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IPRO 312 FALL 2006 Final Report
Applying Rapid Prototyping Techniques to Production Tooling
(Design and Layout of a Caster Factory)

colson

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INTRODUCTION:

This IPRO had 2 different tasks that needed to be achieved. The first task was to design a caster which could be manufactured within 24hrs compare to normal time which is around 5-8 weeks. The second task was to design a facility for this project. To achieve the first goal there were several steps that were followed which are given below:

1. Design a prototype for the caster which can be made in 24hrs.
2. Select machineries to manufacture this caster
3. Do a cost analysis
4. Make necessary changes for the cost to be feasible.

First of all we looked into several designs. Few of them were developed during the previous semester of this IPRO. Initially it was decided that we will stick to the best design from the previous semester, but than we came up with a better design which looks more like the Colson's (our sponsor) design. After several discussions among ourselves and with our sponsor we decide to go with the new design and made the prototype for it. The prototype was designed on AutoCAD as well as plastic prototype. The next task was to do selection of equipment, which was also a difficult task that needed to be achieved. This was difficult because we needed to manufacture the caster with 24 hour time limit and also we needed to make approximately around 250-300 casters to fulfill the requirement of Colson Associates. We initially came up with long list of machinery that needed to be considered and moved on from their eliminating those which were not necessary and at the same time adding anything that was needed. Initially we considered few different kinds of Laser cutting machine, we looked into several CNC lathe, CNC mills, hydraulic presses, welders and water jet. The first task was to compare Laser Cutting v/s water jet, because both of them were considered to do the same task. The comparison for the Laser cutting and water jet was done and with the assistance of Mr. Arvin from Arrow Gear we decided to use laser cutting over water jet.

The few major differences among Laser cutting and Water Jet are given below:

- In Laser cutting, light 10.6um is used while in water jet water is used for cutting.
- The source of energy in laser cutting machine is gas laser while in water jet high pressure pump is used.
- In laser cutting energy is transmitted using beam guided mirrors, while in water jet rigid high-pressure hoses transmit the energy.
- Laser cutting is typical process used for cutting, drilling, engraving, ablation, structuring, welding while water jet is used for Cutting, ablation, structuring.
- 3D material cutting is difficult in laser cutting due to rigid beam guidance and the regulation of distance while it is partially possible in water jet since residual energy behind the work piece is destroyed.
- Common applications for laser cutting machine is cutting of flat sheet steel of medium thickness for sheet metal processing, while applications for water jet are cutting of stone, ceramics, and metals of greater thickness.

Then we looked into details of laser cutter i.e. cutting time, time required to make change, safety consideration and operating environment, precision of process, and what kind of material can be used for caster that laser cutter can handle. We looked at the quotes and details provided by different vendors and chose to use Mitsubishi Laser cutting machine which was perfect for our use.

Next we looked into different kind of CNC mill and lathes. Different quotes were collected for the CNC mills and lathe but later based on the requirement we decided to go with three CNC lathes and decided not to use CNC mills. After selection of these 2 machines task got easier because now we only need hydraulic press and welding machines. We decided to go with 2 welding machines and a one hydraulic press for manufacturing around 5000 casters in one 8 hr shift.

After finishing the design and selecting the equipments, we moved on the final task that was to build a facility for this project. Several land area were considered in Chicago and Arkansas. The decision was left on to Colson Associates to choose the land in Chicago or Arkansas.

BACKGROUND & PURPOSE:

In today’s market caster designs require four to six weeks to develop. It is desired to make casters in a shorter time period while still contending with the varieties provided by competing companies. Colson Corporation would like to be able to provide customers with caster order deliveries in a 24 hour timeframe. The idea is to allow customers the opportunity to order casters in the morning and have them shipped by the close of day. Due to the lack of such turnaround in today’s market it is believed that Colson will also have the advantage of increasing their profits in two ways: one, they may be able to charge a lot more because no other company is providing this service and second, more customers may want the quicker service, thus providing more orders.

