MITLGO

LEADERS FOR GLOBAL OPERATIONS

LGO Class of 2024
Knowledge Review Use Case Summaries

LEADERS FOR GLOBAL OPERATIONS

First Name	Last Name	Thesis Title	Company Name
Alexander	Adelabu	Improving Efficiency in Lubricant Logistics: A RelaDyne Case Study	American Industrial Partners
Siddhant	Agrawal	Digital Twin-Driven Supply Chain Enhancement to Support D2C Growth	Nike
Marcelo	Aguiar	Comparison of solar PV racking options to decarbonize the FPL system	NextEra
Shivam	Bhakta	Sustainability Analytics - Lowering Emissions With Operational Efficiency	Verizon
Regina	Ceballos Mondragon	Improving Supply Chain Resiliency through Solar Panel Delivery Optimization	NextEra
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Matthew	Chew	Development and Modelling of Identification Frameworks for Site Selection, Vendor Evaluation, and Deployment of Nuclear Microreactors in Remote Mining Operations	Caterpillar
Rebecca	Cohen	Oil & Gas Operations Electrification Strategy	NextEra
Juan	Correa	A Data Driven Approach to Uncovering Energy Consumption Reduction Opportunities Within Industrial Operations	American Industrial Partners
Alec	Creta	A Strategic Framework for Evaluating Next-Generation Technologies in Biocatalysis	Amgen Inc.
Gregory	Davis	Automated Cutting in High Mix - Low Volume Manufacturing	Re:Build Manufacturing
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Leah	Gaffney	Extracting Coronary Lesion Information from Angiogram Reports for Patient Screening Applications	Johnson & Johnson
Abraham	Gerzeghier	An Assessment of Environmental Impacts of 3D Printed Medical Devices	Stryker
Ismael	Guereca Valdivia	Preemptive variation reduction in biologic drug substance manufacturing	Sanofi
Evan	Haas	Optimizing thermoplastic composites manufacturing with digital process intelligence	Re:Build Manufacturing
Ana	Haddad	Optimizing Multiproduct Drug Substance Production for Increased Throughput in an Integrated Continuous Biomanufacturing Facility	Sanofi
Caeley	Harihara	Optimization and Rule-Based Models for Hospital Inventory Management	Johnson & Johnson
Heidi	Hatteberg	Product SKU Analysis, Rationalization, and Optimization	LFM Capital
Cameron	Hoffman	Modeling System Efficiency in Mixed-Model Assembly Lines	Nissan-USA
Nicholas	Holmes	Scheduling in a High-Mix Low-Volume Job Shop	LFM Capital
Steven	Hubbard	Empowering Delivery Service Partners: A Study on Leveraging Generative Artificial Intelligence and Text Clustering to Support External Partners	Amazon
Ian	Kleinemolen	Inventory Optimization and Simulation Analysis for Supply Chain Disruption Events	Johnson & Johnson
Ryan	Kochert	Process Digitalization: Deep Learning in Industrial Applications	LFM Capital
Jessica	Lee	Leveraging digital tools and analytics for temperature management in cold chain systems for gene therapies	Johnson & Johnson
Benjamin	Lerman	Techno-Economic Analysis of Line Haul and Switcher Locomotive Propulsion by Diesel, Battery, and Hydrogen Fuel Cell Technologies	NextEra
Evan	Long	Aluminum Rolling Mill Preheat Throughput and Scheduling Optimization	American Industrial Partners
Brandon	Meehan	Green Hydrogen Plant Design and Strategies for Interactions with the Grid	NextEra

First Name	Last Name	Thesis Title	Company Name
Mark	Membreno	Price Elasticity of Air Travel Demand Using Econometric and Machine Learning to Scale Up Sustainable Aviation Fuels	Boeing
Blanca	Murga	Reducing Machined Space Components Lead Time by Reducing Job Shop Operations Complexity	Blue Origin
Daniel	Murphy	Fusion Reactor Shutdown Dose Rate Modeling for Maintenance Requirements Development and Design Using the Rigorous Two-Step Method	Commonwealth Fusion Systems
Teodor	Nicola Antoniu	Enhancing Digital Customer Self-Service Efficiency through Recommendation Systems	Amazon
Donald	Okoye	Evaluating New Business Opportunities for Interregional Transmission	NextEra
Ololade	Olaleye	Machine Learning and Stochastic Simulation for Inventory Management	Amgen Inc.
Yanghan	Qi	Building inventory simulation for high velocity garment retail stores	Zara (Inditex, S.A.)
Theo	Rosenzweig	Greenhouse Gas Optimization Across a Multi-Echelon Manufacturing and Distribution Network	Nike
Stephanie	Severe	Creating The Warehouse Of The Future	Amgen Inc.
Mark	Sweet	Automated Mold Design for Composites Manufacturing	Re:Build Manufacturing
Allison	Tsay	Framework for Enhancing Decision-Making Capabilities in the Decarbonization of the Airline Industry	Boeing
Sajiree	Vaidya	Last Mile Sustainability: Data Roadmap	Amazon
Carlos	Vela Gonzalez	Developing a Digital Twin to Optimize the External Supply Chain Management of Medical Devices	AstraZeneca
Adam	Vignaroli	Establishing Inventory Maturity in a Make-To-Order Manufacturing Environment	LFM Capital
Reimar	Weissbach	Scaling Metal Additive Manufacturing from R&D to Production	American Industrial Partners
Daniel	Willette	Paths to Achieving Scope 1 Carbon Neutrality in Building Utilities	Amgen Inc.
Rong	Yao	Delivery Estimate Accuracy: Understanding and Reducing Virtual-Physical Mismatches and Missorts in Fulfillment Centers	Amazon

Logistics / Distribution | Transportation and logistics | Transportation optimization | Uni / Multi-Objective

Fleet Standardization

American Industrial Partners

BUSINESS PROBLEM

RelaDyne, a major lubricant and fuel distributor with 88 U.S. sites, faces challenges from its 450-truck fleet, diversified across 20+ types due to acquisitions. This mix burdens delivery coordination and amplifies upkeep costs. Objective: Elevate truck operation to amplify gallons/route and advise on truck selection to streamline fleet for economical dispatch and service. With a $60 million 5-year investment plan, the project must guide this capital to rejuvenate the fleet efficiently.

APPROACH

A detailed fleet and demand analysis was conducted across key warehouses. Over 150 hours were spent shadowing deliveries in diverse markets to understand the nuances. Direct interviews with drivers, dispatchers, and warehouse teams provided frontline insights. A comprehensive cost evaluation was done based on route and truck type. From these findings, an optimization model for demand-truck route m

DATA SOURCES

Information was gathered on demand profiles (product volume and revenue), delivery routes, truck specifications, ownership costs, uptime, drive/stop durations, maintenance and fuel expenses, service types, and the previous year's financials. This data, sourced from internal logs and financial statements, provided a comprehensive view of RelaDyne's operations for the optimization endeavor.

Data Types and Format

Data was primarily in Excel spreadsheets and Tableau, with route tracking information sourced from the Samsara website.

Author: Alexander Adelabu

IMPACT

The optimization model transforms RelaDyne's delivery planning. Instead of manual truck selection, dispatchers input data, and the model yields efficient routes, optimizing costs and time. It also minimizes the number of times customers are visited per week. This process bolsters the 'gallons per route' metric, indicating enhanced delivery efficiency and promising cost savings. The time studies on deliveries have further influenced truck feature choices particularly on trucks that can deliver all of RelaDyne's product types. By understanding real-world delivery challenges, there's a renewed emphasis on trucks that maximize driver safety, minimize wasteful movements, and provide dispatch flexibility. This model's insights are also instrumental for future fleet investments. With RelaDyne's planned $60 million investment over five years, the model offers a data-backed guide on optimizing these funds, be it in new truck acquisitions or feature enhancements. In sum, this approach not only delivers immediate operational advantages but positions RelaDyne for streamlined growth, with informed decisions and amplified efficiency across its extensive network.

DRIVERS

Rapid growth and fleet diversification at RelaDyne led to logistical challenges. The company's push for efficiency and cost-effectiveness drove the need for an optimized delivery system.

BARRIERS

Data from varied sources, especially different ERP systems, made consolidation tough. Diverse truck specs and catering to different customer types and locations hindered a single solution approach. Gaps in historical data affected trend analysis. Budget and time limits constrained fleet enhancements and smooth transitions.

ENABLERS

RelaDyne's extensive data and a dedicated team of dispatchers and drivers, open to discussing daily delivery challenges, laid the groundwork.

ACTIONS

An optimization model was developed after analyzing fleet, demand, and route data. This model automated truck selection and route planning. Over 150 hours were spent on truck rides to gauge how truck type influences driver safety, deliveries, and customer satisfaction.

INNOVATION

The multi-compartment vehicle routing model, integrating demand for diverse products, truck details, and route effectiveness, was groundbreaking in refining RelaDyne's deliveries.

IMPROVEMENT

The approach boosted the 'gallons per route' figure, enhanced truck use efficiency, reduced stop durations at client locations, and steered fleet investment insights.

BEST PRACTICES

Gather robust data, grasp real-world delivery issues, and frequently test the model for effective replication.

OTHER APPLICATIONS

The method suits any multi-product, multi-compartment distribution industry, from food to e-commerce to pharmaceuticals, emphasizing route and delivery efficiency.

Logistics / Distribution | Retail | Network optimization | Network analysis

Digital Twin-Driven Supply Chain Enhancement to Support Direct-to-Consumer Growth

BUSINESS PROBLEM

Nike is transitioning its supply chain from wholesale to direct-to-consumer to meet changing customer expectations of cost and service. However, the current distribution system, designed for wholesale, struggles to handle the growing volume of digital orders efficiently. To address this, Nike is adding new physical and digital capabilities, but it is uncertain how these changes will impact the targets defined by supply chain leadership. The project serves two purposes: first, to create a critical module for the digital twin of Nike's supply chain to model the new capabilities, and second, to enhance the performance of the updated network.

APPROACH

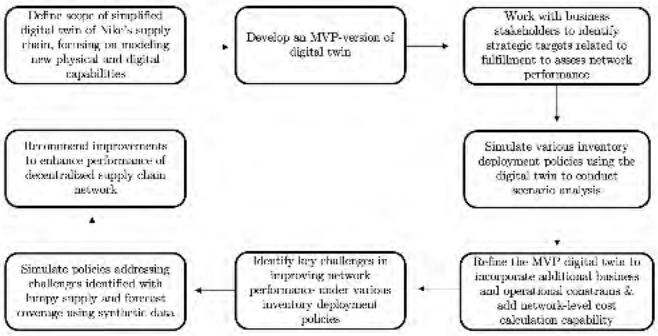
A digital twin of Nike's supply chain distribution was developed, emphasizing new physical nodes and digital capabilities. Various pull and push-based inventory deployment strategies were simulated in the digital twin. Lastly, synthetic data were used to model enhanced forecast coverage and smooth supply to study how these challenges, discovered during simulation, affect network performance.

DATA SOURCES

Demand Forecast, Purchase Orders, Actual Sales, Inventory Levels, Shipping & Processing Costs

Data Types and Format

Numeric, structured data



Author: Sid Agrawal

IMPACT

The digital twin offers Nike the ability to simulate various inventory deployment policies within the updated supply chain network, analyzing their impact on key performance metrics. It also facilitates cost savings assessments for various policies. Additionally, simulation results with synthetic data addressing challenges with forecast coverage and lumpy supply have sparked evidence-driven discussions to tackle these issues. In summary, the digital twin tool along with the synthetic data exercise have equipped Nike with insights and capabilities needed to get closer to the supply chain targets set by the leadership for supporting D2C growth.

DRIVERS

DTC sales are a rapidly growing revenue stream for Nike and the broader retail industry. Consequently, there is a strong push within the company to enhance digital and physical supply chain capabilities to fuel D2C expansion.

BARRIERS

The difficulties in obtaining comprehensive historical forecast data for the period covered in the simulation posed obstacles, which could be overcome by using synthetic forecast data.

ENABLERS

The cutting-edge software development infrastructure, which included AWS SageMaker, SnowFlake database, Git, and Jira, coupled with the support of a proficient data science team and cooperative business counterparts, played a pivotal role in facilitating the success of my project.

ACTIONS

I gathered empirical evidence illustrating the potential financial gains from my proposed solution and delivered these findings to senior leadership, including VPs and Directors from the supply chain team. As a result, Nike has commissioned additional work to delve deeper into the solutions I suggested.

INNOVATION

I created a highly granular digital twin that can be employed to research various supply chain network performance issues. Additionally, the use of synthetic data to tackle forecast coverage gaps and supply irregularities has paved the way for its broader application in cases where necessary data is unavailable.

IMPROVEMENT

The simulation results provided key insights for investment decision-making for a new cross-dock facility, delaying the investment to align with the hypothesized impact on network performance. Additionally, the simulation with synthetic data revealed that resolving identified challenges could triple network performance, measured by the percentage of inventory bypassing the primary distribution center, and simultaneously cut network costs by 1%.

BEST PRACTICES

When constructing a digital twin, it's more manageable to start with a Minimum Viable Product (MVP) and progressively incorporate greater complexity, such as business and operational constraints. In conducting cost scenario analysis, it is crucial to maintain a consistent total product volume flowing through the network across scenarios to ensure a fair comparison of network costs across the scenarios.

OTHER APPLICATIONS

The digital twin I helped expand to model new capabilities can be extended to encompass production and planning, as well as studies focused on sustainability within supply chains.

R&D | Energy | Network optimization | Linear / Non-Linear

Economic Comparison of Solar Racking Options to Decarbonize Florida Power & Light's System

BUSINESS PROBLEM

Florida Power & Light (FPL) has set the Real Zero goal by 2045 of completely eliminating carbon emissions from its operations without acquiring traditional carbon offsets. To do that, FPL plans on relying largely on solar and energy storage. Florida's regulatory environment supports choosing the least expensive option, so it is critical that all projects are cost-effective. The challenge I am working on is how to guide the economic choice of racking system for solar in order to minimize the total system cost. Disclosure: this work is a sensitivity analysis and does not represent concrete plans or analyses for FPL.

APPROACH

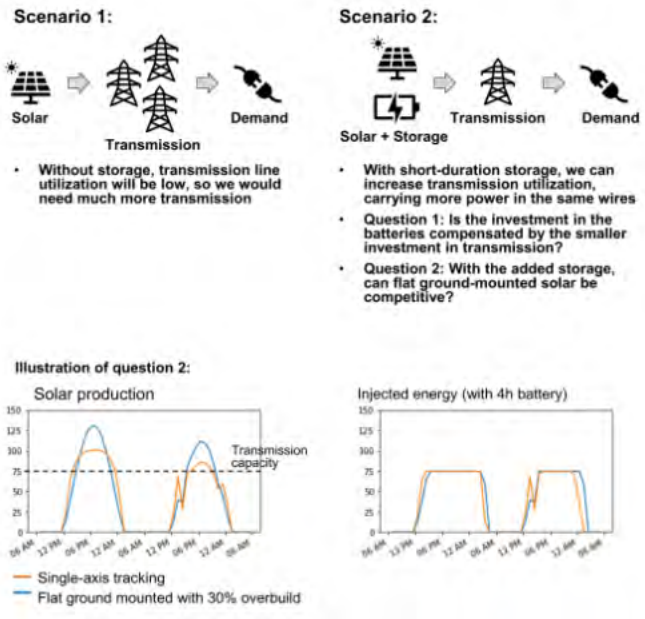
I first constructed a model to estimate the solar Availability Factor based on historical data. We then constructed a Capacity Expansion Model to optimize the generating fleet under a set of assumptions. We then evaluated the trade-off between the racking options by pairwise comparison under several cost assumptions. Our end objective is to to find the Threshold Cost Ratio.

DATA SOURCES

We used three data sources: 1. Solar data - National Solar Radiation Database (NSRDB) historical irradiation data. 2. FPL electricity demand (FERC Form No. 714 has this open data). 3. Transmission, solar and storage costs from different sources, but mostly NREL. All data sources are publicly available and no internal data from FPL was be used in this work.

Data Types and Format

Time series of solar irradiation, electricity demand in FPL, and technology costs (for solar, storage and transmission).



Author: Marcelo Aguiar

IMPACT

Meeting the Real Zero goal is fundamental for NextEra for two reasons. First, this goal is a commitment to investors, customers and regulators, and thus meeting it is critical to the success of the business. Second, as a regulated utility, FPL makes money from the remuneration of capital deployed (CAPEX), so replacing fuel costs with CAPEX will increase the bottom line of the company without increasing customer bills. The objective of my project is to search for lower-cost pathways for this transition. If we can find an approach that lowers cost, it will be possible to implement it faster, thus benefitting the company's achieving its pledge and benefitting it financially. The main conclusions of my work were: Flat Solar is competitive with Tracking Solar if it costs less than ~74% of the cost of Tracking. For Fixed Solar, this Threshold is ~81%. In addition, we found that the Solar Overbuild (Inverter Loading Ratio), availability of DC-connected storage, and availability of Long-Duration Energy Storage are important for this decision.

DRIVERS

The main driver for why this is important is the drop in solar panel costs. With lower panel costs, it starts to make sense to consider options with lower CAPEX per Watt, even at the expense of producing less energy per panel. This might make Fixed or even Flat Solar competitive against the traditional Tracking Solar, which currently dominates utility-scale projects.

BARRIERS

The main difficulty for my project is that very few projects have been built with either Flat or East-West racking, and even Fixed racking is usually only used in situations where using Tracking is not feasible. Thus, it is difficult to estimate the actual cost of each racking option. To resolve this, we focused on finding the Threshold Cost Ratio below which these alternative rackings would be economical.

ENABLERS

With its focus on 2045, many parts of FPL are driving change to achieve its goal. Also, there is a team dedicated to leading the strategy for Real Zero, which was very helpful.

ACTIONS

At this point, this is a high-level analysis to see if this is an idea worth pursuing. If so, the next step is to get engineering involved to consider the details and whether they change the answer. For example, doing flat solar has implications for cleaning and maintenance, and doing DC-connected storage may raise additional challenges. These are questions that NextEra's Engineering teams would be able to address.

INNOVATION

Taking into consideration how storage, tracking, interconnection, and transmission are interrelated. Doing an approximate analysis with the Levelized Cost of Energy can give an approximate answer, but before this study it was unclear to what extent the storage and interconnection costs would impact the tradeoff between different racking options.

IMPROVEMENT

It led to a better estimation of the Threshold Cost Ratio, which will allow NextEra to better evaluate the racking selection decision.

BEST PRACTICES

Start with open data sources, such as NSRDB, and using open source tools such as pvlib to estimate the production from solar panels.

OTHER APPLICATIONS

FPL is a part of the NextEra Energy family of companies, therefore this project would apply to other parts of the enterprise as well, including NextEra Energy Resources, which builds renewables in other states. In particular, in California, land is often difficult to obtain, interconnection is expensive and complex, and solar-paired-storage has specific incentives. Therefore, new solar installations in California may benefit from this approach.

Operations | Agricultural products and processing | Inventory management / control | Discrete / Continuous

Product/SKU Analysis, Rationalization, and Optimization

LFMcapital

BUSINESS PROBLEM

IronCraft, an LFM portfolio company, is a high growth company that specializes in manufacturing skid steer and tractor attachments. The total number of stock keeping units (SKUs) has exponentially increased, to the order of millions of independent product offerings, which introduces variability into their manufacturing operations. This project is scoped to perform a SKU rationalization analysis and provide an optimized product offering list to support the overall growth of IronCraft. Beyond the SKU rationalization, there will be a focus on implementing Lean/5S principles within operations for the company's top selling product families.

APPROACH

Strategy alignment is the first step to this problem by using a qualitative and quantitative approach to determine an optimized list of SKUs. Production operations can then be stabilized for those set SKUs by employing standard work and a quality management system to reduce lead times and rework. Finally, productivity improvements will be made by reducing waste and increasing profitability.

DATA SOURCES

IronCraft recently adopted a new ERP system, Epicor, to track parts and materials purchasing, orders and sales, production jobs, cost accounting, and shipping. This data can be queried and exported into excel files to be analyzed. IronCraft currently uses Power BI to evaluate large subsets of data which will also be used for this project to make decisions about its product offerings.

Data Types and Format

The data from Epicor is exported into excel spreadsheets and analyzed using Power BI data visualizations. For operational/production improvements, time series data and video were collected.

Author: Heidi Hatteberg

IMPACT

The tool created for a SKU rationalization will help leaders make data-driven decisions to help leverage LFM's portfolio company synergies while also driving value to IronCraft and their holding company, Attach Co. The optimized product mix will help reduce inventory costs and improve the overall value stream. Reduced SKU offerings will foster efforts in improving operational efficiencies and quality by driving standard work through high-moving products. Additionally, by optimizing IronCraft's product mix, the dealership network and end users will be better served by having the right product on site, ready to ship, and ready to use. This improves sales opportunities and helps the customers complete their tasks on time.

DRIVERS

Implements are designed to accommodate farmers with different farm sizes, soil types, crops, season, etc. so there are many types and variations of equipment created to fit individual farmer's needs. However, this creates a high product mix that adds variability and complexity to the manufacturing operations. Performing a SKU rationalization will help improve the overall value stream of IronCraft's current production operations.

BARRIERS

While there was significant data to support the argument for a SKU analysis, there is also a qualitative piece to the analysis to ensure IronCraft's value to the industry. Customers, dealers, and sales representatives may have strong opinions towards specific SKUs over others that are rarely unanimous. Aligning everyone with Attach Co.'s vision to reduce SKUs and improve the overall growth of the company is the main barrier of this project.

ENABLERS

IronCraft/LFM and its leadership has been very supportive of this project as they see and understand the need for reducing variations and customizations to add value back into the company.

ACTIONS

After collecting the data to develop an initial design of the tool, I created use cases to begin the conversations around product mix and SKU rationalization. To complement this quantitative approach, I hosted several workshops with key leaders and decision makers (operations, manufacturing general managers, marketing, engineering) to add anecdotal information and develop a finalized list of product offerings.

INNOVATION

Considering that IronCraft has not had this level of visibility to their data, making this tool dynamic so that decision makers can interact directly with the data and make strategic decisions is very innovative for them. The decisions made using this tool also impact their overall value stream and streamlines their operations potential to be more lean and efficient.

IMPROVEMENT

Using this tool, we will be able to reduce IronCraft's inventory costs and overall footprint for both parts and finished goods. Furthermore, by removing the variability across SKUs and focusing on the standard offerings, IronCraft will be able to improve their productivity and quality through 5S/Lean activities.

BEST PRACTICES

To better implement and replicate this solution, it would be a best practice for the ERP system to have a product hierarchy and standard nomenclature for SKUs offered. It is very difficult to automate aspects of this tool and analyze the data from different groups/angles due to data fields missing or not used the same across the various companies and product families.

OTHER APPLICATIONS

This SKU analysis tool could be used in various types of retail industries that offer a larger product mix to consumers. It could also be used to track orders and analyze consumer habits to improve forecasting for the seller/manufacturer.

Operations | Telecom | Network optimization | Linear / Non-Linear

Sustainability Analytics - Lowering Emissions With Operational Efficiency

BUSINESS PROBLEM

Verizon faces significant overcapacity in their central offices. Historically a standard, T1 copper lines now are challenged by technological shifts towards fiber and broadband. With customer migration, many T1s remain underutilized. (max 24 channels per circuit) Presently, manual methods identify "zero-fill" and "low-fill" devices, constituting >60% of central offices. Without strategic equipment consolidation, energy and cost-saving opportunities are lost. Amidst rising T1 costs, there's a pressing need to strategically decommission outdated T1s, addressing underutilization and conserving energy loads.

APPROACH

Start with data from a single central office's Excel file as a pilot. Using Jupyter, process and analyze this data. With insights from the pilot, develop initial, scalable Python scripts for multiple central offices. Engage with Network teams to identify and enhance optimization pathways. The strategy will serve as a blueprint, highlighting gaps, required data, and steps for team continuity.

DATA SOURCES

Using Excel files provided by the decommissioning team for each central office. Aim: Obtain direct read-only database access that feeds the iEN Legacy DCOMS dashboard, bypassing manual Excel extraction. The dashboard pulls data from the NAR (Network Analytics and Reporting) database.

Data Types and Format

Relational Databases. Excel.

Author: Shiv Bhakta

IMPACT

Business and Sustainability Impact of the Solution Verizon, one of the top five corporate electricity users in the U.S., incurs over $1 billion in annual electricity expenses. Much of this is due to outdated, inefficient tech like the 1/0 DCS and D4 channel banks. Decommissioning these systems, especially zero-fill and low-fill T1 circuits, can cut power consumption significantly, thereby reducing operational costs and CO2 emissions. The transition from these energy-guzzling systems can lessen power usage by up to 70% per subscriber and shrink Verizon's carbon footprint substantially. This not only bolsters Verizon's sustainability initiatives but also curtails scope 2 emissions. Moreover, modernizing equipment means heightened reliability with fewer breakdowns in remote Central Offices. This efficiency reduces both operational challenges and costs, ensuring superior service quality. Strategically, pivoting from copper to fiber showcases innovation and future readiness. Such a shift attracts investor confidence, with fiber-centric companies often achieving higher valuations. The proposed solution promises financial savings, environmental responsibility, and enhanced reliability, aligning Verizon's operational goals with global sustainability benchmarks.

DRIVERS

The catalyst for Verizon's solution was the challenge of aging legacy equipment, particularly D4 Channel Banks, which were inefficient in terms of electricity demand and utilization for the diminishing customer base.

BARRIERS

Barriers included the complexity of decommissioning decisions, the necessity to maintain operational integrity, and the need to consolidate underutilized equipment without significant capital investment.

ENABLERS

Features that enabled the project included Verizon's commitment to operational efficiency and sustainability, access to robust network infrastructure data, and collaboration with the Network Decom team.

ACTIONS

We developed an optimization framework using integer linear programming, employed the Gurobi optimizer, and engaged in collaborative problem-solving with Verizon's analytics teams.

INNOVATION

Innovative aspects of the solution were the creation of a detailed optimization model tailored to network equipment decommissioning and the strategic use of analytics to integrate sustainability into operations.

