Portfolio for
Integrated Program/Project Management and Capstone Experience and
Independent Undergraduate and Graduate Industry Projects

Preparing students for management, engineering, and technology practices through engaging in “real world” experiences has been the major focus of my efforts in conducting the Integrated Program/Project Management and Capstone.

Capstone experience includes engagement of students in real-world projects performed on behalf of real-world business and industrial clients. The capstone experience draws upon combinations of all the intended academic knowledge and skill outcomes. It integrates research, proposal development, and design experience based on the knowledge and skills acquired in earlier coursework. The capstone experience also incorporates standards and realistic constraints. To succeed in capstone, students must demonstrate professional competence through the accomplishment of work activities for business and industrial clients. They are required to collaborate as a team to apply their knowledge, think critically, and complete activities.

I also use other opportunities to engage students in business/industry projects. Since spring of 2010, teams of senior level and graduate students have been involved in conducting industry projects as part of individual study courses addressing client needs. The following pages are the posters for some of the projects that were conducted during my service at North Dakota State University by students under my supervision. Each poster summarizes project objectives, deliverables, project team members, and other relevant information.

Thanks for visiting this site,

Reza A. Maleki

Updated May 10, 2012
Aluminum Pneumatic Bulker (APB) Piping Supplier Analysis

Project Objectives
• Explore opportunities to improve/replace current supplier
• Standardize APB piping through the reduction of design

Project Team Deliverables
• Current piping system analysis
• Alternate piping system analysis
• Improvement proposals
• Recommendations based off of economic analysis
• Installation plan
• Recommendations for future projects/improvements

Recommendation
Alternate Piping Supplier and kitted piping parts

Yearly Labor Savings $476,000
Yearly Supplier Cost Increase ($300,000)
Total Savings/Year $176,000

Potential Benefits
• Reduce piping inventory
• Reduce labor hours
• Welding capacity increased by 6 aluminum-welders per year
• Increased trailer throughput
• Decrease in floor space

Reductions
<table>
<thead>
<tr>
<th>Area</th>
<th>Current</th>
<th>Proposed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production time</td>
<td>22.75 hrs</td>
<td>3.5 hrs</td>
</tr>
<tr>
<td>Production lead time</td>
<td>23.5 days</td>
<td>3.25 days</td>
</tr>
<tr>
<td>Floor space savings</td>
<td>800 sq-ft</td>
<td>400 sq-ft</td>
</tr>
</tbody>
</table>

Project Team Members: Alex Anderson, Mark Hendrickson, Michael Schnepf, Luisa Torres.
Faculty Advisor and Consultant: Reza Maleki
Department: Industrial and Manufacturing Engineering
Funding Source: Trail King Industries

Integrated Program/Project Management and Capstone Experience

Spring Semester 2012
Project Objective:
The purpose of this project is to study and standardize the APB piping through the reduction of design and specification variations. Also, explore an alternative piping supplier while evaluating their quality and availability benefits compared to current supplier.

Deliverables:
- Documentation of current piping design variations.
- Development of standardized piping specifications and alternative piping suppliers.
- Economic analysis of standardized piping specifications and alternative piping suppliers.
- Documentation of economic benefits that may result from implementing proposed suggestions.
- An outline of recommendations for future projects and improvements.

Spring Semester 2012
Integrated Program/Project Management and Capstone Experience
Research Project Objective
The project objective is to improve the utilization of the warehouse space by organizing parts and providing a new layout.

Deliverables
Documentation of current warehouse layout and information flow, economic analysis, Implementation plan, and future project recommendations.

<table>
<thead>
<tr>
<th>Problems</th>
<th>Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor Utilization of racking space</td>
<td><img src="image" alt="Star" /></td>
</tr>
<tr>
<td>Storage of Excess inventory</td>
<td><img src="image" alt="Star" /></td>
</tr>
<tr>
<td>Inaccurate Location of parts</td>
<td><img src="image" alt="Star" /></td>
</tr>
<tr>
<td>Underutilization of warehouse area</td>
<td><img src="image" alt="Star" /></td>
</tr>
</tbody>
</table>

Potential Benefits
- Reduced the warehouse footprint (~25%)
- High racking system utilization
- Accurate part location easy to pick up
- Availability to add an additional production line providing potential increased profits of $64,000 per week.
Project Objective
Improve the productivity of Trail King’s warehouse operations including layout, space utilization, information flow, and material handling

Deliverables
Documentation of:
• Current warehouse operations
• Improved warehouse operations
• Cost savings
• Recommended procedure for implementation

<table>
<thead>
<tr>
<th>Problem/Proposal Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposals</td>
</tr>
<tr>
<td>Problems</td>
</tr>
<tr>
<td>1. Material handling</td>
</tr>
<tr>
<td>2. Inventory Quantities</td>
</tr>
<tr>
<td>3. Storage System</td>
</tr>
<tr>
<td>4. Layout Design</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Proposals</th>
<th>Description</th>
<th>Space Saving (ft²)</th>
<th>Cost Avoidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Rearrange inventory and condense racking space</td>
<td>1,398</td>
<td>$136,225</td>
</tr>
<tr>
<td></td>
<td>Reduce the total number of racks</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Relocate office and dust collectors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Use narrow aisle life truck</td>
<td>1,008</td>
<td>$13,025</td>
</tr>
<tr>
<td></td>
<td>Use narrow racking system</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Relocate office and dust collectors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AB</td>
<td>Combination of proposal A and proposal B</td>
<td>2,118</td>
<td>$124,025</td>
</tr>
<tr>
<td>BC</td>
<td>Combination of proposal B and proposal C</td>
<td>1,547</td>
<td>$61,665/$64,036</td>
</tr>
<tr>
<td>ABC</td>
<td>Combination of proposal A, proposal B, and proposal C**</td>
<td>2,488</td>
<td>$152,236/$154,607</td>
</tr>
<tr>
<td>ABC+Dust Collectors + Office Pod</td>
<td>Combination of Proposals A, B, C and the removal the dust collectors and office pod**</td>
<td>3,238</td>
<td>$81,089/$83,469</td>
</tr>
</tbody>
</table>

Spring Semester 2012
Integrated Program/Project Management and Capstone Experience
Project Objective
The purpose of this project is to study, analyze, and document the current pipe and tube storage and handling process and develop proposals for improvements.

Project Team Deliverables
Documentation of
- Current Processes
- Process Improvements
- Labor and Space Savings
- Implementation Plan
- Outline for Future Projects

Benefits
- Improved space utilization
- Reduce labor time
- Better material handling
- Improved information flow

<table>
<thead>
<tr>
<th>Space Not Fully Utilized</th>
<th>Move Current Racks</th>
<th>Add Labeling System</th>
<th>Adapt Current Racks</th>
<th>Information Timing</th>
<th>Bar and Tube Cart</th>
<th>Crane Attachment Device</th>
<th>Proposed Outdoor Layout</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generalized Stock Location System</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unprotected Storage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-centralized Storage Locations Outside</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Specific Order for Cutting Parts</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Information Delay</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Hazardous Driving Conditions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Inefficient Material Handling Equipment</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Current Layout

Proposed Layout

Multi-directional Forklift

Project Team Members: Joshua Mangahas, Yongshin Park, David Rokenbrodt, Joseph Wolverton
Faculty Advisor and Consultant: Reza Maleki
Department: Industrial and Manufacturing Engineering
Funding Source: Trail King Industries

Spring Semester 2012
Integrated Program/Project Management and Capstone Experience
Project Objective
Study, analyze, and document the material handling, information flow, and develop a proposal for improvements.

Project Deliverables
- Understand the current processes
- Recommend ways to improve material handling/storage.
- Demonstrate economic benefits that may occur.
- Outlines procedures for implementing the proposal.

Potential Benefits
- More floor space in the plant
- Reduce material damage
- Faster loading and delivering time
- More condensed storage and space utilization
- Reduce time waiting for material
- Increase saw operator utilization

Economic Analysis
- Initial Costs: $142,397
- Annual Costs: $31,000
- Annual Savings: $79,750
- Payback Period: 2.92 yrs.

Spring Semester 2012
Integrated Program/Project Management and Capstone Experience
PROJECT OBJECTIVE
The purpose of this project is to study, analyze and provide documentation to improve the overall efficiency of the paint system.

PROJECT DELIVERABLES
• Documentation of the current system
• Documentation pertaining to research of paint system options
• Documentation of proposals with improvements to the paint system
• Documentation of cost and time savings Documentation outlining steps for implementing proposals
• An outline of recommendations for future improvements and projects

<table>
<thead>
<tr>
<th>Solutions</th>
<th>Current</th>
<th>Proposed</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultimate Steelhead</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Robotic Wheel Alignment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Invert Paints</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Installing Materials</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemical Retardant Technology</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WebBank TruTime, Core Chipping</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3M Duct Tape Protection System</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lift UPS X/Max Load Lift</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard Paint Colors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Invert Paint Sprayer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Utilization of Paint Pumps</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Documentation</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Potential Profits Resulting from Increased Throughput:

<table>
<thead>
<tr>
<th>Trailers/Year</th>
<th>Current</th>
<th>Proposed</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>522</td>
<td>1,721</td>
<td>1,199</td>
</tr>
<tr>
<td>Materials Cost/Year</td>
<td>$49,543</td>
<td>$709,052</td>
<td>$659,509</td>
</tr>
<tr>
<td>Labor /Year</td>
<td>$177,866</td>
<td>$363,836</td>
<td>$185,970</td>
</tr>
<tr>
<td>Add. Worker Costs/Year</td>
<td>$0</td>
<td>$169,128</td>
<td>$169,128</td>
</tr>
<tr>
<td>Avg Profit/Trailer</td>
<td>$8,000</td>
<td>$8,000</td>
<td>0</td>
</tr>
<tr>
<td>Revenue/Year</td>
<td>$4,176,000</td>
<td>$13,768,000</td>
<td>$9,592,000</td>
</tr>
<tr>
<td>Profit/Year</td>
<td>$3,948,591</td>
<td>$12,525,984</td>
<td>$8,577,393</td>
</tr>
</tbody>
</table>

Duration of Overall Paint System – Current vs. Proposed:

Spring Semester 2012

Integrated Program/Project Management and Capstone Experience
Paint System Throughput Improvement

Project Objective:
Study and analyze the current paint system then develop proposals that will increase the paint system’s throughput without major capital expenses

Deliverables:
- Documentation of
  - Current processes
  - Layouts
  - Proposals
  - Cost savings of proposals
  - Implementation plans
  - Recommendation for future projects

<table>
<thead>
<tr>
<th>Paint System Area</th>
<th>Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prep</td>
<td></td>
</tr>
<tr>
<td>Pre-Wash</td>
<td>Poor method for removing weld splatter</td>
</tr>
<tr>
<td>Masking</td>
<td>Poor method for masking trailer hubs</td>
</tr>
<tr>
<td></td>
<td>Parts hanging process is inefficient</td>
</tr>
<tr>
<td>Paint</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Poor lighting/long paint inspection</td>
</tr>
<tr>
<td></td>
<td>Low end solvent used to clean paint lines</td>
</tr>
<tr>
<td>General</td>
<td>Workers drifting into other areas</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Proposal</th>
<th>Cost</th>
<th>Yearly Time Savings (hours)</th>
<th>Yearly Labor Savings</th>
<th>Payback Period (years)</th>
<th>Throughput Increase per week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pneumatic Chipping Tool</td>
<td>$45</td>
<td>146</td>
<td>$4,010</td>
<td>0.011</td>
<td>1 trailer</td>
</tr>
<tr>
<td>Standardized Paint Rack</td>
<td>$3,185</td>
<td>176</td>
<td>$4,840</td>
<td>0.66</td>
<td>1 trailer</td>
</tr>
<tr>
<td>Bag Hub Masking</td>
<td>$1,500</td>
<td>390</td>
<td>$10,700</td>
<td>0.14</td>
<td>4 trailers</td>
</tr>
<tr>
<td>Inspection Lighting</td>
<td>$380</td>
<td>87.5</td>
<td>$2,406</td>
<td>0.15</td>
<td>1 trailer</td>
</tr>
</tbody>
</table>

| Cost Avoidance and Throughput Increase Resulting from Standardize Work Schedule | $1,815,000 | 17 |

Potential Benefits:
- Ergonomically sound working methods
- Time and labor savings
- Increased throughput
- Reduced material handling
- Higher quality paint job
- Organized job assignment and schedule

Spring Semester 2012

Integrated Program/Project Management and Capstone Experience
Analysis of Proposals for Dedicated Production Centers

PROJECT OBJECTIVE
The purpose of this project is to study, analyze and document proposals which can more efficiently utilize plant floor space through the implementation of target production centers in coordination with the Mitchell, South Dakota plant.

