses. Labor Burden refers to the indirect costs that are associated with the workforce, so any expenses that are incurred to support the people are included in this bucket. Labor Burden accounts for expenses like employee health insurance, training costs, or any other labor-related benefits. Machine burden encompasses the indirect costs that are associated with the use of the manufacturing equipment or machinery. These costs are specific to a department or operation, and they can include expenses such as maintenance costs, a portion of the total utilities, and the cost of the depreciation of the machinery. Each of Muthig's indirect costs associated with a department (Tooling and Resale, Stamping, Laser, Production Machining) was categorized into one of these three burden types. In order to maintain confidentiality, the financial data was randomly perturbed, and the departments were anonymized and scrambled. The results of this burden classification are shown in Table 9-1.

Table 9-1. Total Burden by Department and Burden Type

		Burden Type			
		Machine	**General**	**Labor**	**Total by Dept**
Department	**1**	$ 621,124	$ 723,406	$ 301,915	$ 1,646,444
	2	$ 413,676	$ 587,108	$ 317,923	$ 1,318,706
	3	$ 160,004	$ 272,875	$ 224,628	$ 657,507
	4	$ 522,425	$ 685,622	$ 289,099	$ 1,497,146
	Total by Burden Type	$ 1,717,229	$ 2,269,010	$ 1,133,565	

9.2.3.2 Proposed Calculation of Burden Allocation

By categorizing the income statement expenses into direct and indirect costs, then further classifying these costs as different types of burden (General or Administrative, Machine, and Labor), the total amount of burden was determined for each department and each type of burden. As mentioned earlier, in order to allocate burden for each operation, some basis of allocation must be used for each department and burden type. Ideally, practical capacity should be used as it avoids the trap of allocating all costs to an output volume, but it may be difficult, as it was in this research, to know the true capacity of a past period. Based on discussions with the operations management team, the data was scaled so that the capacity consumed in 2022 was transformed to be representative of Muthig's annual practical capacity. Additionally, the total labor and machine hours were selected as the allocation basis because these both account for the amount of time contributed per department and allow the burden to be allocated as a function of time.

The data regarding the labor and machine hours was pulled from two reports in Muthig's ERP system. The first reported the efficiency of each work center for 2022, and the second contained the efficiency at the employee level for 2022. Both of these reports were cleaned to find the total number of machine hours and labor hours associated with each department and each operation within that department. The total labor burden was allocated across the total labor hours, and the total machine burden was allocated across the total machine hours. Because general burden, as a category, does not include the machine-affiliated costs, it was determined that the total general burden would be allocated across the total labor hours rather than total machine hours.

Because the burden amounts exist only at the department level, it was found that the burden rate could only be applied to the department, not to each operation within that department. It was possible to allocate the amount of burden associated with an operation as a proportion of the department's total burden by using the number of hours for a specific operation, but it was not possible to determine the operation-specific burden rates because that data did not exist. Similarly, because the burden amounts were not separated into setup burden or run burden, it had to be assumed that the burden rates for the two phases of production were equal. The data did not allow for the calculation of operation-specific nor phase-specific burden rates, so the uniform burden rate, calculated at the department level, was the next best alternative.

To provide an illustration of the calculation, data is provided below for a randomly selected department, Department 4, and its machine burden rate. In this iteration, the actual machine hours, rather than adjusted hours, were used; however, it was later learned that the adjusted machine hours provide a more realistic picture of how much machine time was expected and completed. This was explored later in the process of calculating the burden, but it is worth noting at this point that this was the first iteration of the calculation. This department has four operations – Op1, Op2, Op3, and Op4. The amount of machine time contributed by each of these operations, as captured by the Work Center Efficiency report, was summed to provide the total machine time for Department 4 as shown in Table 9-3. The Work Center Efficiency report did contain details on setup versus run time for each operation, but because the burden amount was only available at the highest level (total for the department), it was not possible to allocate the burden between the two phases of production at different rates. As such, the machine burden amount for Department 4, $522,425, was then applied across the total machine time, 11,119.77 hours, to result in the machine burden rate for the selected group, Department 4 – $ 46.98 / hour. The total amount of burden incurred by the department could be split between the total setup and total run time for the department to find the amount of burden each phase individually contributes to the total burden for the department, as seen in Figure 9-3, but the overall rate of burden generated by Department 4 was the same for both phases of production. In the same way, the amount of burden allocated to each operation within Department 4 was calculated as a proportion of time spent on that operation compared to the total time for the department as shown in Figure 9-4.