IMPROVEMENT

The final improvement provided by the solution included a significant reduction in the operational footprint of a representative central office's D4 Channel Banks by up to 40.8%, translating into annual cost savings between $16,000 and $41,000. Beyond financial savings, there is significant environmental benefit by reducing electricity demand, and thereby avoiding related carbon emissions.

BEST PRACTICES

Best practices involved engaging with operational teams for insights, utilizing robust optimization models for decision-making, and considering both financial and practical constraints in decommissioning.

OTHER APPLICATIONS

Other potential applications of the solution include applying the optimization framework to other types of legacy network equipment across the network, thereby expanding the model to address different operational challenges. Driving sustainability goals through operational efficiencies is applicable across industries.

Supply chain planning and inventory management | Energy | Improved process performance | Constrained / Unconstrained

Improving Supply Chain Resiliency through Solar Panel Delivery Optimization

BUSINESS PROBLEM

Given the disruptions in the global solar supply chain and NextEra Energy's accelerated growth, the company's solar panel allocation process is gaining complexity. The allocation process results in a schedule that dictates the delivery of 150 million panels to the 50+ projects which are under construction simultaneously, while balancing requirements from multiple stakeholders. Due to project and contract interdependencies, modifying the delivery schedule leads to costs with consequential impacts across projects. An automated approach to allocation is necessary to minimize costs and make prompt strategic decisions across a growing portfolio.

APPROACH

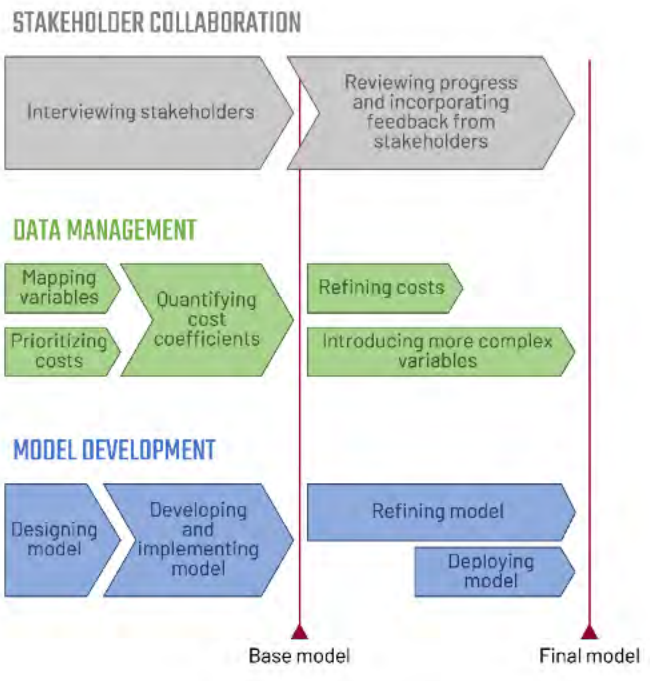
Since an ideal delivery schedule minimizes portfolio costs while meeting various stakeholder constraints, the project automated solar panel delivery scheduling with an optimization. First, it created a "sandbox" model to develop insights into the decisions that the model would have made in historical disruptions. Then, it refined the model to generate pragmatic, strategic solutions.

DATA SOURCES

Data sources are mostly internal and are comprised of current and historical delivery schedules, contracted volumes per supplier, production schedules per supplier, cost data points, and revenue data points. These data come from the Pricing & Analytics project sponsor team, as well as the Commercial (Development), Contracting (Supply Chain & Early Stage), Construction, and Logistics stakeholders.

Data Types and Format

Structured data include Excel spreadsheets. Unstructured data include contracts and documents in PDF formats and interview notes, which were used as inputs for the cost and revenue estimations.



Author: Regina Ceballos Mondragon

IMPACT

The model improves NextEra Energy Resources' supply chain resiliency by responding faster to disruptions and adapting to changes with greater flexibility. Manufacturing delays disrupt equipment deliveries, in turn disrupting the projects' development. By quantifying the impact of potential changes to the delivery schedule in a short amount of time, the model can select the schedule with the least disruptive change. An automated approach to scheduling and allocation has the potential to minimize costs and make prompt strategic decisions across a growing portfolio.

DRIVERS

NextEra Energy Resources' pipeline for solar projects has steadily grown, and they expect it to grow as more businesses pledge to reduce their carbon emissions. However, NextEra Energy Resources will need to realize this growth in a volatile solar energy industry. Not only will the scheduling process need to incorporate a more extensive portfolio, but it will also have to be flexible to increasingly frequent disruptions.

BARRIERS

The costs from the model implementation are directional, not precise, estimations. The model also does not capture the non-linear nature of the costs. Upon future iterations of the model, more details could be introduced to improve the precision of cost estimation. However, this project prioritized using less complex techniques to promote a better understanding and an easier adoption of the model within the organization.

ENABLERS

NextEra Energy Resources has the scale and capabilities to handle these complexities. In contrast to competitors with a single solar panel contract with one supplier, NextEra Energy Resources sources its solar panels from multiple contracts. As such, if there is a disruption in the supply chain, it can adapt to those disruptions by redirecting unaffected supply to support imminent, high-priority projects.

ACTIONS

The various teams that collectively develop solar projects must use the schedule to deliver solar panels. We divided the project into two phases since we required the teams' involvement and approval to create the model that automated the process. Each phase had iterative components of key stakeholders, data management, cost calculation, and model development. The result of each phase was a functioning optimization model.

INNOVATION

The project developed and implemented a novel optimization model to determine the optimal schedule for delivering solar panels to NextEra Energy Resources' project sites. The model abstracts impactful and quantifiable costs and minimizes them to propose a realistic solution. By producing a schedule in significantly less time than the current manual approach, the model can adapt to disruptions in the solar panel supply chain faster.

IMPROVEMENT

The solar panel allocation model is a powerful tool for producing and evaluating delivery schedules for routine operations and if a major disruption happens. We assumed that making a manual schedule takes ten working hours on average, and the tool can identify potential schedules that adapt to disruptions while minimizing costs in minutes. It also uses hard-to-ideate allocations and does not follow the team's traditional heuristics.

BEST PRACTICES

Investing time to understand the problem with key internal and external stakeholders. Employing an iterative approach to faster incorporate feedback and develop modularly. Ensuring thorough testing with multiple scenarios to increase the functionality. Adapting the solution to fit the specific requirements of the context.

OTHER APPLICATIONS

Some additional areas of opportunity to expand on include adding the delivery of other equipment, such as inverters, racking, and storage, into the schedule. As NextEra Energy Resources standardizes and increases its data collection, it will have more information regarding the costs, which can also be introduced into the model.

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

LFMcapital

BUSINESS PROBLEM

The Weller Metalworks platform is seeking to understand how to best integrate portfolio companies that have many different systems, operations, and processes. Integrating businesses that have been family owned and independently operated for years poses a variety of challenges, so this research aims to provide recommendations to address those challenges and to develop guidelines to facilitate the integration. Specifically, there have been two recent acquisitions for the Low-Volume, High-Mix platform, and now, the Weller Metalworks platform must determine how to best proceed with both companies performing as one consolidated organization.

APPROACH

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

DATA SOURCES

The data for this research will primarily be system maps for the production operating systems at each site as well as high-level process maps. These will come from my observations and meetings with the subject matter experts at each business. There will also be data from the ERP on the annual sales revenue and unique SKU numbers that will be included in the background information for each company.

Data Types and Format

Most of the quantitative data came from each site's ERP system (Customer Sales Data), and the qualitative data came from interviews with the company personnel (Process Flow Diagrams, System Maps).

Author: Priya Chacko

IMPACT

By developing an integration roadmap and playbook, this research will achieve three goals: first, it will document the lessons learned from each acquisition; second, it will set up the current portfolio companies for future success as they work together as one consolidated business in the Weller Metalworks platform; and third, it will serve as a guide for future acquisitions and improve the integration process of those portfolio companies.

DRIVERS

This solution relies on sharing the existing best practices of one portfolio companies with the rest of the platform. Because both organizations operate in the low-volume, high-mix fabricated metal products industry, the potential for synergies and alignment between the portfolio companies is high, and this research aims to capitalize on that opportunity.

BARRIERS

As businesses that had been independently operated and family owned for decades, the portfolio companies exhibited some resistance to change. Additionally, there were resources constraints that prevented the implementation of the proposals detailed in this research during the internship period.

ENABLERS

The platform company leadership was supportive of my research, which set the tone for the portfolio company teams to be receptive and helpful as well, and they committed to implementing my research after the internship period. Because Weller Metalworks was in a nascent state during this research, its focus was on integration and growth; as such, my proposals to accelerate integration and increase operational excellence were encouraged.

ACTIONS

One of the proposed solution involved accounting for indirect costs in order to have better financial visibility. For this, I analyzed historical financial data to create a simple time-dependent activity based costing scheme, which was then used to determine the amount of overhead generated by each production department. Each location's operations were also analyzed to identify opportunities to eliminate waste and maximize process efficiency.

INNOVATION

One of the portfolio companies lacked visibility into its costs. Despite being profitable, they were unable to ascertain the profitability of specific orders or production operations. The proposed system offers enhanced financial visibility at the department level. This enables the organization to gain deeper insights into its costs and, consequently, its overall profitability. Overall, this leads to better decision-making and resource allocation

IMPROVEMENT

Because the proposals detailed in this research were not implemented during the internship period, the quantifiable improvement is unknown; however, the thesis details the potential benefits achieved by each solution.

BEST PRACTICES

It is imperative to ensure that the team is fully engaged in the process and possesses confidence in the proposed solution. This begins by garnering early support from the team, collaborating with individuals to understand their workflows, soliciting input from all stakeholders throughout the solution development process, and ultimately presenting the outcomes in a manner that is both meaningful and highlights their impact.

OTHER APPLICATIONS

Though the research specifically focuses on improving one location's practices to drive alignment across the platform, the proposals can easily be applied to any additions add-on acquisitions made by Weller Metalworks in the future. These best practices may also be relevant to any entity in the LVHM industry, and in more general terms, the process outlined in this research can also be used to help accelerate integration in other organizations.

Product design / development / engineering | Metals and mining | Product design and testing | Constrained / Unconstrained

Pilot Proof-of-Value Site and Nuclear Reactor Partner Company Selection

CATERPILLAR®

BUSINESS PROBLEM

Caterpillar aims to provide sustainable microgrid solutions to mining customers to help reduce their carbon footprint. Nuclear Microreactors have emerged as a possible addition to their microgrid solutions however due to the novel nature of these systems, Caterpillar needs a quantifiable approach to determining their suitability for a site and a suitable partner to work with. A set of frameworks would be required to: 1) Identify suitability of mine sites to use microreactors 2) Identify Pilot site 3)Identify suitable partner through financial analysis, timelines & possibility for ROI in feasible timeline

APPROACH

1) Interview mining companies and read public reports. 2) Develop questionnaire from information obtained. 3) Interview reactor companies to understand timeline, investment requirements and estimated costs. 4) Develop database of parameters of companies. 5) Integrated database and questionnaire to help provide numerical score of site suirability and suitable reactor company.

DATA SOURCES

Public reports by mining companies; Public announcements by nuclear microreactor companies; Interviews/calls with mining companies and nuclear reactor companies

Data Types and Format

Audio; Reports

Author: Matthew Chew

IMPACT

Quantifiable score that can help Caterpillar identify suitable Pilot sites and possible beachhead market. In addition, this could help quickly identify what gaps in infrastructure that needs to be built if needed. Shortens lead time for analysis and provides a quantified approach for justification and analysis.

DRIVERS

Caterpillar mining customers are on a path to reduce their carbon footprint through the electrification of the machines on the site. This effort to electrify the mines is creating a large demand for clean energy at the mines. Caterpillar's mining customers are looking to Caterpillar to assist with identifying optimal solutions.

BARRIERS

Lack of knowledge: Many unknown unknowns with a technology that does not have any prototypes in the market

ENABLERS

Top management support: Desire by internal pillars to provide solutions to reduce carbon footprints; Caterpillar's unique position as both machine and energy production (EP) in various sectors

ACTIONS

Product research; mine site visits; software simulations

INNOVATION

Development of a framework that replies on a series of questionnaires and databases which some elements of system dynamics to provide a quantified numerical score.

IMPROVEMENT

A quantified approach to score and determine microreactor suitability for a mine site and a score to identify suitable microreactor partners; Removes some uncertainty in determining a decision

BEST PRACTICES

Having clear knowledge of the critical numbers; Openness and transparency of needs/financials

OTHER APPLICATIONS

Heat process replacement: Maritime power generation; Database baseload/backup power generation

Oil & Gas Regional Operations Electrification Estimation

BUSINESS PROBLEM

The Oil & Gas (O&G) industry is a high emissions emitting segment that the NextEra Energy Resources (NEER) Origination team is targeting. A path for O&G companies to reduce their emissions is through electrification. This creates a growing opportunity for NEER to offer renewable energy solutions. This project is being used to understand megawatt (MW) opportunity by O&G region. With this MW market sizing, the next steps are to understand what companies are operating in a region and what specific products NEER can provide them to meet their electrification goals. A successful project will be developing a targeted strategy for O&G customers.

DATA SOURCES

There are three buckets of data that will be utilized for this project. One is public information including companies sustainability reports & EPA Data. The second bucket is industry data; NEER subscribes to Enverus which is a platform with a variety of O&G information. The third bucket is internal knowledge including salesforce information and O&G industry experience.

Data Types and Format

Public Reporting: Data Tables, Mapping & Qualitative Information, Enverus: Data Tables and Mapping, Salesforce & Internal Information: Qualitative Information

APPROACH

In developing an O&G strategy, 3 steps have been determined. My initial work focused on understanding current decarbonization strategies for O&G. Once the needs of the market are understood, the next step is to evaluate opportunity size, focused on basin geography. This market size will then be broken down into target accounts and wind availability near account operations will be assessed.

Author: Rebecca Cohen

IMPACT

My project developed a focused list of potential Oil & Gas customers for the Origination team to target, including specific company opportunity sizes and wind mapping. What made my project impactful was the evaluation of scope 1 emissions that could be transitioned into scope 2 emissions for Oil & Gas operations. In looking at past evaluations for Oil & Gas, they had been focused on scope 2 emissions opportunities. Developing an opportunity size for scope 1 emissions based on Oil & Gas operations electrification efforts provides a new perspective on how to prioritize Oil & Gas accounts. The other impactful element of my project was relating scope 1 emissions opportunities to wind resources. The wind resource available in the geography where electric energy generation may be needed to replace current energy sources (Diesel & Natural Gas) was evaluated. As demonstrated by past NEER projects there is potential to develop wind projects at Oil & Gas operations sites to aid in load electrification. Examining wind resources in operations areas creates an idea if an onsite wind project would be possible. Combining company specific opportunities with an initial analysis of the opportunity for wind development allows NEER to have a focused approach when developing relationships in the Oil & Gas industry.

DRIVERS

There are two main catalysts for my solution. As NEER is looking to support commercial and industrial companies in their decarbonization efforts, it is important to confirm companies are interested in help, this confirmation was done through reading multiple O&G sustainability reports. Additionally, opportunity sizing for O&G operations electrification was prioritized for analysis as it is a trend NEER solutions can support.

BARRIERS

The largest barrier to my project was understanding the complexity and nuance of EPA regulations and emissions reporting in the O&G sector. I was fortunate to be able to leverage NEER internal resources to help with this. Another barrier at the beginning of my project was determining the best strategy for how NEER could support O&G. This initially resulted in research on specific accounts, but ultimately led to my opportunity sizing analysis.

ENABLERS

There were three groups at NEER that were leveraged to help me complete my project. The first was the O&G focused origination team. Through getting to work with them I was able to understand how NEER is currently connecting with O&G. Working with NEER development allowed me to test how my analysis could be applied. Lastly working with a NEER O&G EPA expert helped me to understand the current and changing emissions reporting regulations.

ACTIONS

I shared the findings of my project with people on my active team and people on adjacent teams that could benefit from the knowledge. As this was a strategy development project there were no direct components that could be measured during my internship. The benefit of my project is providing a framework to help the NEER team as they begin to support O&G decarbonization.

INNOVATION

My solution focused on scope 1 emissions and the ability for those to transition to scope 2 emissions is a different process than I saw others at NEER using. Additionally, when a list of target accounts was determined I took the account locations and tried to identify if their operations sites would be suitable for wind development projects. I had not seen others evaluating wind viability during the research phase for specific O&G accounts.

IMPROVEMENT

My solution provides two benefits. It created a list of top prospect accounts, by opportunity size, for O&G operations electrification which will reduce scope 1 emissions. Additionally, I worked with the NEER development team to do a high-level analysis to understand the possibility of developing wind projects in the geography's that would be looking to convert from fossil fuels to electricity.

BEST PRACTICES

I would advise others to leverage expertise to understand available data and confirm conversion processes. In connecting with an O&G EPA expert I was able to understand regulation details that would have been hard for me to understand on my own. When I started my evaluation, I was leveraging a conversion system for CO_2e emissions that was not appropriate for the data I had, uncovering this allowed me to pivot my analysis.

OTHER APPLICATIONS

A differentiator with O&G is that they are looking to electrify Scope 1 emissions from diesel and natural gas engines. My project can apply to other industries that are also trying to transition Scope 1 emissions from fossil fuels to Scope 2 emissions powered by electricity and ideally renewables.

Operations | Metals and mining | Improved process performance | Regression analysis

A Data Driven Methodology to Uncovering Energy Reduction Opportunities Within Industrial Operations

AMERICAN INDUSTRIAL PARTNERS

BUSINESS PROBLEM

Due to increased energy prices in Europe because of the war in Ukraine, Aluminium Duffel (AD), a leading manufacturer of rolled aluminum, has experienced increased operating costs. As such, AD aims to implement energy reduction initiatives that can help tangibly reduce costs. The objective of this project is to execute and open-ended, data-driven search for energy savings opportunities across the plant and develop tangible implementation plans for the found initiatives.

APPROACH

My approach involves first consolidating all available energy data into a usable format and from there, start an open-ended analysis of energy consumption within the plant. This involves finding patterns across the data that are not visible by looking at the operations. Vital to this approach is modeling an ideal operation of optimal energy consumption to which to compare current consumption.

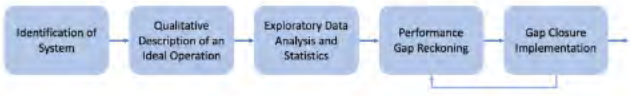
DATA SOURCES

Time-stamped energy consumption data per product is available for all machines and is scattered in different databases. Additionally, data from sensors within each machine is available from a centralized digital dashboard, which shows temperature, pressure, amperage readings, among others.

Data Types and Format

Data types include time series, tabular, and discussions with experts. Data is found within excel files and SQL calls from several databases.

Proposed Methodology



Author: Juan Correa Nunez

IMPACT

The overall project effort to reduce energy consumption will enable AD to reduce operating costs while also reducing its environmental emissions. Numerically, this project will allow AD to reduce energy consumption by 23% in the pre-heating furnaces.

DRIVERS

The dramatic increase in energy prices in Europe due to the war in Ukraine led to AD a very significant increase in operating costs due to increased energy costs. As such, there was a direct need to reduce energy consumption without affecting production levels.

BARRIERS

The biggest barrier was the lack of direction from within AD as to where energy saving opportunities existed. To date, AD has found energy savings opportunities by intuition of where energy is consumed. This meant that I had to develop a data driven approach to finding energy saving initiatives. Another challenge was that energy data was scattered across multiple servers and had to be consolidated prior to use.

ENABLERS

Strong support from AIP and the AD teams. Both teams agreed equally that energy reduction initiatives were imperative and were open to exploring new ways of achieving the energy reduction goals. This project carried high visibility within the company, which made obtaining support for it fairly straight forward.

ACTIONS

I consolidated all energy data in usable excel documents that allowed easy manipulation and analysis. From there, I started an open-ended analysis of energy consumption in order to find patterns or insights within the data. I then compared my findings to an ideal operation model that I developed from conversations with specialists, product recipes, and machine handbooks. This allowed me to identify performance gaps in the current operation.

INNOVATION

AD has relied on intuition to identify energy-saving initiatives. My solution involves and innovative use of energy data to find energy saving opportunities that would normally remain hidden. Another innovative aspect of my solution is the integration of operator feedback and with the energy consumption data. This allows for data to be better analyzed and in proposals of initiatives that result in more tangible solutions.

IMPROVEMENT

My solution will allow AD to reduce energy consumption in the pre-heating furnaces by 23%.

BEST PRACTICES

1. Incorporate qualitative operator knowledge into data analysis process to better understand results and findings. 2. Develop a thorough understanding of the technical/mechanical workings of each machines/process, starting from first principles fundamentals. This is critical to understanding where energy savings opportunities lie. 3. Be open to listen and develop relationships within the operations/manufacturing team.

OTHER APPLICATIONS

This approach can also be used to find operational inefficiencies. Similar to energy inefficiencies, operational inefficiencies can be detected by open-ended data analysis data informed by operational best practices and theoretical production baselines. In general this approach can be applied to other processes industrial operations beyond aluminum rolling.

Operations | Healthcare / Pharmaceuticals | Supply network connectivity / performance | Ranking Systems

A Strategic Framework for Evaluating Next-Generation Technologies in Biocatalysis

BUSINESS PROBLEM

The emergence of a new wave of biocatalysis innovation is rapidly transforming the pharmaceutical industry. This next generation of techniques is reshaping approaches to process development for companies operating in this space. However, significant challenges exist in fully harnessing the potential of this new technology due to limitations in internal capabilities, including time constraints and knowledge gaps. To overcome these obstacles and unlock the true potential of biocatalysis. Amgen must strategically leverage external supply organizations to tap into the next wave of biocatalysis innovation and bridge its existing capability gaps.

APPROACH

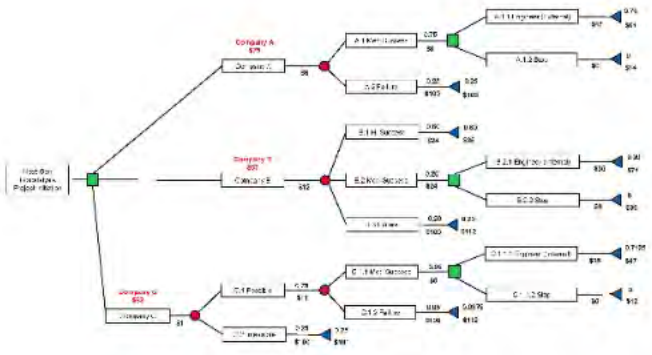
A funnel-like scheme with increasing complexity was used to gradually screen potential CDMOs. First, the framework organized around methods for selection and verification of a CDMO's background. Next, the focus was on identifying down selection criteria. And last, the framework presented the application of real options analysis to final CDMO selection.

DATA SOURCES

Technical information on the state of the biocatalysis industry was sourced from published literature, capability interviews, and market research databases. CDMO-specific information was sourced from publicly available reports as well as proprietary information gathered from requests for proposals and company interviews.

Data Types and Format

Interviews (surveys, notes, audio); Requests for Information/Proposal (Excel files, Word files, PowerPoint presentations); Market Research Reports (online databases, video)



Author: Alec Creta

IMPACT

This project provided a comprehensive framework for the site selection of a next-generation technology contract development and manufacturing organization (CDMO) in biocatalysis, with the potential for adaptation to various pipeline or emerging technology selection processes. The integration of site evaluation methods, decision assessment, and real options analysis within this framework effectively demonstrated an approach that enhanced the technical and financial accuracy of pre-pivotal development and manufacturing engagements. Following the establishment of the framework, the project successfully demonstrated the capability to conduct thorough preliminary investigation prior to engaging with CDMOs directly. And, the successful application of real options analysis led to the recommendation and implementation of a new operating procedure for early-phase biocatalysis work at Amgen.

DRIVERS

The pharmaceutical industry is facing a rapidly changing landscape, driven by technological advancements and evolving patient needs. As a consequence, the industry must remain agile in the adoption of innovation and sustainable practices to continue providing effective and accessible treatments to patients. Advanced biocatalysis techniques are seen as enabling, innovative, and sustainable solutions that play a crucial role in this pursuit.

BARRIERS

Amgen has a history of partnering with CDMOs on process and capability expansions. Nevertheless, the emerging technology space presents a new challenge where Amgen may lack the required expertise, necessitating a collaboration with an external partner to fill the gap. The limited internal knowledge and urgency to act quickly can become significant barriers in selecting and partnering with the right CDMO at the right price.

ENABLERS

Cross-functional collaboration and dialogue among the process development, strategic sourcing, contract development and manufacturing, and portfolio strategy and management groups served as a key enabler, providing the space to experiment with diverse methods

ACTIONS

The framework utilized market analysis, stakeholder interviews, organizational analysis, decision matrices, CDMO outreach, and cross-company benchmarking. The final recommendation was based on a quantifiable comparison and optimization of the primary implications related to cost, technology, and intellectual property for each option.

INNOVATION

The application of quantitative analysis, including real options analysis and Monte Carlo simulation, provided a new level of objectivity to the emerging technology site selection. As a result, the site selection process highlighted the risks and opportunities associated with each option and enabled stakeholders to maximize the chance of success.

IMPROVEMENT

This project showcased the benefits of employing simple, user-friendly tools for quantitative analysis. By doing so, the approach effectively de-risked the upfront investment in an emerging technology and enabled a smooth entry into the space, earning senior leadership's increased confidence in the decision-making process. While also refining existing process development practices, enhancing overall efficiency.

BEST PRACTICES

Identify known unknowns, systematically measure uncertainty, and consider multiple outcomes using the framework. Optimize decision-making by focusing on challenging assumptions and employing risk management strategies. Share insights and learnings across stakeholders, and adapt the framework to suit a projects specific context.

OTHER APPLICATIONS

This framework is suited for projects with uncertain outcomes and potential changes in value over time. It is particularly effective for projects involving phased investments, levels of outcome uncertainty, and inherent risks of failure. This can include drug development projects, manufacturing facility expansions, and technology implementations.