After reviewing Colson’s current sites and available equipment we decided a new building would have to be constructed to meet our needs. Several factors have been explored, such as:

1. Turnaround time
2. Equipment needed material cost
3. Workers needed
4. Layout requirements
5. Equipment capability
6. New building costs, and
7. Variation of casters

Two IPRO classes in conjunction with Chuck Harris of Colson associates and Colson fellows have been created to address this phenomenon: Spring IPRO 312 and Fall IPRO 312 both of 2006. This Fall IPRO was given a wealth of information from the previous semester’s group, from which we were able to extract much necessary data. Spring IPRO 312 finished three caster designs however they were not in agreement with Colson’s expectations. Colson associates stated that they wanted casters with fewer parts that would be similar in looks to the casters they provide in today’s driven market. After checking the previous three designs and applications Colson associates said “We’re sure it works, but it looks too different from what we have now”. Of the three design caster concepts number one was favored. However it would be too complicated to design this caster at the desired 24 hour turnaround due to the number of parts needed and part assembly. During the course of the first four weeks, a new caster design was suggested that contained significantly fewer components, and was much simpler to manufacture than any of the original three designs.

RESEARCH AND METHODOLOGY:

- Establish / refine caster component designs capable of being produced from flexible technologies (such as lasers and water jets) that meet sponsor's performance and responsiveness requirements

- Determine the equipment required to produce caster components that meet quality, economic and flexibility requirements

- Develop representative prototypes and ensure they meet International Caster and Wheel Manufacturers' (ICWM) requirements

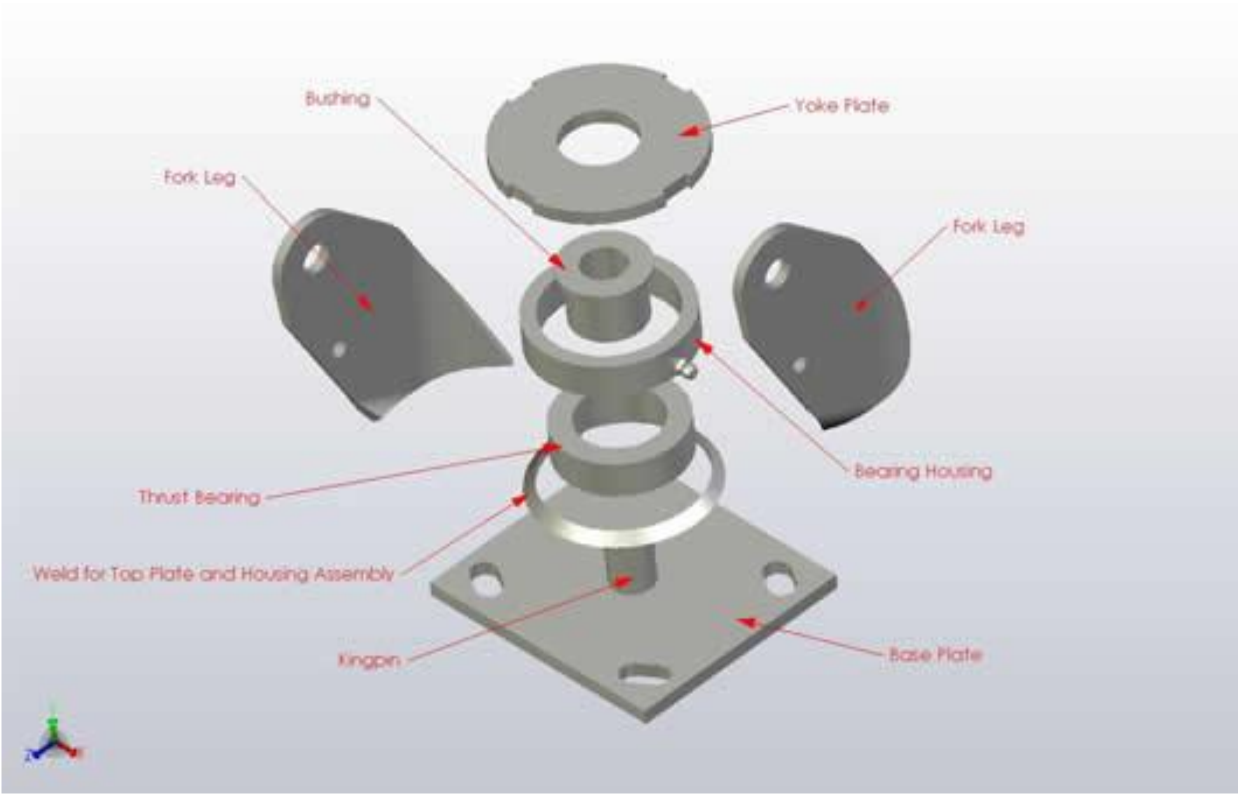
- Determine the economics involved as compared to traditional caster manufacturing methods: equipment cost, cost per part, floor space, staff and return on investment