TEAM DELIVERABLES
Documentation of current production system, target products identification, economic benefits, steps for implementation

<table>
<thead>
<tr>
<th>Production Shifting</th>
<th>West Fargo</th>
<th>Mitchell</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-Beams</td>
<td>Produced</td>
<td></td>
</tr>
<tr>
<td>Axles</td>
<td>Assembled</td>
<td></td>
</tr>
<tr>
<td>Tires</td>
<td>Mounted</td>
<td></td>
</tr>
</tbody>
</table>

Potential Benefits from Freeing-up Axle Area and Installing Weld Stations in the I-Beam Area.
- Increases production & Profit
- Freed-up Floor Space
- $32,000/week increased profit
- 3 weeks Payback Period

Comparison of Reutilization Alternatives

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free up Axle assembly &amp; I-Beam production areas</td>
<td>Low overhead</td>
</tr>
<tr>
<td>Free up axle assembly area &amp; install weld stations</td>
<td>Large cost avoidance</td>
</tr>
<tr>
<td>Increases production &amp; profit</td>
<td>No additional production</td>
</tr>
<tr>
<td>Short payback period</td>
<td>Requires future reutilization</td>
</tr>
<tr>
<td>High overhead</td>
<td>Line rebalancing &amp; bottlenecks</td>
</tr>
</tbody>
</table>

Spring Semester 2012
Integrated Program/Project Management and Capstone Experience
TRAIL KING industries

Analysis of Proposals for Dedicated Production Centers

PROJECT OBJECTIVE:
Analyze the costs and benefits associated with dedicating the production of target components

DELIVERABLES:
Documentation of:
- Current layout and processes
- Identification of target components
- Proposed layout reflecting utilization of production centers
- Proposed transportation methods
- Economic analysis
- Implementation plan
- Recommendations for future improvements

RECOMMENDATIONS
- Expand APB production – West Fargo
- Aluminum machining center – West Fargo
- Small steel part production – Mitchell
- Reduce shipping costs by using suppliers
- Outsource axle assembly

West Fargo’s Shipment to Mitchell Plant

Mitchell Facility’s Shipment to West Fargo Facility

<table>
<thead>
<tr>
<th>Item</th>
<th>Fixed Benefit (Cost) ($)</th>
<th>Annual Benefit (Cost) ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor Reduction - Axles</td>
<td></td>
<td>8,800</td>
</tr>
<tr>
<td>Labor Reduction - I-Beams</td>
<td></td>
<td>34,375</td>
</tr>
<tr>
<td>Shipping - Material Handling</td>
<td></td>
<td>(5,500)</td>
</tr>
<tr>
<td>Shipping - Fixtures</td>
<td>(11,400)</td>
<td></td>
</tr>
<tr>
<td>Transportation*</td>
<td>(150,000)</td>
<td>(130,375)</td>
</tr>
<tr>
<td>Shipping Cost Avoidance</td>
<td></td>
<td>255,200</td>
</tr>
<tr>
<td>Shipping Components to Mitchell</td>
<td></td>
<td>(50,000)</td>
</tr>
<tr>
<td>Equipment Removal</td>
<td>(25,000)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>(186,400)</td>
<td>112,500</td>
</tr>
<tr>
<td>Space Saved</td>
<td>3875 ft²</td>
<td></td>
</tr>
</tbody>
</table>

Payback period: \[
\frac{Total \ Fixed \ Cost \ ($)}{Annual \ Savings \ ($)} \approx 1.7 \ years
\]

Spring Semester 2012

Integrated Program/Project Management and Capstone Experience
Improving In-House Belt Manufacturing and Analysis for Outsourcing

**Project Objective**
Develop proposals that can help with improved belt manufacturing including processes and layouts. This project also includes studies of potential outsourcing of belt manufacturing.

**Project Team Deliverables:** Documentation of:
- current processes and layout
- proposals for improved process and layout
- outsourcing potential
- economic analysis
- Implementation of new processes and layouts

**Project Team Members:** Tucker Richardson, Hanxiao Tian, Patrick Whelan, Aaron Woytcke.

**Faculty Advisor and Consultant:** Reza Maleki

**Department:** Industrial and Manufacturing Engineering

**Funding Source:** Trail King Industries

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**Spring Semester 2012**

**Integrated Program/Project Management and Capstone Experience**

**Benefits Summary**

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time Saved/Belt</td>
<td>38.21 min</td>
</tr>
<tr>
<td>Savings per year</td>
<td>$15,417.30</td>
</tr>
<tr>
<td>Payback Period</td>
<td>2.59 Years</td>
</tr>
<tr>
<td>Potential Throughput Increase</td>
<td>&gt; 100%</td>
</tr>
<tr>
<td>Space Saved</td>
<td>665 Sq. Ft. (45%)</td>
</tr>
</tbody>
</table>
Improving In-House Belt Manufacturing and Analysis for Outsourcing

Project Objectives
• Improve processes and equipment
• Analyze feasibility of outsourcing

Team Deliverables
• Documentation of current process
• Economic analysis
• Recommendations
• Implementation Plan
• Future Recommendations

Project Team Members: Thomas Schantz, Ryan Tapper, Kathryn Whelan, Yang Yang.

Faculty Advisor and Consultant: Reza Maleki

Department: Industrial and Manufacturing Engineering

Funding Source: Trail King Industries

Proposed Layout

Project Objectives

Summary of Potential Benefits
• Reduced footprint by 31%
• Decreased process time by 1.61 hr./belt
• Improved ergonomics
• Decreased material movement

Time Per Belt (hr.) | Avg. $ Per Belt | Total $ Per Yr.
--- | --- | ---
Current Process | 4.24 | $350 | $53,533
Proposed Process | 2.63 | $217 | $33,188
Savings | 1.61 | $133 | $20,345

Payback period = \( \frac{\text{Initial Cost}}{\text{Yearly Savings}} = \frac{\$30,447}{\$20,345} \approx 1.5 \text{ years} \)

Integrated Program/Project Management and Capstone Experience

Spring Semester 2012
Analysis and Selection of Food Packaging and Seasoning Equipment

Project Research Objective
To develop proposals that can help with improved throughput of the packaging equipment used in the facility.

Deliverables
- Documentation and analysis of current processes including information flow, facility layout, and processes lead times.
- Documentation of requirements for improving the throughput of packaging equipment.
- Documentation of economic benefits.

Productivity Improvement of Packaging Machine
- Extra weighing bucket can reduce the cleaning and washing time.
- Industrial washer can reduce washing time and help to increase production.
- Improved production planning can increase the production rate.
- Various combinations of linear and main feed parameters (amplitude and time) may help to increase efficiency and hence productivity.
- Upfront calculation of packaging time can help with better scheduling and improved throughput.
- Reducing setup time will increase the production rate.
- Continuous supply of seeds can increase machine utilization and improve productivity.

Three (3) Major Opportunities for Productivity Improvement
- Extra packaging machine buckets for select machines.
- New Industrial washer and dryer.
- New production planning to reduce setup time.
Improving Allocation of SKUs to Distribution Centers

Research Project Objective
The purpose of this project is to assist with developing proposals for allocating the SKUs to Harrisburg and Sparks centers so they can achieve the SHP’s goal of meeting the target percentage for processing and shipping “complete” orders to customers in their regions.

Deliverables
- Documentation and analysis of current orders from customers that are targeted to be served by the Harrisburg and Sparks “centers.”
- Documentation and analysis of SKUs allocated to the centers.
- Documentation of proposals that can help with improved allocation of SKUs to the centers.

Flow Chart for SKU Selection and Allocation

| Project Team Members: Vaibhav Biradar. |
| Faculty Advisor and Consultant: Reza Maleki |
| Department: Industrial and Manufacturing Engineering |
| Funding Source: Giant Snacks |

Fall Semester 2011
Integrated Program/Project Management and Capstone Experience
Research Project Objective
The purpose of this project is to study, document, and analyze the facility’s frying process emissions, as well as calculate the current emission levels for a typical day of production.

Deliverables
- Documentation of:
  - Research on Clean Air Act and MPCA Standards and Regulations
  - Frying Processes That Use Oil (Flow Charts)
  - Traditional Potato Chips
  - Tortilla Corn Chips
  - Kettle-Cooked Potato Chips
  - Calculations of Current Emission Levels
- Recommendation for Acquiring Air Permit

Project Activities
- Researched Particulate Matter Emissions PM-10 & 2.5 for Frying Process.
- Documented the Barrel O’ Fun Frying Processes and Estimated a Typical Day of Emissions
- Analyzed Other Filtration Systems to Reduce Emissions in Future
  - Scrubbers
  - Mist-Eliminators
  - Impingement Devices

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Total Facility PTE* Thresholds (tons per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM10</td>
<td>Federal: 100 State: 25</td>
</tr>
<tr>
<td>PM2.5</td>
<td>100</td>
</tr>
</tbody>
</table>

*PTE = Potential to Emit

Project Results
The results show that Barrel O’ Fun’s meets state and federal requirements for process emission.

Project Team Members:
Kirsten Kelly, Chance Krom, Tom Swenson, Jianchao Xiao

Faculty Advisor and Consultant:
Reza Maleki
Email: Reza.Maleki@ndsu.edu

Department:
Industrial and Manufacturing Engineering

Funding Source:
Barrel O’ Fun

Integrated Program/Project Management and Capstone Experience
Project Objectives:
- Observe and document current layout and labor practices
- Establish packaging and layout standards

Project Deliverables:
- Documentation of current system
- Proposal of improvements
- Economic analysis

Potential Benefits:
- More consistent and predictable packaging rates
- Improved production planning
- Increase in throughput

Spring Semester 2011

Integrated Program/Project Management and Capstone Experience
**Project Objectives:**
- Study, document and analyze current setup procedures
- Improve Seasoning line capacity

**Team Deliverables:**
- Documentation of current setup procedures
- Documentation of proposed setup procedures
- Documentation of cost savings
- Recommendations for future projects and improvements

**Project Activities:**
Researched and developed improved setup processes

**Current Wipeout Times:**

<table>
<thead>
<tr>
<th>Task Name</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wipeout Front Conveyor</td>
<td>1.1 mins</td>
</tr>
<tr>
<td>Wipeout Rear Conveyor</td>
<td>2 mins</td>
</tr>
<tr>
<td>Wipeout Scale</td>
<td>10.8 mins</td>
</tr>
<tr>
<td>Wipeout Seasoning Hopper</td>
<td>4.5 mins</td>
</tr>
<tr>
<td>Wash Seasoning Drum</td>
<td>11.6 mins</td>
</tr>
</tbody>
</table>

**Proposed Wipeout Times:**

<table>
<thead>
<tr>
<th>Task Name</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wipeout Front Conveyor</td>
<td>1.1 mins</td>
</tr>
<tr>
<td>Wipeout Seasoning Hopper</td>
<td>4.5 mins</td>
</tr>
<tr>
<td>Wipeout Scale</td>
<td>7 mins</td>
</tr>
<tr>
<td>Wash Seasoning Drum</td>
<td>6 mins</td>
</tr>
</tbody>
</table>

**Potential Profit Gain**

- Wipeout 3 ppl
- Wipeout 2 ppl
- Washout 3 ppl
- Washout buckets

**Project Benefits:**
- Capacity increase for traditional and kettle chip seasoning lines
- Potential Profit gain
- Labor savings
- Improved utilization of resources

**Project Team Members:** Andrew Lembcke, Xing Zhuang, Shuang Shi, Andy Ryan
**Faculty Advisor and Consultant:** Reza Maleki
**Email:** Reza.Maleki@ndsu.edu
**Department:** Industrial and Manufacturing Engineering
**Funding Source:** Barrel O’ Fun

**Integrated Program/Project Management and Capstone Experience**

**Spring Semester 2011**
Project Objective:
The purpose of this project is to study, analyze, and document proposals for improved tugger cart logistics.

Deliverables:
• Document current tugger cart flow
• Identify problems in the system
• Document proposals to improve tugger cart logistic
• Document economic benefits
• Outline recommendations for future projects and improvements

Proposals:
• Implement CNH Labor Scheduling at Mangum
• Implement Inventory Tracking System
• Staging Area Organization
• Follow designated CNH Routes
• Universal Cart Connection

Economic Analysis

<table>
<thead>
<tr>
<th>Proposal #1</th>
<th>Proposal #2</th>
<th>Proposal #3</th>
<th>Proposal #4</th>
<th>Proposal #5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Profit</td>
<td>NA</td>
<td>$15,714</td>
<td>$2,946.30</td>
<td>$11,460</td>
</tr>
<tr>
<td>Cost</td>
<td>NA</td>
<td>$5,080.88</td>
<td>NA</td>
<td>$450</td>
</tr>
<tr>
<td>Total</td>
<td>NA</td>
<td>$-5,080.88</td>
<td>$15,714</td>
<td>$2,496.30</td>
</tr>
</tbody>
</table>

Potential Benefits:
• Better employee utilization
• Better communication
• More room in the staging area
• More reliable cart connections
• Large amounts of time and money saved

Spring Semester 2011
Integrated Program/Project Management and Capstone Experience
Boeing 777F Roller Tray Assembly Line Design

Project Objectives
Develop an assembly line that:
- Supports TAKT Time
- Increases Labor Efficiency
- Improves Ergonomics
- Provides Visual Controls that Highlight Production Issue

Team Deliverables
Documentation of:
- Current Assembly Line
- Proposed Solutions
- Cost and Time Savings from Proposed Solutions
- Implementation Plan
- Recommendations

Proposed Solutions
1. Electronic Display for IP/SWIs
2. Ergonomic Tool Arm
3. Improved Work Cell Layout
4. Improved Workstation Design
5. Component Placement Display
6. Sealant Application
7. Cycle Time Reduction

System Metrics

<table>
<thead>
<tr>
<th></th>
<th>Current</th>
<th>Proposal #1</th>
<th>Proposal #2</th>
<th>Proposal #2 Rev 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Throughput/Day</td>
<td>10</td>
<td>18-20</td>
<td>16-18</td>
<td>23-26</td>
</tr>
<tr>
<td>WIP Cart</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td># of Workstations</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Square Feet Consumed</td>
<td>400</td>
<td>245.5</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td># of Workers</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Labor Cost/Day</td>
<td>$172.80</td>
<td>$172.80</td>
<td>$172.80</td>
<td>$345.60</td>
</tr>
<tr>
<td>Revenue/Day</td>
<td>$20K</td>
<td>$36K-$40K</td>
<td>$32K-$36K</td>
<td>$46K-$52K</td>
</tr>
</tbody>
</table>

Project Team Members: Marcus Bruhn, Lindsey Hermanson, Katie Roesler, Rob Strand, Chris Winning

Faculty Advisor and Consultant: Reza Maleki
Email: Reza.Maleki@ndsu.edu

Department: Industrial and Manufacturing Engineering
Funding Source: Goodrich

Project Benefits
- Reduce Labor Time
- Increase Capacity
- Meet Anticipated Growth in Demand
- Improve Profit Margin