Table 9-2. Total Burden for Department 4 by Burden Type

Burden Type	Department 4 – Amount ($)
Machine	$ 522,425
General	$ 685,622
Labor	$ 289,099
Total	**$ 1,497,146**

Table 9-3. Department 4 Operations - Setup, Run, and Total Actual Machine Hours

Dept 4 Operations	Setup Hours	Run Hours	Total Actual Machine Hours (Setup + Run)
Op1	291.66	1883.29	2174.95
Op2	2.41	6919.68	6922.09
Op3	0.0	249.95	249.95
Op4	0.0	1772.78	1772.78
Department 4 Total	**294.07**	**10,825.7**	**11,119.77**

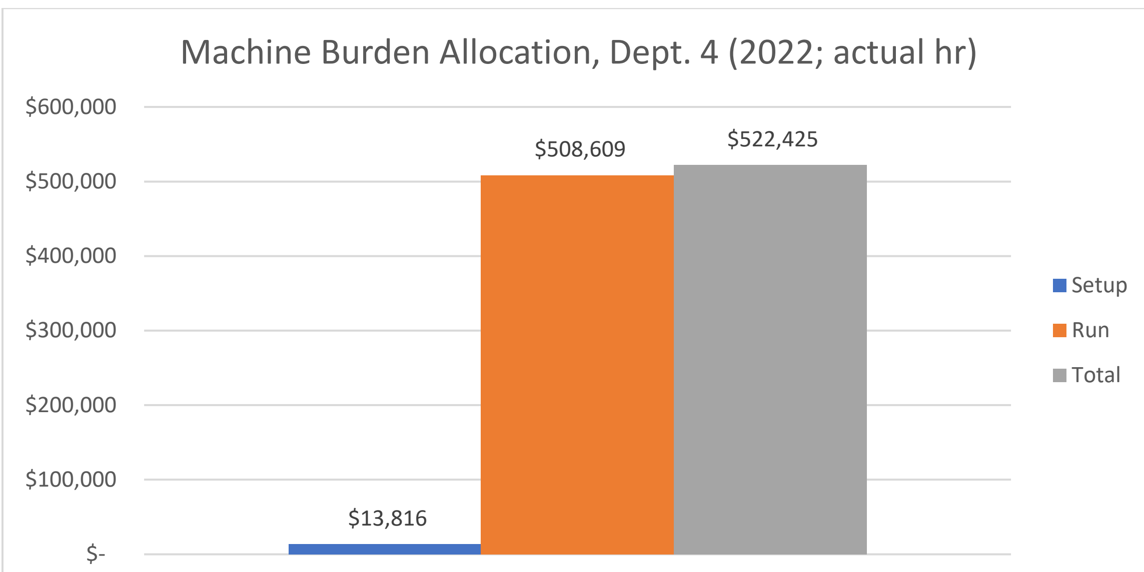

Figure 9-3. Machine Burden Allocation for Department 4 (2022, actual hours)