The team was divided, based on need, into four sub-teams: **equipment**, **caster design**, **factory design** and **business**, with their names suggesting their function. The **equipment team** was responsible for finding out all the information on any equipment that would be required in the process. The **caster design team** was responsible for selecting a design that would comply with Colson's design requirements and also exceed the International Caster and Wheel Manufacturers' (ICWM) requirements. The **factory design team** was responsible for locating and selecting possible sites for the facility, designing the facility layout and ensuring that building and environmental codes were met. The **business team** was responsible for all costing and predictive financial calculations.
During the course of this project, what became critically important was to share information on a timely basis in order to reflect current progress. This made us dependent on one another.
The findings and conclusions of each team were combined and scrutinized, allowing the IPRO team to draw final conclusions.

Caster Design Sub Team:

The caster design team was responsible for going over the Caster designs from last semester and trying to optimize the design to have the least machinery and the least processes to get a finished caster. There were 3 previous design concepts from the last semester, but the team decided to go with a new fourth design which had fewer parts and also eliminated the need for heat treating the caster which is very advantageous to the team.

The parts of the caster are:
1. Yoke Plate
2. Bushing
3. Fork Legs
4. Bearing Housing
5. Thrust Bearing
6. Kingpin



The **base plate**, **fork legs** and the **yoke plate** would be made from **1018 cold-rolled stee**l.
The **kingpin** would be made from **1018 steel rods.**
The **bearing housing** would be made from **1018 steel tubing**.
The **bushing** and **thrust bearing** would be **purchased.**

<u>Advantages:</u>

- Less complicated design (Parts are easier to machine)
- No heat treating is necessary
- Cheaper to manufacture
- Looks more like Colson's original Caster design
- Design is easily adaptable for different Caster sizes
- Fewer parts

<u>Disadvantages:</u>

- Welding is involved
- Cost of the Thrust bearing

Initial Caster Prototype:

The steel prototype shown above is the initial caster design #4 prototype. It was manufactured by one of the students in the IPRO team and was able to show is the caster design #4 and better make us able to identify what are the drawbacks as well as the possible improvements to the design in order to optimize the design.

The prototype was also useful in approaching Colson Casters and giving the sponsor an opportunity to look at some of the work we had done and a chance to give us some feedback on what they were looking for in terms of the caster aesthetics. There were several changes suggested to the prototype and the team was able to make the changes to its AutoCAD prints and sent the prints to Colson to review. This led to the refined Prototype #4. This is a plastic composite prototype created on 3D printing software by Colson Associates and has several improvements over the initial prototype.

Here is a picture of the revised prototype;

The revised caster prototype had several changes made to it and these included the following:

1. The fork legs are rounded and this makes them stronger and they look more like the current Colson casters.
2. The yoke plate is added and this is circular unlike the square base that the forks were initially welded to. This makes for a more pleasing aesthetic look.
3. Finally, the nut and pin ending on the caster pin is changed. Instead, the assembly will be kept in place by mushrooming the pin over the nut. This has 2 main advantages namely: The caster cannot be taken apart and tampered with once fully assembled and the caster is more reliable as it is unlikely that the mushroomed head will give way over time.