Production | Industrial automation | Improved process performance | Rules-based

Automated Nesting for Throughput Improvement in High Mix-Low Volume (HMLV) Manufacturing

BUSINESS PROBLEM

Re:Build CDI is a site capable of sheet metal fabrication for aerospace and defense parts. To maximize material use when cutting parts out of material, R:CDI batches jobs which use the same material on sheets before cutting them with lasers, water jets, and routers. This job of determining which jobs to batch together and laying them out in an efficient manner currently requires significant manual work which increases lead times, reduces throughput, and reduces flexibility. R:CDI needs to increase the speed of nesting to keep up with significant growth expected in the coming years.

APPROACH

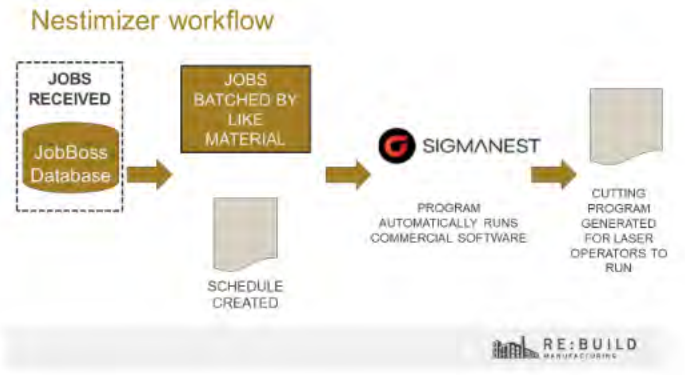
This project used process flow analysis to determine opportunities for automation within the nesting process. The project involved understanding and navigating tradeoffs between user input and automation in a HMLV shop by creating a Python program to automate collection of job information from databases and operators to write scripts that run commercial nesting software instantly.

DATA SOURCES

This project used data from the Enterprise Resource Planner (ERP) on numbers of jobs completed at each machine to get throughput estimations. Time studies were conducted to estimate how long jobs took generally and specifically how long nesting took. Further interviews were conducted with operators and management to understand how delays in nesting affect production operationally and financially.

Data Types and Format

Numerical data, text transcriptions of interviews.



Author: Alex Davis

IMPACT

This project significantly reduced the amount of time it takes to batch and nest jobs properly, saving hours of time for several critical stakeholders. Machine programmers at R:CDI are capable of nesting and re-nesting parts within minutes whereas the previous technique took hours to nest several together. This not only significantly reduces the lead time from job received to job ready to cut, but also makes the manufacturing system as a whole much more responsive to change. Whenever customer or production requirements cause a change, the work centers are able to respond with minimal effort. Additionally, the increased automation makes it easier for new people to learn how to program machines without a lengthy train up on nesting software. This makes the skill more democratized and will allow for people with the correct information (material handlers, laser operators, etc.) to program the lasers rather than a separate person that is more separated from the physical process. Finally, in the spirit of Re:Build's Lean Operating System and Lean operations in general, the extra time that has been freed up for the laser programmer can now be used to up-skill and increase his education so that they can work on other automation projects throughout CDI. This will allow the improvement efforts here to "snowball" into further successful improvement projects later.

DRIVERS

Low volume manufacturing for aerospace and defense customers involves significant variability in production. This variability increases lead times and causes stress among operators. Speeding up the process of nesting allows for better customer service while increasing quality of life for workers.

BARRIERS

It was ambiguous what exact needs and resources would be required to implement the project. This means that I needed to work closely with members of the company to quickly get access and resources when the needs arise. Coordinating with commercial nesting software providers was also difficult because they often try to sell their own version of the solution that we are implementing.

ENABLERS

Openness to change and good self-awareness helped push the project along. We needed to make sure that the problem we are solving is important to the people involved since it was a very collaborative process. The solution never could have been developed without leadership and worker buy-in to the concept of developing a small solution, rapidly implementing and experimenting with it, and then revising it.

ACTIONS

Built and iterated on a tool that takes data from the ERP and a custom material availability database to interface with commercial nesting software. My tool automatically feeds information into the software which automatically nests the required parts and programs cutting machines. The solution allows for the minimal amount of interaction from the machine programmer to deal with variability in the production environment while speeding the process

INNOVATION

This solution uses lean methodology to enact a digital change that is specific to the company's needs while being versatile enough to be applied to other similar contexts. The implementation is simple and easy to understand for management and operators. This is what makes it work well.

IMPROVEMENT

Testing of the solution on a line of parts which typically have similar order quantities showed a decrease in nesting time of 83% while the time required to re-nest parts when a production schedule change occurs was reduced by 95%.

BEST PRACTICES

Begin with aligning stakeholders at the very beginning so that the people involved agree that this is an important problem to solve and are willing to work with you to implement it. This solution required significant work with line operators to determine requirements and required buy-in from management to test the solution so that we could make many iterations towards a useful solution. Without this buy-in this solution could not be developed.

OTHER APPLICATIONS

This solution can be expanded to other cutting operations and the general methodology of applying lean principles to digital automation can be applied broadly to any process.

Product design / development / engineering | Industry components | Improved process performance | Ranking Systems

Engineering Strategy for Reshoring

BUSINESS PROBLEM

Re:Build seeks to find industries and value chains where it can leverage its capabilities and investments to successfully and profitably build manufacturing related businesses. Therefore, the project is to search very widely for opportunities, and assess those that look promising for addressing ReBuild's business problem by considering market intelligence, current programmatic pursuits, and existing portfolio strengths and capabilities. The project will thereby provide an independent, data-driven assessment of reshoring opportunities and Re:Build's product portfolio strategy.

APPROACH

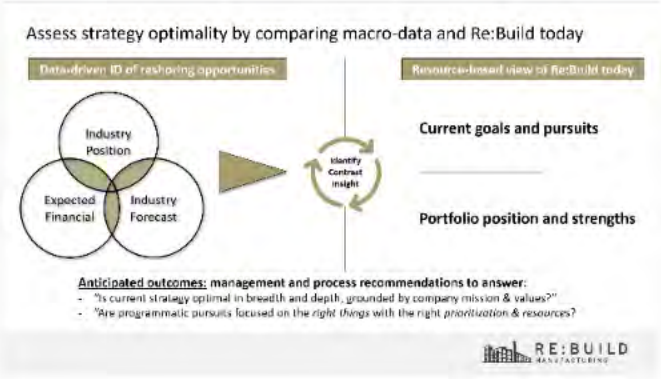
Conduct global trade and supply chain value assessment to identify and rank attractive product archetypes to reshore; validate business development efforts against company stated goals; map existing product portfolio to form resource-based view of capabilities. Compare and contrast aforementioned results to yield insights on strategic positioning.

DATA SOURCES

US trade data by HTS-10 product codes (US Trade Commission);
US Supply-Use Table by industry (Bureau of Economic Analysis);
OECD Input-Output Table by country and industry (OECD);
industry sector profitability data (multi-source, aggregated);
industry sector growth projections (multi-source, aggregated);
Total Cost of Ownership Calculator (Reshoring Initiative)

Data Types and Format

Time-series, MS Excel, and CSV



Author: Jack Easley

IMPACT

Re:Build has many opportunities knocking on its doors as the young company enters growth stage with a portfolio of capabilities. Against such backdrop is a strategic question of how it may best achieve its aspirational growth, balancing focus between capitalizing on existing products and endeavoring on new pursuits. Under such context, this project serves to provide an independent assessment of reshoring opportunities and uncover management/process recommendations to answer 1) "Is the company's current strategy optimal in breadth and depth, grounded by stated values?" And 2) "are the right things being pursued with the right prioritization & resources? A successful outcome will inform and help shape the company's growth strategy to achieve its long term mission.

DRIVERS

With both resiliency of extended global supply chain tested by COVID and the increase in geopolitical risk such as armed-conflicts in Europe, the idea of reshoring manufacturing capabilities has gained momentum both in popular press and in studied business decisions. There is interest to look broadly at what the prime candidates for reshoring are, and such analysis would be more useful when viewed under established strategy frameworks.

BARRIERS

The biggest barrier to the project are data availability and detail sufficiency. Specifically, global supply chain data availability, cross-source concordance, and levels of detail proved challenging to find and merge for insight.

ENABLERS

The project benefitted from direct support of supervisor and project sponsor as well as overall company culture of collaboration and openness to experiment.

ACTIONS

The key framework that enables project success is the Deming cycle of iterative development. As the project naturally evolves to maturity, it is important to set the overall framework but allow for room to absorb additional information to support a systems level solution on the strategy question.

INNOVATION

Macro-data analysis and join of information across sources to form a reshoring opportunity ranking model that produces results at a Harmonized System (HS) - 4 level of detail. This goes a step beyond traditional studies of reshoring which focus on generalized reshoring characteristics.

IMPROVEMENT

Establishment of a strategic tool based on synthesized HS roadmap to compare/contrast business positions today, near term expansion opportunities, and a gauge on "cost" to pursue for new ventures; the tool may also serve as a screen for assessment of new product strategic fit, general reshoring attractiveness, and Re:Build's capabilities to support rapid growth.

BEST PRACTICES

Ensure model interpretability and data source traceability.

OTHER APPLICATIONS

Immediate adjacency applications may include research in support of international trade policies and industrial investment decision support.

Operations | Automobile manufacturing | Network optimization | Constrained / Unconstrained

An Optimization Model for Make or Buy at Nissan North America

BUSINESS PROBLEM

The firm strategically charting a path to optimize the utilization of their production assets in response to supplier disruptions to their past model service division and anticipated shifts to their operational landscape due to the introduction of EVs. Resolutions to these challenges involve in-sourcing more parts to remain competitive and introduce make or buy trade-offs between 2 core businesses: future model production and past model service production. Historically, these business units have operated independently, but there is a call to unite the two and strike a balance between in-house production and outsourcing.

APPROACH

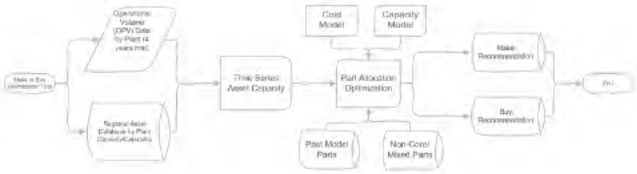
The proposed solution encompasses a mixed-integer optimization model driven to minimize the cost of producing a set of assemblies or individual parts, weighing each buy scenario and all internal make scenarios, subject to regional asset capacities to determine the optimal production scenario. This approach ensures all potential production scenarios are explored.

DATA SOURCES

Data sources spanned multiple business units and functions. Design data for parts/assemblies from new model engineering, cost data from costing/pricing/logistics groups, capacity data from production engineering in each plant, and vehicle demand data from industrial strategy.

Data Types and Format

Data Types are numerical or categorical. Capacity and demand information are time series. The remaining data are numerical or categorical and describe a part's/asset's attributes or cost metrics.



Author: Branden Francis

IMPACT

The impact of this project is three-fold. First, the model allows the business to perform feasibility studies before committing to an in-depth make or buy study of a production scenario for a part or assembly. Currently, effort may be expended studying a part or assembly that ends up not being cost competitive to in-house or that the business does not have capacity for. A positive externality of the research was gathering information on key inputs from other groups, such as a pricing/costing, engineering, and logistics, and replicating their calculations in the model. This significantly cuts down on the turnaround time for those inputs and allows the strategy group to focus on requesting information from supporting groups for competitive cost studies only. Secondly, the model allows the business to simulate different operational scenarios, which is a critical capability for the strategy group. Volumes, start/end of production dates, costs, assets, shift patterns, etc. that are input into the model can be adjusted and the subsequent make or buy decisions determined. Finally, this approach allows the business to holistically and exhaustively evaluate all production scenarios to discover potential cost savings – an activity that would that would be time prohibitive to pursue under the current make or buy workstream. Overall, the aim of this project is to determine optimal make or buy production scenarios, discover cost savings, and simulate different operational landscapes.

DRIVERS

The anticipation of an increased focus on in-sourcing more assemblies and parts across different models/verticals to be more cost competitive lead to the need for a more holistic and efficient method of determining which parts to insource or outsource.

BARRIERS

Working with design information that is 3+ years upstream of production and operational data projected 7+ years into the future means there can often be gaps/low confidence in an assembly's or plant's "dataset". Having incomplete information on can produce an optimal solution that may not reflect reality.

ENABLERS

The data science and analytics teams were particularly helpful in getting the project started from a technical point of view. Given the breadth of the project, key stakeholders from the supporting groups of the make or buy workstream were enthusiastic about providing context around their contributions to the workstream.

ACTIONS

Made it as easy as possible to use the model through Python and provided a manual with instructions on how to install the necessary programs and how the model reads information from Excel.

INNOVATION

This solution/model was developed using open-source optimization solver in Python and reads data from a commonly used spreadsheet editor, enabling large scale optimization, scalability, and lowers a barrier of entry for other groups to use this tool.

IMPROVEMENT

This provided the Industrial strategy team the ability to efficiently approximate costs, generate make or buy recommendations without relying on inputs from multiple teams, and identify cost optimal production scenarios. It allows them to simulate different operational scenarios with ease.

BEST PRACTICES

When dealing with projects that draw information from international teams, make sure to test, question, and compare any assumptions or information derived from other countries. One can discover key operational differences that may impact the model's output.

OTHER APPLICATIONS

Putting aside the optimization aspect, a model of regional assets, labor/logistics rates, and vehicle demand can be used to simulate many different operational scenarios a business may want to explore. Any input in the model can serve as a lever to examine how key outputs impact operational and financial metrics.

Product design / development / engineering | Healthcare / Pharmaceuticals | Product design and testing | Rules-based

Extracting Coronary Lesion Information from Angiogram Reports for Patient Screening Applications

Johnson&Johnson

BUSINESS PROBLEM

Abiomed's Impella pump is indicated for use in high-risk percutaneous coronary interventions (HRPCI) to support heart function during the procedure. The company is sponsoring the PROTECT IV trial to create evidence toward a clinical guideline with Class I recommendation. High-risk PCI itself is an emerging, life-saving clinical option for patients with complex coronary artery disease (CAD) that are often not offered revascularization or are lost to follow up. Abiomed is building a screener to support clinicians (specialized in complex PCI techniques) in identifying eligible patients within their health systems.

APPROACH

Focused on a specific component of the patient screener algorithm - presence of obstructive coronary artery disease, a requirement for eligibility for revascularization - we developed an information extraction algorithm for coronary lesion descriptions from angiogram reports. We leveraged text from registry clinical reports for training and validation.

DATA SOURCES

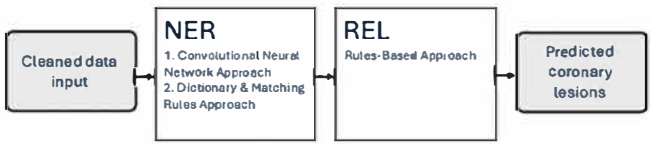
Medical text data can be complicated to access. We used deidentified cardiac catheterization reports available to Abiomed in their cVAD registry. This data is uploaded by participating health systems and collected for research purposes. We specifically curated diagnostic angiogram reports from within the database for use on our specific information extraction task.

Data Types and Format

Data was stored in large PDF binders as image files in a relational database. The PDF binders were often composed of multiple reports and files without a standard organizational scheme.

Entities (NER)				
1 *VESSEL*	2 *SEVERITY*	3 *LOCATION*	4 GRAFT	5 LESION

Relations (REL)					
1 Location Start	2 Vessel Start	3 Location End	4 Vessel End	5 Graft	6 Severity
"Mid rca to dist rca lesion , 65-70% stenosed."					
Mid	RCA	Distal	RCA		65-70%
"Left anterior descending artery seemed to have 70-80% ostial severe stenosis followed by 60% proximal diffuse stenosis."					
Ostial	LAD				70-80%
Proximal	LAD				60%
"The left internal mammary artery graft anastomosis is at the mid left anterior descending artery. There was 100% occlusion in the mid to distal graft."					
	LAD			LIMA	100%



Author: Leah Gaffney

IMPACT

We built a data pipeline for using cVAD registry data for training and validating information extraction models which can then be deployed as components of patient screeners. We present this as a pilot case study which we hope future projects will model for leveraging the information stored in internally-available unstructured text. We built an initial Named Entity Recognition and Relation Extraction (NER + REL) serial pipeline for lesion information extraction from diagnostic coronary angiogram reports. Each standalone component achieved reasonable performance (>83% recall and >89% precision for both NER and REL). We analyzed errors and provided recommendations for model refinement and expansion of the training dataset. This project demonstrates the viability of using registry data for developing algorithms that can be deployed into EHR environments. It also introduces tools (like efficient annotation with Prodigy) to the business for accelerating these projects. We expect this methodology will provide a roadmap for developing and validating future information extraction algorithms.

DRIVERS

Increasingly, CAD patients have higher risk profiles for revascularization procedures, and may not receive them because of those risks, instead receiving just medical management. The field of interventional cardiology is seeking solutions and protected PCI has emerged as an option. Abiomed is building an digital screening tool to support clinicians in identifying eligible patients for the protected PCI option.

BARRIERS

The project scope was limited due to necessary data access barriers. We focused on a project that could be achieved with only Abiomed's internal data and cannot therefore extrapolate how it would impact screener efficacy when deployed. The cVAD dataset is not appropriate for evaluating the entire screening tool holistically and is used here only in the narrow context of learning how well we can extract coronary lesion descriptions.

ENABLERS

Abiomed has a culture of sharing knowledge and consulting experts. I was able to consult with Explosion AI, Natural Language Processing (NLP) experts and the developers of Prodigy and Spacy (software that I used to annotate data and develop models and pipelines), which supercharged the project.

ACTIONS

We followed a systematic approach: dataset creation and curation, algorithm and pipeline development, and analysis of intermediate results. Error analyses drove model improvements. We also analyzed the impact of sample size to assess if additional input data could improve model performance.

INNOVATION

This is the first time unstructured data from cVAD has been used to support patient screener development within Abiomed, so the approach itself is innovative. We are also not aware of any prior work that applied an NER + REL architecture to the information extraction task of coronary lesion descriptions. It was ambitious and innovative to try this approach.

IMPROVEMENT

The solution developed a data pipeline that is operational and usable. We also quantified performance metrics for the full solution and individual components so that future improvements can be modular and well-informed.

BEST PRACTICES

Important considerations include curation of input data and establishment of a robust data model with rules for consistent annotation. We used best practices like investigating training curves to understand the impacts of sample size and distributing variation between train and test set.

OTHER APPLICATIONS

This project could inform other Abiomed screener projects and other projects that use clinical text (like notes from clinical sales staff). Further development could provide general scientific value by reducing registry data collection burden (where manually reporting lesion info is redundant and burdensome) or building toward an automated Syntax score or other risk score workflow (simplifying data collection for research in cardiology).

Product design / development / engineering | Healthcare / Pharmaceuticals | Improved process performance | Dimensionality reduction

Preemptive variation reduction in biologic drug substance manufacturing

SANOFI

BUSINESSPROBLEM

Biomanufacturing processes are inherently complex and subject to variability, leading to significant challenges in maintaining product consistency and efficiency.

APPROACH

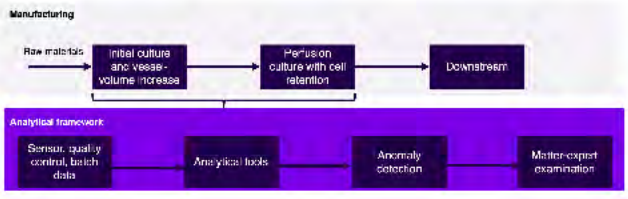
The core hypothesis in this thesis is that the decision-making workflow can be significantly improved by integrating a digital twin (a dynamic, data-driven model that simulates the biomanufacturing process), and soft sensors for real-time monitoring and estimating critical parameters.

DATA SOURCES

Time series data was collected from sensors across the four reactors, focusing on critical variables typically monitored in bioprocesses from 20 batches spanning from 2020 to 2023.

Data Types and Format

Five-minute interval data from PI Datalink 2018, which employed interpolation to align timestamps across variables. Data was saved as comma-separated values (.csv) to facilitate modeling.



Author: Ismael Guereca Valdivia

IMPACT

A digital twin such as the one developed for this thesis presents the company with greater process insight and control than previously. By constructing a dynamic and accurate digital replica of the bioreactor environment, the digital twin has the potential to facilitate an in-depth, real-time monitoring of the process. This advanced level of monitoring can enable the preemptive identification and mitigation of potential process variations before they are significant, therefore reducing the overall variation in the manufacturing process. By enabling the capability to monitor cell growth through a calculation, the soft sensor for biomass concentration can validate the measurements of current physical sensors. Within the broader biomanufacturing industry, such biomass measurements are validated through offline laboratory tests. An online validation allows the company to adjust to cultivation conditions immediately, ensuring that the bioreactor operates with in optimal conditions. This possibility of control allows the company to maintain product quality, maximize yield, and ensure regulatory compliance. This can be done by detecting deviations from expected patterns early, potentially flagging issues before they impact product quality or yield.

DRIVERS

In a highly regulated industry such as biomanufacturing precise control of process variables during manufacturing is not just nice to have – it is imperative. Keeping process and quality variables within pre-established control limits is crucial. As such, technologies such as digital twins and soft sensors can provide a solution to reduce process variation and allow the potential of process improvement.

BARRIERS

One important barrier while implementing technologies such as the ones presented in this project is the need for multidisciplinary skills. The modeling requires knowledge about the information systems, the business drivers, and process knowledge. There was a learning curve in getting sufficiency to drive the project.

ENABLERS

The management team of the MSAT group was supportive in driving digital initiatives.

ACTIONS

The general approach was taken: speak with stakeholders to gain process knowledge, gather data, build the models, validate the models with real-world data, and then engage with experts within the company to gather their feedback.

INNOVATION

The proposed solution leverages such tools to drive process knowledge and improvement using the process data from the company. Building such tools can help the decision-makers to make better business decisions.

IMPROVEMENT

The improvement my solution provided was a proof of concept of the performance of the tools. They would still would need to be further refined and implemented. Nevertheless they proved that important process parameters can be estimated using process data, and that digital representation of the manufacturing process can be developed to drive continuous improvement.

BEST PRACTICES

A best practice is engaging with technical experts early in the process and often while developing the solution. Furthermore building simple tools as a proof of concept is useful to validate their applicability. If validated then more resources can be used to improve and expand the scope of digital tools with applications on manufacturing.

OTHER APPLICATIONS

My solution focused on a specific part of the biomanufacturing process. Similar approaches can be applied to other steps of the large scale drug manufacturing process.

Production engineering | Industrial automation | Improved process performance | Regression analysis

Optimizing thermoplastic composites manufacturing with digital process intelligence

BUSINESS PROBLEM

Oribi Composites is a thermoplastic composite manufacturing company specializing in the production of medium-volume thermoformed products. Such high-draw composite thermoforming is a challenging process unique to Oribi. To date, process parameters have been developed through learned experience and trial & error, with limited understanding of the underlying drivers of material behavior or product quality. As a result, yields for some products are quite low, and as the company looks to scale, improved process insight and control is critical to tightening product development times and reducing costs.

APPROACH

A suite of process and environmental sensors were installed across the manufacturing line to capture high-resolution data of the production process. In parallel, a telemetry & database infrastructure was built to stream this data and enable machine-learning based analysis. Leveraging those insights, targeted experiments were performed to understand drivers of quality and composite properties.

DATA SOURCES

This project included end-to-end data source creation and connectivity. Process sensors including temperature, pressure, current, flow, and environmental sensors were installed across the manufacturing line. Additional digital data sources such as infrared imagery were installed, with all sensors streaming through a custom telemetry system to AWS data lake and accessed via SQL.

Data Types and Format

Primary numerical data sources were streamed in a time-series format at 1-100Hz, depending on data needs. Triggered data collection was also implemented, including FLIR imagery and traceability data.

Author: Evan Haas

IMPACT

Leveraging this high-resolution data and the series of experiments it enabled, scrap rates for the target product were sustainably reduced by 6X. This robust data telemetry infrastructure also provides the foundation for a scalable, multi-site digital backbone that will become the core to a machine intelligence program at Re:Build.

DRIVERS

Polymer composites are finding an increasing number of applications across industries like aerospace, automotive, sporting goods, and medical devices. However, traditional thermoset composites are expensive and slow to manufacture, increasing component cost. Thermoplastic composites have the potential to change this paradigm by enabling legacy high-volume methods of manufacturing like thermoforming to this industry.

BARRIERS

Oribi's deep-draw processes are highly unique in the industry, so little research has been done in the field around the properties that drive product quality, material behavior, or optimal process parameters. This challenge is compounded by the lack of documentation and experimental rigor in the culture at Oribi, which meant this project had to be built from the ground up in conjunction with a cultural shift towards science-first design.

ENABLERS

A culture of rapid change, engineering-led management, and strong executive support were all essential enablers of this process.

ACTIONS

This project involved the buildup of a data collection suite from the ground up. First, an initial suite of sensors were selected and installed across the production line. In parallel, a telemetry infrastructure and database system were built to send and receive this data. Finally, these systems were tied to a pre-processing suite and modeling software to extract valuable insights across a series of targeted experiments.

INNOVATION

The success of this project depended on multi-model data collection. Tying data from continuous, time-series, quantitative sensors such as time or coolant flow to triggered data capture such as infrared imagery was a critical enabler in distinguishing correlation and causation across process parameters.

IMPROVEMENT

The target product improved 600% over the course of the project when compared to the prior 6-month rolling average scrap rate, and this improvement was sustained month-to-month. In addition, it built a scalable data pipeline for deployment across future sites.

BEST PRACTICES

Adopting a broad, agnostic approach when tackling a novel question is critical to avoiding bias in the selection of sensors and modeling parameters. Avoiding inbuilt assumptions about the factors that were critical to the process enabled us to identify unexpected errors and correlations in our manufacturing processes.

OTHER APPLICATIONS

Such a system can be deployed across any manufacturing or experimentation line to better understand the correlation between process and environmental parameters with outcomes. Additionally, such a system should be core to any SPC or quality control program.