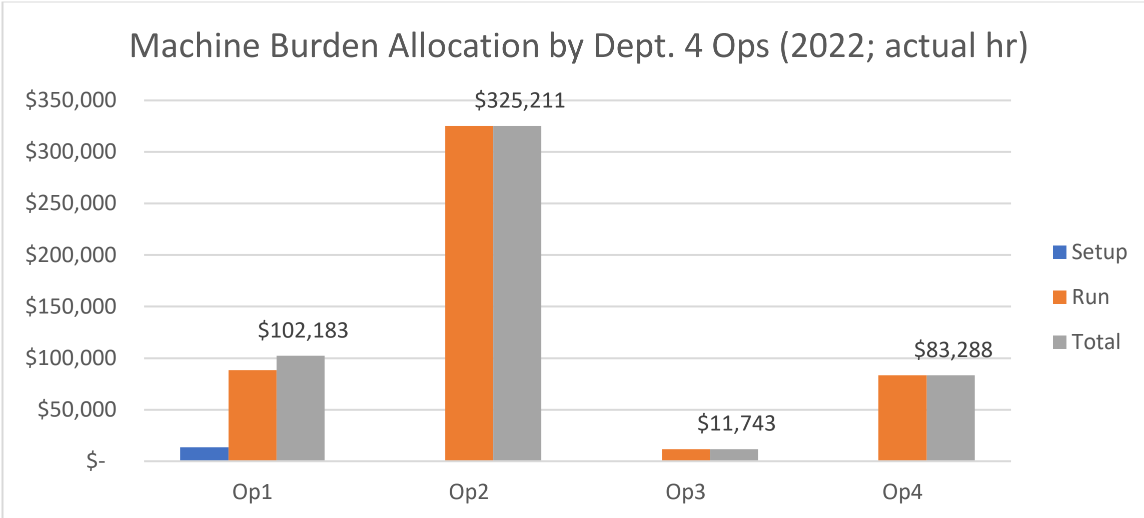

Figure 9-4. Machine Burden Allocation by Department 4 Operations (2022, actual hours)

As mentioned at the start of the previous paragraph, the example above uses the actual rather than adjusted machine hours. The difference between the two is that actual hours is the number of hours that an employee logged to complete the job, whereas the adjusted hours are the number of hours required for the machine to complete the job. This is a small but critical distinction in which efficiency gains are captured – an employee running two machines during the same single shift will log 8 hours of labor time but 16 hours of machine time. During the data analysis, it was found that the actual machine hours found in the work center efficiency report were approximately equivalent to the actual labor hours found in the employee efficiency report. This being the case, the total burden for each category (general, labor, and machine) was being allocated across the same allocation basis, i.e., labor hours. Because the labor hours applied to the labor burden and general burden, only the machine burden required updating to the more precise allocation basis.

The second iteration, therefore, used the adjusted machine hours to determine the machine burden rate for a department. This was performed in the same manner as the first iteration with the key difference being that the adjusted hours for setup and run were used instead of the actual hours. By using the adjusted machine hours rather than the logged labor hours, the machine burden rate for each department decreased for most departments. This was expected because the number of machine hours was usually greater than the number of labor hours logged on each machine, so allocating the machine burden across a greater number of hours would result in a smaller machine burden rate for a given department.

To illustrate this difference and continue with the example of Department 4, the new values and machine burden allocation amounts were obtained and shown in Table 9-4. Figure 9-5 and Figure 9-6, respectively, provide graphical illustrations to highlight the amount of burden allocated to each phase of production, setup and run, as well as how the department's total burden is allocated to each operation using the adjusted machine hours.

Table 9-4. Department 4 Operations - Setup, Run, and Total Adjusted Machine Hours

Dept. 4 Operations	Setup Adj Hours	Run Adj Hours	Total Adj Machine Hours (Setup + Run)
Op1	429.98	2292.65	2722.63
Op2	1.10	6569.46	6570.56
Op3	0.0	273.44	273.44
Op4	0.0	2079.82	2079.82
Dept. 4 Total	**431.08**	**11,215.37**	**11,646.45**