The IPRO Team was also able to find the Material Cost necessary to manufacture each caster and this is summarized in the table below:

Material Cost per Caster:

MATERIAL SIZE & TYPE	**SOLD IN**	**COST**	**PART NAME**	**# OF PARTS**	**COST PER CASTER**
1" Diameter 1018 C.R.S	12ft Lengths	$24.77	Pin	57 Per 12ft Length	0.43¢
Tubing 2 3/4 O.D / 2" I.D 1018 C.R.S	12ft Lengths	$181.00	Bearing Housing	164 Per 12ft Length	$1.10
Tubing 3" O.D / 7/8" I.D 1018 C.R.S	12ft Lengths	$275.00	Fork Base	144 Per 12ft Length	$1.90
4 X 8 Sheet of 1018 C.R.S 1/4" Thick	4 X 8 Sheet	$176.31	Base Plate	230 Per Sheet	.76¢
4 X 8 Sheet of 1018 C.R.S 1/4" Thick	4 X 8 Sheet	$176.31	Forks	135 Sets Per Sheet	$1.30
			PURCHASE ITEMS		
			Thrust Bearing		$2.09
			Bronze Bushing		.50¢
			Wheel		$5.00 Estimate
			Coating		. 64¢
			TOTAL COST PER CASTER		$13.72

Equipment Sub Team:

The Equipment sub team was responsible for several things, Firstly they were accountable for deciding what machines were required in order to produce the different parts of the caster based on the design. It was also very important that the machinery was also such that we did not have 2 machines with similar capabilities but tried to minimize the number of machines needed. With our caster concept in place and approved by Colson, the team then selected appropriate tools that would be used in the caster manufacturing process. Once these machines were selected, various companies were contacted for details ranging from cost and capabilities to power and floor space requirement.

The equipment selected was:

1. Mitsubishi Laser
Price - $700,000
Used For – Cutting out base plate and Caster Forks
Machining Times – Base Plate (30 Seconds) One Set of Forks (60 Seconds)
Maximum Monthly Capacity – 6400 Units
Floor Space Required – 19ft X 40ft
Electrical Requirements – 208VAC / 3 Phase / 60Hz

2. NC Lathe / Duraturn 2030
Price - $116,700
Used For – Machining King Pin which will be welded onto the Base Plate
Machining Time – Two Minutes
Maximum Monthly Capacity – 4800 Units
Floor Space Required – 73 inches X 64 inches
Electrical Requirements – 20.9 KVA

3. CNC Lathe / Duraturn 2550
Price - $132,600
Used For – Machining Bearing Housing which will be welded to the Base Plate
Machining Time – 1½ Minutes
Maximum Monthly Capacity – 6400 Units
Floor Space Required – 92 inches X 69 inches
Electrical Requirements – 20.9 KVA