Operations | Healthcare / Pharmaceuticals | Improved process performance | Linear / Non-Linear

Optimizing Multiproduct Drug Substance Production for Increased Throughput

SANOFI

BUSINESS PROBLEM

The Sanofi Massachusetts Biocampus employs state of the art integrated continuous biomanufacturing (ICB) to produce multiple drug substances. This new technology allows for multiproduct production, but its flexibility introduces operational complexity not previously faced in industry. Shared resources between products makes production capacity difficult to quantify. The biocampus is focused on better understanding of their process capabilities.

APPROACH

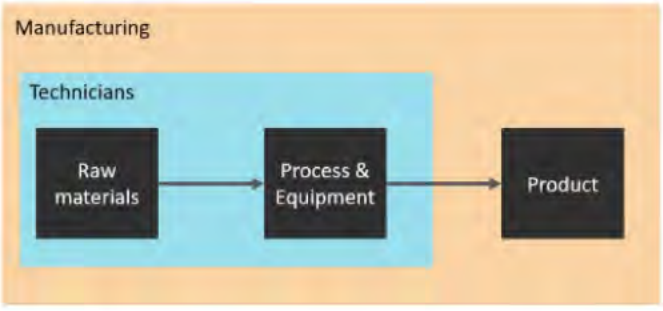
To increase throughput at current resource limits, linear optimization will be employed to improve resource scheduling and to increase capacity utilization. The model will also provide leaders with a framework to understand operations and resource needs. Lean principles will be applied to inventory balancing and storage techniques to increase material availability on the production floor.

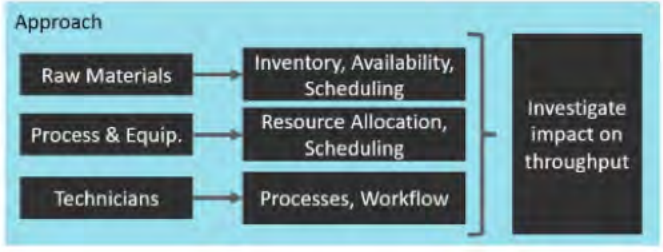
DATA SOURCES

The primary data required is manufacturing data such as the labor and time needed to complete the process. The process must also be divided into a series of steps or operations. Some of this data can be obtained through Sanofi's manufacturing systems and process documentation. Other data, such as required technician labor hours per operations was collected via time studies.

Data Types and Format

The majority of the data was collected and stored in Excel spreadsheets. Some data was available for export from the site's AP system.





Author: undefined

IMPACT

This project seeks to provide a deeper understanding of multiproduct drug substance production in an ICB facility. Current understanding of unit capacity considers each product's process individually, without regard for the shared resources which all processes utilize; labor, equipment, floor space, etc. The gap between theoretical single product capacity and true multiproduct capacity has lead to scheduling and planning issues such as scheduling more daily operations than resources allow. To understand the site's true capacity, the operations will be modeled in two parts: upstream production and downstream production. These models will account for resource constraints to throughput so that better decisions can be made. In addition to the models, optimization algorithms will be developed as tools to aid in operations scheduling so that constrained resources are fully utilized. The expected impact is better understanding around resource and hiring needs to operate at desired throughput levels.

DRIVERS

The central question being answer is if technician hiring should be increased. The thought at the site, at the time of this investigation was that increased labor might increase throughput. The thesis develops a detailed understanding of the system's available capacity and labor requirements. The final result being that labor is not the capacity constraint.

BARRIERS

Data availability was the biggest hurdle. The site had an abundance of data on the process itself, flows, weights, cell counts, etc., but less data collection regarding the operation run times, technician labor, scheduling milestones, etc. Modeling system capacity as a function of labor began with careful collection of job takt time data.

ENABLERS

Trust and openness between teams made this thesis possible. I was aligned to the supply chain organization, but was asked to answer manufacturing questions. The culture at the site is one of helping other teams. The trust already present allowed for earnest discussion with manufacturing and observation of their work for the purposes of data collection.

ACTIONS

Implementation was not fully realized at the end of the thesis. The work was centered around increased understanding of the process to better inform leadership decisions. The impact that was left was a curiosity to question long standing process assumptions and find new ways to collect data and model the system.

INNOVATION

The solution challenged the site to rethink how they operated their system as a whole. Previously, the upstream and downstream operations were artificially coupled which was a self-imposed constraint. Through cross-functional collaboration, design, planning, and manufacturing organizations were all part of the project and each organization came away looking at their system in a new light.

IMPROVEMENT

The solution provides a potential to increase downstream throughput by 38%. This does not relieve the upstream bottleneck, and therefore does not increase overall throughput, however, excess downstream capacity means that inventory can build ahead of downstream and downstream can be run to best match the shipment schedule and dampen upstream variability.

BEST PRACTICES

Careful and rigorous collection of takt time data is critical to the success of this approach. The models require good data to produce good results.

OTHER APPLICATIONS

The thesis sets out a framework which can be used by any manufacturing facility to examine system capacity as a function of a resource of interest. In this case, labor was the resource, but the same methods can apply to modeling resource availability in a difference process.

Product design / development / engineering | Healthcare / Pharmaceuticals | Improved process performance | Linear / Non-Linear

Optimization and Rule-Based Models for Hospital Inventory Management

Johnson&Johnson

BUSINESS PROBLEM

The AITA™ Smart System helps hospitals better manage their surgical inventory via three types of devices: Kiosks, Smart Shelves, and Mobile Hubs. Each device has its own planogram, which defines the set of products stocked in each device and the products' locations. Unfortunately, the current process to create these planograms is manual, time-consuming, and prone to errors. The AITA™ team needed a tool that could automatically create planograms by determining which products should be placed in each device and the location of the products within the devices.

APPROACH

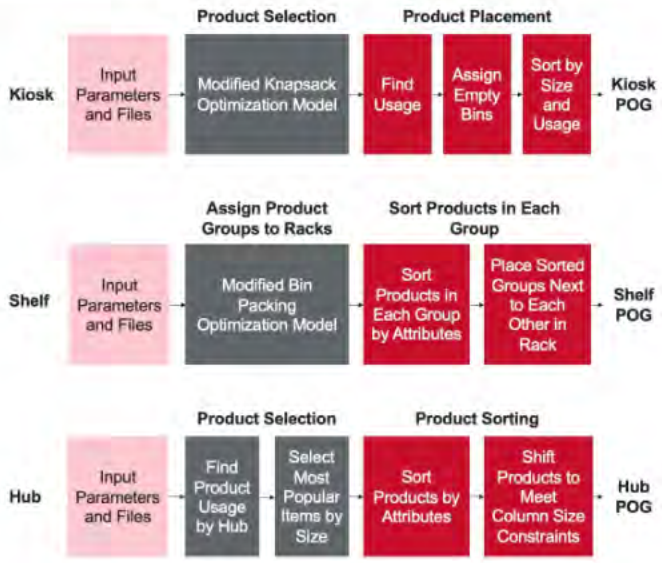
I created three Python models to automatically design planograms for each of the devices. The kiosk model uses optimization to maximize the number of surgical procedures that the device can cover. The shelf model uses a rule-based system to place products according to a set of constraints. The hub model uses operational analytics to select the most popular items in a given set of operating rooms.

DATA SOURCES

1) Preference Card Details: Summary of products surgeons need for each procedures. 2) Historical Procedure Schedules: List of procedures that took place at the hospital historically. 3) Historical Purchase Data: Products that were bought by the hospital over a specific period. 4) Suture Dimension Library: Sizes of each suture (can be small, medium, or large).

Data Types and Format

1) Preference Card Details: Structured, text. 2) Procedure Schedules: Text, time-series. 3) Purchase Data: Count, time-series. 4) Suture Dimension Library: Categorical, structured, static.



Author: Caeley Harihara

IMPACT

My solution will benefit the business by improving both the accuracy and efficiency of the planogram creation process. From an accuracy standpoint, my models produce better planograms than their manually created counterparts. The definition of "better" varies by device type. The kiosk model covers 7% more historical procedures than handmade planograms. The shelf model can fit all the products into a minimal number of racks while ensuring that product groups are not split between racks. The hub model can fulfill more add-on requests while eliminating manual sorting mistakes. From an efficiency perspective, the models allow for a faster planogram creation process. Previously, it took days to choose products for the devices, sort the items, and iterate with the clients on the final assortment and configuration. However, these models now save the team an average of 145 hours (18 business days) per hospital per year by automating the planogram creation and iteration process. These time savings compound with each new hospital that the AITA™ team serves. Now that the models created in this project have been implemented by the AITA™ team, their accuracy and efficiency improvements will add value across the entire chain of care. The AITA™ team will have more time to grow their business and to develop new features. Meanwhile, providers will save time when managing and retrieving hospital inventory, which will free up more capacity for direct patient care.

DRIVERS

The current process to create planograms for AITA™ inventory management devices has its challenges. The planograms are currently created manually, making the task time-consuming, necessitating frequent iterations, and often leading to imperfect results. So, the team needed a model that could address these challenges by enabling fast, automated planogram creation, easily adjustable parameters, and optimized results.

BARRIERS

The largest barriers to the project were implementation and integration into existing workflows. Once the models were completed, they needed to be rigorously tested, documented, and circulated to ensure that they were adopted for real-world use and that they were easily accessible to both technical and non-technical team members.

ENABLERS

One of the best enablers for this project was my team's well-documented and well-organized data management system. My team keeps clear logs for every piece of relevant information including input datasets, business rules for inventory management, and logs of past planogram design attempts. These records, and my team's frequent support, ensured that I was able to access the data needed for my project, as well as understand how to use it.

ACTIONS

I made my solution more adaptable and easier to use, so that it could be more easily adopted by the data science team. On the adaptability side, I created dozens of mutable parameters that would allow the team to change factors such as the size of the device, the time period to consider, and the types of products to include. I also created a single Excel file that can control every parameter, so that the code itself does not need to be updated.

INNOVATION

My solution combines optimality with practicality. From an output quality perspective, it uses the software package Gurobi to generate optimized product selections. Then, from an ease of use perspective, my model automates many of the more tedious aspects of the planogram creation process. It cleans the input data files, pulls parameters from a central Excel, formats the output into an easy-to-digest visualization, and analyzes the results.

IMPROVEMENT

From an accuracy perspective, my models' planograms are error-free and enable a 7% increase in kiosk procedure coverage (when compared to the manual approach). This additional coverage could save healthcare workers over 100 hours a year. On the planogram creation and iteration side, my models save the AITA™ team an average of 145 hours (18 business days) per hospital per year. These time savings scale as the team serves more hospitals.

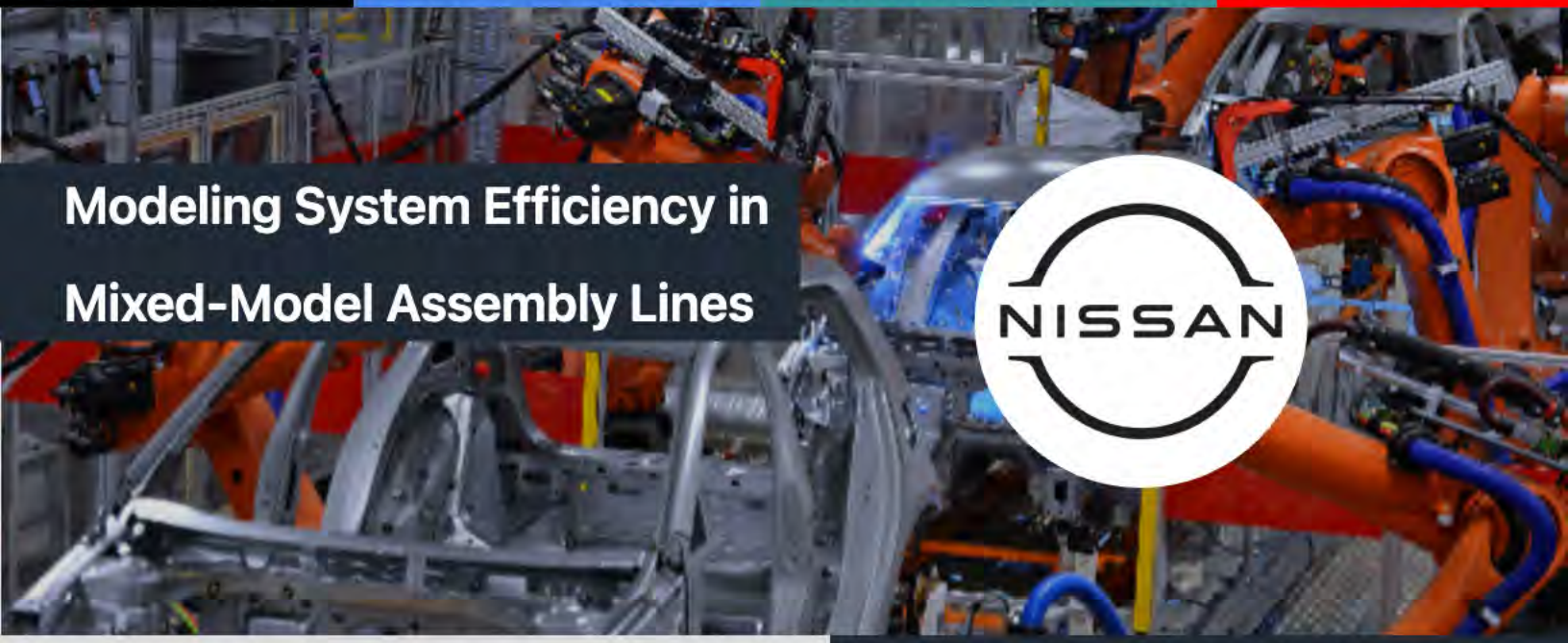
BEST PRACTICES

I found it helpful to break the solution into smaller steps. For example, I have two separate kiosk models: one to choose the planogram's products, and one to place the products in the kiosk. An optimization model cannot perform both functions simultaneously, so they need to be separated. From there, it is helpful to rigorously test the model with corner cases and to validate the results with as many team members as possible.

OTHER APPLICATIONS

Within the medical space, the models can be used for general hospital inventory management by selecting and sorting products that are not eligible for AITA™ devices. The models can also be used to improve inventory management in other industries. In the retail sector, for example, the kiosk model could suggest products to maximize the coverage of customers' orders.

Industrial Engineering | Automobile manufacturing | Improved process performance | Discrete / Continuous



Modeling System Efficiency in Mixed-Model Assembly Lines

BUSINESS PROBLEM

A primary leadership objective at the Nissan Smyrna Vehicle Assembly Plant is to obtain new business for the plant (i.e., plans to build vehicles at the plant). This requires strong performance on key performance indicators, prompting teams to be regularly engaged in production improvement projects, which typically focus on fault reduction and line balancing. These efforts leverage either vehicle or process data, but none incorporate both, as no combined data system exists. Lack of such a system containing the area work content for the sequence of vehicles produced limits the plant's understanding of and ability to improve system efficiency.

APPROACH

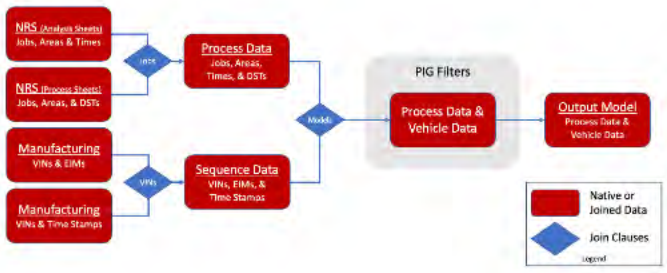
Development of a system efficiency model consisted of three iterative phases of different novel approaches to data linking and modeling. This involved grouping relevant data systems using a series of joins across common data fields contained within those systems, resulting in collation of the important elements of each system into a common model, which could then be used for output analysis.

DATA SOURCES

Assembly Processes, Assembly Areas, Assembly Times, Assembly Design Standard Times, Vehicle EIMs, Vehicle VINs, Parts Installed on Vehicles, Assembly Area Time Stamps, Vehicle Options and Features, Manufacturing Downtime, Manufacturing Defects, Manufacturing Pull Cords, Vehicle Costs, Vehicle Revenues

Data Types and Format

Internally-Developed, Exportable Web Tools (Nissan Rebalancing System); Microsoft Excel; Snowflake; Tableau



Author: Cameron Hoffman

IMPACT

The developed model and model use cases demonstrate how internal innovation using existing resources can unlock new capabilities for the company. This directly aligns with the plant's culture of internal innovation and continuous improvement. The model and use cases represent opportunities to significantly enhance existing workflows, including production system improvements, production system scheduling, and data system maintenance. For production system improvements, the model and use cases enable identification of inefficient areas, zones, and jobs, as well as areas of high transition complexity. These are then optimal intervention points for production improvement projects to improve system efficiency and reduce quality defects. For production system scheduling, the model and use cases enable data-driven identification of manufacturing constraints, which can be used to improve schedule optimization. Incorporating financial information into this enhanced scheduling workflow also represents an opportunity to identify optimal model-mix ratios that are most efficient and most profitable for the company. For data system maintenance, the model makes identification of data errors more obvious, enabling more timely and precise correction of errors in the underlying data. Each of these applications of the model enable enhanced improvements to the plant and to key performance indicators, advancing the goal of bringing new business to the plant.

DRIVERS

The Nissan Smyrna Vehicle Assembly Plant maintains a continuous improvement culture rooted in internal innovation. In this environment, it is imperative to identify optimal intervention points and to cross-functionally design solutions. The existence of this culture enabled cross-functional collaboration to iterate on the underlying models and identify new data structures to unlock new capabilities.

BARRIERS

The lack of native connections between data systems and the quality of the underlying data were the biggest barriers to model design. Data was collected from four independent systems that contain different vehicle and process data, and though these systems contain common fields, they do not natively connect in any way. These systems also have different data entry and upkeep requirements, leading to erroneous entries that complicated the output.

ENABLERS

The support of Nissan leadership and of the industrial engineering and manufacturing teams was the biggest enabler for completing this project. The support of LGO alumnus at Nissan also enabled rapid onboarding and a steady drive to project and thesis completion.

ACTIONS

To generate the model, the researcher identified relevant stakeholders; identified relevant data systems; studied data structures, inputs, and errors; and iteratively linked data systems using novel approaches. To develop implementation points, the researcher examined existing workflows and identified model use case scenarios to improve existing processes. The model was then thoroughly documented and handed off for workflow implementation.

INNOVATION

The model leverages existing system data but represents a structure that is novel for the company. This unlocks new ways to improve existing workflows and generates a wealth of new information that can be used to improve the business beyond the scope of this study. The solution also introduces new data management tools that, at the time of the study, were used sparingly throughout the company.

IMPROVEMENT

The model represents new data architecture and process methodology knowledge for the company. Leveraging these new process improvement methodologies using outputs of the model will drive more targeted, data-driven improvements to plant KPIs. This enables reductions of assembly times, improvements to assembly efficiencies, and reductions to assembly costs.

BEST PRACTICES

Exhaustively understand the input, structure, and errors of your data. Identify actionable ways that developed models can be implemented into new or existing workflows to improve the business.

OTHER APPLICATIONS

This type of solution could be developed for any mixed-model assembly line where process and product information can be collected and systematically linked. This solution could also be implemented in other areas of the Smyrna Plant or at other Nissan plants where the underlying data is structured in a similar way.

Operations | Custom Manufacturing | Improved process performance

Scheduling in a High-Mix Low-Volume Job Shop

LFMcapital

BUSINESS PROBLEM

Rainier focuses on customer-specified, made-to-order products consisting of four different business lines. These lines share graphics, fabric, wood, and metal production shops. The challenge lies in predicting shop utilization due to varied custom jobs, with each job potentially involving multiple shops and resources. Complexity increases as jobs require different processes, machines, and resources. Without an effective scheduling system, delays and inefficiencies can disrupt on-time delivery and customer satisfaction. Establishing an efficient scheduling strategy and tool is vital for success in this high-mix low-volume shop.

APPROACH

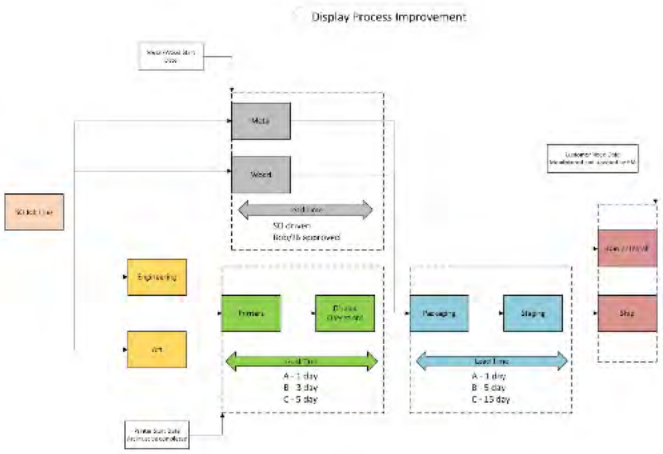
The project started by modeling the scheduling tool from one that is used by another LFM PortCo. The approach was to build a scheduling tool within the ERP system that could be updated to establish the production schedule and then hold biweekly meetings to update the schedule. Through this process we were able to identify what worked well and what needed to be improved on or changed completely.

DATA SOURCES

The data for this project was sourced from the companies ERP system, Epicor. The data was obtained through OData queries through the Epicor platform. It included data such as the due dates, completion dates, customer names, rework, estimated hours and actual hours for all operations on each job.

Data Types and Format

The data used was simple tabular data. It was pulled from the Epicor system into Power BI and Excel as simple data including columns with numeric data, text data, boolean data etc.



Author: Nick Holmes

IMPACT

The impact this project has on the business is a comprehensive process and tool that can be utilized in a high-mix low-volume job shop to improve overall production scheduling. The initial model adapted from the other portfolio company proved to not be useful in the Rainier production process. It became clear through the biweekly meetings and analyzing the company data, which led to a new process where key business rule changes were identified that would provide value to the business. The updated process and tool will be able to schedule jobs effectively and efficiently on a regular basis by prioritizing production based on profitability, customer needs, and the efficient utilization of capacity. This will grant stakeholders control over production decisions, enhancing visibility and tracking of scheduled versus completed tasks. Additionally, the project addresses inefficiencies introduced by the scheduling process and finds opportunities to improve the flow of products within the system. The implementation of this enhanced scheduling process will enable Rainier to minimize bottlenecks, reduce production delays, and ultimately enhance on-time delivery and customer satisfaction. The project also provides visibility into the company's data and allows real time knowledge of what is happening on the production floor.

DRIVERS

The driver for this solution was the need to stay competitive and win more business for the company. Rainier ultimately wants to be able to drive higher revenue and serve more customers and need the consistency in their production process to be able to accomplish that.

BARRIERS

One key barrier faced during the project was buy in from the shop floor managers on the implementation of the process and tool. A few key managers were skeptical of the change and stubborn to buying into the iterative process that would lead to more effective scheduling. Another barrier came during spikes in demand that led to everyone being extremely busy, with little time and motivation to invest in the process change.

ENABLERS

The leadership team at Rainier were all very supportive of the project and wanted it to be successful. They understood the implications of how it could affect the overall business. The LFM Capital team as well were very invested in the success of Rainier and therefore played a key role of ensuring the project got the light it needed in order to be successful.

ACTIONS

One main action taken to implement the solution was to develop the tool within the ERP system that could be used to update the schedule. Another action was to analyze their data to understand where they were having issues and how a scheduling tool could be of use to increase efficiency. A third action was to identify key areas where business rules needed to be implemented to provide more discipline in their production process.

INNOVATION

One key innovative aspect was the use of Power BI dashboards. The data at Rainier is very accessible but not understood or visible to the shop floor. My solution provided dashboards that would show real time insights into what was available to work on the shop floor and areas that might be at or above capacity. Being able to see and interpret the data will have a long term impact on how the shop floor should be run.

IMPROVEMENT

The overall final improvement the solution provides is standard lead times and ship-by dates that can be trusted by the managers and operators on the shop floor. This will provide a clear path for the scheduling team by allowing them to only focus on scheduling the work at the printers based on the capacities of each resource in the shop. It will also lead to consistent on-time delivery.

BEST PRACTICES

The key is to understand what step in the production process is causing the biggest pain points to the production floor. In this project, major problems on the shop floor were a result of issues on the front end of the sales, order entry and art department. These problems flowed down stream to the shop floor resulting in inefficiencies and production mishaps.

OTHER APPLICATIONS

Applications of this process can be applied to any job shop dealing with high-mix low-volume production regardless of the product.

Product design / development / engineering | Transportation and logistics | Product design and testing | Natural language processing

Leveraging Generative Artificial Intelligence and Text Clustering to Support External Partners

Amazon

BUSINESS PROBLEM

Amazon has an increasing need to improve the overall partnership experience with its external partners, the Delivery Service Partners. Despite employing diverse listening mechanisms, the company struggles to derive actionable feedback for program leaders. The existing approaches fail to effectively translate gathered data into tangible insights, hindering decision-making and inhibiting the company's ability to reduce partnership exits. Resolving this issue is critical to enhancing program effectiveness, improving partner satisfaction, and maintaining a competitive edge in the market.

APPROACH

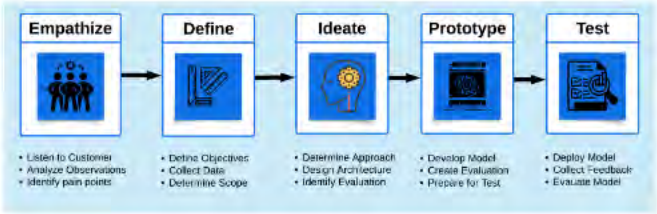
This problem will be approached using design thinking methodology, where collaboration with stakeholders, customer empathy, ideation, and prototyping will be performed alongside the application of text clustering and large language models. Through iterative testing, insights will be refined, empowering program leaders with actionable feedback to enhance overall satisfaction.

