

## Senior Capstone Projects

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**Project A:** Layout of a Chemical Analysis Laboratory

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**Description:** The Analytical Lab of the Montana Department of Agriculture (MDA) provides reliable and defensible analytical results for the MDA's feed, fertilizer, pesticide and groundwater protection programs. They also offer their services to the public on a fee-for-service basis. Their current facility is located in McCall Hall on the MSU Bozeman campus. This 1960's era building no longer serves the needs of the lab well, thus the laboratory is planning to build a new facility west of campus.

The objective of the project is to develop a recommended laboratory layout for the eventual new facility that supports the flow of samples, storage and use of chemicals, workflow of laboratory technicians, and information flows needed to analyze feed, fertilizer, pesticide and groundwater samples as well as the expanding hemp program. To do this will require a deep understanding of the various workflows, material flows and information needs of the current operation; and of the unique space, workstation and equipment requirements of a chemical analysis laboratory. From there, the team is expected to identify the key layout considerations and propose layout alternatives that demonstrably support the needs of the lab. Lab leadership is also interested in recommendations to improve operations in the current facility that they could implement in the interim as they await approval for a new lab space.

**Project B:** Furniture Inventory Warehouse Redesign

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**Description:** Montana Correctional Enterprises (MCE) is an enterprise agency under the Montana Department of Corrections. MCE operates several training programs for inmates in different industries at both the Montana State Prison and the Montana Women's Prison. The goal is to train inmates in marketable job and life skills, instill a sense of accountability and pride, and prepare them for eventual reintegration into society with a lower likelihood of recidivism. The inmates earn a wage and accrue sick time like in a "real

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world” job. A portion of their earnings goes directly into a Victim Services fund and any restitution that they are subject to paying comes out of their earnings. MCE is treated as a profit center, and so must support itself financially to remain viable.

One of the industries MCE operates is wood furniture production. A warehouse supports these production areas in addition to upholstery and sewing shops by receiving and storing raw materials, storing and shipping finished product and storing some work-in-process inventory. Additional materials are stored in a separate location because they do not currently fit in the warehouse. The objective of this project is to study the material storage and transportation needs of the operation and devise a new storage system subject to the constraints of the facility, including allowing adequate security camera visibility. Ideally, the client would like to bring all material storage into the one location. A simple inventory control system is also needed to track inventory levels and ensure the right amount of the right materials is on-hand.

MCE will provide a standard product list with historical demand data, materials needs for each product, and a floor plan of the warehouse. Access to the site will be supervised by a civilian employee of MCE.

**Project C:** Design of Product Delivery Solution for Automated Storage and Retrieval System

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**Description:** Bastian Labs, the Boise location of Bastian Solutions, is a research and development facility specializing in various applications of industrial automation. They are currently developing an automated storage and retrieve system (AS/RS) in which a shuttle places and retrieves products by navigating a grid system of storage locations. There will be multiple shuttles operating in the grid at the same time. The grid accommodates two bin sizes (7.5” x 16.5” x 28” and 7.5” x 16.5” x 28”) holding products that range in size from 0.5 in<sup>3</sup> to roughly 700 in<sup>3</sup>. The company currently has solutions under development for the shuttle design, grid system and associated controls. However, at the present time they do not have a solution to deliver product from the grid to a shipping dock or other warehouse location.

The objective of this project to is investigate different solutions for getting product from the perimeter of the AS/RS grid to a shipping truck. This would include offloading product from the shuttle, transporting it to a shipping dock, and (potentially) loading a trailer. The recommended solution must be suitable or easily configured for a range of customer needs, including a range of product throughput and transportation distances. The company would like to have a simulation model of the solutions for comparison and refinement as well as a detailed economic

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analysis of the different options investigated. They also expect that recommended solutions will have worker safety and ergonomics built in. All of these will be useful selling points for future customers.

**Project D:** Efficiency Study of Campus Mail Services

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**Description:** MSU Mail Services processes all incoming mail from the United States Postal Service (USPS) for the entire campus and MSU entities located near campus, delivers mail to and collects mail from departments, and processes all outgoing mail including bulk mail from individual departments such as Admissions. In addition, they operate a USPS retail window that is open the public and a passport office. The 11 dedicated employees provide a vital service to the campus community and strive to maintain a high level of timeliness and quality in their processing and delivering of mail.

This project has a two-fold objective. The first objective is an overall assessment of mail operations to identify potential opportunities to improve efficiency and quality. Operations to be considered include sorting and bundling of incoming mail, delivery routes, sorting and processing of outgoing mail, and retail operations.