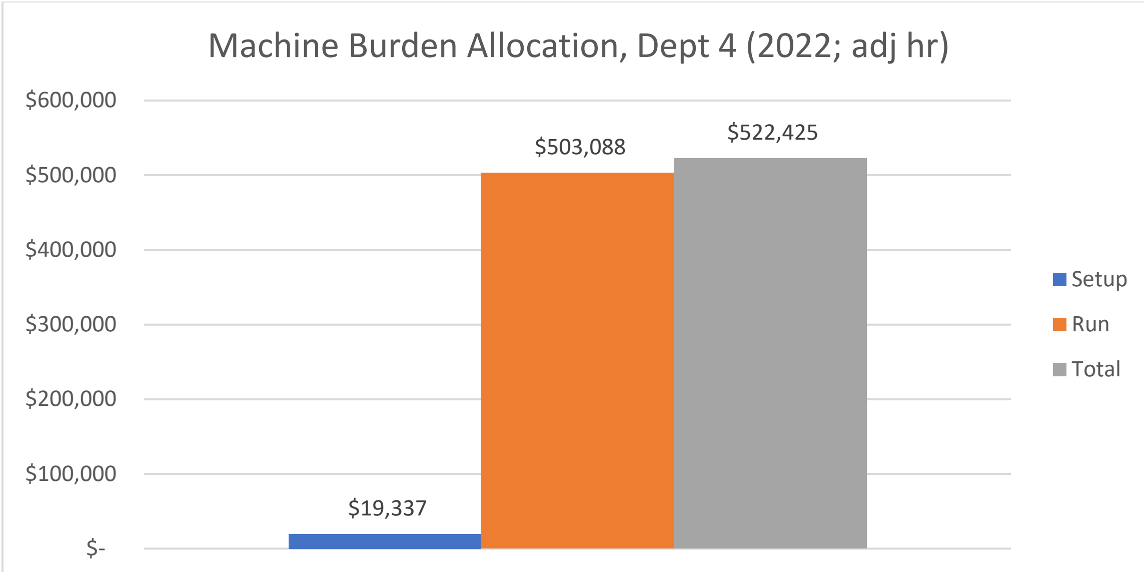

Figure 9-5. Machine Burden Allocation for Department 4 (2022, adjusted hours)

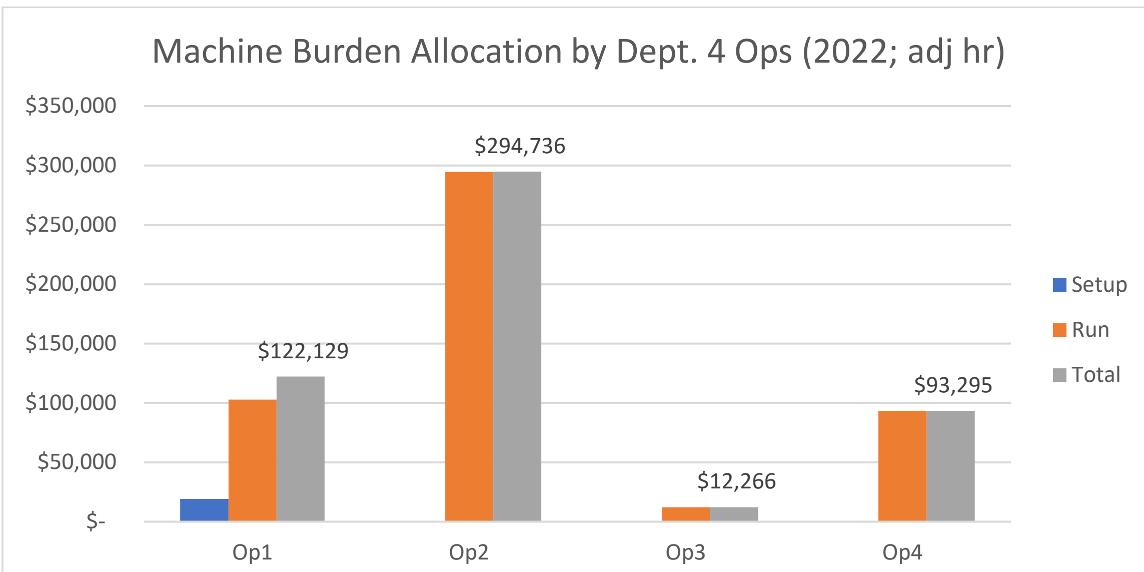

Figure 9-6. Machine Burden Allocation by Department 4 Operations (2022, adjusted hours)

9.2.3.3 Proposed Application of Burden Allocation to Work Center Bill Rates

At this point, the burden rate for each department had been determined, so the next step was to incorporate these burden rates into the work center bill rates so that there would be greater visibility into the cost of a product based on the hours it required to be produced. As mentioned in Section 9.2.3, at the time of this research, Muthig only used bill rates and did not have any burden rates nor costs included in the total amount billed. In order to incorporate these new burden rates, the total amount billed had to be recalculated. The amount billed was still the sum of the setup cost and the production cost, but the setup and production costs were updated to include the newly calculated labor, general, and machine burden rates.