DATA SOURCES

Amazon: Customer interviews/feedback, social media, survey comments, monthly customer satisfaction scores

Data Types and Format

Unstructured text (Text/JSON): survey responses and feedback
Numerical data (Excel/CSV): ratings, scores, CSAT trends
Categorical data (Excel/CSV): multiple-choice responses, demographic information



Author: Steven Hubbard

IMPACT

By leveraging diverse data from surveys and pretrained large language models, the solution enables improved survey interpretation which drive actionable insight generation. This will empower Amazon to make informed strategic decisions to align program requirements with partner needs, resulting in heightened customer satisfaction and improved program effectiveness.

DRIVERS

The catalyst was Amazon's recognition of a persistent challenge in translating gathered data into actionable feedback with the presence of an evolving artificial intelligence landscape. Improved natural language processing tools, advanced sentiment analysis, and generative artificial intelligence capabilities sparked innovation and actions towards the solution.

BARRIERS

Adapting natural language processing tools to Amazon's specific needs posed technical hurdles in extracting insights from unstructured data. Some stakeholders within the organization may be accustomed to traditional feedback methods, resisting change with artificial intelligence techniques. Lastly, product design and development required iteration and may not immediately yield tangible results, requiring patience from the stakeholders.

ENABLERS

The company as a whole supports "customer obsession" as a leadership principle and is continuously exploring ways to improve feedback mechanisms. The company also has state-of-the-art tools, including generative artificial intelligence models, made available through Amazon Web Services (AWS) Console to analyze feedback.

ACTIONS

Solution included development of prototypes using available AWS tools and models, customer feedback data, and integration of existing data system. This solution explored the use of text clustering to discover unlabeled themes in conjunction with large language model insight. The solution also included iterative testing and regular feedback from program leaders.

INNOVATION

Innovative aspects of the solution will be centered around the combination of text feedback with advanced language processing tools and techniques. The direct utilization of large language models for sentiment analysis, topic modeling, and extracting actionable insights from unstructured text data will be a significant leap from traditional methods that required human analysis of large amounts of feedback.

IMPROVEMENT

The solution has not been yet fully adopted, but results inspire future research and implementation of a large language model-based feedback system. This is intended to enable Amazon fleet program leaders to respond faster to external partner needs which may ultimately result in improved customer satisfaction scores.

BEST PRACTICES

In a rapidly evolving space, usage of the latest advances in large language models would produce the best results. Others are also recommended to explore various text embedding models for improved results.

OTHER APPLICATIONS

An generative AI-powered solution can be employed to analyze customer feedback across various channels, including surveys, social media, and focus groups. Sentiment analysis, topic modeling, and text summarization techniques can unveil nuanced customer sentiments and recurring themes which can then be tailored to generate strategic insights.

Operations | Healthcare / Pharmaceuticals | Inventory management / control | Deterministic / Stochastic

Inventory Optimization and Simulation Analysis for Supply Chain Disruption Events

Johnson&Johnson

BUSINESS PROBLEM

J&J are committed to delivering life saving medical products to patients around the world. In order to deliver on this promise, J&J is investing in digital products to help ensure a reliable supply chain. Over the last few years, the industry has faced supply chain disruptions due to Covid, geopolitical tensions, climate events, regulatory change and more. These challenges are compounded by an increasingly interconnected, global supply network. This project will focus on the question: How do we predict and prevent a supply chain risk before it becomes a disruption?

APPROACH

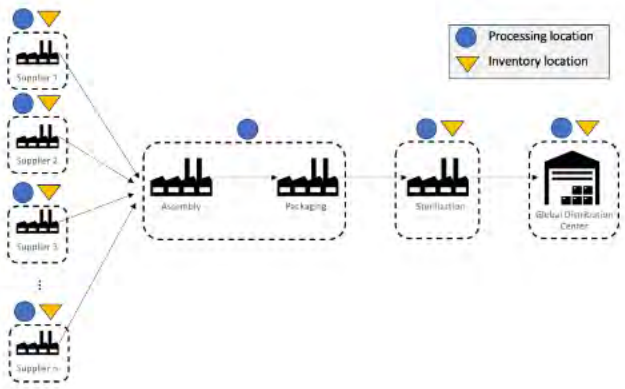
An optimization and simulation-based inventory management model was developed to augment the decision making of supply planners in these networks. The model supports supply planners in safety stock allocation decisions by quantifying inventory cost and stockout probability risk for products with multi-stage, converging supply networks.

DATA SOURCES

J&J is rich with data, however the multitude of data storage and reporting systems can pose its own challenges. Some data is provided from contract manufacturers on a manual basis, other data is stored in raw format in a centralized data lake, and other data is already curated in the form of dashboards and reports.

Data Types and Format

The majority of data is stored in tables in Excel spreadsheets or accessible via a SQL database.



Author: Ian Kleinemolen

IMPACT

The Planning team is responsible for ensuring timely supply of products, however they are limited by the type and usefulness of information at their disposal. An inventory model of the supply chain with scenario planning capability could help illustrate the value of inventory optimization as well as prepare the Planning team for future disruption events. The goal is a more robust supply chain that can deliver critical medical devices to those in need.

DRIVERS

J&J and the healthcare industry in general has faced significant disruption due to the Covid-19 pandemic's impact on global supply chains. The company is focused on transitioning from a reactive to proactive supply chain to combat the disruptions of tomorrow.

BARRIERS

The complex nature of the supply chain means data is sometimes stored in disjointed sources. J&J is actively working on a digital transformation to centralize data sources and access, which will be a huge enabler to future projects.

ENABLERS

The company is very transparent about the challenges and opportunities for a robust, digitized supply chain and employees are well aligned on the priority of these initiatives.

ACTIONS

A critical first step to understanding the supply chain and developing an inventory model was to work hands-on with the supply planning team to develop tools to improve data visibility. These tools used supplier data sources from around the globe to provide limited but actionable insights to management and planning teams.

INNOVATION

Historically, planners have employed Multi Echelon Inventory Optimization (MEIO) models to optimize the safety stock at each distribution node of the supply chain. The refinement of optimization models by simulation as shown in this work can improve accuracy and create more predictive models based on the unique supply chain variables of a given product.

IMPROVEMENT

This work led to the development of an Optimization and Simulation based inventory management model to serve as a tool for supply planners to set safety stock more quantifiably in their supply networks to hit cost and customer service targets.

BEST PRACTICES

It is important to consider data sources and data validation to ensure that any solution is correct in its assumptions. Any continuation of this work should be careful to ask "what is the root truth" when using any data.

OTHER APPLICATIONS

The approach of using simulation to reinforce the accuracy of optimization models is relevant in many industries where analytical models cannot fully incorporate all the variability in a system.

Operations | Industrial automation | Improved process performance | Auto-encoders

Process Digitalization: 3D Deep Learning in Manufacturing Applications

LFMcapital

BUSINESS PROBLEM

Company X was interested in building a digital platform to shorten the manufacturing cycle for contract manufacturers from months to weeks. With the continued pace of cutting-edge technologies and AI, we identified a need to conduct multi-modal queries across Company X's different data repositories to draw insights from the data and harness AI capabilities. Beyond text and numbers, one of the input modalities desired was to use geometric shapes. Our initiative to compare and identify geometric similarities in 3D models aims to accelerate design and engineering processes, thereby reducing product lead times and enhancing profitability.

APPROACH

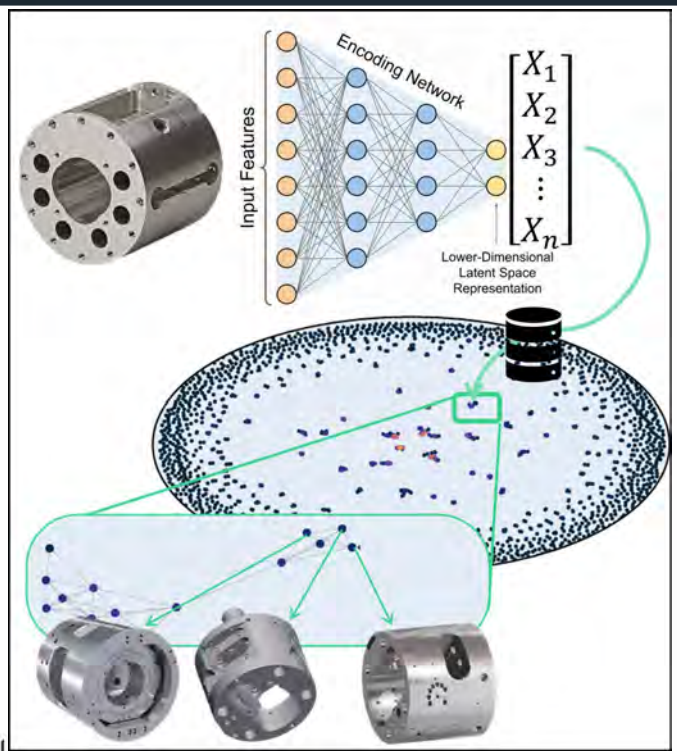
Assessed current digital maturity and developed a roadmap for digitalization with an end state to support integration of an AI tool to solve the problem. Built out the data pipelines, connecting different company data sources and experimented with different shape comparison techniques. After building and training a deep learning model, made a repository to feed a queryable digital dashboard.

DATA SOURCES

The primary sources of data for the project came from machine part files and historic operational data contained in an older SQL server and an ERP system. The researcher had to scrape much of the part and enabling data from the company network drives, while obtaining historic operational data through SQL pulls.

Data Types and Format

3D part data used was in the form of .stp, .step, .stl, .iges files, processed into point clouds and voxel grids. Operations data pulled from the ERP using SQL and stored temporarily in CSV files.



Author: Ryan Kochert

IMPACT

Contract manufacturers can use this tool to conduct queries across their entire inventory of digital models to pull historic manufacturing data, fed directly from the ERP, all based on common geometries. This can enable several things, such as reduction of common inventory items or consolidation of parts if at an assembly manufacturer level. The tool can support rapid quoting based on historic jobs, in addition to driving engineering process standardization through comparison of operations tied to similar parts.

DRIVERS

In many operations and manufacturing activities, there is a reliance on 3D data woven throughout the entire product life cycle, especially with the rise of model-based definition operations. Given the smaller cash flows and lack of knowledge at the lower levels of the automotive and aerospace supply chain pyramid, there is substantial potential for adoption and integration of AI to drive operational and ultimately business improvements.

BARRIERS

Working with spatial data in deep learning is difficult, as it exponentially increases the potential inputs the model could encounter. Typical deep learning models using convolutional layers adopt basic data augmentation strategies to make the model more robust. The increased complexity of an additional dimension tends to decrease model performance drastically. As well, standard data formats for CAD files and ERP data cleanliness were challenges.

ENABLERS

The inclusive company culture and team-like nature of the business leaders enabled the project and provided substantial support throughout the process. Additionally, the executive team's vision and backing of the project were pivotal factors for success.

ACTIONS

Fielded several versions of the model and tool, iterating on feedback through each version. Final version was tailored to output and feed an easily queryable digital dashboard, using the same program that the executive team already knew how to use, for a user-friendly and latency-free experience.

INNOVATION

The method for building out and tying the entire digital pipeline system together to allow for automated refreshes as new data comes into the company. The manner in which the 3D models are converted to a format that enables easy storage and comparison, as well as how all the information is tied back to the ERP system and feeds a digital dashboard.

IMPROVEMENT

Quantifiable impact is difficult to measure due to the nature of the specific use case at the company.

BEST PRACTICES

Conduct thorough research on the best methods applicable to the particular problem at hand since different 3D data representations all have unique tradeoffs. If looking to implement an AI solution at a small manufacturing company, the technical aspect is important, but the people aspect is arguably just as important. Identify the key influencers and get them onboard early.

OTHER APPLICATIONS

Rapid prototyping for product design, similar SKU reduction, automated quoting support, and manufacturing vendor consolidation. As companies move more and more to model-based definition manufacturing and incorporating digital twins, the ability to conduct multimodal queries across 3D datasets will become increasingly important.

Supply chain planning and inventory management | Healthcare / Pharmaceuticals | Improved process performance | Rules-based

Leveraging digital tools and analytics for temperature management in gene therapy cold chain

Johnson&Johnson

BUSINESS PROBLEM

Emerging pharmaceutical products at Janssen, such as gene therapies, require ultra-cold temperatures throughout the supply chain to maintain safety and efficacy of the product. The business is aiming to develop a monitoring approach and digital solution to improve decision-making to release a product to a customer based on its temperature exposure throughout the end-to-end supply chain. The project will focus on defining the requirements and solution for temperature monitoring for a new temperature-sensitive product, to mitigate risks of temperature exposure and improve management of excursions in the event that they do occur.

APPROACH

I first assessed the current state systems, processes, and real-time temperature data. Then, I outlined the use cases, requirements, and data schema for an integrated temperature capability. Then, I modeled tradeoffs in reliability and cost in the system to define performance needs. Finally, I synthesized findings to propose an approach for temperature management for the new product.

DATA SOURCES

Real time temperature data for select lanes, historical temperature excursion and product disposition reports, and customer temperature inquiries via post market vigilance

Data Types and Format

Time series temperature sensor data, CSV extracts from Quality Management systems

Characterize **current state** temperature monitoring for traditional cold chain drugs and identify gaps

↓

Define **system requirements** for cumulative temperature assessments and proposed data schema

↓

Model **trade-offs** in temperature sensor reliability and cost due to failure to inform performance requirements and business expectations

Author: Jessica Lee

IMPACT

The solution will help to streamline temperature management processes to reduce the time in reviewing temperature data and releasing product, as well responding to customer inquiries about product quality. Additionally, the proposed solution will more granularity for assessing temperature history which could reduce product wastage. Further, the impact of this approach can be scaled to additional temperature sensitive product portfolios.

DRIVERS	There is a shift in the industry toward high value, targeted cell & gene therapies that require tailored solutions for customers
BARRIERS	Product identification (serialization), accessing sources of data across teams, identifying key decision makers for implementation across teams
ENABLERS	Key stakeholders in quality were aligned to the proposed problem statement and solution, and there was a core team established and interest in new capabilities for the upcoming product launch
ACTIONS	Analyzed historical real-time temperature data to understand current performance, validate requirements across stakeholders for a cumulative temperature management tool, developed simulation to define reliability requirements for the system, and outlined plan for implementation
INNOVATION	This solution leverages temperature data in new ways to streamline assessments for product releases. Additionally, this work provided an approach for assessing the reliability of a temperature monitoring solution in multiple stages of a supply chain
IMPROVEMENT	This solution provided the opportunity to reduce the time to release a product after an excursion, drive efficiency in managing and responding to customer complaints related to temperature, and minimize product wastage due to over-estimates on temperature impact
BEST PRACTICES	Map the key data fields available across systems, understand existing processes in depth, trace an individual product end-to-end before scaling to a larger dataset, and gain buy-in across stakeholders early to test early concepts
OTHER APPLICATIONS	This solution can be scaled to support management for other temperature-sensitive products, with different routes and distribution centers in the supply chain.

Sales | Energy | Customer service / connectivity | None

A Strategic Roadmap for the Decarbonization of U.S. Freight Rail

BUSINESS PROBLEM

No viable options presently exist to address Scope 1 emissions (from sources owned by the company) for the freight rail transportation industry, particularly in locomotives. The primary drivers are gaps in battery technology and availability of near-zero emissions green fuels (i.e., hydrogen and renewable diesel). A roadmap is needed to decarbonize this industry from now to 5-10 years from now when technology catches up. NextEra Energy Resources would use this roadmap to engage with and transition their clients to lower-emissions energy sources.

APPROACH

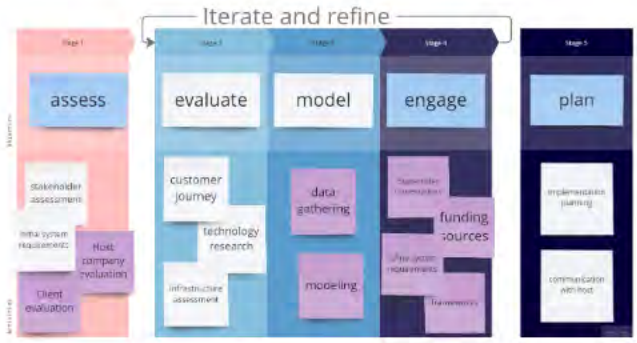
The approach to the project will be based on the principle of iteration and failing fast. Most stages of the project (outlined in 2b) will be done more than once to ensure that new knowledge and inputs are being properly reflected in the work and will propagate to the final deliverable. Below is the outline of different components of the projects.

DATA SOURCES

Given that the project is focused on a strategy, there will be a large amount of data collected through conversations with stakeholders. Stakeholders include subject matter experts within NextEra Energy Resources© and the freight rail industry. Additional data will be collected from public sources that document financial and statistical performance information on US freight rail.

Data Types and Format

Through stakeholder conversations data will be collected in the form of notes. Financial data is presented in Excel spreadsheets. Statistical performance data is presented in Excel spreadsheets.



Author: Ben Lerman

IMPACT

A robust understanding of the U.S. Freight Industry would allow for increased market intelligence for NextEra Energy's sales organization. Recently, NextEra Energy Resources has been increasing its energy solutions portfolio for commercial and industrial customers, including for U.S. freight rail companies. NextEra Energy Resources has discovered that the U.S. freight industry cannot be decarbonized using the traditional products that it has been selling. For this reason, it was decided that increased market intelligence of this industry would identify pathways for NextEra Energy Resources to play a part in the decarbonization of the U.S. freight rail system. This project would provide this knowledge to NextEra Energy Resources to be able to strategically engage with rail customers and realize their decarbonization goals. In total, sales to the U.S. freight industry could bring NextEra over $50 billion in revenue over the next 25 years.

DRIVERS	There are several key drivers that were identified that impact NextEra Energy Resources and its customers. First, NextEra Energy Resources' commercial and industrial sales teams is looking to continue to grow its offerings outside of wind and solar builds and power purchasing agreements. Second, freight rail companies are facing new regulations that are forcing them to reduce their emissions profile.
BARRIERS	The sales process prohibits me from speaking directly with freight rail companies. Further, the organization is so complex, it takes considerable time to find the right contacts. Finally, no precedent has been set for reducing Scope 1 emissions from current customer engagements.
ENABLERS	Support was provided by some members of the organization to leverage their external connections for stakeholder interviews. Additionally, the summer followed a structured schedule that concluded with a presentation given to the top executives in the company.
ACTIONS	I have created a financial analysis to understand the total cost of ownership and NPV of a rail company purchase of a new locomotive. The locomotives analyzed were switcher and line haul locomotives powered by either diesel, battery electric, or hydrogen fuel cell. I also summarized my findings in a final presentation given to my team and top-level executives. Further, I have initiated discussions with locomotive manufacturers in the U.S.
INNOVATION	One aspect is the estimation of rates at which different locomotive technologies are being adopted, as understood through technological readiness, net present value, and total cost of ownership. Additionally, part of the solution is to explore the creation of a joint venture between NextEra Energy Resources, a locomotive manufacturer, and a fueling infrastructure company.
IMPROVEMENT	The solution provides substantial market intelligence including financial analysis of locomotive technologies that ultimately creates a roadmap for NextEra Energy Resources executives. Once executed, this should provide additional revenue over the long term.
BEST PRACTICES	To continue having conversations with all stakeholders and updating the roadmap accordingly. The strategy is meant to be executed over the long term, so there will be new inputs that, when applied to the roadmap, can change its course.
OTHER APPLICATIONS	Governments and rail companies could use the information to have a better understanding of the pathway to decarbonizing freight rail.

Analytics | Energy Industry | Green Hydrogen | Minibatch Stochastic Gradient Descent

US Green Hydrogen Production: Approaches to Enhancing Economic Viability and Market Development

BUSINESS PROBLEM

In light of the recently passed Inflation Reduction Act (IRA), energy companies are looking to establish a presence in the green hydrogen sector. Although there is an increasing demand for green hydrogen, pre-IRA production costs surpassed those of conventional gray hydrogen, resulting in constrained market share for the green variant. The IRA incorporates production tax credits (PTCs) to mitigate the costs, expanding opportunities within the green hydrogen sector. Prompted by the incentive, energy companies are devising strategies to effectively compete in this quickly growing market.

APPROACH

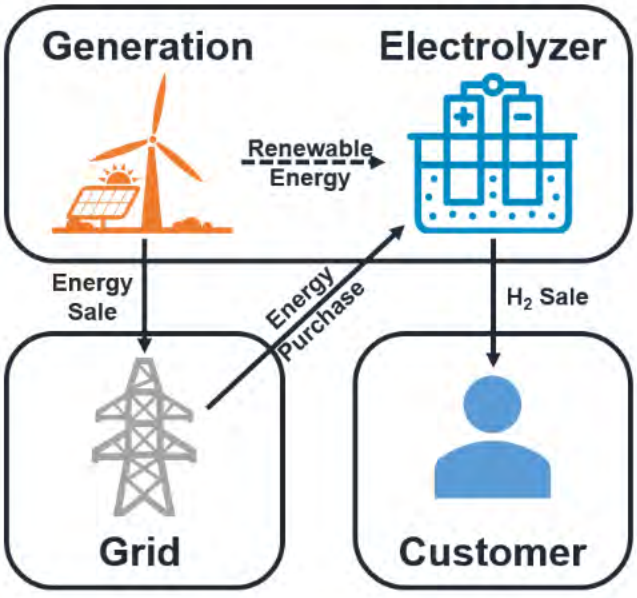
This study employs discounted cash flows and optimization methods to map production costs across the continental US. Costs are modeled under two temporal renewable energy credit (REC) matching frameworks, hourly and annual, as defined by recent legislation. This comparison highlights the advantages and challenges of each framework, offering strategic direction for companies and policymakers.

DATA SOURCES

(1) Historical power prices from Yes Energy _____
(2) Historical wind and solar net capacity factors (NCFs) from the National Oceanic and Atmospheric Administration (NOAA) _____
(3) Infrastructure cost and performance metrics from internal NextEra Energy assessments

Data Types and Format

Time series, 1hr granularity



Author: Brandon Meehan

IMPACT

This thesis identifies a strategic roadmap designed to bolster the industry's economic viability and market penetration. For policymakers, it emphasizes the necessity to recalibrate the value of PTCs and to restructure the REC matching criteria, proposing a phased transition from annual to hourly matching that aligns with the industry's maturation. Such recommendations are aimed at fostering a competitive green hydrogen sector that can challenge the conventional hydrogen market. Businesses are advised to focus production efforts in specific geographies, particularly the middle regions of the US, like Texas, where renewable resources and market conditions are most favorable. Additionally, the thesis advocates for strategic curtailment, an operational adjustment that has been shown to reduce costs significantly in areas with high electricity price volatility. Engaging in demand response programs is also highlighted as a potential avenue for additional revenue and power market stabilization. The cumulative impact of these recommendations is significant, offering a pathway for the green hydrogen industry to expand its footprint and for the US to make substantial strides in its decarbonization efforts. The thesis not only contributes to the academic discourse on sustainable energy production but also provides actionable insights for industry leaders and policymakers, enabling green hydrogen as a transformative element of America's sustainable energy strategy.

DRIVERS

The primary drivers behind the solutions proposed in this thesis are the heightened global urgency for decarbonization and the consequent policy shifts such as those in the the Inflation Reduction Act (IRA). The IRA's introduction of production tax credits (PTCs) for green hydrogen production has catalyzed interest and investment in the sector.

BARRIERS

Some of the barriers impacting this project include the complexity of integrating fluctuating renewable energy sources into a stable hydrogen production process, and the initial high costs of green hydrogen production relative to gray hydrogen. Regulatory uncertainties and the evolving nature of REC matching criteria posed additional challenges, as did the limited availability of comprehensive power price data for all regions.

ENABLERS

The collaborative environment fostered by NextEra was a significant enabler for this project. The team's supportive nature and collective knowledge in sustainable energy were invaluable assets that drove the research forward.

ACTIONS

The primary action taken for this thesis was the formulation and dissemination of strategic recommendations aimed at enhancing the economic viability of green hydrogen. After thorough research and analysis, these recommendations were crafted for government and business stakeholders, focusing on optimizing REC matching frameworks and adjusting production tax credits.

INNOVATION

Some innovative aspects of the solution include the application of advanced optimization methods and discounted cash flow analysis to map production costs across the continental US. Additionally, the evaluation of different legislative frameworks for temporal matching of RECs with PTCs—hourly and annual matching—provides novel insights into policy dynamics and industry strategies.

IMPROVEMENT

The final improvement provided by this solution is the detailed quantification of how different REC matching criteria—hourly versus annual—affect the economic viability of green hydrogen production across various regions of the United States. This analysis not only illuminates cost implications but also carefully balances the necessity of creating a viable market for green hydrogen with the imperative to achieve sustainability goals effectively.

BEST PRACTICES

It is crucial to engage in comprehensive data collection with regards to renewable energy sources, and power market prices. Additionally, regular engagement with industry experts, policymakers, and academic peers is essential for refining methodologies and ensuring the relevance of the findings. Finally, researchers should stay updated on legislative and market developments as these dynamically influence outcomes.

OTHER APPLICATIONS

The analytical framework developed for assessing green hydrogen production in this thesis can be effectively adapted for other energy storage technologies, such as utility-scale batteries, to evaluate economic viability and operational efficiency. Additionally, this methodology is highly adaptable for international contexts, provided similar datasets on local energy prices, renewable potential, and regulatory environments are available.

Product Marketing | Aerospace and defense | Predictive forecasting | Feed-forward networks

Price Elasticity of Air Travel Demand to Scale Up Sustainable Aviation Fuels

BUSINESS PROBLEM

Sustainability is rapidly becoming a key requirement, and potential differentiator, in commercial aviation. This project will examine the current state of the art of quantifying and valuing sustainability measures in aviation. The main strategy to decarbonize aviation is to use sustainable aviation fuels (SAF) to lower emissions. Consequently, airfare may increase despite subsidies from government regulations since SAF is significantly more expensive than fossil fuels. This project will focus on the consumer's willingness to pay the SAF "green premium" and its impact on travel demand.