Integrated Program/Project Management and Capstone Experience

Spring Semester 2011
**GOODRICH**

**Paint Line Analysis**

**Project Objective:**
Improve the efficiency and use of the paint line

**Deliverables:**
- Document current paint line operations
- Document researched paint system options
- Recommend proposals to improve the paint line
- Document potential economic benefits from proposals
- Develop a phased installation plan
- Recommended future projects and improvements

**Proposals:**
- Redesigned Facility Layout
- New Curing Ovens
- Color Coded PAA Paint Booth
- Ergonomic Material Handling Carts
- New Ergonomic Work Stations
- Color Coded Prep Work Instruction
- Multi Axis Tape Dispensers

**Benefits From Proposals**

<table>
<thead>
<tr>
<th>Process</th>
<th>Current/Proposed</th>
<th>Mfg. Lead Time (hr/batch.)</th>
<th>Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Current</td>
<td>7.17</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Proposed</td>
<td>6.18</td>
<td>0.99</td>
</tr>
<tr>
<td>2</td>
<td>Current</td>
<td>20.37</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Proposed</td>
<td>17.01</td>
<td>3.36</td>
</tr>
<tr>
<td>3</td>
<td>Current</td>
<td>43.28</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Proposed</td>
<td>39.41</td>
<td>3.87</td>
</tr>
<tr>
<td>4</td>
<td>Current</td>
<td>55.49</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Proposed</td>
<td>48.05</td>
<td>7.44</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td></td>
<td><strong>3.92</strong></td>
<td><strong>13%</strong></td>
</tr>
</tbody>
</table>

**Material Handling Savings**
- Travel Distance Saved: 15,816,120 ft.
- Time Saved: 2,746 hrs.
- **Annual Savings**: $123,563.44

**Economic Analysis Summary**
- Initial Investment: $422,737.50
- Annual Savings: $200,771.68
- Payback Period: 2.11 years
- **ROR**: 46.80%

**Current Layout**

**Proposed Layout**

**Exit to Assembly**

**Input from Process Line**

**Input from PAA Process Line**

**Spring Semester 2011**

**Integrated Program/Project Management and Capstone Experience**

**Project Team Members:** Jeff Schmaltz, Lars Peterson, Zach Bullinger, Conor Herron, Baird Cuppy

**Faculty Advisor and Consultant:** Reza Maleki
Email: Reza.Maleki@ndsu.edu

**Department:** Industrial and Manufacturing Engineering

**Funding Source:** Goodrich
Project Objective: Analyze and document services to discover opportunities for improvement in throughput.

Project Deliverables:
Documentation of:
✓ current practices and proposals for information and patient flow
✓ benefits analysis from implementation of the proposed suggestions
✓ recommendations for future projects and improvement

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Patients/Day</th>
<th>Patients/Year</th>
<th>$Daily Value</th>
<th>$Yearly Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Schedule</td>
<td>66</td>
<td>11,404</td>
<td>$5,478</td>
<td>$944,108</td>
</tr>
<tr>
<td>Purchase Printers</td>
<td>+12</td>
<td>+1,632</td>
<td>+$996</td>
<td>+$13,546</td>
</tr>
<tr>
<td>Nurse Pooling</td>
<td>+9</td>
<td>+1,465</td>
<td>+$747</td>
<td>+$12,848</td>
</tr>
<tr>
<td>Nurse and Provider Pooling</td>
<td>+24</td>
<td>+4,179</td>
<td>+$1,992</td>
<td>+$342,624</td>
</tr>
<tr>
<td>Staggered Lunch</td>
<td>+2</td>
<td>+410</td>
<td>+$166</td>
<td>+$28,607</td>
</tr>
<tr>
<td>Shifted 9-6</td>
<td>+4</td>
<td>+691</td>
<td>+$333</td>
<td>+$57,214</td>
</tr>
<tr>
<td>New Daily Schedule</td>
<td>+8</td>
<td>+1,338</td>
<td>+$665</td>
<td>+$11,442</td>
</tr>
<tr>
<td>Standardize patient questioning procedure</td>
<td>Improved throughput</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Audible Alert</td>
<td>Improved throughput</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fix or Discontinue use of expansion overhead light system</td>
<td>Improved throughput</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Recommendation Benefits:
✓ Reducing provider backtracking could allow for up to three more patients/provider/day
✓ First come first serve queuing in simulation helped to show benefits of pooled resources
✓ Better communication through questioning procedures and notification systems will reduce miscommunication occurrences and wait times
✓ Final recommendation allows for 87 patients per day or 22 patients per provider per day

Project Team Members: Ryan Adams, Cooper Anderson, Kayla Bergee, Evan Buchholz, Jacob Makuei
Faculty Advisor and Consultant: Reza Maleki
Email: Reza.Maleki@ndsu.edu
Department: Industrial and Manufacturing Engineering
Funding Source: NDSU Student Health Service

Spring Semester 2011
Integrated Program/Project Management and Capstone Experience
The Development and Documentation of an ESD Control Program

**Project Objective:** Construct an ESD control program so SJE Rhombus can meet certification requirements according to the ANSI/ESD S20.20 standard.

**Deliverables**
- Document current operations highlighting major ESD concern areas
- Construct ESD control program
- Create manuals/slideshows used to train Personnel
- Provide an outline of recommendations

**Weighted Recommendations Table**

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Scale (1-10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal Precautions/Good Practices</td>
<td>10</td>
</tr>
<tr>
<td>Smocks/Pinpoint Wrists Straps</td>
<td>9</td>
</tr>
<tr>
<td>Drop Chains</td>
<td>9</td>
</tr>
<tr>
<td>Electrostatic Protective Clothing</td>
<td>9</td>
</tr>
<tr>
<td>Electrostatic Sensitive Device Handling</td>
<td>9</td>
</tr>
<tr>
<td>Ionized Fans</td>
<td>9</td>
</tr>
<tr>
<td>Conductive/Non-Conductive Materials</td>
<td>9</td>
</tr>
<tr>
<td>Humidity Control</td>
<td>9</td>
</tr>
</tbody>
</table>

**Level One:** Full ESD Protection (Heel and Wrist Strap with Smocks)

**Level Two:** Moderate ESD Protection (Heel Strap and Smock)

**Level Three:** Slight ESD Protection (Smock)

**Overview of ESD Control Program Document**
- Purpose
- Scope
- Responsibilities
- Applicable Documents
- Definitions

**ESD Control Program Plan**
- Basic Control Standards
- General Guidelines

**Training Plan**
- Training Requirements
  - What is Covered in Training
  - How Often Training is Required

**Compliance Verification**
- ANSI Technical Requirements
- Testing of Grounding Equipment
- Workstation Requirements

**Project Team Members:** Cory Kiemele, Matt Roberts, Laura Vaske, Yachao Wang

**Faculty Advisor and Consultant:** Reza Maleki

**Email:** Reza.Maleki@ndsu.edu

**Department:** Industrial and Manufacturing Engineering

**Funding Source:** SJE Rhombus

**Spring Semester 2011**

**Integrated Program/Project Management and Capstone Experience**
Project Objective
The purpose of this project is to study, analyze, and document proposals which can help Tecton with improved manufacturing, warehousing and distribution of APEX siding systems.

Project Team Deliverables
Documentation of...
- Current warehouse layout and practices
- Current process for assembling marketing kits
- Proposed improvements
- Proposed cost savings
- An outline of recommendations for future project

### Opportunities

<table>
<thead>
<tr>
<th>Opportunities</th>
<th>New Warehouse Layout</th>
<th>Racking System</th>
<th>Redesign Workstation</th>
<th>New Mfg. Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excessive material handling</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Less than optimal space utilization</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Improper racking system</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Marketing Kits</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiple workstations</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lack of fluidity</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excessive operator travel</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Racking Systems

<table>
<thead>
<tr>
<th>Ease of Picking</th>
<th>Current</th>
<th>Cantilever Racks</th>
<th>Pallet Racks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material Handling</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Foot Print (Sq Ft)</td>
<td>1185</td>
<td>1755</td>
<td>2048</td>
</tr>
<tr>
<td>Cost</td>
<td>-</td>
<td>$56,681.64</td>
<td>$22,953.45</td>
</tr>
</tbody>
</table>

### APEX Siding

#### Total Saved

<table>
<thead>
<tr>
<th>Warehouse Layout</th>
<th>Total Saved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance (ft)</td>
<td>1583 (77%)</td>
</tr>
<tr>
<td>Space (Sq ft)</td>
<td>590.58 (12%)</td>
</tr>
<tr>
<td>Time (Min)</td>
<td>9.2/Order (48%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Marketing Kits</th>
<th>Total Saved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance (ft)</td>
<td>370 (84%)</td>
</tr>
<tr>
<td>Space (Sq ft)</td>
<td>242.3 (45%)</td>
</tr>
<tr>
<td>Time (Min)</td>
<td>1.28/Kit (29%)</td>
</tr>
</tbody>
</table>

### Benefits
- Reduced material handling
- Better space utilization
- Balanced manufacturing processes
- Reduced manufacturing lead time
- Reduced order picking time
Analysis of Dynamometer Process and Scheduling

Research Project Objective

• Analyze the current dynamometer and testing resources to develop a testing schedule for the demand for the next four years.
• Analyze the current development procedure and recommend changes that would allow for more testing or earlier completion dates.

Project Team Deliverables

• Documentation and analysis of current setup processes including information flow, facility and work force utilization, and test lead time.
• Documentation of proposals for improving engine dynamometer facility utilization.
• Documentation of economic benefits that may result from implementing proposed suggestions.

<table>
<thead>
<tr>
<th>Resource Needed for Dyno Cells (Solution 2, Snowmobile Group Dyno Status)</th>
<th>Total</th>
<th>Capital Cost</th>
<th>Operating Cost /Year</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dyno No.</strong></td>
<td><strong>Equipment Needed</strong></td>
<td><strong>Capital Cost</strong></td>
<td><strong>Operating Cost /Year</strong></td>
</tr>
<tr>
<td><strong>Dyno 1</strong></td>
<td>Data acquisition Software</td>
<td>$144,500</td>
<td></td>
</tr>
<tr>
<td>New Dyno</td>
<td>$53,675</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dyno Base</td>
<td>$8,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dyno Shaft</td>
<td>$4,500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel System Upgrade</td>
<td>$2,200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Operator</td>
<td>$0</td>
<td>$50,000</td>
<td></td>
</tr>
<tr>
<td><strong>Dyno 2</strong></td>
<td>Data acquisition Software</td>
<td>$144,500</td>
<td></td>
</tr>
<tr>
<td>New Dyno Base</td>
<td>$8,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dyno Shaft</td>
<td>$4,500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Dyno</td>
<td>$53,675</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emission Tester Cells 1 &amp; 2</td>
<td>$60,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Dyno 3</strong></td>
<td>Data acquisition Software</td>
<td>$151,000</td>
<td></td>
</tr>
<tr>
<td>New Operator</td>
<td>$0</td>
<td>$50,000</td>
<td></td>
</tr>
<tr>
<td><strong>Dyno 4</strong></td>
<td>Emission Tester Cells 3 &amp; 4</td>
<td>$210,000</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>$844,550</td>
<td>$100,000</td>
</tr>
</tbody>
</table>

Resource Needed for Dyno Cells (Solution 2, Snowmobile Group Dyno Status)

<table>
<thead>
<tr>
<th>No. of hours/Day</th>
<th>100%</th>
<th>90%</th>
<th>80%</th>
<th>70%</th>
<th>60%</th>
<th>50%</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>2.13</td>
<td>2.37</td>
<td>2.67</td>
<td>3.05</td>
<td>3.56</td>
<td>4.27</td>
</tr>
<tr>
<td>10</td>
<td>1.71</td>
<td>1.90</td>
<td>2.13</td>
<td>2.44</td>
<td>2.85</td>
<td>3.42</td>
</tr>
<tr>
<td>12</td>
<td>1.42</td>
<td>1.58</td>
<td>1.78</td>
<td>2.03</td>
<td>2.37</td>
<td>2.85</td>
</tr>
<tr>
<td>14</td>
<td>1.22</td>
<td>1.36</td>
<td>1.52</td>
<td>1.74</td>
<td>2.03</td>
<td>2.44</td>
</tr>
<tr>
<td>16</td>
<td>1.07</td>
<td>1.19</td>
<td>1.33</td>
<td>1.52</td>
<td>1.78</td>
<td>2.13</td>
</tr>
</tbody>
</table>

Spring Semester 2010

Individual Study Design Research Project
**Research Project Objective:**
The objective of this project is to develop a new layout for the shipping area that can help with improved operational efficiencies for production, storage and inventory management, and shipping.

**Team Deliverables:**
- Documentation of the following:
  - Current production, inventory management, and shipping practices.
  - Current facility layout.
  - Proposals for improving production, inventory management, and shipping practices
  - Improved layout alternatives
  - Estimated shipping labor requirements.
  - Economic analysis of proposals

**Benefits:**
The proposals can help with:
- Minimize labor required to ship product
- Adequate storage capacity during peak seasons
- Maintain a safe working environment
- Minimize capital expense
- Provides for First-In-First-Out inventory movements

**Project Team Members:** Benjamin Flotterud, John Koehler, Brandon Vold.

**Faculty Advisor and Consultant:** Reza Maleki
Email: Reza.Maleki@ndsu.edu.

**Department:** Industrial and Manufacturing Engineering

**Funding Source:** Phoenix International

---

**Graph:**
- Average time spent on computer
- Time to Configure Package
- Operator Movement and Handling
- Total time

---

**Spring Semester 2010**

**Individual Study Design Research Project**
Research Project Objectives

1) To study, analyze, and document proposals which can help improve the Emissions Testing Facility Utilization.
2) Research will be done to identify required equipment for Chassis Testing.

Team Deliverables

Documentation of:
1) Current testing processes.
2) Proposals for improved testing processes.
3) Specifications and Requirements of chassis testing equipment.
4) Economic benefits.
5) An outline of recommendations for future projects and improvements.