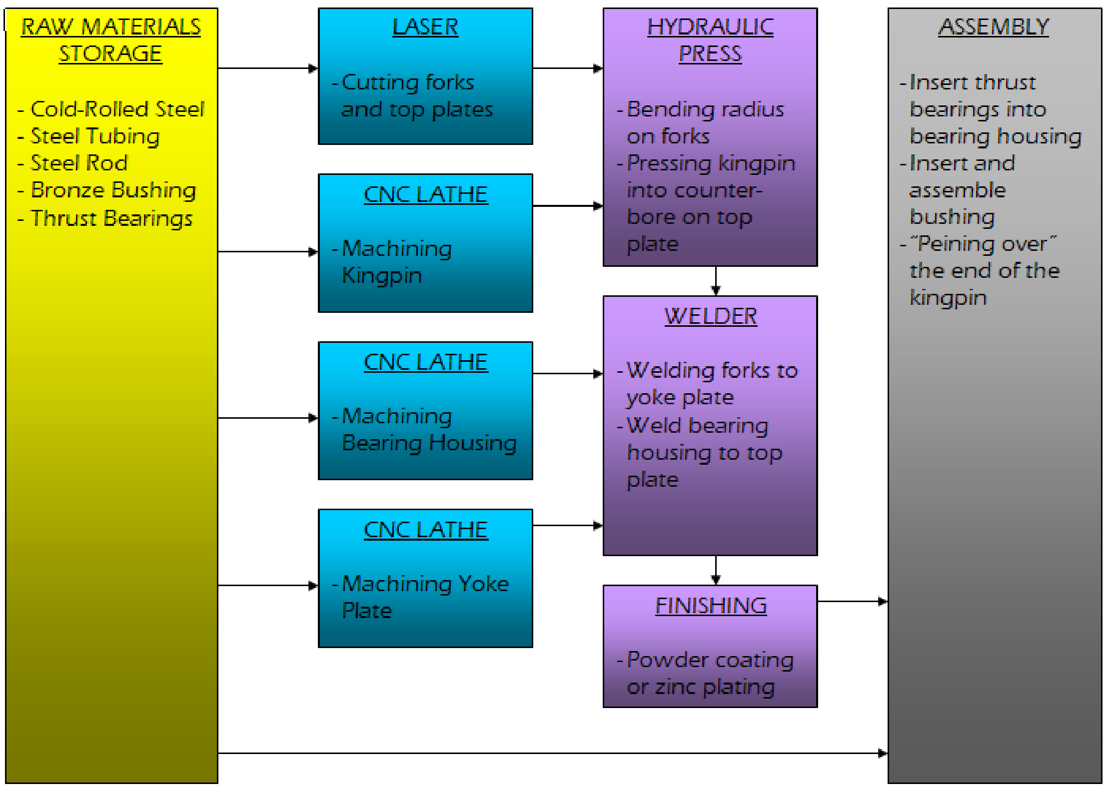
4. CNC Lathe / Duraturn 2550
Price - $132,600
Used For – Machining Fork base / Yoke Plate (Forks will be welded onto this part)
Machining Time – Two Minutes
Maximum Monthly Capacity – 4800 Units
Floor Space Required – 92 inches X 69 inches
Electrical Requirements – 20.9 KVA

5. 100 Ton Enerpac Hydraulic Press
Price - $12,000
Used For – Bending Radius on Forks
Bending Time – 1½ Minutes per set
Maximum Monthly Capacity – 6400 Units
Floor Space Required – 36 inches X 51 inches
Electrical Requirements – 110 volts

6. Miller Multiprocess Welder Model #XMT 456 CC/CV (Two Required)
Price - $5,655 each / $11,310 total
Used for – All Welding Applications
Welding Time Required – Four Minutes per Caster
Maximum Monthly Capacity – 4800 Units (This is based on having two welders)
Floor Space Required – Allow 4ft X 4ft for each welder and another 5ft X 5ft for two welding tables
Electrical Requirements – 480 volt / 3 phase

In addition to machining the parts, the equipment sub team was also responsible for thinking of the finishing process involved with the caster. The caster needs to be finished in order to increase the life span of the caster as well as for the following reasons: corrosion resistance, wear resistance, hardness, and appearance. Two different finishing processes were identified as viable options. These finishing processes were: zinc coating and powder coating. The former is currently being used by Colson Casters for their current operations and the later is an emerging and fast gaining hold form of part finishing. Research was performed to compare both of these finishing processes to investigate the equipment necessary, the costs as well as the capabilities of each. A comparison matrix was prepared and is going to be forwarded to Colson Casters for them to make a decision as they see fit regarding the finishing process for the proposed facility.

Process Schematic:



Factory Design Sub Team:

The IPRO Team was also varied enough in the skills and backgrounds of the team members that we were able to dedicate our architectural students to the Factory Design sub team of the facility. This included the building codes, machine and power requirements, land costing as well as incentives for location selection. All in all the 2 architectural students were able to show the best possible location for the facility, the necessary power and building requirements as well as a layout of the facility and several inside and outside renderings of the facility. These will be touched on later in the building portions of this report.