APPROACH

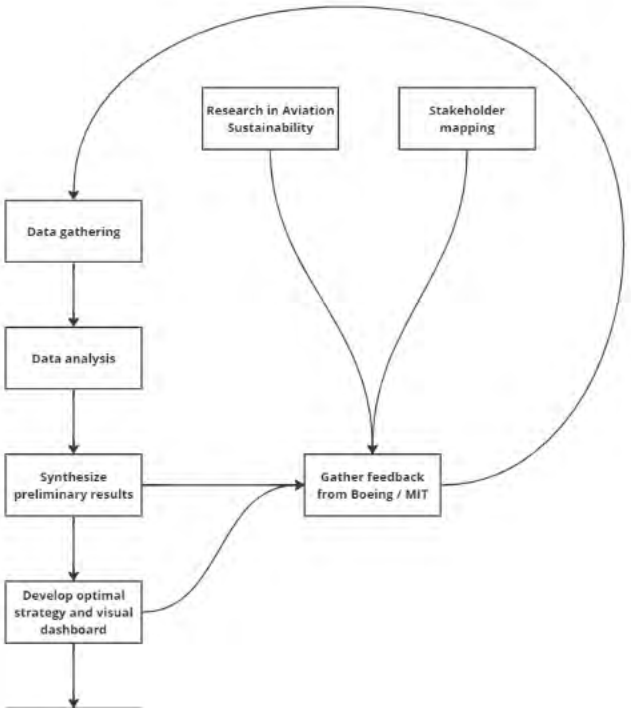
Boeing has access to flight fare and operational data, which will be enhanced by integrating other indicators such as GDP, population, oil prices, and more, in the process of constructing econometric and machine learning models for predicting air travel. These models aim to estimate the elasticity of travel demand in relation to price fluctuations based on historical data.

DATA SOURCES

Historical airfare data from Direct Data Solutions (DDS), oil prices from NASDAQ, global GDP per capita in purchase power parity in current prices from the IMF, global GDP real growth rates from the IMF, population of global cities exceeding 300k from the UN, airport codes with latitude and longitude coordinates from Boeing, and DDS participating airlines from Boeing.

Data Types and Format

Panel data of flight routes around the world for their passenger count and revenue from 2016 to 2023. The data was received in csv format.



Author: Mark Membreno

IMPACT

This research is expected to reveal insights of how increases in airfare due to SAF could affect air travel. By identifying and quantifying which passenger segments, routes, and regions are more inelastic, Boeing can determine how different groups will respond to fair increases. This research will help Boeing engage various stakeholders around SAF policy, regulation, and adoption. Ultimately, this will help Boeing lead the efforts to strategically scale up SAF adoption in identified markets while understanding the potential impacts on revenue and demand. The deliverables will be calibrated models to predict air travel demand based on various factors such as region, route length, world oil price, SAF price, etc. Future work includes using the models to provide an optimal strategy to scale up SAF with the objective of maintaining a healthy air travel system against the constraint of net-zero by 2050. Furthermore, an interactive Tableau dashboard with sliders can be developed to explore sub-optimal but feasible scenarios to scale up SAF when talking with various stakeholders.

DRIVERS

Sustainability is rapidly becoming a key requirement and potential differentiator in commercial aviation. Many airlines have set net-zero goals for 2050 due to the goals set by the Paris Climate Agreement. One of the most significant levers is adopting Sustainable Aviation Fuels (SAF) instead of traditional fossil fuels to reduce carbon emissions. However, SAF still holds a price premium, and many questions remain on who will pay this premium.

BARRIERS

There is much resistance to sharing proprietary data even with partner airlines, even though the outcome of this research would benefit everyone decarbonizing aviation. Some improvements to the project could have been made, such as conducting A/B testing with these partners to determine causality.

ENABLERS

Tom Sanderson, my supervisor, was essential to the success of this project. He connected me with key stakeholders throughout Boeing to network and learn from their expertise. As I was scoping my project, these experts were willing to hear about the project and provide feedback. Boeing's culture is extremely open, collaborative, and helpful.

ACTIONS

I identified key experts in Boeing with complementary expertise who were the most bought into the project. With these individuals, I organized monthly project update sessions with everyone in the room so they could cross-talk and provide feedback on current progress and where the project should head. This worked well in getting diverse expertise and opinions in the room at once to adjust the project's direction throughout my internship.

INNOVATION

Price elasticity is typically estimated using econometric methods such as ordinary least squares and 2-stage least square regression models. The DDS data is richer than the 10% sample used in literature. Furthermore, machine learning models were trained to predict passenger count based on relevant features, including price. Another innovation was the application of machine learning models to estimate price elasticity after training.

IMPROVEMENT

The project did not specifically focus on improving a specific process. However, the research provides a foundation for using insights into passengers' willingness to pay, which can be used with other research on SAF availability and the impact of carbon reduction emissions. This collaboration can be used to determine data-driven strategies to scale up SAF adoption in certain markets and create a demand signal.

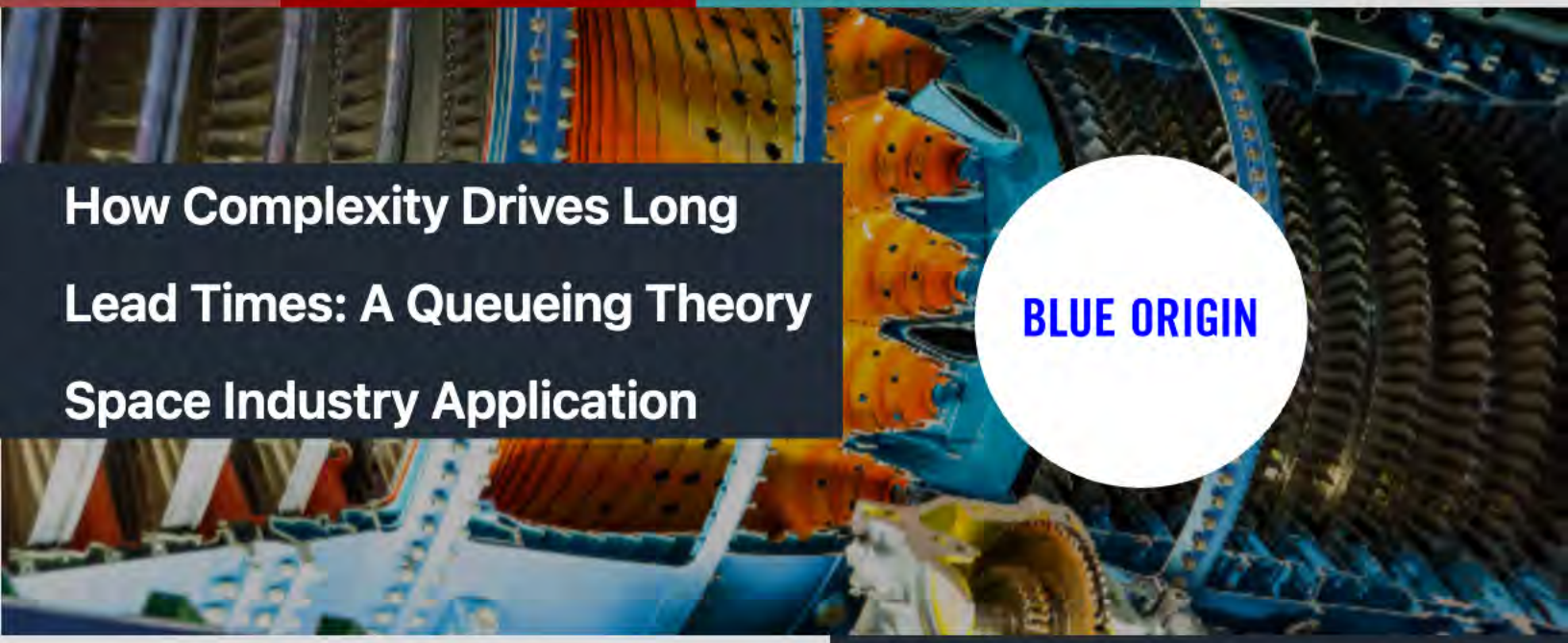
BEST PRACTICES

I received advice from the previous Boeing intern to invest significant time interviewing people throughout the company. I found this extremely helpful in helping me better understand the operations of this massive corporation and leverage the vast expertise found throughout the company. The periodic progress meetings to gather feedback were extremely effective since all the attendees had different complementary expertise.

OTHER APPLICATIONS

The developed models performed well in predicting passenger count. Therefore, they can be used to forecast air travel and aid in aircraft sales and production. As mentioned previously, the insights from price elasticity for certain segments can be complemented with data on SAF availability and impact on carbon reduction in those same segments to guide decisions in SAF adoption and scale-up.

Operations | Aerospace and defense | Improved process performance | Statistical Analysis



How Complexity Drives Long Lead Times: A Queueing Theory Space Industry Application

BLUE ORIGIN

BUSINESS PROBLEM

The space industry is going through a major transformation. In today's space industry, commercial companies compete in the market for customers and resources; no longer the exclusive domain of government agencies and legacy aerospace giants. Many aerospace companies produce their components in high-mix, low-volume operations known as job shops. Job shops are notorious for having long lead times. The research for this thesis was conducted at a manufacturing site at Blue Origin that operates as a job shop. The purpose was to identify the sources for the long lead times observed in the production of machined components.

APPROACH

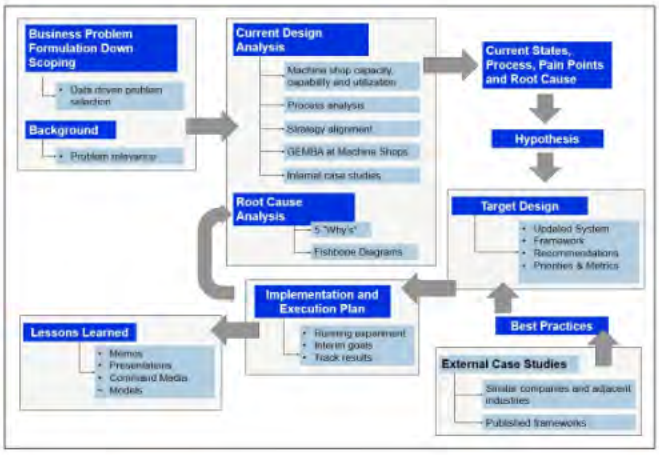
The hypothesis the thesis investigates is long lead times are the result of high variability caused by the complexity of producing space components. Using the method proposed by Factory Physics and queueing theory, this thesis demonstrates via case studies and a queueing simulation that high variability drives long wait times leading to the long lead times experienced in job shop operations.

DATA SOURCES

All data used for this research is data recorded in the manufacturing system as part of standard operations. The data was captured over several months that were representative of the current system operations. All analyses are based on the data from the same time period.

Data Types and Format

Engineering and manufacturing data can be accessed with SQL queries. The data is captured as lists and can be processed using Python or Excel.



Author: Blanca Murga

IMPACT

The research conducted for this thesis helps the business understand their sources of long lead times and potential options to reduce them. The simulation can be used to iterate through different solutions and test improvements to the production system.

DRIVERS

Morgan Stanley's Space Team estimates that the roughly $350 billion global space industry could surge to over $1 trillion by 2040; a $650 billion increase from 2020. The cost of space launches has decreased 95%. This creates pressure to increase launch frequency which can be achieved by making components reusable and/or producing components at high rate.

BARRIERS

In complex operations of complex products, observed issues can hide the true problem. Therefore, some of the issues being experienced can actually be symptoms of the main problem. In addition, often times there are proposed solutions on the table based on an understanding of the problem. However, as proposed in Factory Physics, one must spend time defining the problem from a systems view.

ENABLERS

Blue Origin is rich in manufacturing data and open to improvements. They also provided me the time to conduct the research and define the problem statement.

ACTIONS

Once I identified the problem statement and the root cause, it became obvious the problem was a queueing problem. I looked for research that proposed solutions to approach this type of operations, which are commonly known as Jackson open queueing networks (OQN). I selected a mathematical model proposed by Bitran and Morabito (1994), then took a transfer line python simulation from MIT course 2.854 and modified to be an OQN simulation.

INNOVATION

I validated the OQN simulation using observed data from the job shop at Blue Origin. It now can be used for improvement ideas comparisons.

IMPROVEMENT

My solution provides Blue Origin with a tool to investigate potential solutions for improvement in their job shop operations.

BEST PRACTICES

One of the best practice is to approach the problem methodically to ensure the solution is addressing the root cause of the problem. Then, the model and simulation require verification and validation as proposed by Factory Physics.

OTHER APPLICATIONS

The simulation can be used to any job shop operations, not just the space industry.

Shutdown Dose Rate Modeling for Fusion Radiation Requirements Development and Design Trend Analysis

Commonwealth Fusion Systems

BUSINESS PROBLEM

Recent developments in High Temperature Superconducting magnets allow a novel, compact fusion reactor design, ARC, which will achieve positive energy production. However, a key to commercial success lies in the ability to rapidly replace components damaged during normal operation. Particularly, the Vacuum Vessel, at the core of the reactor, becomes highly radioactive and must be replaced. The purpose of this project was to model the shutdown radiation environment for radiation requirements development, design trend analysis, and workflow development.

APPROACH

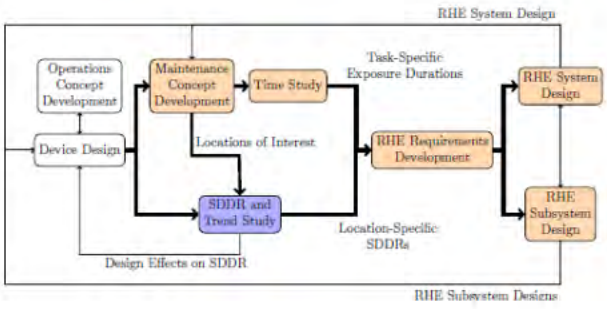
I used the Rigorous Two-Step (R2S) method to conducts 61 separate radiation transportation calculations in various device configurations, material choices, and time steps for the purpose of determining how these changes affect the dose rates in seven measurement locations. These locations were chosen to inform the requirements development of RHE (Remote Handling Equipment).

DATA SOURCES

The data source for this project was the existing specifications for ARC. I worked with co-workers to create a CAD model from these specifications and add several characteristics which were not present in the 2D specifications.

Data Types and Format

Existing CAD models of ARC, known properties of the materials under consideration, and known plasma physics outputs are the data for this project.



Author: Dan Murphy

IMPACT

The result of this work is threefold: first, to provide initial scoping estimates of the shutdown radiation environment. Second, to identify how ARC-level design decisions affect the shutdown radiation environment. Finally, to provide an iterative radiation hardness requirements workflow. The initial scoping estimates will be used, with vendor input, as a coarse discriminator for feasible RHE concepts. The ARC-level design decision analysis allows the Assembly and Remote Maintenance team to enter ARC-level, cross-functional design trade-off studies with initial data on the effects of those decisions on maintenance. Given the importance of minimizing outage duration to ARC's commercial viability, having maintenance impact data is key. ARC's design is still in its early stages. Therefore, the shutdown radiation environment estimate will change with future design updates. This project created an iterative requirements development process which will allow the process to be re-run for major ARC design updates.

DRIVERS	**A commercial fusion power plant needs to maintain a high capacity factor to be financially viable. Therefore, the timeline of the outage must be minimized. If ARC is designed without maintenance in mind, the outage duration will be longer than necessary. To determine how best to incorporate maintenance, the outage radiation environment must be understood.**
BARRIERS	**The largest barrier to the project is the nascent stage of the industry and the effort within the company itself. Almost none of the proposed actions have ever been done before, especially not on the timeline considered. The problem set was, therefore, undefined and nebulous. Adding clarity was made additionally difficult by short history of the team itself and other challenges with poorly defined requirements.**
ENABLERS	**The company's prior (and ongoing) work on its prototype, SPARC, enabled my work in some cases because there were limited parallels to my work. Additionally, my supervisor provided me a broad mandate but limited guidance which allowed me to explore multiple areas of the literature in an attempt to find all variables relevant to maintenance.**
ACTIONS	**I wrote a technical report which was entered into the company's official engineering documents repository, allowing it to be referenced in the future. Additionally, I provided the workflow designs in a final presentation and digitally via the thesis.**
INNOVATION	**This project was the first application of R2S to ARC for the purpose of determining the shutdown dose rates. Also, the use of different device configurations and material choices for maintenance trade-off analysis was new to ARC. Finally, I incorporated previous work from NASA and the fission power industry to map out RHE radiation hardness requirements development.**
IMPROVEMENT	**This project cannot be put in terms of time or monetary savings to the company, but it does provide a starting point for iterative design where there was none.**
BEST PRACTICES	**When confronted with a brand new problem set and serious ambiguity on how to proceed, the more time spent on literature review the better. In haste to show progress, many, myself included, many will start down a path too soon only to find out it's been tried or isn't relevant. A slower process of gathering information on previous efforts ensures a comprehensive approach on something actually usable.**
OTHER APPLICATIONS	**The neutron activation in fusion applications is unique. The process in this project to use the R2S method to determine the shutdown dose rates would be broadly applicable to other fusion efforts.**

Product design / development / engineering | Technology | Customer service / connectivity | Recommender Systems

Enhancing Digital Customer Journeys: A Comparative Analysis of Knowledge Retrieval Approaches

Amazon

BUSINESS PROBLEM

One of the primary factors that sets AWS apart in the landscape of cloud services is its exemplary customer support. To uphold this standard of excellence, AWS needs to complement their rapidly expanding support knowledge base with improved knowledge retrieval and recommendation systems designed to optimally guide customers during their digital self-service journey. Continuously improving these content navigation mechanisms has the potential to facilitate shorter, more successful, and inherently more satisfying digital customer journeys, leading to business scalability and cost savings through improved self-service capabilities.

APPROACH

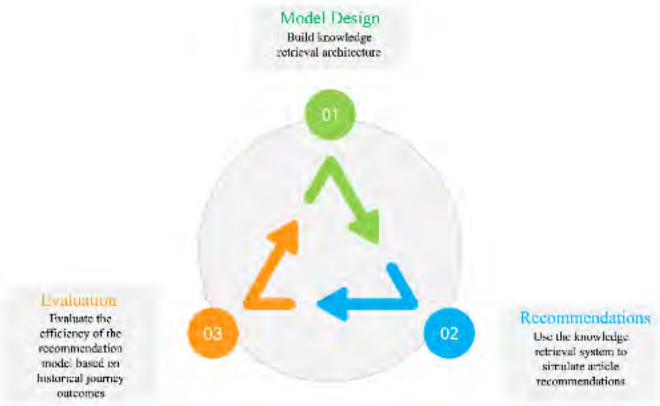
We designed the mechanism by which AWS support content is surfaced to customers, ensuring they can access the information they need both swiftly and efficiently. The foundation of our approach was the hypothesis that prior customer interactions with the AWS Support knowledge base held insights about the customer intent which could enable us to guide the customers to their desired solution.

DATA SOURCES

Data is collected by AWS Support's web pages, capturing customer interactions with support content without the ability to identify the customer identity. All the interactions are captured in touchpoint format, a set of features that show the type of interaction a user had with the platform. All the touchpoints are saved using a batch process which stores them into a RedShift Cluster.

Data Types and Format

The collection of touchpoints is stored as table with fields containing information about these user interactions. The fields are of type String, Int, Float, Bool or Datetime.



Author: Teodor Nicola Antoniu

IMPACT

The implementation of the three knowledge retrieval systems for article recommendations is anticipated to enhance the self-service journey for customers interacting with AWS Support's digital content. Immediate impacts include: 1. Improved User Experience: Customers will experience a seamless journey, directed towards relevant articles based on their prior interactions, eliminating time-consuming searches and the associated frustrations. 2. Reduced Case Volumes: By guiding customers to the most pertinent solutions, the need to escalate issues to customer support will diminish. This not only saves costs related to case handling but also reduces the workload on customer service representatives. 3. Increased Engagement: Providing precise, relevant content boosts customer confidence in the knowledge base, promoting prolonged engagement. 4. Optimized Content Strategy: The insights derived from the recommendation system can offer valuable feedback on which articles are most effective, allowing content creators to refine their strategies, ensuring the continuous improvement of the support material. 5. Financial Savings: A reduction in escalated cases directly translates to fewer resources being allocated to handle customer queries. 6. Scalable Solution: The model can continuously learn and adapt. As the content library grows and user behavior evolves, the system can be retrained to keep recommendations relevant, ensuring it remains effective over time.

DRIVERS

With a rapidly increasing AWS knowledge base, there is a need to guide users efficiently across AWS Support's thousands of support resources. Furthermore, the global trend towards data-driven personalization means today's users expect tailored experiences. Meeting these needs ensures enhanced customer satisfaction and support infrastructure scalability.

BARRIERS

The project faces several barriers. Customers engage with the AWS Support knowledge base with a broad array of intentions, from browsing to troubleshooting or research, leading to diverse journey patterns. Moreover, the data captured is limited as we're unable to track interactions outside of AWS, leading to gaps in customer journeys. The absence of a system that offers real-time journey data adds complexity to production deployment.

ENABLERS

The continued support from the AWS Applied Science teams proved invaluable, bringing technical acumen to the table. Active involvement from stakeholders ensured alignment of our objectives with broader business goals. The AWS Support product teams also collaborated with us, aiding in practical integration. Proactive managerial support was instrumental.

ACTIONS

To implement the solution, I first performed rigorous exploratory data analysis to better understand the dataset's structure. Key preprocessing steps were then mapped out, followed by conceptualizing the model architecture. To ensure structured progress, the project was segmented into tangible milestones, focusing on curating a 'golden' input dataset pivotal for training. Lastly, robust evaluation criteria and success metrics were established.

INNOVATION

The solution's innovation lies in its novel application of Siamese BERT networks for recommendation within support content. Unlike traditional systems, ours leverages sequential content interactions, capturing intricate user behavior nuances. By representing articles as embeddings, we address content size variability, ensuring model consistency.

IMPROVEMENT

The solution is anticipated to increase case deflections by guiding customers to relevant content more efficiently. The proposed model aims to shorten the average customer journey length, enhance content engagement and positively impact overall user experience and support metrics.

BEST PRACTICES

To replicate this solution's results, ensure a clean and comprehensive dataset that accurately reflects user journeys. Utilize thorough exploratory data analysis to identify patterns and anomalies. Engage in consistent collaboration with stakeholders, ensuring alignment with project goals. Design a robust preprocessing pipeline for diverse content lengths.

OTHER APPLICATIONS

Our solution's emphasis on sequentiality offers rich applications, especially in shaping learning paths for educational content, ensuring step-by-step progression that aligns with learners' needs. Another application could be guiding users through intricate software or apps. The sequentiality innovation makes the model ideal for enhancing tailored content navigation.

R&D | Technology | Improved process performance | Constrained / Unconstrained

Evaluating New Business Opportunities for Interregional Transmission

BUSINESS PROBLEM

Transmission is the single most important enabling technology for decarbonization. The large transmission projects that are critical to enabling access to renewable energy resources have generally taken 10-20 years to build. Once these projects are completed, the electricity landscape will look different due to projected high growth of electricity consumption and renewable energy generation through the next few decades. Therefore, it is important to leverage research-backed, modeled predictions of the electricity sector's future to assess transmission line's business viability on a forward-looking basis.

APPROACH

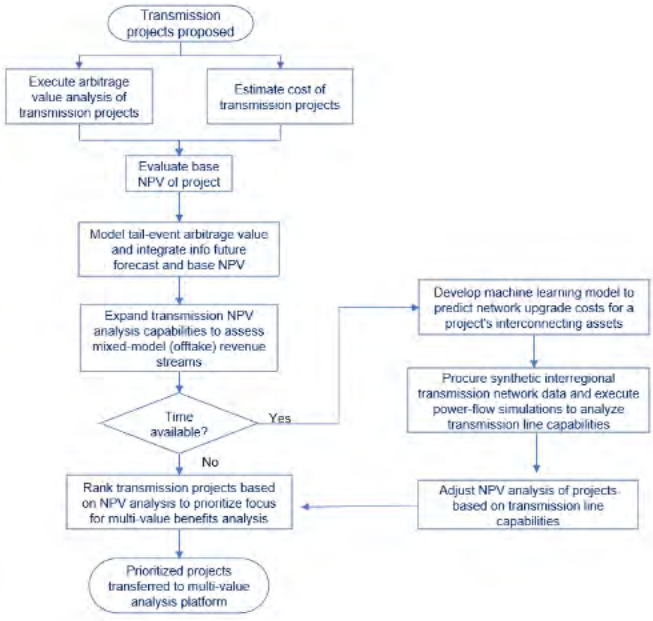
A transmission business evaluation tool will analytically demonstrate the business viability of proposed interregional transmission projects through their useful lifespan. The tool will perform NPV analysis of the projects with input from modeled predictions of the electricity sector's future, historical electricity market volatility, and cost estimates of transmission infrastructure.

DATA SOURCES

Data of transmission project concepts was obtained through internal channels. Wholesale electricity prices was obtained through subscription-based data suite and public sources. Transmission asset cost estimations are obtained from public sources. Transmission capacity contracts are obtained through internal channels and public sources.

Data Types and Format

Transmission project, capacity contracts, and other proprietary data source formats are not able to be disclosed. Wholesale electricity prices and transmission costs are time and location series.



Author: Don Okoye

IMPACT

These efforts will result in a valuation of potential transmission projects and will ultimately support project pipeline growth for NextEra Energy Transmission. A successful project would enable NextEra Energy Transmission to move more quickly towards identifying high business value transmission projects and expanding the grid's transmission capacity. High business value transmission projects need to be able to increase revenue through rate-of-return, contracted, or merchant projects, and unlocking opportunities for NextEra Energy Resources to build additional wind and solar projects.

DRIVERS

Evaluating the comprehensive benefits of proposed transmission projects is computationally expensive and unfeasible to execute for early-stage, exploratory analysis of multiple projects. Therefore, this solution focuses on the development and use of a computationally-reduced transmission business evaluation tool that heuristically evaluates critical components of comprehensive benefits and assesses cost recovery viability.

BARRIERS

Data access is primary barrier for the transmission business evaluation tool's analysis, and the availability of pertinent electricity sector data impacts the ability to make data-driven decisions. For example, due to the standardized and publicly available nature of RTO/ISO LMPs, they are the only historically observed wholesale electricity prices that will be utilized by the tool for energy arbitrage analysis.