Project Team Members: Jared Wagner, Phillip Loy, Joe Marcella, Michael Sayler.
Faculty Advisor and Consultant: Reza Maleki, Email: Reza.Maleki@ndsu.edu.
Department: Industrial and Manufacturing Engineering
Funding Source: Arctic Cat

Project Benefits

1) Proposed recommendations can help Arctic Cat to better utilize the Emissions Test Facility.
2) Recommended Test equipment will allow Arctic Cat to continue and meet the future EPA emission regulations.

Spring Semester 2009

Integrated Program/Project Management and Capstone Experience
Engine Emissions Testing Facility Layout

**Research Project Objective**
- Analyze the current engine emission testing facility.
- Develop proposals to include chassis testing.

**Project Team Deliverables**
Documentation of:
- The current emission testing facility layout and procedures.
- Equipment, capacity, and space requirements.
- Proposals to accommodate both current and chassis testing.
- Recommendations for future projects and improvements.

### Functional Areas

<table>
<thead>
<tr>
<th>Functional Areas</th>
<th>Projected ft²</th>
<th>Alternative A</th>
<th>Alternative B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine Dynamometer</td>
<td>494</td>
<td>494</td>
<td>1000</td>
</tr>
<tr>
<td>Storage</td>
<td>668</td>
<td>0</td>
<td>668</td>
</tr>
<tr>
<td>Setup</td>
<td>446</td>
<td>450</td>
<td>800</td>
</tr>
<tr>
<td>Support Systems</td>
<td>378</td>
<td>378</td>
<td>378</td>
</tr>
<tr>
<td>Engine Receiving</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Field Test</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Chassis Dynamometer</td>
<td>828</td>
<td>828</td>
<td>1000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>2814</td>
<td>2150</td>
<td>3492</td>
</tr>
</tbody>
</table>

### Recommendation Criteria

<table>
<thead>
<tr>
<th>Recommendation Criteria</th>
<th>Weight</th>
<th>Alternative A Rating</th>
<th>Weighted</th>
<th>Alternative B Rating</th>
<th>Weighted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support Chassis Test</td>
<td>17</td>
<td>4</td>
<td>68</td>
<td>5</td>
<td>85</td>
</tr>
<tr>
<td>Effectiveness Setup Area</td>
<td>12</td>
<td>3</td>
<td>36</td>
<td>5</td>
<td>60</td>
</tr>
<tr>
<td>Sufficient Storage System</td>
<td>13</td>
<td>1</td>
<td>13</td>
<td>5</td>
<td>65</td>
</tr>
<tr>
<td>Updated Support Systems</td>
<td>17</td>
<td>5</td>
<td>85</td>
<td>5</td>
<td>85</td>
</tr>
<tr>
<td>Closeness of Engine Receiving</td>
<td>5</td>
<td>5</td>
<td>25</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>Closeness of Field Test</td>
<td>7</td>
<td>5</td>
<td>35</td>
<td>3</td>
<td>21</td>
</tr>
<tr>
<td>Possibility of Shared Resources</td>
<td>12</td>
<td>1</td>
<td>12</td>
<td>5</td>
<td>60</td>
</tr>
<tr>
<td>Ease/Cost of Implementation</td>
<td>13</td>
<td>1</td>
<td>13</td>
<td>4</td>
<td>52</td>
</tr>
<tr>
<td>Work Environment</td>
<td>5</td>
<td>3</td>
<td>15</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td>302</td>
<td>463</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Summary of Benefits**
- Reduce the number of engine testing cells from four to two.
- Have additional setup area to accommodate external setups.
- Create two chassis dynamometer cells to meet EPA requirements.
- Allow for shared resources with other departmental groups.
- Have sufficient storage with secure access.

**Project Team Members:** Peter Nelson, Robert Berg, Neil Viola.

**Faculty Advisor and Consultant:** Reza Maleki
Email: Reza.Maleki@ndsu.edu.

**Department:** Industrial and Manufacturing Engineering

**Funding Source:** Arctic Cat

---

**Integrated Program/Project Management and Capstone Experience**

Spring Semester 2009
Research Project Objectives

The purpose of this project is to study, analyze, and propose new methods for improving the fabrication of the Manhole-Assembly.

Project Deliverables

• Documentation of current production processes
• Recommendations for improving fabrication processes
• Economic Analysis
• Recommendations for future projects and improvements.

Economic Analysis

<table>
<thead>
<tr>
<th>Proposals</th>
<th>Initial Cost ($)</th>
<th>Recurring Cost ($)</th>
<th>Time Savings of Total Time (%)</th>
<th>Labor Savings ($/Assembly)</th>
<th>Payback Units (# of Assemblies)</th>
<th>Improve Environmental/Safety Factors?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cutting Templates</td>
<td>$63</td>
<td>-</td>
<td>8%</td>
<td>$14</td>
<td>5</td>
<td>Yes</td>
</tr>
<tr>
<td>CNC Rebar Forming</td>
<td>-</td>
<td>$17.60</td>
<td>8%</td>
<td>$23</td>
<td>Immediate</td>
<td>Yes</td>
</tr>
<tr>
<td>Spin Forming</td>
<td>-</td>
<td>$10.20</td>
<td>4%</td>
<td>-$3.70</td>
<td>N/A</td>
<td>Yes</td>
</tr>
<tr>
<td>Alternative Water Sealing</td>
<td>$260</td>
<td>$11.25</td>
<td>42%</td>
<td>$58.00</td>
<td>4</td>
<td>Yes</td>
</tr>
<tr>
<td>Standardized Work Methods</td>
<td>$90</td>
<td>-</td>
<td>86%</td>
<td>$600</td>
<td>Immediate</td>
<td>Yes</td>
</tr>
<tr>
<td>Reduce Number of Fasteners</td>
<td>0</td>
<td>$0.00</td>
<td>1%</td>
<td>$2</td>
<td>Immediate</td>
<td>Yes</td>
</tr>
<tr>
<td>Water-jet Cutting</td>
<td>$330,000</td>
<td>$25.00</td>
<td>12%</td>
<td>-$5.50</td>
<td>N/A</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Potential Benefits

Proposals: Standardized Processes → Reduced Welding
Intermediate Effects: Process Time → Improved Environmental/Safety Hazards
Outcomes: Throughout → Cost Savings

Spring Semester 2009
Integrated Program/Project Management and Capstone Experience

Project Team Members: Scott McCamy, Matt Antony, Chris Bingea.
Faculty Advisor and Consultant: Reza Maleki
Email: Reza.Maleki@ndsu.edu
Department: Industrial and Manufacturing Engineering
Funding Source: Johnston Fargo Culvert, Inc.
Research Project Objective: The objective of this project is to test and document the performance of various gaskets for a watertight CSP coupling system.

Deliverables:
- Documentation reflecting research and testing of the CSP joint system
- Documentation of recommendation for improving CSP joint system
- Recommendations for future projects and improvements

Project Work and Research Activities

**CSP Joint System**
- Band Design
- Gasket

**Testing**
- Development of Apparatus
- Testing, Data Collection, Analysis

**Recommendations**
- Band Design
- Gasket
- Cost Analysis
- Future Projects

Test Results and Recommendations

Various Bands and Gaskets were tested, but all failed to meet proposed standards. Based on tests performed and literature reviewed, a CSP Joint System Recommendation Matrix was developed.

CSP Joint System Recommendation Matrix

<table>
<thead>
<tr>
<th>Gaskets</th>
<th>Superior</th>
<th>Questionable</th>
<th>Poor</th>
<th>Incompatible</th>
</tr>
</thead>
<tbody>
<tr>
<td>Profile</td>
<td>Band Design</td>
<td>Band Design</td>
<td>Band Design</td>
<td>Band Design</td>
</tr>
<tr>
<td>Clamp</td>
<td>Band Angle</td>
<td>Log Angle</td>
<td>Bar and Strap</td>
<td>1 Place</td>
</tr>
<tr>
<td>Structure</td>
<td>Piano Hinge</td>
<td>Loose</td>
<td>Piano Hinge</td>
<td>Loose</td>
</tr>
</tbody>
</table>

Spring Semester 2009

Integrated Program/Project Management and Capstone Experience
Laminated Residential Garage Panel Assembly Line Analysis

Research Project Objective
Determine if the current residential laminated door panel assembly line has the capacity and capability to produce the commercial laminated door panels.

Project Deliverables
Documentation of:
- Residential line capability and capacity
- Residential and Commercial Door demand
- Proposal for modifications to Residential Line
- Economic analysis
- Future project recommendations

Potential Benefits
The proposed modifications will allow Midland to produce commercial door panels on the current residential assembly line. The modifications can help with cost savings as well meeting some growth in demand.

Spring Semester 2009
Integrated Program/Project Management and Capstone Experience

Project Team Members: Kevin Ronsberg, Kim Lammers, Erika Hedger, Adam Hilzendager

Faculty Advisor and Consultant: Reza Maleki
Email: Reza.Maleki@ndsu.edu.

Department: Industrial and Manufacturing Engineering
Funding Source: Midland Garage Door Manufacturing
Facility Layout Analysis and Improvements

RESEARCH PROJECT OBJECTIVE
To develop proposals for improving layout which will provide more efficient flow of product, reduced WIP, and improved manufacturing lead time.

PROJECT DELIVERABLES include documentation of:
• Current layout and production methods
• Improved layout
• Economic analysis

 Proposed Layout

Current Space Allocation

Proposed Space Allocation

Potential Benefits

Reduction of WIP allows space for future expansion
Decreasing travel distances will reduce material handling costs
Reduction of MIT allows for an increase in capacity
Increase in profit

Project Team Members: Kurt Semanko, Jacob Chan, Ray Berry, Sean Osowski
Faculty Advisor and Consultant: Reza Maleki
Email: Reza.Maleki@ndsu.edu
Department: Industrial and Manufacturing Engineering
Funding Source: Midland Garage Door Manufacturing Company

Integrated Program/Project Management and Capstone Experience

Spring Semester 2009
**Research Project Objective**
The purpose of this project is to study, document, analyze, and propose improvements for the facility layout and process systems.

**Deliverables**
- Documentation of:
  - Current facility layout and coating systems processes
  - Proposal for improvements
  - Analysis of the required space to meet the current and anticipated growth in demand
  - Economic impact of the proposed recommendations
  - Proposals for future projects

<table>
<thead>
<tr>
<th>Alternative Layouts</th>
<th>Monorail</th>
<th>Smal Utility Oven</th>
<th>Large Utility Oven</th>
<th>Wet Booth Memoral</th>
<th>Compatible</th>
<th>Small Powder Booth</th>
<th>Improved Vacuum</th>
<th>Equipment Movement</th>
<th>Expansion</th>
<th>Continuous Oven</th>
<th>Removal of wall</th>
<th>Vinyl Covering</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>500K</td>
</tr>
<tr>
<td>1</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>54K</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>225K</td>
</tr>
<tr>
<td>3</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>22K</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Capacity Increase</th>
<th>Payback Period (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Labor</td>
<td>Additional Labor</td>
</tr>
<tr>
<td>Alternate 1</td>
<td>56%</td>
</tr>
<tr>
<td>Alternate 2</td>
<td>96%</td>
</tr>
<tr>
<td>Alternate 3</td>
<td>96%</td>
</tr>
</tbody>
</table>

**Potential Benefits**
- Reduced Man-hours
- Increased Capacity
- Process Orders Faster
- Meet Anticipated Growth in Demand
- Improved Profit Margin

**Project Team Members:** Jenna Ludwig, Paul Gieseke, Luke Johnson, Anthony Ross, Chris Opland.

**Faculty Advisor and Consultant:** Reza Maleki
Email: Reza.Maleki@ndsu.edu.

**Department:** Industrial and Manufacturing Engineering

**Funding Source:** Neal’s Industrial Painting

---

*Spring Semester 2009*

*Integrated Program/Project Management and Capstone Experience*
DUST COLLECTION SYSTEM DESIGN

Project Team Members: Dayne Efta, James Dravitz, Thomas Steckler, George Auen.
Faculty Advisor and Consultant: Reza Maleki
Email: Reza.Maleki@ndsu.edu
Department: Industrial and Manufacturing Engineering
Funding Source: Northern Contours

Research Project Objective
The purpose of this project is to document, analyze, and propose improvements to the current dust collection system.

Project Team Deliverables
- Documentation of current processes and evaluation of dust collection system
- Proposals that can help with effective collection and containment of dust
- Economic analysis
- Recommendations for future projects and improvements

Potential Benefits
The recommendations shown in the above chart (labeled “feasible”) can help reduce the spread of dust and reduce the number of defects caused by dust. Some recommendations can help reduce operational expenses as well.

Spring Semester 2009
Integrated Program/Project Management and Capstone Experience
Facility Layout Analysis and Improvements

Research Project Objective
Study, analyze, and document proposals which can help with improving layout to reduce manufacturing lead time within the Fastlane building.

Recommendations
- Revise Layout
  - Process relocation
  - Improved wash station
  - Additional equipment
- New scheduling practices

Project Deliverables
- Documentation of:
  - Current production processes including layout, product, and process flow
  - Improved facility layout
  - Economic benefits from implementing proposed suggestions
- Recommendations for future projects and improvements

Macro Process Flow

Project Team Members: Brad Buck, Tony Noga, Ashley Kringle, Jordan Debilzen.

Faculty Advisor and Consultant: Reza Maleki
Email: Reza.Maleki@ndsu.edu.

Department: Industrial and Manufacturing Engineering

Funding Source: Aldevron

Current Fastlane Layout

Proposed Fastlane Layout

Spring Semester 2008

Integrated Program/Project Management and Capstone Experience
RESEARCH PROJECT OBJECTIVE:
To develop a proposal for a new facility layout capable of accommodating future growth in production and expansion of research and development activities.