Business sub Team:

The final sub team that was instrumental to the work of this IPRO team as a whole is the business sub team. This team was responsible for making a detailed cost matrix for the review of Colson. This cost matrix is very robust and takes several of the parts from each of the other sub teams and puts all the information related to the cost to come up with the cost of the project as well as some assumptions of volume, sales and selling price in order to extrapolate and come up with breakeven scenarios as well as the revenue and the income projections. There are a lot of assumptions that had to be made for the cost matrix, but the scenarios are set up in independent variable format and thus any assumptions made can be changes in such a way that the scenarios are redone at the new variables and therefore it is a flexible matrix.

ASSIGNMENTS:

We had eleven people in our IPRO so we divided ourselves into 4 groups initially. The four groups were administrative group, the design group, the equipment group and the factory design group. The task of the administrative group was involved in liaising with the IPRO office, and ensuring that the deliverables followed the formatting rules and were submitted on time. The task of the design group was involved in choosing and validating the caster design. The equipment group was involved in selecting machinery for the project and the task of factory design group was site selection, building plans, factory layout for the project.

During the course of the IPRO, however, we have realized that this setup is not the most effective one. Since the IPRO team consists of people with different capabilities, we decided that in order to optimize brainpower, members can move between groups as long as deadlines are met. The design group was dissolved once the design was finalized. Once we decided that whole class is just one large group things started to get done pretty quickly and everything occurred in timely manner. Each person used their skills to finish the deliverables of the project.

OBSTACLES:

- The amount of time to fully understand the requirements of the IPRO and to differentiate between last semester's and this semester's objectives

- The amount of time to finalize the caster design, which consequently delayed virtually all other aspects of the project

- Gathering up-to-date information (capabilities, costs) on equipment required for the processes involved in manufacturing the caster.

- It took our current team a significant amount of time (2 weeks), to get a good background and grip over the IPRO objectives and results achieved so far by the team last semester. This was necessary in order to go forward and work on the new objectives.

- It also took us a while to get a good understanding of what exactly our objectives this semester were and how our objectives were different from the objectives last semester.

- After reviewing our current objectives and our project in detail, we realized that we had a lot more objectives that needed to be accomplished in order to present a complete solution to Colson. This increase in the number of objectives to be achieved in the same amount of time has put a lot of pressure on our team. Hence, the larger deliverables-to-time ratio is a huge obstacle.

- It took a significant amount of time to finalize the caster design. The main reason for this is that Colson made it clear, last semester, that the concepts presented at the time were too different from the casters that Colson provides. As such, in designing the new caster, we had to follow the design guidelines provided by Colson, but still significantly reduce the complexity of the concept so that the casters can be produced with the equipment we plan to use, within the stipulated time frame.

- As a result of the delay in finalizing the design, research about other aspects such as, equipment selection, materials, finishing, etc., also got delayed.

- Communication with Colson Associates; hence, we still have many questions unanswered such as the number of casters that Colson would like to be able to manufacture per shift, how many shifts in a day they would like to run and, most importantly, if they fully approve of our concept. This is however understood due to the fact that Colson Associates do not have all of those answers either.

- One of our biggest barriers was gathering current information on equipment. Most equipment companies didn't help us out with equipment details and price quotes, because they knew that we were just college students and not actual buyers.

RESULTS/ACCOMPLISHMENTS:

1. Conceived and refined caster designs and had the designs approved by Colson Casters Inc so we were able to move forward with the project

2. Created working caster prototypes based on original and refined caster concept designs.

3. Designed a flexible process that eliminates the need for hard tooling, thus significantly reducing inventory and other costs as well as flexible for various needs.

4. Create appropriate cost model based on the business needs and other factors such as equipment, building and materials, with accommodations for direct costs

5. Identified two possible locations for the proposed factory site (compared Illinois to present site in Arkansas) and investigated the benefits of both.