Burden was applied to both the setup cost and production cost because both phases of production required resources and incurred expenses. Upon calculating the updated bill rates that now factored in burden, it was found that, in some cases, the total burden rate was greater than the original bill rate. For these operations, the original billing amount was less than the amount of burden incurred by the operation, indicating that the original amount billed was insufficient to cover the burden generated. This is a result of certain operations being overcosted while others are undercosted, as described in Section 9.2.1. Because the burden rate is applied to the whole department rather than the specific operations, the breakdown of the burden rate for each operation remains unknown, and as a result, operations that actually generate less burden are perceived as equivalent to those that actually generate more burden. Essentially, the burden is averaged across the department, which means that higher burden-generating production operations are being subsidized by lower burden-generating production operations and vice versa. Therefore, it is recommended that Muthig updates its bill rates for each operation to more accurately account for the amount of burden that each operation incurs.

9.2.3.4 Limitation of Proposal

While this proposal would provide Muthig a better approximation of total costs by accounting for their indirect costs, there is one important limitation to note – this proposal is based on historical costs extracted from the 2022 Income Statement, not present ones, and that comes with two significant restrictions [41]. First, the data comes from the previous period, which means that the period must end before calculations can be updated. The period used in this proposal was the full 2022 year, but this could be updated to shorter periods, such as the first half of 2023 or even a single month of the year. Regardless of their lengths, however, all of these periods are in the past, so they may not be the best predictors of future performance. Second, the costs incurred during a historical period reflect the costs supplied, regardless of whether they were used, which can inflate the cost allocation rate. The more accurate way to calculate this cost would be based on practical capacity of the upcoming period: the costs incurred over a period should be allocated across the full, planned capacity of the activity rather than just the capacity that was used. The total cost of the capacity supplied is, therefore, the sum of the cost of the capacity used and the cost of any unused capacity [41]. Understanding this delineation between used and unused capacity can lead Muthig to make more informed decisions about how to price their products.

If this current model based on historical data is to be improved, the next iteration should be based on the practical capacity of operations, and with these updates, the cost allocation rate would be based on the efficiency of the activities. Though there is room for improvement, the use of historical data to create activity-based costing models is still a worthwhile first step in understanding the performance of specific activities as well as of the business overall. In this case, it was particularly relevant because the actual capacity used in 2022 was an accurate representation of Muthig's true practical capacity. While past performance is not necessarily the best indicator of future results, it is a reasonable place to start, and analyzing this historical data can provide insights into how certain activities should be changed in the future [41].

9.3 Impact of Proposal for Integration

If the goal of integration is to knit multiple organizations together to better serve customers as a single contract manufacturing platform in the LVHM metal fabricated products realm, then it is critical that those distinct organizations within the platform are able to efficiently and effectively work together. One step in achieving this level of collaboration is establishing a common language among the organizations, especially in the cost calculation and quoting processes. While the exact equations used to calculate costs at each location may not necessarily need to be the same, each location should have an idea of its costs and, subsequently, the profit earned for each product manufactured. This is especially true in the low-volume, high-mix production environment in which there can be quite high margins for work. The best option would be to use activity-based costing to determine the true or actual costs of each operation per product, which would then allow for the calculation of the true profit per product, but if the data is not available, an approximation can be used as an alternative. By having better visibility into even a portion of the costs for each product, the platform can make better decisions about which products are worth manufacturing and which are not. Based on the operations required for a particular item, the burden amount associated with the manufacturing of that item can be calculated, and this information should then be used to determine the amount billed for that product. If a shop has limited capacity, then perhaps only the items with larger profit margins should be accepted. Taking this example one step further, this additional insight can also lead to greater resource allocation so that the more profitable operations have better staffing or more directed marketing toward customers that require products with greater profit potential. By better understanding its costs, such as burden, the Weller Metalworks organization, as a whole, can become more responsive, strategic, and intentional about optimizing profitability.

Similarly, standardizing the quoting process allows the platform to share work more easily between the portfolio company locations. This enables a much smoother process for cross-selling so that each site can advertise and offer the platform's full capabilities. For example, without standardized quoting, if a Laser Precision customer requests a quote for a product that requires stamping, an operation that only Muthig possesses, then the Laser Precision team would have to pass that RFQ over to the Muthig team, wait for the Muthig team to complete the quote, then return that information to the customer. This requires additional time, may be quoted at different rates than those with which the customer is familiar, and may seem clunky to the customer, as if their work was being outsourced rather than handled directly by the Laser Precision team. Instead, by implementing a common quoting process, the Laser Precision team would be able to create the quote for Muthig's operation and deliver it to the customer immediately.