PROJECT TEAM DELIVERABLES:
- Documentation of the current layout and processes
- Documentation for a new facility layout
- Estimation of building costs
- Recommendations for future projects

PROJECT BENEFITS:
- New facility layout that accommodates future growth
- Improved product flow
- Reduced risk of contamination
- Improved communication

Space Analysis

<table>
<thead>
<tr>
<th>Facility Categories</th>
<th>Current Square Feet</th>
<th>Adjusted Square Feet</th>
<th>100% Increase In Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Support</td>
<td>1728</td>
<td>1782</td>
<td>2256</td>
</tr>
<tr>
<td>2 Lab Support</td>
<td>1455</td>
<td>1813</td>
<td>2645</td>
</tr>
<tr>
<td>3 GMP Lab</td>
<td>1293</td>
<td>1293</td>
<td>2000</td>
</tr>
<tr>
<td>4 Research Grade Lab</td>
<td>3375</td>
<td>3709</td>
<td>4810</td>
</tr>
<tr>
<td>5 Receiving</td>
<td>0</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td>6 Shipping</td>
<td>121</td>
<td>200</td>
<td>300</td>
</tr>
<tr>
<td>7 Storage</td>
<td>225</td>
<td>375</td>
<td>470</td>
</tr>
<tr>
<td>8 Maintenance</td>
<td>636</td>
<td>766</td>
<td>800</td>
</tr>
<tr>
<td>9 QC</td>
<td>426</td>
<td>475</td>
<td>500</td>
</tr>
<tr>
<td>10 Office</td>
<td>1523</td>
<td>2250</td>
<td>2500</td>
</tr>
<tr>
<td>Total: *Hallways Not Included</td>
<td>10782</td>
<td>12813</td>
<td>19511</td>
</tr>
</tbody>
</table>

Current Facility Layout

New Layout = 19,600 ft²

Proposed Facility Layout

Spring Semester 2008

Integrated Program/Project Management and Capstone Experience

Project Team Members: Jeff Comegys, Doug Peterson, Chris Rivard, Dheeraja Kaja
Faculty Advisor and Consultant: Reza Maleki
Email: Reza.Maleki@ndsu.edu
Department: Industrial and Manufacturing Engineering
Funding Source: Aldevron
Research Project Objective:

The purpose of this project is to develop a proposal for an improved facility layout, which will reduce manufacturing lead time, lower work in process inventories and lower material handling.

Project Team Deliverables:

Documentation of...
- Current layout, including flow of products and work in process inventories
- Improved layout, including flow of products and work in process inventories
- Cost savings that may result from implementing proposed suggestions
- Recommendations for future projects and improvements

Recommendations:

Relocate machines which will improve the problem areas that BTD clients defined

| Problems | Solutions |

| Project Team Members: Jesse Johnson, Woo Kim, Yasaman Kazemi, Robert Wessel |
| Faculty Advisor and Consultant: Reza Maleki Email: Reza.Maleki@ndsu.edu |
| Department: Industrial and Manufacturing Engineering |
| Funding Source: BTD Manufacturing, Inc. |

<table>
<thead>
<tr>
<th>WIP</th>
<th>External Handling</th>
<th>Internal Handling</th>
<th>Lead Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Move Press Brake to Plant 1</td>
<td>X</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Press Brake, Spot Weld, Hand Weld Cell</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Move Two Hand Welders to Plant 1</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Laser, Press Brake and Hand Weld Cell</td>
<td>X</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

Benefits:

- Reducing manufacturing lead time resulting in higher productivity
- Elimination of WIP will result in lower inventory carrying cost
- Decreasing travel distance will reduce material handling costs

Integrated Program/Project Management and Capstone Experience

Spring Semester 2008
Warehouse Operations Analysis

Research Project Objective
Study, analyze and improve the utilization of the warehouse space and operations.

Project Team Deliverables
- Analysis of current warehouse layout and processes
- Documentation of proposed recommendations
- Documentation of economic benefits resulting from implementation of proposed recommendations
- Recommendations for future projects and improvement

Recommendations
- Reduce amount of cross-traffic
- Save 1,600+ square feet
- Organize east and south walls

Kanban
- Set order date requirement for customer
- Pull reports based on firm order date
- Send orders to production of what is not in warehouse

Shelf Standardization
- Group customers’ parts in common areas
- High-volume parts closest to shipping docks
- Specific spot for partial bins

Project Team Members: Andrew Larson, Scott Engberg, Andrea Hopf, Matt Olson.

Faculty Advisor and Consultant: Reza Maleki
Email: Reza.Maleki@ndsu.edu.

Department: Industrial and Manufacturing Engineering

Funding Source: BTD Manufacturing, Inc.

Spring Semester 2008
Integrated Program/Project Management and Capstone Experience
Research Project Objective:
The purpose of this project is to analyze and document the current logistics of the returnable racks used at the CNH Fargo plant. Through this analysis recommendations will be made to improve tracking methods for the racks.

Team Deliverables:
Documentation of the following:
- Current information flow
- Physical rack flow
- Current physical rack count
- Possible improvements for tracking system
- Economic analysis of recommendations
- Recommendations for Future projects

Benefits:
- Streamlined system with better communication
- Reduction in lost racks
- CNH reimbursed for lost racks
- Substantial cost avoidance

<table>
<thead>
<tr>
<th>Problems</th>
<th>Losing Racks</th>
<th>Poor Communication</th>
<th>Lack of Liability</th>
<th>Inadequate Number of Racks Available</th>
<th>Difficulty Locating</th>
<th>Difficulty Identifying</th>
<th>Inaccurate count of Rack Inventory</th>
<th>Financial Management</th>
<th>Lack of Rack Technology</th>
<th>Shipping Incorrect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improve CSCN</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Liability Contract</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tracking Technology</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

All recommendations contribute to better management and tracking of the returnable racks

Spring Semester 2008
Integrated Program/Project Management and Capstone Experience
Improving Inventory Management and Warehousing Operations

**RESEARCH PROJECT OBJECTIVE:**
The purpose of this project is to study, analyze and improve warehouse locations and reduce inventory management difficulties.

**PROJECT TEAM DELIVERABLES**
Based on extensive observation and research, the following documents were provided to the client:
- Current warehouse practices, information, & process flow
- Proposed improvements
- Proposed cost savings
- An outline of recommendations for future projects

**RECOMMENDATIONS**
- New warehouse ID inventory locations
- Corresponding warehouse names within ERP
- Cellularize workstation to decrease travel
- Enhance barcode system

**PROJECT BENEFITS**
- Making the physical production facility match the ERP system will result in ease of tracking inventory
- Reduction in search area will considerably reduce time spent searching for inventory
- Relocating the Epoxy/Sanding workstation will result in reduced travel distances

**Project Team Members:** Dave Holloway, Nate Granquist, Mike Hedlund, Dave Stenseth.

**Faculty Advisor and Consultant:** Reza Maleki
Email: Reza.Maleki@ndsu.edu.

**Department:** Industrial and Manufacturing Engineering

**Funding Source:** Sioux Manufacturing Corporation

**Proposed Inventory Designations**

**Current Warehouse ERP Hierarchy**

**Spring Semester 2008**

**Integrated Program/Project Management and Capstone Experience**
SK Food
Specialty Processing

Research Project Objective
The purpose of this project is to develop a proposal for the improvement of packaging and warehousing operations; included in this will be the layout, inventory tracking, material handling practices, and ergonomics

Deliverables
• Documentation of the current processes
• Documentation of the proposal for improvements
• Documentation of the economic analysis
• An outline of recommendations for future projects and improvements

Problems Identification
• Inefficient Packaging
• Difficulties tracking inventory
• Poor utilization of warehouse

Recommendations
• Purchase and install a Super Sack frame and filler and scissor lift table
• Implement a bar coding system to improve the inventory tracking
• Purchase and install a new racking system, allowing more efficient access to all products
• A new layout is recommended to utilize the new racking system

Improving Packaging and Warehousing Operations

Project Team Members: Nate Bruns, Joshua Brantner, Tom Cinnamon, Jennifer Vad.
Faculty Advisor and Consultant: Reza Maleki
Email: Reza_Maleki@ndsu.edu
Department: Industrial and Manufacturing Engineering
Funding Source: SK Food Specialty Processing

Spring Semester 2008
Integrated Program/Project Management and Capstone Experience
Research Project Objective
The purpose of this project is to study, analyze and improve the raw material warehousing practices, inventory management, and the pre-assembly operations in order to decrease work in process and material handling.”

Team Deliverables
- Documentation of current processes
- Improve warehousing and pre-assembly operations
- Economic analysis of proposed solutions
- Recommendations for future projects

Current Layout

Proposed Layout

Recommendations / Benefits
- **New Warehouse Layout**
  - Decrease Handling
  - Visible Workplace
- **Material Movement Cart**
  - Decrease Handling
- **Forklift Attachment**
  - Decrease Handling
- **New Manufacturing Layout**
  - Reduce WIP
  - Reduce MLT

Project Team Members: Lance Straabe, Nathan Noble, Jared Baldwin, Joey Marvig.

Faculty Advisor and Consultant: Reza Maleki
Email: Reza.Maleki@ndsu.edu

Department: Industrial and Manufacturing Engineering

Funding Source: Vinylite Windows

Spring Semester 2008

Integrated Program/Project Management and Capstone Experience
Research Project Objectives
Research and document the design of an anti-corrosive system for hydraulic cylinder components that offers safety and economic advantages over the current painting methods while meeting the production requirements.

Project Team Deliverables
- Documentation of the current systems that relate to the project
- Documentation of researched alternatives of anti-corrosive methods, and application systems
- Documentation of recommendations for a new, more robust anti-corrosive system
- Documentation of cost and time savings that may result from implementing proposed suggestions.
- An outline of recommendations for future projects and improvements

Problems Identified
- Fully assembled cylinders are powder coated
- Internal seals exposed to high heat
- Expensive seal warranties due to excessive heat
- Bore hole manually cleaned

Proposed Process
- Shafts coated in parallel with cylinder tubes
- Hydraulic cylinder assembled after coating processes
- Seals no longer exposed to heat

Potential Benefits
- Purchase less expensive seals
- Reduce warranty costs
- Decrease masking costs
- Pay back period of 1.61 years

Spring Semester 2007
Integrated Program/Project Management and Capstone Experience
Hydraulic Test Bench Design

Research Project Objectives
Design a test bench to verify the quality and functionality of a fully assembled undercarriage hydraulic system for a 430 / 435 excavator. The system needs to identify any leaks, verify component functionality and specifications in less than 5 minutes.

Project Deliverables
- Documentation of Current Assembly and Testing Procedure
- Research Alternative Methods
- Recommendations for Improved Assembly
- Recommendations for Test Bench
- Recommendations for Future Improvements

Potential Benefits
- Proposed assembly procedure will help improve quality of hydraulic system and decrease costs.
- The proposed testing procedure will help confirm that the machine is indeed a quality product.

Proposed Hydraulic Circuit

Undercarriage Hydraulic System

Mark Henning
Project Manager
Joseph Haman
Project Engineer

Undercarriage Project Team Members: Mark Henning, Joseph Haman, Jack Lubka, Kristopher Braaten.

Faculty Advisor and Consultant: Reza Maleki
Email: Reza.Maleki@ndsu.edu

Department: Industrial and Manufacturing Engineering

Funding Source: Bobcat

Spring Semester 2007
Integrated Program/Project Management and Capstone Experience
**Manufacturing Lead Time Improvements**

**Research Project Objective**

The Purpose of this Project is to Document the Current Production Processes and Information Flow and to Develop Proposals to Help Improve the Productivity of the Resources.

**Team Deliverables**

- Documentation of current system, production processes and Information Flow
- Documentation of recommendations for improved production processes and Information Flow
- Documentation of associated Cost and time Savings
- Documentation of Future Recommendations

**Recommendations**

- Schedule/Hire a Material Handler
- Implement Staging Areas
- Routings Sheets
- Implement Scheduling Methods
- Utilize ERP System
- Companywide Training

**Spring Semester 2007**

**Integrates Program/Project Management and Capstone Experience**

**Current MLT = 53.23 days  Potential MLT = 14.23 days  Potential Decrease in MLT = 73%**

**Throughput Improvement**

<table>
<thead>
<tr>
<th>Critical Areas Addressed</th>
<th>Information Flow</th>
<th>Process Flow</th>
<th>Material Handling</th>
<th>WIP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information Flow</td>
<td>Improvement</td>
<td>Improvement</td>
<td>Improvement</td>
<td></td>
</tr>
<tr>
<td>Process Flow</td>
<td>Improvement</td>
<td>Improvement</td>
<td>Improvement</td>
<td></td>
</tr>
<tr>
<td>Material Handling</td>
<td>Reduction</td>
<td>Reduction</td>
<td>Improvement</td>
<td>Reduction</td>
</tr>
<tr>
<td>WIP</td>
<td>Reduction</td>
<td>Reduction</td>
<td>Improvement</td>
<td></td>
</tr>
<tr>
<td>Labor</td>
<td>Reduction</td>
<td>Reduction</td>
<td>Improvement</td>
<td></td>
</tr>
<tr>
<td>Space Utilization</td>
<td>Improvement</td>
<td>Improvement</td>
<td>Improvement</td>
<td></td>
</tr>
<tr>
<td>Excessive Operator Movement</td>
<td>Reduction</td>
<td>Reduction</td>
<td>Reduction</td>
<td>Reduction</td>
</tr>
<tr>
<td>Shop Floor Organization</td>
<td>Improvement</td>
<td>Improvement</td>
<td>Improvement</td>
<td></td>
</tr>
<tr>
<td>Material Availability</td>
<td>Improvement</td>
<td>Improvement</td>
<td>Improvement</td>
<td></td>
</tr>
<tr>
<td>Process Operation Control</td>
<td>Improvement</td>
<td>Improvement</td>
<td>Improvement</td>
<td></td>
</tr>
<tr>
<td>Project Management</td>
<td>Improvement</td>
<td>Improvement</td>
<td>Improvement</td>
<td></td>
</tr>
<tr>
<td>Process Time</td>
<td>Improvement</td>
<td>Improvement</td>
<td>Improvement</td>
<td></td>
</tr>
<tr>
<td>Individual Impact On MLT</td>
<td>- 4 Days</td>
<td>- 7 Days</td>
<td>- 4 Days</td>
<td>- 24 Days</td>
</tr>
<tr>
<td>Total Impact On MLT</td>
<td>- 30 Days</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Current MLT = 53.23 days  Potential MLT = 14.23 days  Potential Decrease in MLT = 73%**