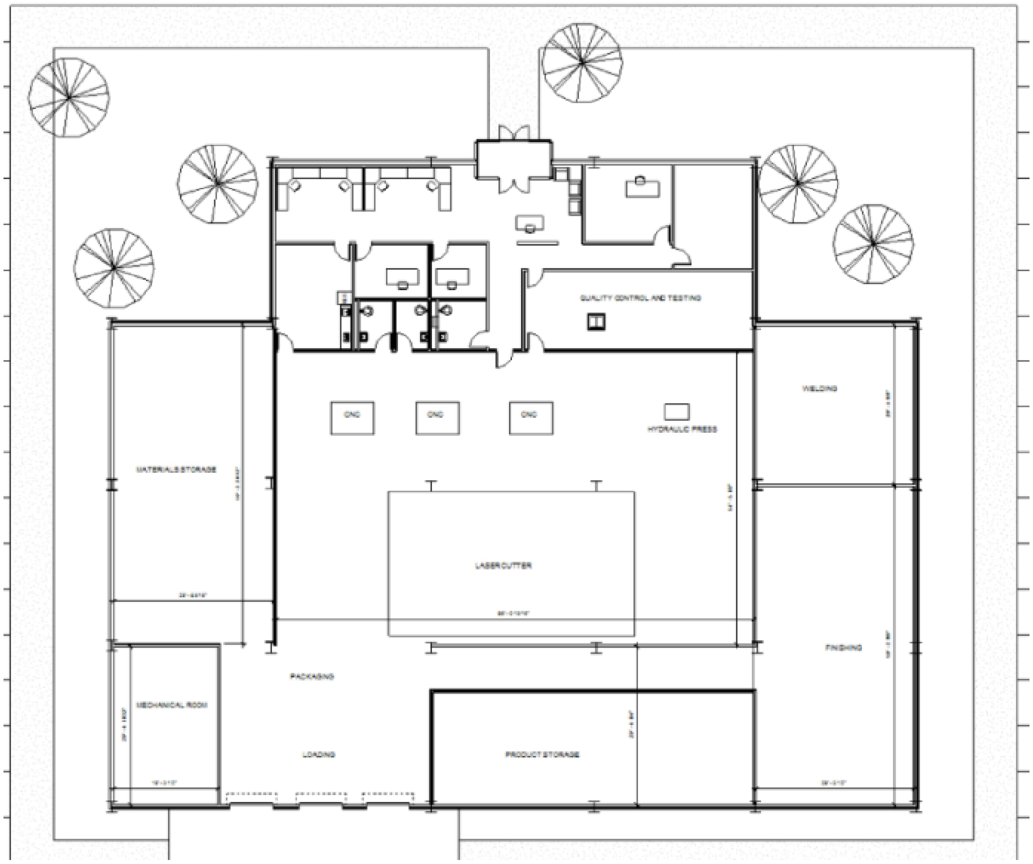
6. Drafted building designs for the facility with accommodations for expansion and thorough space considerations as well as up to date with building codes and requirements.

7. Created a robust cost model for the first year with flexible variables which will let us forecast the financial impact that the proposed facility will bear for Colson Casters. The cost matrix is thoroughly done including all of the machinery, building, labor as well as materials.

Building

The IPRO team was able to come up with the building layout as well as the general requirements to set up the building. 2 sites were looked into concerning the location for the building; Chicago and Arkansas. After several comparisons on different attributes it was decided that Arkansas was the best location for the facility.

Outside Rendering of the Proposed Colson Facility



Layout of the Proposed Colson Facility

RECOMMENDATIONS:

The IPRO team after this semester and the experience and knowledge gained from the project thus far are making the following recommendations to Colson Casters Inc. in respect to what they should invest. The objective once again is for Colson to produce specialized casters with a short turn around time with the use of flexible technology that is going to be profitable to the company in the long run.