ENABLERS

The Transmission Fundamentals team at NextEra Energy Transmission develops energy system modeling, data analysis, and comprehensive transmission valuation tools for project development. The energy arbitrage model's representation of wholesale electricity markets and transmission operation and capacity contract model's energy offtake agreement logic were informed by concepts and frameworks collected while conducting graduate research at NEET.

ACTIONS

The Transmission Business Evaluation Tool was developed in the Python programming language to assess the value of proposed projects. It is segmented into three modules that align with the transmission cost-recovery mechanisms explored and objectives of the overarching investment analysis. The modules are aptly named: Energy Arbitrage, Capacity Contract, and Net Present Value.

INNOVATION

The innovation of the transmission business evaluation tool is that it heuristically analyzes critical components of transmission benefits for customers and cost recovery viability for investors in a computation-reduced form. Prior to this development of this tool, this analysis was done with computationally expensive resources that rendered the analysis unfeasible to replicate across a large number of projects.

IMPROVEMENT

The transmission business evaluation tool analysis resulted in the valuation of multiple early-stage transmission project plans and will ultimately support project pipeline growth for NextEra Energy Transmission.

BEST PRACTICES

The analysis and results of the transmission business evaluation solution depends primarily on the data sources that are input into the tool. The solution was fine-tuned to accommodate data inputs of a specific format. Therefore, this format should be followed for all data inputs. In addition, an object-oriented programming language should be used to program the analysis to provide the ability to modularly scale-up the analysis.

OTHER APPLICATIONS

The transmission business evaluation solution can be utilized to analyze all manifestations of long-range transmission projects that are intended to interconnect renewable energy into the grid. Therefore, this solution can be used to also originate new long-range transmission plans by analyzing where there is low-cost, renewable energy generation and existing transmission congestion that can be alleviated by additional transmission capacity.

Operations | Retail | Inventory management / control | Deterministic / Stochastic

Building stochastic store simulation for retail store operations

INDITEX

BUSINESS PROBLEM

For a brick-and-mortar retail business with omni-channel fulfillment, high sales velocity, product portfolio complexity, limited store capacity, and inherent demand stochasticity, agile store inventory planning is crucial to its success. To facilitate such agility in replenishment, backstock, transfers and in-store movements, this project aims to create a tool that simulates how these decisions directly impact store operations (i.e. capacity utilization and product complexity), in order to inform better store inventory planning. As an extension, the project will also explore opportunities for improvement to store operations as they fit.

APPROACH

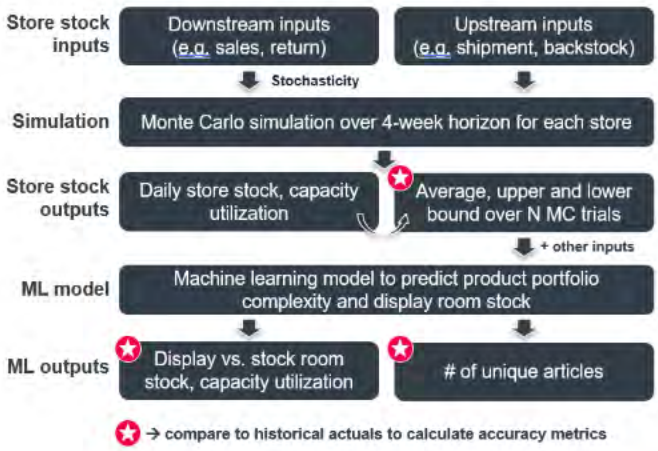
The simulation tool will approach downstream (e.g. sales and returns), upstream (e.g. replenishment, backstock) and in-store movements separately. Downstream and in-store movements will be modeled stochastically, based on historical actuals (and forecasts). Upstream movements will be direct inputs to the model, with some parameters calculated from historical data.

DATA SOURCES

Historical store volume flows, stock level, as well as downstream forecasts are leveraged. All data are pulled directly from the enterprise data systems, using a combination of Scala, SQL and PySpark, enabled by Databricks. Additionally, institutional knowledge on the business rules for relevant operations will also be leveraged to enhance simulation fidelity.

Data Types and Format

Volume flows, stock level and forecasts are all provided as time series.



Author: Davy Qi

IMPACT

For store stock, no significant systematic biases are observed, while the daily mean absolute inventory deviation remains under 2-4% for the store total. Some systematic biases are observed for the machine learning outputs. Daily mean absolute deviation ranges from 3-10% for display inventory and can be up to 10-20% for unique articles.

DRIVERS	Need to understand the precise impact of operational practices on inventory visibility for forward-looking periods
BARRIERS	Lack of historical or forecast data
ENABLERS	Data pipeline integration with existing systems; Real-time cloud computing capabilities
ACTIONS	Careful reconciliation of various data sources; Model feature designs and fine-tuning informed by the minimization of quantitative accuracy metrics for the model outputs
INNOVATION	Application of Monte Carlo and machine learning techniques to model future inventory
IMPROVEMENT	Not quantifiable since the project is a proof of concept
BEST PRACTICES	Data quality is paramount, since the basis of the model is accurate historical and forecast inventory in and out flow data; Integration with data system is also important for the tool to be practically usable, both from an interface and runtime perspective; Quantitative accuracy metrics should be carefully defined to inform the best combination of model parameters
OTHER APPLICATIONS	The techniques can be applied to any system where volume in and out flows that can be modeled and overall volume is conserved

Supply chain planning and inventory management | Retail | Network optimization | Uni / Multi-Objective

Greenhouse Gas Optimization Across a Multi-Echelon Manufacturing and Distribution Network

BUSINESS PROBLEM

Businesses across the world have begun to pledge reductions in Greenhouse Gas (GHG) emissions across their organizations to better preserve the planet. The host company has committed to a percentage reduction of its Scope 3 GHG emissions, which includes that of its outsourced multi-echelon manufacturing and distribution network. The task of optimally allocating supply amongst global production locations and transport modes while reducing GHGs, preserving low costs, and serving a global consumer base is beyond the human decision making capacity, and requires optimization technology in order to achieve viable results.

APPROACH

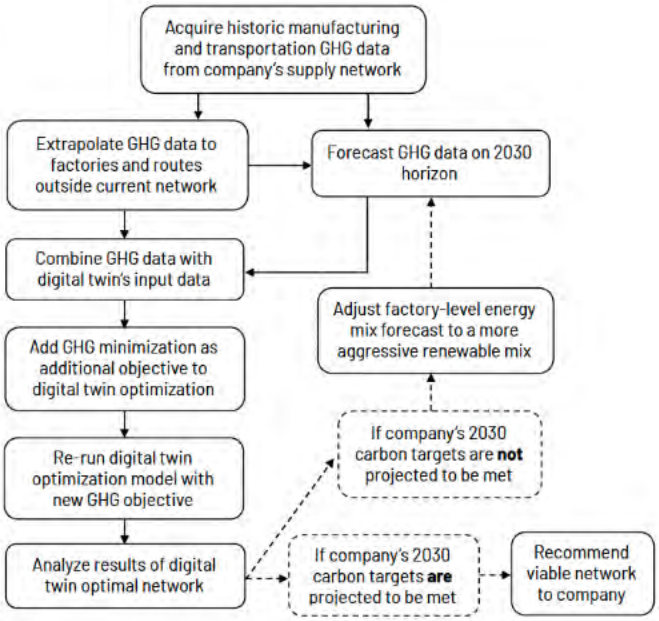
Historic manufacturing and transportation GHG data from the upstream network were acquired. Projections were developed to estimate emissions on a 2030 time horizon and for facilities that may join the manufacturing network by 2030. Projections were incorporated into a digital twin optimization model, set to optimize for GHGs, cost, risk, and lead time, then optimal networks were generated.

DATA SOURCES

Two database were used to access network historic GHG emissions information. One database contained an emission breakdown based on energy purchased and generated onsite at upstream manufacturing locations. The other database contained an emission breakdown based on historic transportation routes and modes within the upstream transportation network. Both databases were company internal reporting.

Data Types and Format

GHG emissions data were extracted from Snowflake tables and processed using Python.



Author: Theo Rosenzweig

IMPACT

In a time when emissions are of increasing importance, the supply plans produced using the GHG optimization algorithm will help the company do its part to reduce emissions to better preserve the planet. The host company has pledged to significantly reduce its Scope 3 GHG emissions by 2030 as informed by the Paris Agreement's guidelines, and it will take data-driven strategies to meet those aggressive targets. The optimization algorithm of focus in this project helps create optimized supply plans to meet the GHG reduction targets. The algorithm also helps find the lowest cost, lowest risk, and most responsive network solutions that can meet emission targets. The combination of these objectives makes the algorithm not only climate-centric but also savvy for business use.

DRIVERS

The Paris Agreement's goal to keep the increase in global average temperatures below 2 degrees celsius above pre-industrial levels was a major driver for the company's GHG reduction targets. These targets are the motive for the GHG optimization algorithm.

BARRIERS

The company had less manufacturing GHG related data in further removed tiers of the upstream supply chain than in near tiers of the supply chain. Due to these data gaps, the algorithm's accuracy was diminished when distant tiers were included in scope, which was a barrier when reviewing the exact network GHG values of the algorithm's solutions.

ENABLERS

The company was willing to share any available data to enable the creation of the optimization algorithm. Additionally, the company provided a strong mentorship support network from the first day of the internship, which helped the project flow smoothly. Employees were eager to implement solutions into their full-time practices, which made the project impactful on the long term scale.

ACTIONS

GHG emissions related to the production of goods at all in-scope manufacturing facilities were either directly extracted or extrapolated. GHG emissions from the transportation of materials and goods were calculated. All emissions information was fed into the optimization algorithm input stream with cost, risk, and lead time related data. An objective function was added to minimize network GHGs.

INNOVATION

The algorithm is innovative in that it allows for optimization of GHGs, cost, risk, and lead time together instead of limiting to sole optimization for GHGs. The multi-objective optimization quality makes the algorithm useful in business settings, so it can be used as more than a standalone tool for sustainability purposes.

IMPROVEMENT

The solution provides a supply plan that the company can follow to meet their 2030 GHG reduction targets, which was an unknown before commencement of the project.

BEST PRACTICES

Best practice is to ensure that adequate emissions-related data is available for every in-scope tier of the manufacturing and distribution network. If adequate data cannot be made available for a network tier, consider removing that tier from the optimization algorithm because it may obscure results.

OTHER APPLICATIONS

The GHG optimization strategy could be implemented in any manufacturing and distribution network, regardless of if the network is global or local, multi or single echelon, and regardless of the type of good manufactured. As long as there is adequate emissions-related data, the methodology behind the algorithm may be applied.

Logistics / Distribution | Healthcare / Pharmaceuticals | Improved process performance | Regression analysis

Warehouse of the Future

BUSINESS PROBLEM

Competitive pressures require ARI warehouses to be as efficient and low cost as possible. An Outside Service Provider (OSP) has led operations within the warehouse since September 2021. The work is considered safe and compliant. However, there are many opportunities to mature their processes and make the work more efficient. The goal of this project is to support Amgen as it creates the warehouse of the future. Amgen is targeting volume-based growth as it expands, aiming a 130% increase to its production of drug substances by 2026. Ensuring that the warehouse can support the site's long-term growth is key.

APPROACH

To support the changes of 2026, I focused on organizational design and automation. To rethink the organizational design, I first established the staffing needed, then calculated utilization and finally investigated different shift structures. With regards to the automation, I researched different automated guided vehicles companies and ascertained the engineering effort needed to retrofit.

DATA SOURCES

SAP data Warehouse standard work created by the Amgen team through their observation Historical production data

Data Types and Format

The majority of the data used was contained in spreadsheets

Author: Stephanie Severe

IMPACT

I determined that the current staffing supports future growth plan of the organization. I also ascertained the level of utilization of the different groups (receiving, shipping, mid-shift, night-shift) and modeled the inherent uncertainty and variability in task completion times. I established which task would be best for automation. If Amgen focuses its automation efforts on supporting mid-shift and night-shift picking to locations requiring equipment, the likelihood of needing overtime is very unlikely even in an extremely volatile scenario. I highlighted the need for cross-training between the different teams.

DRIVERS

The catalyst for the solution is the competitive nature of the pharmaceutical industry that drives the need to remain efficient and low-cost in the face of competition.It is leading here to an increase in production of drug substances by 2026 at ARI while needing to cut costs.

BARRIERS

For every activity performed in the warehouse I do not have the exact time it took to perform the task. It would have been ideal to be able to follow a pallet digitally from the time it entered the warehouse. This information would have allowed me to predict the exact utilization of every team. We used standard work and simulation to estimate utilization.

ENABLERS

I was surrounded by a great team that was very supportive. They were instrumental in creating the standard work document that was the foundation for most of the analysis.

ACTIONS

I engaged the different stakeholders with whom I was working throughout my internship to ensure buy-in of all solutions. The stakeholders include the outside service provider, the Amgen team, the automated guided vehicle vendors, and the engineering team.

INNOVATION

I used Monte Carlo simulation to model the volatility in the task performed within the warehouse. I then used simulation again to ascertain which activity would be best to automate.

IMPROVEMENT

With the increase in volume coming to the organization by 2026, Amgen would have had to increase its cost by 11%. This research shows that Amgen does not need to increase its cost and can potentially decrease them by at least 9%.

BEST PRACTICES

-Use simulation to model volatility -Engage with engineering to understand the impact of retrofitting

OTHER APPLICATIONS

Understanding the utilization of staff is an important concept that all organization care about. This project can serve as a blueprint.

Product design / development / engineering | Industrial automation | Product design and testing | Rules-based

Automating Mold Design and Toolpath Generation for Composites Manufacturing

BUSINESS PROBLEM

Project engineers will play a critical role as Re:Build Composite Resources (CR) pursues growth goals. The existing project engineer workstream consists of high-value decision-making and low-value repetitive tasks, including the design of molds for simple geometry parts. This internship project aims to automate mold design and toolpath selection for simple geometry composite parts. This will reduce lead times, increase project engineer capacity, reduce indirect labor costs, and standardize engineering outputs.

APPROACH

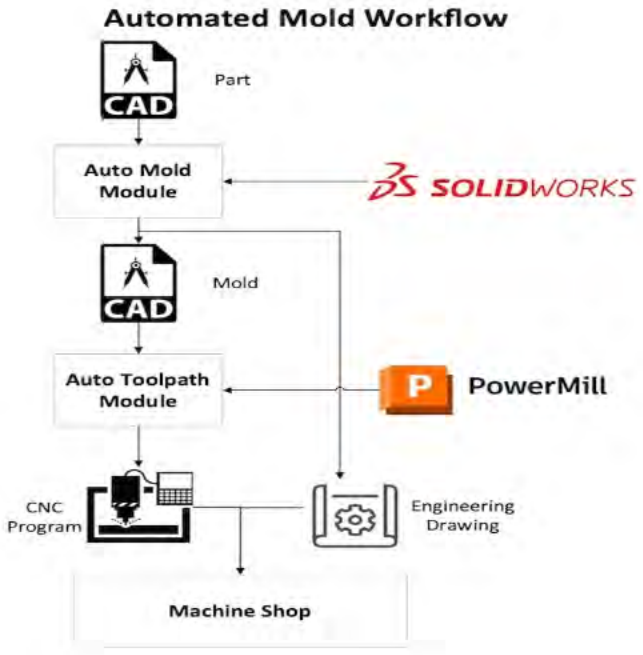
Historical parts were studied to qualitatively define in-scope parts based on geometric complexity. The manual mold design and toolpath selection processes were mapped. Using a combination of CAD/CAM API calls, engineering heuristics, and rules-based decision-making, a suite of C# and Python-based algorithms was iteratively developed to automate mold design and toolpath selection.

DATA SOURCES

Mold data was gathered by qualitatively analyzing CAD files. Toolpaths were characterized by scraping thousands of CAM files and extracting toolpath parameters. ERP entries were collected and analyzed via SQL queries. Engineer/ CNC programmer interviews were conducted to understand technical decision-making. Management interviews were conducted to understand the greater business context.

Data Types and Format

CAD/ CAM files, aggregate toolpath parameters, ERP data including work center processing times and PO frequency, and text from interview notes.



Author: Mark Sweet

IMPACT

Based on tests on historical parts, the automated mold design algorithm developed in this research could design molds for 12% of CR's parts. The automated toolpath generation algorithm created toolpaths for 18% of CR's parts. The algorithm's run time was typically 5 minutes or less. Lead times are projected to decrease from 8-10 weeks to 5-7 weeks for in-scope parts. The automated mold design algorithm, seamlessly integrated as a SolidWorks plug-in, is designed to enhance the existing project engineer workflow. Similarly, the automated toolpath generation tool, implemented as a PowerMill plug-in, offers an intuitive experience for CNC programmers. This user-friendly approach ensures that project engineers / CNC programmers can easily modify outputs from both algorithms, if required, without disrupting the workflow.

DRIVERS

Re:Build seeks to leverage digital manufacturing technologies as a competitive differentiator. This industry is competitive on lead times. CR is pursuing aggressive growth goals and seeks to win more business by reducing lead times. By automating up-front design work, production can start earlier, and lead times will be shorter. Automation will also play a critical role in decoupling revenue from headcount.

BARRIERS

This project encountered technical and human barriers, both of which were manageable. Technical barriers included learning new programming languages and using the CAD/CAM APIs to perform design tasks. Human barriers included healthy skepticism among company personnel. Concerns included wasting time on buggy/ ineffective automated tools and skepticism that design and toolpath generation could be automated robustly.

ENABLERS

Strong continuous improvement culture. Experts were willing and enthusiastic to share their knowledge. Recent growth has increased project engineer and CNC programmer workload and they are motivated to find ways to work more efficiently.

ACTIONS

The automated algorithms were developed in a highly iterative manner. A carefully crafted pilot program was launched with project engineer and CNC programmer champions. The pilot program was designed to add value while also collecting feedback on algorithm performance. A critical aspect of this pilot program was a streamlined workflow that included decision aids, special part numbering, and automated macros.

INNOVATION

Use of the SolidWorks API to automatically orient parts, perform draft analysis, place a parting surface, and generate a mold without human intervention. Through analysis of historical CAM files, determined that a majority of in-scope machining work could be completed using only three toolpaths that could be applied uniformly over all in-scope parts. This simplified and standardized CNC programming outputs.

IMPROVEMENT

Automated the mold design for 12% of parts and automated the toolpath generation for 18% of parts. For in-scope parts, lead time is projected to decrease from 8-10 to 5-7 weeks.

BEST PRACTICES

Study existing manual processes thoroughly to understand key decisions. Study parts to identify common features compatible with automation. From there, define a scope that makes the problem more manageable. Focus solely on in-scope activities and parts. Start with the simplest possible version of the problem and iteratively increase the complexity. Find resident experts who are interested in your work and build relationships.

OTHER APPLICATIONS

This research is a case study of the value of automating up-front engineering design work. Design automation is a productivity enhancer in high-mix, low-volume manufacturing environments. Design automation can reduce changeover costs and provide rapid prototyping capabilities to manufacturers. Similar automated design tools could be helpful in metallics manufacturing or any mold-based manufacturing process.

Product design / development / engineering | Aerospace and defense | Product design and testing | Tree-based

Framework for Enhancing Decision-Making Capabilities in the Decarbonization of the Airline Industry

BUSINESS PROBLEM

The path to executing on the airline industry's net-zero goals by 2050 remains nebulous, with sustainable aviation fuels (SAF), electrification, and liquid hydrogen (LH2) at nascent technology readiness levels. In order to mitigate risk, airline industry leaders may begin to rely upon decision-support systems (such as Cascade) to tackle uncertainty through scenario analysis, fleet replacement modeling, and techno-economic assessments. In other words, what strategic questions should airlines pose to successfully execute sustainability targets?

APPROACH

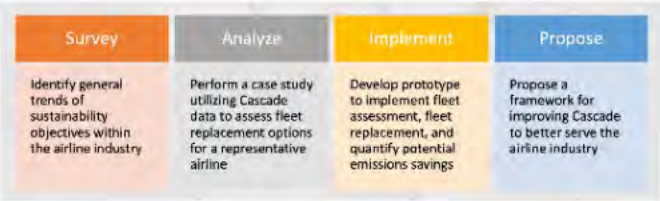
1. Identify general trends of sustainability objectives within the airline industry 2. Perform a case study utilizing Cascade data as a means to assess fleet replacement options for a representative airline 3. Develop prototype to implement fleet assessment, fleet replacement, and quantify potential emissions savings 3. Propose a framework for improving Cascade to better serve the airline industry

DATA SOURCES

Global flight traffic data: Cascade (FlightRadar24, Cirium) Airline fleet and network data: Wikipedia, PlaneSpotters

Data Types and Format

CSV files



Author: Allison Tsay

IMPACT

At present, Cascade relies on basic approximations for payload, flight trajectories, and adoption rates of alternative energy sources and future aircraft technologies. With the release of Cascade to the public in May 2023, the critical question remains as to how Cascade can be transformed from an educational tool into a high-precision, decision-support system for the airline industry. The proposed framework for improvement and resulting prototypes will serve to enhance the decision-making capabilities of Cascade and better serve the airline industry in achieving its net zero emissions goals. Thus, adding momentum in Cascade's evolution from a high-level educational tool to a more robust and granular decision-making system.

DRIVERS

While over 290 airlines have made pledges to fully decarbonize by 2050 (IATA), the path to executing on net-zero goals by 2050 remains nebulous at best. With that in mind, how should an airline approach making decisions about implementing or investing in sustainable aviation technologies? How can an airline leverage Cascade to make these decisions? How can Cascade be transformed from an educational tool into a high-precision, decision-system for

BARRIERS

Barriers to progress included data quality and availability of airline fleet data, proprietary release processes, change management, and lack of airline stakeholder input

ENABLERS

The combination of Boeing's technical expertise, collaboration with Aurora Flight Sciences for modeling advanced technologies, and access to industry insights and resources created a fertile ground for the successful development of this project.

ACTIONS

Survey of sustainability goals across the airline industry, comprehensive data collection and research into representative airline's fleet and network data for the case study, implementation of a prototype within Cascade for increased customization and specificity for airline emissions analysis, and documentation for integration into the web-app

INNOVATION

Innovative aspects of this solution include enhancing precision in emissions reduction strategies for the airlines.

IMPROVEMENT

The solution will transform Cascade into a precise decision-support system that optimizes flight operations, leveraging accurate data on payload, load factors, and route traffic growth. This enhancement will empower the airline industry to make informed, data-driven decisions using Cascade.

BEST PRACTICES

1. Robust Data Collection: Gather accurate and comprehensive data on flight operations, sustainability investments, and technology adoption. 2. In-depth understanding of the current Cascade architecture and technological roadmap

OTHER APPLICATIONS

Within Cascade, this solution can be extended to assist the airlines in planning for electrification and introduction of alternative energy sources. Beyond the airline industry, this data-driven decision fleet replacement framework could be adapted for sustainable operations in shipping, logistics, and transportation sectors.

Supply chain planning and inventory management | Healthcare / Pharmaceuticals | Inventory management / control | Deterministic / Stochastic

Enhancing Supply Chain Resilience through Digitalization

AstraZeneca

BUSINESS PROBLEM

Ensuring an uninterrupted supply of medical products is a business necessity and a moral imperative for pharmaceutical companies. Since disruptions constantly threaten to impact supply chains for prolonged periods, AZ defines business continuity plans (BCP) for their products; however, doing so is not trivial given the large network of suppliers, component interdependencies across brands, intellectual property of hardware and software, and pharmaceutical regulatory compliance. Thus, the company wanted a digital tool (digital twin proof of concept) to test their end-to-end supply chains under stress scenarios and facilitate the BCP process.

APPROACH

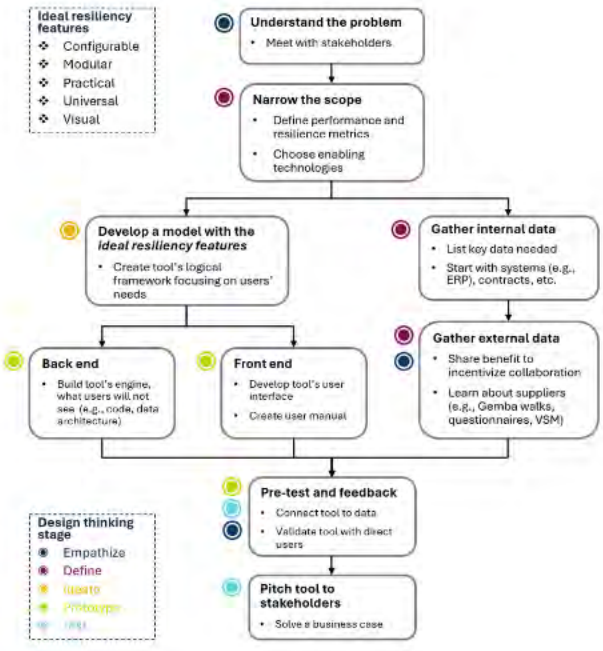
The tool was developed using a design thinking approach, consisting of five stages. 1. Empathize: gain stakeholders' perspectives of current state, opportunities, and constraints. 2. Define: set expectations, collect data from internal and external sources. 3. Ideate: develop a conceptual model. 4. Prototype: build the tool's front and back end, validate with users. 5. Test: solve a business case.

DATA SOURCES

Data for the project was gathered from internal and external sources. Internal data mainly came from spreadsheets managed by supply chain managers and from tier-one supplier contracts. External data was obtained during Gemba walks and through questionnaires answered by suppliers.

Data Types and Format

The input data collected from the operations was numeric and static. After simulating scenarios, the output data was carefully structured to leverage relational interactions among the visualizations.