**Margin Per Conveyor**

- **Current MLT**
- **73% MLT Reduction**
- **50% MLT Reduction**

**Funding Source:** Rapat Industries

**Project Team Members:** Melissa Brown, Ivan Anheluk, Damon Anderson, Jean Ostrom-Blonigen, Laura Sagness.

**Faculty Advisor and Consultant:** Reza Maleki

Email: Reza.Maleki@ndsu.edu

**Department:** Industrial and Manufacturing Engineering

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**Integrated Program/Project Management and Capstone Experience**
**RECOMMENDATIONS / BENEFITS**

Three Proposals Pertaining To Capital Investment
- Cure Oven – Reduces Curing Time
- Powder Coat Booth – Improve Ventilation & Quality
- Chemical Wash System- Speeds Up Preparation Time

Purchase Hose Spools
- Decrease painter travel Distance
- Increase time available to paint

Parking Lot Spots for Fabricated Material
- Decrease Material Handler Time
- This includes looking for and moving parts

Utilize Both Booths In Between Paint Coats
- Increase Painter Utilization By 20%

Utilize 2nd Employee to Paint when Available
- Increase Throughput

---

**Economic Analysis**

<table>
<thead>
<tr>
<th>Costs</th>
<th>Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Utilities</td>
<td>Equipment Cost</td>
</tr>
<tr>
<td>$12,000</td>
<td>$179,931</td>
</tr>
<tr>
<td>$70,241</td>
<td>$8,303</td>
</tr>
<tr>
<td>$14,000</td>
<td>$92,544</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>Total</strong></td>
</tr>
<tr>
<td>$191,931</td>
<td><strong>$92,544</strong></td>
</tr>
</tbody>
</table>

Simple Payback Period
- **2.23 Years**

---

**Project Team Members:** Emily Walstead, Cameron Wahl, Ryan Steinert, Jason Melcher.

**Faculty Advisor and Consultant:** Reza Maleki
Email: Reza.Maleki@ndsu.edu.

**Department:** Industrial and Manufacturing Engineering

**Funding Source:** Rapat Industries

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**Team Deliverables**
- Document Current Paint System
- Research Paint System Options
- Recommend Improved Paint Systems
- Document Cost and Time Savings
- Recommend Future Projects

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**Research Project Objectives**
Develop a document that reflects research and identification of a paint system that can adequately address the current and future needs of the Rapat Corporation.

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**Project Team Members:** Emily Walstead, Cameron Wahl, Ryan Steinert, Jason Melcher.

**Faculty Advisor and Consultant:** Reza Maleki
Email: Reza.Maleki@ndsu.edu.

**Department:** Industrial and Manufacturing Engineering

**Funding Source:** Rapat Industries

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**Paint System Design**

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**Integrated Program/Project Management and Capstone Experience**
Facility Expansion Plan

Research Project Objective

- Study, analyze, and document the requirements of manufacturing, order fulfillment, material handling, and storage/warehousing for the purpose of developing alternative layouts that can be used for the facility’s planned expansion.

- Integral to this project is the development of a plan that facilitates the move into the expanded facility.

Project Deliverables

- Documentation of processes & material flow
- Develop a layout that utilizes the facility expansion and accommodates alternative equipment and systems
- Benefit analysis of proposed solutions
- Move plan which minimizes downtime
- Recommendations for future projects & improvements

Benefits of Proposed Layout

- Material flow reduces material handling and is critical to an efficient layout
- Flexibility is necessary to accommodate future growth
- A meticulous move plan is necessary to accomplishing a move of this magnitude

Move Plan Summary

- Cost of move plan will be $97,685.50
- Does not include the cost of any temporary systems or rental equipment
- 7-day move plan for order fulfillment
- 3-day move plan for manufacturing

Spring Semester 2007

Integrated Program/Project Management and Capstone Experience
Order Picking Improvements

Research Project Objective
The purpose of this project is to analyze and develop proposals that can help to improve the order picking throughput at Swanson Health Products.

Deliverables
- Documentation of current order picking process.
- Documentation of proposals for improved throughput.
- Cost/benefit analysis for proposed improvements.
- Outline of the opportunities for future projects.

Areas of Opportunities & Proposals
- Input into PTL
- Equip. & Setup
- Operator
- Info Flow
- Proposal
- New Order Picking System

Low Throughput

Improved Throughput

Benefits
- Throughput increase: 11000 → 18000 orders/day
- Balanced workload among zones
- Reduced manual handling of boxes

Project Team Members: Aki Yanagi, Shaun Phipps, Kelsey Foldesi, Laura English.
Faculty Advisor and Consultant: Reza Maleki
Email: Reza.Maleki@ndsu.edu.
Department: Industrial and Manufacturing Engineering
Funding Source: Swanson Health Products

Spring Semester 2007
Integrated Program/Project Management and Capstone Experience
Wil-Rich
Material Handling Analysis and Improvements

Research Project Objective
The purpose of this project is to study, analyze, and develop proposals to improve the material storage and handling, as well as material delivery schedule to the fabrication shop.

Project Team Deliverables
- Documentation of current raw material and information flow processes
- Analysis of current processes
- Proposed improvements for processes
- Economic analysis reflecting potential benefits of proposed recommendations

Project Team Members: John Kline, Eric Wieland, Jeremy Hjelseth, Adam Gumke.
Faculty Advisor and Consultant: Reza Maleki
Email: Reza.Maleki@ndsu.edu.
Department: Industrial and Manufacturing Engineering
Funding Source: Wil-Rich

Recommendation
- Optimize Batch Picking Model
- Streamline Information Flow
- Combine current Work Order and Pick Slip into Traveler
- Incorporate Planning Board
- Proactive Scheduling

Improvement Breakdown

Information Flow

Proactive Scheduling
- Visually see trends and patterns of machine usage
- Planning board will allow forward thinking and scheduling
- Planning board will allow travelers to be ranked by priority
- Hot orders easily inserted in planning board when necessary

Combination
- Work order combined with pick slip
- Elimination of the pick slips
- Paper work reduced by 22%
- Combine traveler orders to eliminate redundant trips
- Reduce amount of retrievals by Material Handler
- Creation of work order and pick slip is now one step of creating a traveler
- Only one document needed for data entry

Non Value Added Activities

Current Facility Layout

Potential Economic Annual Savings
- Distance: 288.06 Miles
- Time: 17,250 Minutes
- Dollars: 18,488.92

Spring Semester 2007
Integrated Program/Project Management and Capstone Experience
Wil-Rich, LLC
Paint System Analysis and Improvements

RESEARCH PROJECT OBJECTIVE:
To study and analyze the paint system and develop proposals for improved throughput

PROJECT DELIVERABLES:
- Documentation of current paint line processes
- Documentation of proposals for improved paint line processes
- Documentation of economic analysis showing the impact of proposed improvements
- An outline of recommendations for future projects and improvements

PROPOSAL SUMMARY AND BENEFITS:
- Identified areas of improvement throughout the paint system
- Developed proposals for increasing system utilization and reducing part rework
- Developed proposals for increased cleanliness and safety throughout the paint system

Potential Recommendation Benefits

<table>
<thead>
<tr>
<th>Processes</th>
<th>Reduce Rework</th>
<th>Decrease Line Shutdowns</th>
<th>Increase Throughput</th>
<th>Improve 5S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Load</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wash</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Shot Blast</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Paint</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cure</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Cool Down</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unload</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Output</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

Spring Semester 2007
Integrated Program/Project Management and Capstone Experience
Production Cell Analysis and Redesign

Research Project Objective
The purpose of this project is to study, analyze and improve the production line for the DD133A intake manifold including the layout, manufacturing processes, and material handling.

Project Team Deliverables
Documentation of:
- Current layout and manufacturing process flow
- Proposed improvements for layout and process flow
- Cost and time savings from improvements
- Recommendations for future improvements

Bottlenecks
- Permanent Mold
- Robot
- Machine Cell

Areas of Improvement
- Reduce Work in Process (WIP)
- Reduce Lead Time
- Increase Throughput
- Reduce Travel Distance for Parts
- Reduce Material Handling
- Move Inspection ‘Up the Line’
- Soft Costs
- -Building Insurance
- -Overhead Costs

Project Benefits
- Reduced material handling
- Significantly decreased WIP
- Increased throughput
- Decreased optimal lead time

Travel Distance (feet)

<table>
<thead>
<tr>
<th></th>
<th>Without Rework</th>
<th>With Rework</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current</td>
<td>3,948</td>
<td>6,452</td>
</tr>
<tr>
<td>Proposed</td>
<td>3,375</td>
<td>3,826</td>
</tr>
<tr>
<td>% Changes</td>
<td>14.5</td>
<td>40.70</td>
</tr>
</tbody>
</table>
**Fargo Tank & Steel**  
**Decreasing Manufacturing Lead Time**

**Research Project Objective**  
To document current layout and manufacturing processes, identify problems and make recommendations to decrease manufacturing lead time and increase throughput of tanks.

**Project Deliverables**  
- Documentation of:
  - Current manufacturing processes, layout and flow of tanks
  - Recommendations for improving:
    - Manufacturing processes
    - Layout
    - Work in process inventory
  - Cost and time savings for proposed improvements

**Current Layout**

<table>
<thead>
<tr>
<th></th>
<th>Travel Distance</th>
<th>Mfg. Lead Time</th>
<th>Response Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large Tank</td>
<td>1710 ft</td>
<td>27 hrs</td>
<td>2.44</td>
</tr>
<tr>
<td>Small Tank</td>
<td>1223 ft</td>
<td>12 hrs</td>
<td>2.01</td>
</tr>
</tbody>
</table>

**Proposed Layout**

<table>
<thead>
<tr>
<th></th>
<th>Travel Distance</th>
<th>Mfg. Lead Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large Tank</td>
<td>1345 ft</td>
<td>18 hrs</td>
</tr>
<tr>
<td>Small Tank</td>
<td>863 ft</td>
<td>10 hrs</td>
</tr>
</tbody>
</table>

**Benefits**  
Decreasing lead time will enable increased throughput  
Reconfiguration of the layout will enable better tank flow

**Project Team Members:** Ben Horejsi, Chad Consoer, Phil Siek, Santiago Garza, Jeremy Korczak.  
**Faculty Advisor and Consultant:** Reza Maleki  
Email: Reza.Maleki@ndsu.edu  
**Department:** Industrial and Manufacturing Engineering  
**Funding Source:** Fargo Tank & Steel
Research Project Objective

The purpose of this project is to develop proposals for improving the current office layout that will effectively utilize the space and meet the anticipated staff growth.

Team Deliverables

- Documentation of current layout and space utilization
- Documentation of proposals for redesigned layout
- Documentation of required budgets to support proposed improvements and cost savings
- Outline of recommendations for future planning and additional projects

Recommendations

- A demolition and construction plan to create an open-office layout and allow for future growth
- Introduce systems furniture to utilize work area and promote efficient working environment

Proposed Layouts

<table>
<thead>
<tr>
<th>Zoning Space</th>
<th>Floor</th>
<th>Option 1</th>
<th>Option 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Square Feet</td>
<td>Square Feet</td>
<td>Square Feet</td>
</tr>
<tr>
<td>Work</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First</td>
<td>2090</td>
<td>1227</td>
<td>1094</td>
</tr>
<tr>
<td>Second</td>
<td>2055</td>
<td>2076</td>
<td>1678</td>
</tr>
<tr>
<td>Storage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First</td>
<td>105</td>
<td>99</td>
<td>40</td>
</tr>
<tr>
<td>Second</td>
<td>144</td>
<td>47</td>
<td>207</td>
</tr>
<tr>
<td>Community</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First</td>
<td>258</td>
<td>1265</td>
<td>1222</td>
</tr>
<tr>
<td>Second</td>
<td>1161</td>
<td>575</td>
<td>545</td>
</tr>
</tbody>
</table>

Employees

<table>
<thead>
<tr>
<th></th>
<th>Current</th>
<th>Proposed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>25</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

Fargo Tank & Steel Co.
Office Needs Analysis & Redesign

Project Team Members: Colby Grupa, Amy VanderLinden, Emily Tarr, Tom Mohagen, JT Rhode.

Faculty Advisor and Consultant: Reza Maleki
Email: Reza.Maleki@ndsu.edu.

Department: Industrial and Manufacturing Engineering

Funding Source: Fargo Tank & Steel

Spring Semester 2006

Integrated Program/Project Management and Capstone Experience
Airbus A380LD Cell Layout and Cycle Time Reduction

Research Project Objective

The purpose of this project was to redesign the A380LD manufacturing cell to help with reducing cycle time and increasing capacity.

Team Deliverables

- Documentation of current manufacturing cell including the major issues effecting cell throughput
- Documentation of proposed cell addressing key issues utilizing lean concepts
- Documentation of cost and time savings that may result from implementing proposed solutions
- Document for implementation plan
- An outline of recommendations for future projects and improvements

Techniques Used

- Design of kitting to reduce operator part collection
- Centralized parts storage/“Supermarket” optimization
- Eliminated non-value added operations
- Addition of three workstations (future growth)
- Improve existing assembly methods (workstation design, product design)

Current A380LD Cell Layout

Potential Benefits

- MLT reduced by 16%
- Operator travel distance reduced by 97%
- $8,500 cost savings per cargo system
- Support Staff area accommodates two more engineers
- Cell supports three additional workstations

Project Team Members: Mitch Keller, Adam Steinke, Adam Buckhouse, Jeremy Heim.

Faculty Advisor and Consultant: Reza Maleki
Email: Reza.Maleki@ndsu.edu

Department: Industrial and Manufacturing Engineering

Funding Source: Goodrich

Project Team Members: Mitch Keller, Adam Steinke, Adam Buckhouse, Jeremy Heim.