The second objective is to address one of the department's biggest pain points: calls from departments concerning the whereabouts of a particular piece of mail. One potential solution is a mail tracking system to track department deliveries (currently being investigated), but other solutions may be possible. The senior design team will investigate the root causes of the issue, identify potential solutions (likely including a mail tracking system), analyze feasibility and make recommendations.

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**Project E:** Increasing Production Throughput at a Metal Fabrication Facility

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**Description:** Montana Steel Industries (MSI) fabricates structural steel and other products for the construction industry in their shops located a few miles north of Belgrade, MT. Based on architectural and construction drawings they receive from their clients, they design and engineer steel structures, procure raw materials, fabricate the components to client specifications, and deliver them to the construction site. Fabrication consists of cutting the raw material to length on a bandsaw, drilling holes using a CNC drill line, welding flanges and plates to the main structure, grinding down welds if needed, and painting/coating if needed. Plates and flanges are cut on a CNC plasma cutting the shop next door.

Business growth has reached a point where production capacity is being limited by the existing facility size and setup. A new facility is planned for some recently purchased land, but the company is not yet ready to build. Thus, in the meantime, MSI owners desire to become more efficient with their space and operations.

One of the challenges of this project is defining a good efficiency measure for the job shop – every job is different and there are no time standards for jobs in the shop. A second challenge is that the material is massive, so all material handling is accomplished by overhead crane or forklift. A third challenge is painting and coating, which is done outside in the yard in good weather, but is brought into the shop (or not done at all) during inclement weather.

The design team is therefore expected to analyze the current fabrication operations, identify the bottleneck resources, and generate low-capital solutions to increase fabrication capacity and therefore throughput. The team will need to demonstrate a solid business case for all recommendations in addition to engineering analysis or simulation to demonstrate the benefit to the company.

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**Project F:** Improving First Pass Yield of Solid-State Laser Production

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**Description:** Quantel USA manufactures high power solid-state lasers for industrial, medical, scientific and defense/security applications in Bozeman, Montana. Due to the nature of these markets, their products are built-to-order in a high-mix / low-volume manufacturing environment.

Company leadership desires to further improve the first pass yield (FPY) of laser production. The project will entail standing up a FPY metric based on an assessment of existing production and quality systems. Once set up, data will need to be collected over a specified number of weeks, during which time the team is expected to observe and analyze the existing laser production process. The data will be analyzed for trends and the opportunities for improvement prioritized based on impact on cost, lead time, reduction in rework or other factors important to the business. After conducting a root cause analysis, the team will develop one or more solutions to the top priority issues, and present their recommendations (with justification) in an on-site presentation to management.

**Project G:** Optimizing Snow Plow Routes

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**Description:** The City of Bozeman faces a significant challenge every winter in keeping city roads clear of snow and ice. When a significant snow event occurs, the city's 8 plow trucks will start plowing as early as 3:00 a.m. to clear the high priority streets, ideally by 7:00 a.m. before morning traffic gets busy. Depending on the nature of the snow event, they may continue plowing throughout the day. Over the years, as the city has grown, so has the amount of snow plowing. Routes have been added and expanded to meet the

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growth. But currently, the Bozeman Street Department is not sure that the routes in use are optimal. Thus the first priority for this project is to develop optimized snow plow routes for the priority snow removal streets (see: <https://www.bozeman.net/government/streets/snow-plowing>).

The client is interested in optimized routes for the 8 plow trucks they currently own, with a goal of clearing all priority streets in 3-4 hours when a major snow event occurs. A simulation model that incorporates the variability of different snow amounts, traffic congestion, and other uncertainties would be beneficial for estimating how well the recommended routes meet the goal and for resource planning.

A second priority for this project is to similarly optimize routes for residential city roads.

**Project H:** Layout Planning of the Habitat for Humanity Restore

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**Description:** The Habitat for Humanity of Gallatin Valley provides a helping hand-up to families by building affordable, decent homes in partnership with the families and the broader community. The ReStore sells new and gently-used furniture, building materials, tools, appliances and home goods to the public at a fraction of the retail price. Proceeds from sales are used to fund the organization's affordable homeownership and home repair programs.

The Restore currently occupies about 15,500 ft<sup>2</sup> in Belgrade, MT, and turns over approximately \$300K in sales annually. Given the constant flux in donations and mix of products and materials, the Restore faces significant challenges in how to best utilize their space for donations processing, inventory storage, product display, customer flow, material flow and efficient store operation. In this project, the engineering team will assess current space utilization and flow, and recommend changes to increase productivity of Restore personnel and product throughput. In addition, the organization may consider relocating non-Restore office personnel to a different site. Management is interested in an evaluation of such a decision, including how that space could be used. Expected deliverables include a proposed store layout, recommended space management plan and additional recommendations for efficient store operation.