With a standardized quoting process, these organizations that have been operating independently for decades would be able to share work and streamline their collaboration – both of which are particularly important in cross-selling, as demonstrated in the example above. A standardized quoting process will allow all Weller Metalworks customers to have one touchpoint for all their low-volume, high-mix metal fabrication needs rather than having to work with different teams within the platform. As customers continue to consolidate their vendor lists, it is important for the Weller Metalworks platform to implement processes that allow its portfolio companies to present a unified front and operate as one consolidated organization.

Chapter 10. Recommendations for Operational Improvements

In an effort to provide practical recommendations that build on lean principles, the current research noted some areas of opportunity at each portfolio company location. This chapter first describes those opportunities for potential continuous improvement (CI) projects by identifying wastes at both Laser Precision and Muthig Industries. These recommendations were developed over limited time with the organizations and, as a result, are influenced by the researcher's experience and understanding of each location's operations. There was not enough time to implement these projects during the research period, and though these are not directly tied with advancing the integration of the Weller Metalworks platform, these potential operational improvements would be beneficial to the platform overall as well as the individual portfolio companies.

10.1 Opportunities at Laser Precision

As documented throughout this research, Laser Precision was found to be an exceptional organization, advanced in its data management and unparalleled in its adherence to quality and on-time delivery. As it moves into this new chapter with the Weller Metalworks platform, the organization will need to continue improving its operations in order to support the growth the participation in the platform will bring. Two potential areas of opportunity for this organization are raw material inventory management and work in progress (WIP) inventory locations.

The first area of opportunity for Laser Precision is in its raw material management. When this research was conducted, Laser Precision's raw material was kept in multiple locations within one area of the production floor. When raw material is delivered from suppliers, it must be transferred from the pallets in receiving to one of many locations in the raw material storage area. There was one main vertical storage rack for some raw material metal sheets, but the other sheets were stacked in various piles, separated by wooden blocks, on the floor according to their size, material, and/or use. Some piles contained the standard 60” x 120” steel sheets while others contained the sheet metal skeletons, the frame that remains after a sheet is processed through the laser cutters. These piles were currently occupying roughly 1200 sq ft of valuable space on the production floor. In order to free some of this space and reduce two forms of waste (transportation and overprocessing), we recommend implementing a taller vertical storage rack for this material. The two systems researched – one from Vidir Vertical Storage Solutions and the other from Lean Manufacturing Products – provide different advantages.

The Vidir Sheet Metal Vertical Lift System (VLS) offers an automated storage and retrieval option that advertises increasing retrieval times and improving capital equipment output by 15 – 20% [42]. Because the storage/retrieval operation is performed by an automated lift rather than a human-operated forklift, this system could be built much higher than manual access systems. The VLS would better capitalize on the vertical space in the warehouse, and the automated retrieval option seems like a good way to increase efficiency in raw material transportation. The other option, the sheet metal storage racks from Lean Manufacturing Products, offers a cartridge-based system in which the racks themselves are cartridges on which raw material may be loaded [43]. This system eliminates the need for wooden pallets and their affiliated costs, and if these cartridges can be sent to the raw material supplier, then the supplier can load the material directly onto the cartridge, thereby eliminating the process of transferring the material from the supplier pallets to Laser Precision’s storage. Though this system is not automated, the cartridge system would be a significant benefit if Laser Precision’s raw material suppliers are amenable to using them and not damaging them during use. As the Weller platform grows, Laser Precision’s raw material needs will subsequently increase, as will the amount of time required to be spent organizing and transferring material. While each option has specific advantages, both of the options described would likely increase the available space on the production floor and reduce the over-processing and transportation wastes that are currently present in Laser Precision’s raw material processes.