Faculty Advisor and Consultant: Reza Maleki
Email: Reza.Maleki@ndsu.edu

Department: Industrial and Manufacturing Engineering

Funding Source: Goodrich

Project Team Members: Mitch Keller, Adam Steinke, Adam Buckhouse, Jeremy Heim.

Faculty Advisor and Consultant: Reza Maleki
Email: Reza.Maleki@ndsu.edu

Department: Industrial and Manufacturing Engineering

Funding Source: Goodrich

Project Team Members: Mitch Keller, Adam Steinke, Adam Buckhouse, Jeremy Heim.

Faculty Advisor and Consultant: Reza Maleki
Email: Reza.Maleki@ndsu.edu

Department: Industrial and Manufacturing Engineering

Funding Source: Goodrich

Spring Semester 2006

Integrated Program/Project Management and Capstone Experience
**Research Project Objective**

Develop Improved Processes and Procedures for the Packaging and Shipping Logistics for the Airbus A380LD Cargo Handling System.

**Deliverables**

- Documentation of Current Processes
- Documentation of Alternative Methods for Improved Packaging and Shipping
- Documentation of Cost and Time Savings
- Recommendations for Future Improvements

**Cargo Handling System**

**Improving Process**

- Standardize Packaging Process
- Standardize Packaging Material

**Explore Alternatives**

- Reusable Shipping Containers
- Methods of Transportation
- Eliminate Repackaging in Hamburg

**Potential Benefits**

<table>
<thead>
<tr>
<th>Proposed Method</th>
<th>Range of Savings*</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standardization</td>
<td>$750</td>
<td>$2,000</td>
</tr>
<tr>
<td>Packaging Material</td>
<td>$0</td>
<td>$400</td>
</tr>
<tr>
<td>Shipping Method</td>
<td>$4,122</td>
<td>$6,571</td>
</tr>
<tr>
<td>Total Savings/Shipement</td>
<td>$4,872</td>
<td>$8,971</td>
</tr>
<tr>
<td>Total Savings/Year</td>
<td>$243,600</td>
<td>$448,550</td>
</tr>
</tbody>
</table>

* One Cargo Handling System (Savings Based on $25-$40 Wage)

**Current Packaging and Shipping Operations**

**Project Team Members:** David Bartholome, Yuriv Astanasov, Kristin Nuss, Adam Maus.

**Faculty Advisor and Consultant:** Reza Maleki

Email: Reza.Maleki@ndsu.edu.

**Department:** Industrial and Manufacturing Engineering

**Funding Source:** Goodrich

Spring Semester 2006

Integrated Program/Project Management and Capstone Experience
RESEARCH PROJECT OBJECTIVE
The purpose of this project is identifying what processes and procedures are affected and determine what material number cross-references are required to support operations at Gremada Industries, Inc. due to Gremada transitioning to a new business model.

PROJECT DELIVERABLES
- Documentation of requirements for a new numbering system.
- Recommendations for a numbering system to satisfy the requirements.
- Recommendations for training employees.
- Recommendations for the use of Gremada’s current infrastructure to support the proposed numbering system.
- Documentation of potential benefits.
- Recommendations for future projects.

RECOMMENDATIONS
- Additional production support and system analyst positions
- Additional computer monitors for production support
- New Wireless Data Collection System
- Mobile Wireless Data Collection Hardware
- Online Quality Assurance forms

POTENTIAL BENEFITS
- Better understanding of functional department needs
- Tighten inventory control
- Increase control over shipping and receiving
- Create an environment to explore engineering opportunities
- Accommodate new customers at a faster rate
- Increase employee access to information
- Reduce paper consumption inline with ISO requirements
- Establish organizational identity unique to Gremada

Project Team Members: Kyle Rolfson, Chris DeHaan, Shawn Nieuwsma, Jace Manning
Faculty Advisor and Consultant: Reza Maleki
Email: Reza.Maleki@ndsu.edu
Department: Industrial and Manufacturing Engineering
Funding Source: Gremada Industries

Project Team Members: Kyle Rolfson, Chris DeHaan, Shawn Nieuwsma, Jace Manning
Faculty Advisor and Consultant: Reza Maleki
Email: Reza.Maleki@ndsu.edu
Department: Industrial and Manufacturing Engineering
Funding Source: Gremada Industries

Spring Semester 2006
Integrated Program/Project Management and Capstone Experience
Research Project Objectives
Develop a proposal for a new facility layout as well as a proposal for an improved supply chain to help IMAR Group, LLC meet expected growth and demand.

Project Team Deliverables
- Document the current layout, manufacturing and assembly processes, as well as procurement practices
- Document of recommendations for improved processes, layout and supply chain
- An outline of recommendations for future projects and improvements
- Documentation of cost and time savings that may result from implementing proposed suggestions

Proposed Layout and Supply Chain Recommendations
- Decreased mold transportation distances
- Side by Side gel-coating and fiberglass operations vs. single mold Bottlenecks
- Increased Curing area square footage
- Increased Grind Shop Capacity
- Decreased Buffing time
- Optimized Final Assembly Kitting
- Cellular Manufacturing Techniques
- Alleviated Finished Product Bottlenecks
- Trailer assembly close to shipping doors
- Develop Tool to Evaluate Suppliers
- Work to Establish Local Network of Suppliers
- Reduce some lead time issues
- Develop metrics to have better control over information flow
- Introducing a Kanban Ordering System
- Lead into MRP system
- Enhance 5S Program (housekeeping)
Research Project Objective:
Analyze, refine, & document processes for reducing and accurately measuring Ultrex waste.

Project Team Deliverables:
- Documentation of current Ultrex utilization process
- Procedures for accurate measurement & disposal of Ultrex waste
- Methods for reducing waste
- Financial justification
- Recommendations for future projects & improvements

Expected Benefit: Waste reduction (44%) and ergonomic improvements present potential for an annualized savings of $79,450.

Recommendations:
- Change system to accommodate 2 lineal lengths of Ultrex and larger batch size
- Order and install self dumping hoppers
- Phase in computational weight recording method

Spring Semester 2006
Integrated Program/Project Management and Capstone Experience
Facility Layout Improvements

Research Project Objective
Provide the documentation of current and proposed process flow and layout in the production facility. Study and document operations for improved ergonomics in facility.

Project Deliverables
- Documentation of current and proposed production kitchen area layout and flow
- Documentation of current and proposed material handling system
- Documentation of current ergonomic issues and recommendations for improvements

<table>
<thead>
<tr>
<th>Product Family</th>
<th>Current Dist Traveled</th>
<th>Proposed Dist Traveled</th>
<th>Total Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emulsified</td>
<td>1884 ft.</td>
<td>608 ft.</td>
<td>1276 ft.</td>
</tr>
<tr>
<td>Coarse Ground</td>
<td>2339 ft.</td>
<td>1233 ft.</td>
<td>1106 ft.</td>
</tr>
<tr>
<td>Fresh Ground</td>
<td>881 ft.</td>
<td>623 ft.</td>
<td>258 ft.</td>
</tr>
</tbody>
</table>

Total Distance Traveled X 2 (1) 8446 ft. 2464 ft. 5982 ft.

Time @ 2.5 FT/Sec 3378 sec. 986 sec. 40 min.

Space and Investment Savings Summary

<table>
<thead>
<tr>
<th>Floor Space Saved</th>
<th>SQFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooler</td>
<td>638</td>
</tr>
<tr>
<td>S Side of Current Cooler</td>
<td>239</td>
</tr>
<tr>
<td>Cooler</td>
<td>325</td>
</tr>
<tr>
<td>Used Combo Storage</td>
<td>583</td>
</tr>
<tr>
<td>Total Storage Added</td>
<td>1785</td>
</tr>
</tbody>
</table>

| Warehouse Space Saved     | 1202 |
| Production Space Saved    | 583  |

Cost for Warehouse Space $75
Cost for Production Space $200
Total Cost to Add Space $206,746

Spring Semester 2005

Integrated Program/Project Management and Capstone Experience
Material Handling Analysis

Research Project Objective

- Analyze material handling and its effect on warehousing cost
- Quantify the benefits and costs associated with relocating the inspection and disassembly of transmission units to West Fargo

Deliverables

- Document outlining recommendations
- Cost benefit analysis
- Future project recommendations

Potential Benefits

- More reliable data associated with material handling and transportation costs providing for better management decisions
- Improved product and process flow
- Reduced material handling and warehousing costs

Project Team Members:  Tadd Busch, Mike Lougheed, Mathew Mueller, Marcus Vetter
Faculty Advisor and Consultant: Reza Maleki
Email: Reza.Maleki@ndsu.edu

Department: Industrial and Manufacturing Engineering

Funding Source: Gremada Industries, Inc.

Spring Semester 2005

Integrated Program/Project Management and Capstone Experience
New Facility Layout

Research Project Objective
To develop a proposal for a new facility layout capable of meeting anticipated production needs and future expansion.

Project Team Deliverables:
- Document of current process flow, material handling, and storage requirements
- Detailed plan for new layout
- Cost estimate of the site preparation and building construction

Implementation Plan:
- Create schedule for moving into new facility
- Organize purchased equipment in new facility
- Move existing equipment gradually
- Train employees on new layout & equipment

Project Team Members: Lisa McCarvel, Tyler Albert, Derrick Tuma, Jordan Graff, Laura Anderson.

Faculty Advisor and Consultant: Reza Maleki
Email: Reza.Maleki@ndsu.edu.

Department: Industrial and Manufacturing Engineering

Funding Source: Infinity Windows and Doors

Spring Semester 2005

Integrated Program/Project Management and Capstone Experience
Research Project Objective
Determine the feasibility of establishing a full-service childcare center for faculty, staff, and students at NDSU.

Project Team Deliverables
- Documentation of:
  - Current and future childcare needs.
  - Location and funding sources.
  - Recommendations for future projects.

Recommendations
- Build new on-site childcare facility to be managed by NDSU or a 3rd party.
- Partnership with YWCA to assist with the expansion and use of its current facilities.

Project Benefits
- Provide child care services for NDSU faculty, staff & students.
- Increase employee satisfaction.
- Attractive benefit to recruit & retain young faculty and staff.
Sioux Manufacturing
Plant Layout and Process Improvement

RESEARCH PROJECT OBJECTIVE
To study, document and evaluate the current layout, material and process flow and propose an improved plant layout that can contribute to improved throughput.

PROJECT TEAM DELIVERABLES
Documentations of:
• Current layout, material flow and processes
• Proposals for improved layout and processes
• Savings resulting from improvement proposals
• Recommendations for future projects

POTENTIAL BENEFITS
• Improved productivity of some of the processes
• Improved quality
• Reduced travelling distances
• Increased throughput
• Improved safety and ergonomics

Spring Semester 2005
Integrated Program/Project Management and Capstone Experience
Research Project Objective
Develop and document a proposal that can help with increased bottling operations throughput.

Team Deliverables
1. Documentation of current bottling process
2. Improving Bottling Operations throughput by use of setup reduction methodology
3. Economic justification of recommendations

Recommendations
1. Transfer Double Cremer cleaning operations from an internal setup to an external setup
2. Utilize Double Cremer Computer Programming capabilities to reduce setup time
3. Purchase Trackstar brackets to improve guide rail systems

<table>
<thead>
<tr>
<th>Bottling Operations Throughput Increase</th>
<th>Cremer Cleaning</th>
<th>Cremer Standardization</th>
<th>TrackStar Brackets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time saved</td>
<td>25 min</td>
<td>10 min</td>
<td>10 min</td>
</tr>
<tr>
<td>Setups Completed</td>
<td>4 per shift</td>
<td>4 per shift</td>
<td>0.333 per shift</td>
</tr>
<tr>
<td>Time saved per shift</td>
<td>100 min</td>
<td>40 min</td>
<td>3.33 min</td>
</tr>
<tr>
<td>Bottles filled per shift</td>
<td>2700</td>
<td>1080</td>
<td>90</td>
</tr>
<tr>
<td>Throughtput Increase per Year</td>
<td>675,000</td>
<td>270,000</td>
<td>22,500</td>
</tr>
</tbody>
</table>

Total Throughput Increase Per Year: 967,500

Project Team Members: Mike Rooks, John Rogstad, Phillip Gaugler, Brad Okonek.

Faculty Advisor and Consultant: Reza Maleki
Email: Reza.Maleki@ndsu.edu

Department: Industrial and Manufacturing Engineering

Funding Source: Swanson Health Products

Bottling Operations Throughput Improvement

Department: Industrial and Manufacturing Engineering

Bottling Operation Layout CAD Drawing
White Earth Health Center
Improving Patient Access

RESEARCH PROJECT OBJECTIVE
Determine and propose methods to improve patient access, by increasing the number of patients seen per provider through analysis, documentation, and recommendations.

PROJECT DELIVERABLES
Documentations of:
- Current appointment scheduling process
- Recommendations for addressing scheduling problems
- Recommendations to increase patients seen per provider
- Recommendations for future projects and improvements

RECOMMENDATIONS
- Reduce number of “ruled” appointment slots
- Reduce number of carved appointment slots
- Require providers’ work availability three months in advance

POTENTIAL BENEFITS
- Increase number of fifteen minute appointment slots able to be filled by general or follow-up appointments by 8.
- Help to reduce no show rates as patient’s appointment will be scheduled while they are still at the health center.