Author: Carlos Vela González

IMPACT

The digital tool developed has simulation and visualization capabilities that enable the company to outline BCPs more effectively by testing the potential impact on revenue of inventory, capacity, and demand disruptions at any node in the supply chain. The tool reduced the order of magnitude of the BCP process length from days to hours, but beyond allowing the company to improve resilience practices, the tool provides additional use cases: -> In case of disruption, the tool allows the company to understand the extent of the potential impact and respond swiftly. The tool facilitates adopting a proactive supply chain resilience stance. -> When launching medicines, the tool facilitates designing resilient supply chains since their inception and validates that the supply chain design is robust enough to meet the expected demand. -> The tool also helps supply chain managers engage in conversations with suppliers to plan equipment investments or divestments. Most importantly, the tool promotes learning for supply chain managers in a risk-free environment where the consequences of certain policies or decisions can be evaluated before implementing changes in the actual supply chain.

DRIVERS

Requesting information from third parties can be perceived as intrusive and potentially harmful to business relations. However, in the pharmaceutical industry, virtually all companies care about patients and publicly state such concern in their mission or values statements. Framing the project as a means to reduce stockouts in case of disruption (by increasing supply chain resilience) made it easier to persuade suppliers to share crucial data.

BARRIERS

First, a value stream mapping for the external supply chain had not been performed yet and there was no single source of truth for the internal data available about the supply chain. Second, there was no clear understanding of the implications of building the digital tool (nor even of the term digital twin) among the team involved. Thus, collecting data, aligning the project's expectations, and creating a user-friendly tool proved time-consuming.

ENABLERS

The project's likelihood of success increased by having a Steering Committee – a group of stakeholders with whom to meet regularly to reach a consensus on key decisions, get guidance , and obtain feedback. Another key practice was having individual meetings with direct and indirect users as well as business leaders to gather expectations, detect constraints, and identify opportunities to add value to the overall business.

ACTIONS

1. Design the tool's logical framework and select the software to fit such a framework. 2. Conceptualize a model for simulating the supply chain and disruptions, and validate its assumptions. 3. Code the model and build the interface where users determine the stress-test scenarios and supply chain conditions. 4. Design a dashboard to showcase the simulation results. 5. Create a user manual.

INNOVATION

The digital tool devised was an in-house solution designed to be modular (able to represent as many nodes and tiers in a supply chain as desired) and universal (applicable to any desired product or set of products); thus, it could easily scale across the entire organization. The tool became one of the few 'process digital twin' proof of concepts at the company.

IMPROVEMENT

The digital tool upgraded the BCP process. Scenarios can now be evaluated and visually compared with minutes (took days), multiple types of disruptions and response mechanisms can be evaluated simultaneously (formerly only outages were evaluated and one node at a time), and stress test consider interdependencies as well as future supply chain conditions (formerly only 'current' supply chain state).

BEST PRACTICES

A practice that increased the project's likelihood of success was having a Steering Committee – a group of stakeholders with whom to meet regularly to reach a consensus on key decisions, get guidance from, and obtain constant feedback. Another key practice was having individual meetings with direct and indirect users as well as business leaders to gather expectations, detect constraints, and identify ways to add value to the overall business.

OTHER APPLICATIONS

The digital tool also laid the groundwork for developing a supply chain digital twin. It currently works with static data and there is no interaction between the physical and digital supply chains, but the company could leverage the solution to transition towards a digital twin by investing in IoT sensors, cloud computing, and other technology that enable the automatic connection between the physical and digital entities of the twin.

Supply chain planning and inventory management | Technology | Inventory management / control | Rules-based

Establishing Inventory Maturity in a Make-To-Order Manufacturing Environment

LFMcapital

BUSINESS PROBLEM

Accelevation LLC has grown very quickly from its beginning in 2018 via acquisitions and natural expansion. This growth in sales has not been perfectly followed by maturing processes. The lack of established inventory management policies to reduce stockout events and optimize costs presents an especially troublesome issue. The business historically purchased material based on jobs released to production and does not have strong forecasting abilities based on the make-to-order nature of the products. Additionally, physical counts of inventory on-hand often do not align with the amount of material in the enterprise resource planning system.

APPROACH

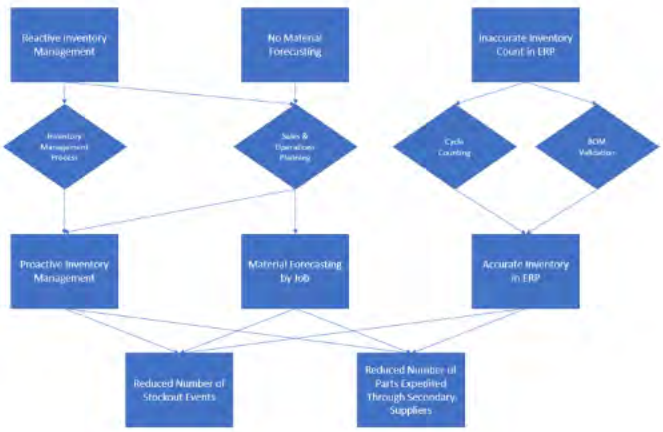
The research will be split into three correlated efforts. A basic re-order level and quantity inventory management policy will be put in place. Next, bill of material validation and material cycle counts will be introduced to improve inventory accuracy. Internal processes for material storage and consumption will also be reviewed. Finally, sales & operations planning will be implemented.

DATA SOURCES

Data came from the Enterprise Resource Planning (ERP) system, from engineering documentation, and from researcher conducted on-site data gathering. Data from the ERP included material demand, Bills of Material (BOMs), order information, and inventory position over time.

Data Types and Format

Primarily time series data, with some cost data and data containing characteristics of parts.



Author: Adam Vignaroli

IMPACT

For growing make-to-order businesses, the quantities of materials that are consumed will continue to increase without being able to build finished product stock as buffer. As the supply chain complicates, stock-out events can become a nuisance and slow production. Processes in place also need to be robust to grow with the company's revenues and throughput without additional cost. The legacy processes in this project included manual purchase order quantities and timing with tracking occurring by the buyer's individual checks. With these existing processes, growth requires additional headcount to maintain similar levels of material effectiveness, with likely diminishing effectiveness among more complicated material consumption and orders. Enhancements to Accelevation's inventory management through policy, accuracy, and forecasting enhancements will allow for revenue growth with a less than directly proportional increase in operations support personnel. While the business continues to evolve and serve different aspects of the data center containment market, demand may deviate from historical usage. Processes that plan for these deviations from historical usage will allow Accelevation to plan material beyond their inventory policy for situations where they would otherwise be at risk of stock-out events. In all, creating robust inventory management processes will aid Accelevation's continued growth.

DRIVERS

The solution was largely driven by the past success of operations management techniques at manufacturing operations. The solution included many standard inventory management techniques. The demand forecasting solution was catalyzed by the experience of the former COO.

BARRIERS

Barriers that impacted the project's success were the engagement of cross-organizational engagement in demand forecasting. Also, the ERP in place had limited operational capabilities that prevented effective tracking and traceability as well as a limited array of inventory policy options.

ENABLERS

The operations team and the operations support team enabled the project through their desire to improve the operation and perform at a higher level. The buy-in from this team allowed for regular useful suggestions and feedback on the project and its solutions.

ACTIONS

To implement the solution, the researcher first performed an initial state assessment to determine the areas of the business that required the most immediate attention. These focus areas were inventory policy, demand forecasting, and inventory accuracy. An inventory policy was developed and implemented, demand forecasting was established via Sales & Operations Planning (S&OP), and multiple inventory accuracy campaigns were started.

INNOVATION

The most innovative aspect of the solution could be found in the inventory policy, where the largest supplier for Accelevation agreed to terms on storage of material with the supplier with far lower lead times in exchange for guaranteed purchase quantities. This agreement allowed for a significant decrease in the amount of inventory required on-hand for Accelevation and shorter lead times for some of their most critical materials.

IMPROVEMENT

The inventory policy is expected to decrease average inventory of parts under the policy by 25% once parts above target maximum on-hand have been consumed down to target levels. With this policy, the number of stock-out events realized from inventory policy related shortcomings decreased per unit produced by 33% in the two months following policy implementation. Stock-outs from forecasting shortcomings decreased 65% following implementation.

BEST PRACTICES

To attempt to replicate the solution, the manufacturing environment should be one that is make-to-order. Also, the organization should likely have volume growth that has not been met with maturing processes at the same speed. Additionally, with high variability of materials used, demand forecasting should be based on sales pipeline and projections together with past usage trends.

OTHER APPLICATIONS

This solution could apply to any small, make-to-order manufacturing firm that has experienced volume growth that outpaces its processes. While many of the concepts are more broadly applicable, this exact solution relies on those characteristics of a firm. However, mature processes in any of inventory policy, demand forecasting, or inventory accuracy should not limit the application of the other areas.

Logistics / Distribution | Transportation and logistics | Predictive forecasting | Regression analysis

Data Roadmap for Amazon Last Mile Sustainability

Amazon

BUSINESS PROBLEM

In 2019, Amazon signed the Climate Pledge to reach net-zero carbon emissions by 2040. Amazon's last mile delivery team (AMZL) is focusing on various initiatives such as use of electric vehicles for delivery and powering delivery station operations with 100% renewable energy. The AMZL team is pursuing a mechanism to measure accuracy of carbon data inputs and existing forecasts. This project focuses on strengthening last mile's sustainability efforts by creating data analytics tools to perform evaluations of decarbonization projects and provide performance tracking.

APPROACH

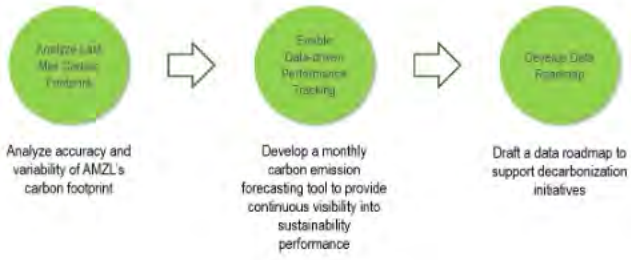
The research consists of three primary components: data source analysis, development of a carbon emission forecasting tool, and drafting last mile sustainability data roadmap. We developed tools for carbon data analysis to assess the impact of last mile activity variables and predict carbon emission using both process and business-level data.

DATA SOURCES

Carbon emission forecast input variables are last mile activity related parameters. Access to required data of input variables was provided by involved stakeholder teams.

Data Types and Format

Most of the data is stored in Amazon's data cluster, which was accessed using SQL queries. Some of the data was shared by teams in Excel spreadsheets.



Author: Sajiree Vivek Vaidya

IMPACT

In the context of last mile logistics and the imperative to reduce carbon emissions, continuing to improve carbon forecasting capabilities helps decision-making regarding decarbonization initiatives. In this research, we built a tool to analyze the accuracy and variability of AMZL USA's carbon footprint. Additionally, I built a monthly carbon emission forecasting tool, creating a shorter and more adaptive feedback loop to track decarbonization progress. This tool also enables the team to pinpoint delivery stations with the highest carbon footprint, facilitating the tracking of individual delivery station performance. I also drafted a data roadmap outlining how AMZL USA can leverage existing data to ensure short-to-medium term decarbonization strategies remain aligned with long-term targets. The development and alignment of these tools with a strategic roadmap offer a data-driven approach to the last mile sustainability team at Amazon.

DRIVERS

Amazon co-founded the Climate Pledge, and aims to implement decarbonization strategies to achieve net-zero carbon emission by 2040, ten years ahead of the Paris agreement. Amazon's sustainability efforts span across many business units, including Amazon Logistics. Last mile, albeit short, carries significant environmental impact. Last mile's carbon reduction is essential to Amazon's net-zero carbon delivery trajectory.

BARRIERS

To employ a robust AI carbon emission forecasting model, it's important to get independently observed CO2 data to serve as training dataset, and also for validation purposes. Currently, we lack independently observed CO2 emission data from last mile activities, which restricts the application of advanced forecasting approaches.

ENABLERS

Amazon is a data-driven company. Data storage and access procedures are organized systematically, simplifying tasks, particularly during the exploration phase.

ACTIONS

I validated the model using historical data and examined its accuracy month-over-month. The tool was also presented to various stakeholders in review meetings, and their feedback was incorporated in subsequent revisions.

INNOVATION

The current carbon projection model offers yearly projections of carbon emissions, while this project has introduced a monthly carbon emission forecasting tool. By reducing the forecast cycle, the model can better adapt to the latest data changes. Additionally, this tool offers more detailed results by forecasting carbon emissions at the delivery station level, as opposed to the aggregated results at the country level by the existing model.

IMPROVEMENT

The monthly carbon emission forecasting model predicted carbon emissions for upcoming months. However, due to the constraints of the internship duration, we were only able to conduct testing over a limited timeframe.

BEST PRACTICES

Following the data roadmap framework (Collect - Observe - Course Correct - Follow Up) provides a structure for working on data analysis problem. Higher frequency of stakeholder engagement can help understand sources of forecast variation more accurately.

OTHER APPLICATIONS

This approach can be replicated in other business units at Amazon, along with other Amazon logistics teams. Complementing existing first and middle mile carbon forecasts with a monthly forecast will serve as a useful tool for logistics sustainability teams.

Scaling metal additive manufacturing from R&D to production

AMERICAN INDUSTRIAL PARTNERS

BUSINESS PROBLEM

Metal additive manufacturing (AM) has been successfully commercialized, yet widespread adoption has not been achieved so far. This is partly because companies struggle to operate AM factories profitably and efficiently at industrial scale. Rapidly growing an AM business requires both (i) winning substantial customer orders as well as (ii) maturing and growing operationally to be able to deliver on those orders.

APPROACH

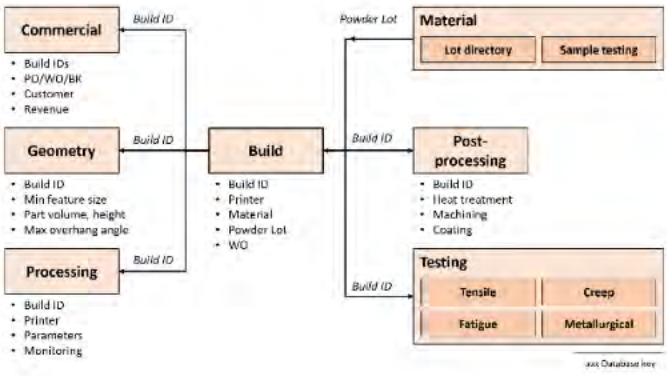
This work proposes a data strategy to support the rapid growth and successful operation of an AM factory. The central idea is to connect relevant data to the central unit of a build, i.e. one unit of manufacturing in AM. This includes commercial data, information about geometry, processing, materials, post-processing, and testing.

DATA SOURCES

- ERP data - CRM data - Financial data - Machine data - Test reports (mechanical and material testing, from third party providers) - Misc operational documents (e.g., work order travelers, purchase orders, quotes, invoices) - Employee testimonials - 3D models/part files and AM build files

Data Types and Format

- Numerical data - Strings and text documents - Time series - Images - Spreadsheets - CAD/CAM files



Author: Reimar Weissbach

IMPACT

After implementation, the framework can be used to (i) qualify processes and certify materials, (ii) improve quoting quality and efficiency, (iii) support engineering and R&D, (iv) derive critical operations KPIs such as revenue per build, builds per week, and days per build, which can be used for budgeting and capacity planning as well as business control, (v) make strategic decisions on capital expenses and headcount planning, as well as (iv) ensure traceability of materials and parts. Together, these applications support decision makers as well as commercial and technical staff in their work, both strategic as well as during day-to-day operations.

DRIVERS	**Additive manufacturing is inherently a digital manufacturing technology. Additionally, given the young age of the company, there were very limited legacy systems or data architectures in place.**
BARRIERS	**Running and growing a fast-paced business, while simultaneously implementing processes and a digital architecture is challenging.**
ENABLERS	**Entrepreneurial mindset and can-do attitude of the team were critical enablers of the project.**
ACTIONS	**The business implemented new IT systems and organizational processes.**
INNOVATION	**Defining the 'build' as central unit of manufacturing and focusing operations around it.**
IMPROVEMENT	**Improvement of production throughput.**
BEST PRACTICES	**Get buy-in from team and management early.**
OTHER APPLICATIONS	**Any platform/standardized batch manufacturing business, such as an AM business.**

Operations | Healthcare / Pharmaceuticals | Improved process performance | Linear / Non-Linear

Paths to Achieving Scope 1 Carbon Neutrality in Building Utilities

BUSINESS PROBLEM

Amgen's carbon neutrality target is based on a three-pronged approach. The first is innovation to reduce the amount of energy required to develop and produce their medicines. The second is operational efficiency. The third is pursuing renewable energy to the fullest extent in the regions they operate. Only after innovation, efficiency, and renewable energy projects are implemented, decarbonization efforts such as carbon removals or high-quality carbon offsets are evaluated. This project investigated innovative solutions to permanently reduce Scope 1 emissions in building utilities while minimizing the use of carbon removals and offsets.

APPROACH

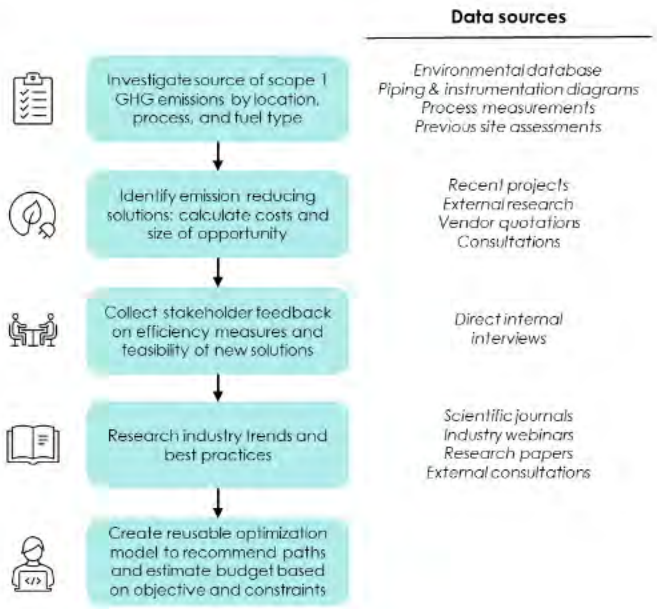
Information on energy demands of core business functions was gathered and mapped. Commercially available and emerging technologies were evaluated by their Scope 1 emission impact, cost, and feasibility. Stakeholders, such as site engineers, were interviewed to collect feedback and evaluate solutions. An optimization model was created to select projects to maximize NPV under varying constraints.

DATA SOURCES

The following data sources were accessed for this project: 1. Global environmental tracking system - a repository of all sustainability projects and historical energy consumption at a site level with monthly granularity 2. PI system - a database of sensor data from individual assets 3. Past energy assessments 4. Qualitative data from site visits and stakeholder interviews 5. Vendor quotations

Data Types and Format

Data was available in a variety of formats, including, but not limited to: a) Excel files, b) .csv files, c) PI graphs d) written reports, and e) stakeholder interview notes.



Author: Daniel Willette

IMPACT

This project aimed to assess and quantify Scope 1 emission reduction opportunities in line with Amgen's three-pronged strategy focused on innovation, efficiency, and renewable energy. The project encompassed both established technologies and emerging solutions. Utilizing an optimization model, the study prioritized initiatives that maximize net present value (NPV) while ensuring carbon neutrality. This model charts sustainable routes to carbon neutrality, while minimizing the utilization of decarbonization efforts such as carbon removals or high-quality carbon offsets. Furthermore, the findings guide current prioritization of carbon abatement strategies and offer insights for future sustainability targets beyond 2027. The adaptable optimization model remains a valuable tool, amenable to updates with refined data and assumptions, facilitating the evolution of innovation, efficiency, and renewable energy strategies for building utilities.

DRIVERS

The biotechnology industry has unique challenges in reducing Scope 1 carbon emissions due to the clean manufacturing and lab processes they manage. To achieve carbon neutrality, Amgen has a three-pronged approach focused on innovation, efficiency, and renewable energy. This project set out to better understand how to permanently reduce Scope 1 emissions in building utilities in line with Amgen's strategy.

BARRIERS

Granular energy consumption data was often unavailable at a building or process level. Past site energy assessments and validated assumptions were required to fill these data gaps.

ENABLERS

Incredible support from the project supervisor, as well as supportive peers and LGO alum within the organization. The company has a collaborative culture focused on its mission, team support, transparency, innovation. The large organization is easy to navigate; this made it possible to access necessary tools, acquire data access authorization, organize travel, and coordinate meetings with stakeholders.

ACTIONS

Subject matter experts were key stakeholders in the project and their expertise enabled the creation of the model and its inputs. The model findings were presented to those subject matter experts and the Sustainability Engineering team for feedback, a review of the insights, and discussion. The outputs of the research and model will help to shape the future sustainability strategy.

INNOVATION

An innovative aspect of this solution is the use of a linear optimization model to select capital projects. In parallel, innovative and emerging emission-reducing technologies, which have not yet become standard practice in commercial building utilities or biotechnology processes, was researched and recommended for future investigation and pilot projects.

IMPROVEMENT

The outputs of this project provide updated projections of capital requirements and operating costs to implement solutions which reach carbon neutrality in line with Amgen's approach focused on innovation, efficiency, and renewable energy. Additionally, the research provides a view of applicable projects and their associated costs to help inform future budgets for sustainability programs.

BEST PRACTICES

Focus on accessing granular building and process energy data as quickly as possible. Where gaps are identified, create a path to close those data gaps, or even pursue long-lasting side projects such as the installation of key sensors and data collecting mechanisms.

OTHER APPLICATIONS

Once innovation, efficiency, and renewable energy projects, affecting either Scope 1 or 2 emissions, are identified and analyzed, the model can be applied to any organization aiming to identify carbon neutral implementation paths which maximize NPV, minimize annual OpEx, or minimize the marginal abatement cost.

Operations | Retail | Supply Chain Quality | Regression analysis

Understanding and Reducing Virtual-Physical Mismatches and Missorts in Fulfillment Centers

Amazon

BUSINESS PROBLEM

Delivery Estimate Accuracy (DEA) is the Amazon Operations metric that measures the percentage of items that attempted delivery on or before the Promised Delivery Date. There are significant costs and customer experience impacts when packages are not delivered on time, resulting in a DEA miss. Virtual-Physical Mismatch (VPM) and Missort are two major types of DEA misses that are difficult to detect and prevent. This project focuses on understanding and reducing the number of VPM and Missort misses in Fulfillment Centers, with the scope being Amazon's Traditional Non-Sort Fulfillment Centers in the US.

APPROACH

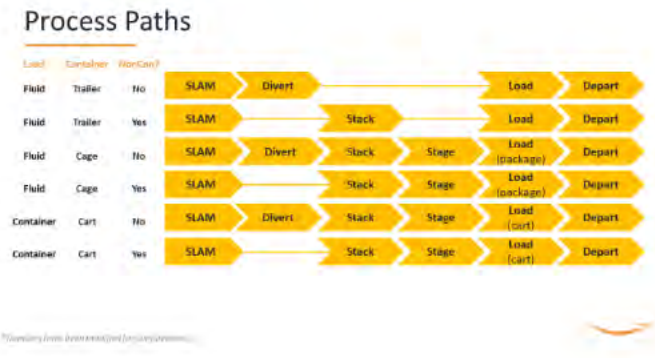
The project was conducted in 2 phases – understanding causes and exploring solutions. For causes, the current process and misses were analyzed and multiple linear regression models were built. Solutions were brainstormed with domain experts and condensed to 7 for pilots and studies. Expected costs, savings, efforts, impact, and effects on staff experience were quantified for prioritization.

DATA SOURCES

The majority of the data is based on system logs of shipment history, including package attributes, container types, timestamped scans, and planned routes. Additional data leveraged from business intelligence dashboards, such as quality defects and staffing. Some pilot data were collected via stopwatch and counting. Qualitative data were collected through 20+ stakeholder interviews.

Data Types and Format

Internal databases and clusters were accessed via Amazon's web browser-based SQL client. CSV and Excel files exported from business intelligence dashboards. Some pilot data were collected manually.



Author: Jenny Yao

IMPACT

A total of 7 solutions have been proposed, studied, and/or piloted on-site. These solutions vary in effort and impact, with some incurring almost no cost while others require a $84k set-up cost. Financially, the estimated total savings of these solutions is expected to be up to $1.3M per site per year. Operationally, some of the solutions will require a few extra steps within the existing process, while others (such as RFID technology) will fundamentally change the structure of the supply chain.

DRIVERS

The problems and solutions of this project were driven by the need to both improve customer experience and reduce operational costs associated with quality issues. Lost and missorted packages are common issues within both the retail and the logistics industry.

BARRIERS

Locating the appropriate data was initially challenging given the vast amount of data available within the organization. Linking and making sense of data was difficult for similar reasons. Running a controlled experiment was also near impossible since operations are always running and processes are always changing.

ENABLERS

Amazonians' willingness to help and collaborate was immensely helpful, especially in the beginning. Being in the Gemba and having access to those on the job was also helpful in understanding the actual processes, including any potential deviations from the standard procedures. The culture of documenting made large libraries of information possible, which were useful during self-studies and research.

ACTIONS

While solutions were not fully implemented, two of the solutions were piloted to estimate efforts and measure potential impact. These pilots were about 1 to 2 weeks in length. They required no change to the existing process and minimal effort from others. The results of these pilots were analyzed against the baseline to gauge its effects.

INNOVATION

The use of linear regression techniques to identify the relationship between potential factors and top causes is an innovative approach. It allowed for more quantitative evidence to support previous hypotheses from supervisors and subject matter experts. It also provided identified some insights that were surprising to internal domain experts.

IMPROVEMENT

Final improvements from the project include a better understanding of the top causes, identification of factors that contribute to these causes, and a pathway to reducing virtual-physical mismatches and missorts based on a number of short-term, medium-term, and long-term solutions.

BEST PRACTICES

Breaking the problem down into its own separate problem and solution space is helpful as design thinking allows us to truly understand the problem before solving it. Being close to the Gemba and front line throughout is important. Getting a wide range of perspectives from stakeholders in multiple teams can help eliminate blind spots. Testing out hypotheses through simple pilots should be done more often.

OTHER APPLICATIONS

Specifically, the findings of this study can be applied to other similar fulfillment centers across the Amazon network. More broadly, the general approach as well as some of the proposed solutions can be applicable to the broader transportation and logistics industry, as this is a common problem wherever packages are being moved and delivered.