The second area of opportunity for operational improvement at Laser Precision is its work in progress (WIP) inventory locations. As a product progresses throughout various operations on the manufacturing floor, it is often held in between operations at different WIP stations. Each operation, for the most part, has a dedicated area from which it pulls products, and the operations also have specific locations to push products to when complete. These WIP racks have multiple levels and slots in which products may be placed to wait for the next operation. The individual slots on each rack have been tagged with scannable labels, but the Laser Precision production team does not actually use these labels. As a result, WIP is staged between consecutive operations in these racks, but when an operator needs to pull WIP, they first must find the product in these staging areas, which is not always an easy task. When operators have to check the higher racks, they must bring over a ladder and check the upper rack locations before pulling the material with a forklift if found. All of this searching primarily leads to motion waste, in the context of lean principles, but it also adds unnecessary and non-value add time to the production process. By scanning products into and out of these already-labelled WIP locations, operators would no longer have to spend time searching through the racks for their products. This system has the potential to increase the efficiency of the production process, increase visibility and management of WIP inventory, and reduce the motion waste that currently exists in locating items in WIP.

10.2 Opportunities at Muthig Industries

As a much smaller manufacturer, Muthig Industries faces challenges that are quite distinct from those faced by Laser Precision; however, they too can address these challenges to achieve operational improvements. Based on the observations made during this research, Muthig seems to be an outstanding shop with a wide variety of capabilities, but as they grow from a small to a medium-sized manufacturing business, certain changes to their current processes will be required. The two areas of opportunity identified as areas for CI projects and operational improvements are tracking metrics and eliminating the paper-based processes.

The first proposal for Muthig is to start tracking certain metrics, such as quality and on-time delivery, so that it has better visibility into how the business is performing each month. Currently, Muthig does not evaluate any performance metrics on a monthly basis, so this would be a significant change for the organization. While this proposal does not eliminate a certain type of waste, it is in line with the lean principle of continuous improvement. By better understanding how they are performing in specific areas, the Muthig team will be able to adjust accordingly: for instance, if quality is tracked at the department level, then if a problem arises with one department, the team will have a more specific area to target within the organization. Taking this one step further, they can also drive alignment to these goals throughout the organization by tying them to financial rewards, like the annual employee bonus. By tracking metrics for each department on a monthly basis, Muthig can start to introduce a continuous improvement mindset to its workforce, thereby enabling them to constantly strive for greater performance.

The second proposal for operational improvement is for Muthig to eliminate its paper-based cover sheet process. This process is described in detail in Chapter 6 – essentially, as each functional area completes specific sections of the cover sheet, it is advanced through Muthig's various teams until the product work order has been scheduled in production. While this process allows Muthig to ensure it is using the most up-to-date pricing and not missing any information in the ERP required for production, it also is full of both overprocessing and waiting waste, and it is a substantial barrier to growth and scalability. Each group must wait for the function that owns the previous section to complete its part before the cover sheet can advance, so they are all inevitably waiting on each other to pass this paper through the organization. Because all of the information already exists in the ERP, this process seems to require extraneous, non-value-add effort. As a part of the Weller Metalworks platform, Muthig should expect to grow significantly over the next five years, and as it grows, this paper-based and people-dependent process will become even more of a bottleneck. By eliminating or replacing the current cover sheet system, Muthig can reduce its overprocessing and waiting waste, remove barriers to scalability, and set itself up well for future growth.

10.3 Implementation of Recommended Operational Improvements

In the low-volume, high-mix production environment of the Weller Metalworks platform, production organizations must seek ways to drive efficiency gains, eliminate wastes, and constantly improve their operations. Each of the four projects for recommended operational improvements at both of the Weller Metalworks' portfolio companies have been evaluated in terms of its ease and impact of its implementation as shown in Table 10-1. For Laser Precision, the team's first priority should be the raw material management project as it is both easier to implement and will have a greater impact on operations compared to the implementation of the WIP inventory locations. The raw material management project requires an initial capital expenditure for the new vertical racking system and will likely require some recurring maintenance, but once installed, the new raw material storage system will immediately be useful, organizing the raw material area and clearing valuable floor space for new product lines or equipment. The implementation of the WIP inventory locations, on the other hand, is more difficult to implement because, despite the locations already being labeled, the custom ERP system will require some updates to support the use of these intermediate locations.