Summary of Providers’ Activities During the Study Period

<table>
<thead>
<tr>
<th>Provider</th>
<th>Total Hours Currently Scheduled w/ Appointments</th>
<th>Total Hours Available for Appointments after Implementation of Recommendations</th>
<th>Additional Hours Available for Appointments after Implementation of Recommendations</th>
<th>Additional Patients after Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>68.00</td>
<td>86.65</td>
<td>18.65</td>
<td>36</td>
</tr>
<tr>
<td>2</td>
<td>78.75</td>
<td>98.88</td>
<td>20.13</td>
<td>39</td>
</tr>
<tr>
<td>3</td>
<td>82.50</td>
<td>88.27</td>
<td>5.77</td>
<td>11</td>
</tr>
<tr>
<td>4</td>
<td>60.50</td>
<td>74.21</td>
<td>13.71</td>
<td>26</td>
</tr>
<tr>
<td>5</td>
<td>39.00</td>
<td>53.74</td>
<td>14.74</td>
<td>28</td>
</tr>
<tr>
<td>6</td>
<td>15.75</td>
<td>22.93</td>
<td>7.18</td>
<td>13</td>
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<tr>
<td>7</td>
<td>0.00</td>
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<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>34.00</td>
<td>42.15</td>
<td>8.15</td>
<td>15</td>
</tr>
<tr>
<td>9</td>
<td>32.50</td>
<td>39.19</td>
<td>6.69</td>
<td>12</td>
</tr>
<tr>
<td>10</td>
<td>63.31</td>
<td>92.77</td>
<td>29.46</td>
<td>58</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
<td>238</td>
</tr>
</tbody>
</table>

Project Team Members: Audrey Rondeau, Nichole Haan, Alesia Schilke, Nick Zilka.
Faculty Advisor and Consultant: Reza Maleki
Email: Reza.Maleki@ndsu.edu
Department: Industrial and Manufacturing Engineering
Funding Source: White Earth Health Center

Integrated Program/Project Management and Capstone Experience

Spring Semester 2005
Small Miscellaneous Parts (SMP) “Supermarket” Design

Research Project Objective
Design a centralized “supermarket” facility to be used for the storage and distribution of small miscellaneous parts

SMPs are produced and painted in Gwinner and used in the assembly of Bobcat skid-steer loaders

Project Deliverables
- Documentation of
  - Layout and hardware requirements for the “supermarket”
  - Inventory replenishment policies for the “supermarket”
  - SMP delivery routes
  - Recommendations for future projects

Potential Benefits
- System for monitoring of both painted and unpainted parts
- A more reliable delivery system for SMPs to assembly
- Reduced lead time
- Higher number of inventory turns
- Decreased material handling

Using principles of JIT, the project team designed a “supermarket” that will assist Bobcat in proper monitoring of SMP inventory and distribution

Project Team Members: Patrick Brandt, Tom Tveter, Josh Tysver, James Klein.
Faculty Advisor and Consultant: Reza Maleki
Email: Reza.Maleki@ndsu.edu.
Department: Industrial and Manufacturing Engineering
Funding Source: Bobcat

Spring Semester 2004
Integrated Program/Project Management and Capstone Experience
**Design of a Flexible Assembly Device**

**Research Project Objectives**
Design a flexible holding device that will aid in improving cabinet assembly processes.

**Project Deliverables**
Documentation of:
- Current Processes
- Proposed holding device
- Investment requirements
- Recommendations for Future Projects and Improvements

**The Team designed a device that had the potential to:**
- Reduce Assembly Time
- Improve Ergonomics
- Decrease Employee Turnover

**Potential Savings and Payback Periods**

<table>
<thead>
<tr>
<th>Cabinets Per Day</th>
<th>Time Savings (minutes)</th>
<th>minutes saved/day</th>
<th>$ saved/month</th>
<th>payback period (months)</th>
<th>payback period (days)</th>
<th>minutes saved/day</th>
<th>$ saved/month</th>
<th>payback period (months)</th>
<th>payback period (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>30 45 60 75 90</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>374 562 749 937 1124</td>
<td>minutes saved/day</td>
<td></td>
<td>$ saved/month</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>31 21 16 13 11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>638 424 319 255 212</td>
<td>payback period (months)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>36 54 72 90 180</td>
<td>minutes saved/day</td>
<td></td>
<td>$ saved/month</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>449 674 899 1124 2249</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>26 17 13 11 6</td>
<td>payback period (months)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>531 354 266 212 106</td>
<td>payback period (days)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>48 72 96 120 240</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>599 899 1199 1499 2999</td>
<td>$ saved/month</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>20 13 10 8 4</td>
<td>payback period (months)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>398 266 199 159 80</td>
<td>payback period (days)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>60 90 120 150 300</td>
<td>minutes saved/day</td>
<td></td>
<td>$ saved/month</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>749 1124 1499 1874 3749</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>16 11 8 7 4</td>
<td>payback period (months)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>319 212 159 128 64</td>
<td>payback period (days)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Spring Semester 2004**

**Integrated Program/Project Management and Capstone Experience**
Material Handling & Ergonomics

Research Project Objective
To develop a proposal and make recommendations for improved ergonomics through utilizing improved methods and equipment for material handling and packaging equipment loading.

Project Team Deliverables
Documentation of:
- Current procedures for material handling
- Detailed report on improved methods for material handling
- Cost benefit analysis for proposed solution
- Future project recommendations

Recommendations

Power & Free Conveyor System
- Transports two loads at one time
- Relieves the operator of carrying the load
- Basic
- Takes up minimal space

Fork Lift
- Adjustable height
- Maneuvers easily
- No scissor arm

Self-Leveling Cart
- Transports two or more loads at one time
- Relieves the operator of carrying the load
- Takes up minimal floor space

Additional Recommendations
- Footwear
- Lifting Techniques - Training
- Stretching – Encouraged

Recommendations Cost Benefit

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Cost</th>
<th>Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lift Truck</td>
<td>$12,200</td>
<td>Workers will not have to bend over.</td>
</tr>
<tr>
<td>Overhead Trolley</td>
<td>$5,400</td>
<td>Workers will be able to move corrugate easily.</td>
</tr>
<tr>
<td>Spring Loaded Cart</td>
<td>$500</td>
<td>Workers will be able to move corrugate easily.</td>
</tr>
<tr>
<td>Footwear</td>
<td>$1,600</td>
<td>Reduce foot fatigue.</td>
</tr>
</tbody>
</table>

Additional Potential Benefits of the Recommendations:
- Reduce worker injuries
- Reduce time loading magazine
- Reduce travel distances
- Labor time for load/unload

Project Team Members: Greg Frey, Dan Anderson, Nathan Davis, Emily Ekeren.
Faculty Advisor and Consultant: Reza Maleki
Email: Reza.Maleki@ndsu.edu.
Department: Industrial and Manufacturing Engineering
Funding Source: Dakota Growers Pasta Company

Spring Semester 2004
Integrated Program/Project Management and Capstone Experience
RESEARCH PROJECT OBJECTIVE
To develop a proposal and make recommendations for the material handling methods for loading, transferring, and unloading of wood parts to improve the overall productivity and quality of the paint line.

PROJECT TEAM DELIVERABLES
- Documentation of current processes
- Documents proposing improved material handling methods
- Cost justification for improvements
- Recommendations for future projects

RECOMMENDATIONS
- Automated in-feed loading system for Primer line
- Transfer with robotics from Primer line to Paint line
- Installation of ring wrapper in the unloading area of the paint line

RING WRAPPER
- Reduces amount of material handling for wrapping of pallets
- Decreases the amount of distance traveled for this process

AUTOMATED IN-FEED SYSTEM
- Allows for operator to concentrate on inspection
- Consistency in the loading process and the release of parts
- Creates even spacing of product on the oven belt
- Increases the overall utilization of the oven belt

ROBOTIC TRANSFER
- Relieves operator from repetitive motions
- Reliable system for consistency in transfer
- Maintains the utilization from the priming process
- Minimal defects due to part handling

Recommendations have potential to help with:
- Improved throughput
- Decrease in labor input

Potential additional improvements in:
- Quality
- Ergonomics
- Employee morale
- Turnover rate

Spring Semester 2004
Integrated Program/Project Management and Capstone Experience
Research Project Objective

to study, document, and analyze the existing methods for processing library materials and propose a streamlined process and workplace layout.

Project Team Deliverables

- Documents for:
  - Current layout and methods
  - Improved layout and methods
  - Furniture and equipment specifications
  - Budget and cost benefits analysis

- Document of Recommendations for:
  - Material handling equipment
  - Future projects
  - Further improvements

Some Facts

The library processes books, magazines, CD’s, DVD’s and donated items

2003: the library processed 163,000 materials

The work room where processing takes place is not designed to accommodate large numbers of materials efficiently

The number of materials processed is continuing to grow

Problems Identified

- Material handling issues
- Cluttered work areas
- Inefficient process/workflow
- Outdated furniture and equipment
- Storage spaces not being utilized effectively

Proposed Solutions

New ergonomically correct furniture, up to date equipment, a more efficient process and a new layout with better usage of space was proposed.

Implementing proposed changes will:

- Accommodate future processing needs
- Utilize space more effectively
- Save processing time
- Increase safety
- Improve staff morale
RESEARCH PROJECT OBJECTIVE
To determine and propose methods to minimize the operating room downtime and recommend ways to improve efficiency and turnover rates.

RECOMMENDATIONS:
- Early Patient Entry
- Local Certified Registered Nurse Anesthetist (CRNA)
- Front Loaded Anesthesia
- Redefining Patient Transportation

RECOMMENDATIONS INVOLVE:
- Parallel processing
- Reducing wait time and wasted time
- Redefining staff roles

PROJECT TEAM DELIVERABLES
- Documentation of the current turnover process of the operation room suites
- Document with recommendations for improving operating room suites
- Documentation providing cost benefit analysis for the proposed improvements
- An outline of recommendations for future projects and further improvements

PROJECT BENEFITS:
- Implementation costs negligible
- Possible additional cases & revenue
- Increased surgeon satisfaction

Spring Semester 2004
Integrated Program/Project Management and Capstone Experience
Error Rate Reduction in Order Picking

Project Team Members: Andrea McGhan, Ben Ostarello, Adam Jones, Sun Ho Nam.

Faculty Advisor and Consultant: Reza Maleki
Email: Reza.Maleki@ndsu.edu.

Department: Industrial and Manufacturing Engineering
Funding Source: Swanson Health Products

Research Project Objective
The objective of this project was to improve the quality inspection process for order picking.

Project Team Deliverables
Provide Documentation for:
- Current process used for picking orders and quality inspection
- Recommendations for improving picking order process and quality inspection
- Recommendations for an improved order picking layout
- Cost benefits analysis for the proposed improvements
- Recommendations for future projects and further improvements

Quality Assurance Alternatives
- Solution sought to replace current quality assurance methods and process
- Weight Scale is not best solution
- Alternatives:
  - Keep current inspection process but use fixed scanners
  - Begin eliminating inspection process
  - Best Solution: Place quality into order picking process

Potential Benefits
- Implementing the proposed layout will decrease error rate by reducing operator fatigue and separating similar sized products.
- An in-line scanning system will put quality into the process and eliminate the existing quality inspection area.
Improve Press Department Throughput

Research Project Objective
Develop a proposals for improving the throughput of the press department while optimizing the number or operators through improved setup and operator interaction with the press equipment.

Project Team Deliverables
Documentation of:
- Current methods of operations
- Improved methods and operator interface with press equipment
- Effective mix of products, people, and work-centers
- Economic analysis
- Recommendations for future projects

The recommendations made included proposals for improving the following:
- Storage and retrieval of press plates.
- Slat insertion methods
- Trim operations
- Product/worker matrix

Potential Benefits
- Reduce worker movement and time to perform operations. In turn, this can help with:
  - reduce employee turnover rate
  - reduce worker fatigue
  - reduce insurance premiums
- Increase press uptime
- Improve employee and production scheduling

Time available per shift (min)

<table>
<thead>
<tr>
<th>Product</th>
<th>Flat Stock, 14 oz Press 8</th>
<th>MRT 1003541 Press 8</th>
<th>Swather belt, rubber slat 1001551 Press 1</th>
<th>Swather belt, rubber slat 1001551 Press 6</th>
<th>Totals (Averages)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual demand</td>
<td>500</td>
<td>800</td>
<td>1200</td>
<td>2000</td>
<td>4500.0</td>
</tr>
<tr>
<td>Monthly demand</td>
<td>42</td>
<td>67</td>
<td>100</td>
<td>167</td>
<td>375.0</td>
</tr>
<tr>
<td>Weekly demand</td>
<td>10</td>
<td>15</td>
<td>23</td>
<td>38</td>
<td>50</td>
</tr>
<tr>
<td>Daily demand</td>
<td>2.1</td>
<td>3.3</td>
<td>5.0</td>
<td>8.3</td>
<td>18.8</td>
</tr>
<tr>
<td>Percent of total sales</td>
<td>11%</td>
<td>18%</td>
<td>27%</td>
<td>44%</td>
<td>18.8</td>
</tr>
<tr>
<td>Takt time (min/unit)</td>
<td>201.6</td>
<td>126.0</td>
<td>84.0</td>
<td>50.4</td>
<td>89.6</td>
</tr>
<tr>
<td>Operator cycle time</td>
<td>154.3</td>
<td>154.6</td>
<td>151.4</td>
<td>161.2</td>
<td>156.6</td>
</tr>
<tr>
<td>Ideal # of operators</td>
<td>0.8</td>
<td>1.2</td>
<td>1.8</td>
<td>3.2</td>
<td>2.2</td>
</tr>
</tbody>
</table>

*Based on 5 section belts

Spring Semester 2004

Integrated Program/Project Management and Capstone Experience
Analysis of Service Work Order System

RESEARCH PROJECT OBJECTIVE
The objective of this project was to document the current service work order (SWO) system’s process, any employee concerns discovered during the interview process, and a formal submission of any potential improvements the group recommends.

PROJECT TEAM DELIVERABLES
- Document describing existing SWO System process.
- Document detailing user feedback obtained during department interviews.
- Document detailing group recommendations.

DEPARTMENTS
- Purchasing
- Building Services
- Phone Systems
- Computer Services
- Data Security

Potential Benefits
The recommendations should:
- Contribute to boosting employee moral and satisfaction with the current SWO System
- Better departmental coordination
- Minimizing overtime due to imperfect scheduling