For Muthig Industries, priority should be given to the metric tracking project as it will create a systemic change within the organization: as Muthig grows, its financial and performance standing, as well as how that standing has changed over time, will become more important to the Weller Metalworks platform, so it is imperative for them to enable visibility into these targets and to build a continuous improvement mindset in the organization by creating a system to track these various metrics over time . This metric tracking system can also allow them to better understand the individual performance of each department and direct improvement efforts based on that understanding. The other project, the elimination of their paper-based cover sheet process, will likely be more challenging as it is a process that has become fundamental to how Muthig operates; that being said, if they are able to implement a more efficient version of this process, it will remove the barrier to growth that the current process poses. For both Laser Precision and Muthig Industries, these projects will help enable a continuous improvement mindset in order to stay flexible but efficient in the low-volume, high-mix fabricated metal products realm.

Table 10-1. Summary of Proposed Operational Improvement Projects

	Challenge Addressed	**Ease of Implementation**	**Impact of Implementation**
Laser Precision			
Raw Material Management	Transportation Waste Overprocessing Waste	High	High
WIP Inventory Locations	Motion Waste Non-value-add time	Medium	Medium
Muthig Industries			
Metric Tracking	Lack of tracking and visibility into progress	High	High
Eliminate Paper-based Process	Waiting Waste Overprocessing Wastes Barrier to growth and scalability	Low	High

Chapter 11. Conclusions

This research intended to investigate the challenges of aligning two independent organizations in low-volume, high-mix production environments in order to propose methods that would accelerate their integration into the Weller Metalworks platform. The two portfolio companies studied in this research – Muthig Industries in Fond du Lac, Wisconsin, and Laser Precision in Libertyville, Illinois – had a complex interrelationship of shared characteristics and disparities: though both were in the metal fabricated products industry, each had its own unique operating systems, business rules, production equipment, and best practices – all of which were designed to meet specific needs and achieve specific results. It was necessary, therefore, to first analyze both the initial states of these organizations as well as the overall objective of the integration from the perspectives of all parties involved.

The analyses involved creating process diagrams, detailing production floor layouts, shadowing production work orders, interviewing stakeholders, and analyzing data from each site's ERP. Combined with the review of academic literature on the topic, which provided additional background for the context of this research, this information defined the initial and goal states of the organizations. The next stage of the research strategy employed in this thesis was to perform a gap analysis between these two states and to perform strategic benchmarking of each organization. In this step, opportunities for integration were identified in specific processes, and the strategic benchmarking highlighted best practices at each organization that could now be shared across the platform. These findings informed the integration recommendations that focused on two areas of opportunities within operations – data management as it relates to production and indirect cost allocation as it impacts the quote creation process.

This thesis documents these recommendations as avenues to promote integration by driving alignment at the platform level in the aforementioned fields, and it provides additional recommendations for operational improvements at the site level for both Laser Precision and Muthig Industries. Due to time and resource limitations, these recommendations were not able to be implemented during the period of this research, but these opportunities have the potential for significant positive impact on the operations of both the platform company as a whole as well as the individual portfolio companies. While these recommendations are specific to the Weller Metalworks platform and its two locations, the general concept and motivation supporting them can be applied to other low-volume, high-mix production environments. Similarly, the research strategies employed in this thesis may also be used in other organizations to provide a framework for them to evaluate their current state, define their objectives, and determine strategies for closing the gap and achieving their goal states.

The Weller Metalworks platform has an exciting journey ahead. The metal fabrication industry is highly fragmented, and Weller stands to effectively capture market share by acquiring and integrating multiple contract manufacturing organizations within this field. As the Weller platform, this consolidated organization will be able to meet unique customer needs in low-volume, high-mix production at all stages of the product lifecycle and capitalize on the greater margin potential of these highly customized parts. The research documented in this thesis will be a helpful tool as the current portfolio companies progress in their journey toward integration and additional acquisitions are brought into the platform. Though some additional work will be required to evaluate the initial states of the new acquisitions, the best practices learned from this research can be applied at any time. Ideally, this thesis can serve as a playbook or roadmap to achieving greater alignment and integration not only for the Weller Metalworks platform, its current portfolio companies, and any additional ones that may be acquired in the future, but also for any organization interested in strategies to accelerate integration.

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