Firstly, the caster design should be the design that the IPRO team developed. The caster design is recommended because it eliminates some issues like heat treatment of the bearing related parts. Also, it allows for maximum use of automated CNC machining as well as reduces the time for the casters to be made as these parts do not need hard tooling to be manufactured.

In addition to the caster design, the IPRO 312 team also believes that Colson should buy the machinery outlined earlier in this report. This machinery as well as the attached process schematic is optimized to make machining of the casters in the fastest and most efficient manner. The building layout and building specifications are also estimated to the best of the team's ability.

In addition, the IPRO team investigated the different locations that the manufacturing facility can be located and it is decided that Arkansas is the best location for this factory. Not only is it the current location of the Colson factory in operation, but it is cheaper, close to some of the parts required and close to the already established facility.

Finally, the IPRO 312 team was also able to come up with a cost schedule for the project. This schedule includes the machinery, raw materials, building and everything that goes into the manufacturing of casters. All assumptions are accounted for and the cost schedule is presented in a matrix form and is easily manipulated to account for the variables according to the wishes of the IPRO sponsor.

FUTURE WORK:

1. Find ways of reducing equipment cost in order to reduce cost of production per caster.
2. Find possible ways of incorporating new caster families into the production line.
3. Liaise with the marketing department at Colson to get a better picture about customer relations.

APPENDIX A: Comparison of Cutting Techniques

Comparison between water jet cutting and Laser cutting techniques:

Fundamental process differences

Subject	CO_2 Laser	Water Jet Cutting
Method of imparting energy	Light 10.6 µm (far infrared range)	Water
Source of energy	Gas laser	High-pressure pump
How energy is transmitted	Beam guided by mirrors (flying optics); fiber-transmission not feasible for CO_2 laser	Rigid high-pressure hoses transmit the energy
How cut material is expelled	Gas jet, plus additional gas expels material	A high-pressure water jet expels waste material
Distance between nozzle and material and maximum permissible tolerance	Approximately 0.2" ± 0.004", distance sensor, regulation and Z-axis necessary	Approximately 0.12" ± 0.04", distance sensor, regulation and Z-axis necessary
Physical machine set-up	Laser source always located inside machine	The working area and pump can be located separately
Range of table sizes	8' x 4' to 20' x 6.5'	8' x 4' to 13' x 6.5'
Typical beam output at the work piece	1500 to 2600 Watts	4 to 17 kilowatts (4000 bar)

Typical process applications and uses

Subject	CO_2 Laser	Water Jet Cutting
Typical process uses	Cutting, drilling, engraving, ablation, structuring, welding	Cutting, ablation, structuring
3D material cutting	Difficult due to rigid beam guidance and the regulation of distance	Partially possible since residual energy behind the work piece is destroyed
Materials able to be cut by the process	All metals (excluding highly reflective metals), all plastics, glass, and wood can be cut	All materials can be cut by this process
Material combinations	Materials with different melting points can barely be cut	Possible, but there is a danger of delaminating
Sandwich structures with cavities	This is not possible with a CO_2 laser	Limited ability
Cutting materials with limited or impaired access	Rarely possible due to small distance and the large laser cutting head	Limited due to the small distance between the nozzle and the material
Properties of the cut material which influence processing	Absorption characteristics of material at 10.6 µm	Material hardness is a key factor
Material thickness at which cutting or processing is economical	~0.12" to 0.4" depending on material	~0.4" to 2.0"
Common applications for this process	Cutting of flat sheet steel of medium thickness for sheet metal processing	Cutting of stone, ceramics, and metals of greater thickness

Initial investment and average operating costs

Subject	CO_2 Laser	Water Jet Cutting
Initial capital investment required	$300,000 with a 20 kW pump, and a 6.5' x 4' table	$300,000+
Parts that will wear out	Protective glass, gas nozzles, plus both dust and the particle filters	Water jet nozzle, focusing nozzle, and all high-pressure components such as valves, hoses, and seals
Average energy consumption of complete cutting system	Assume a 1500 Watt CO_2 laser: Electrical power use: 24-40 kW Laser gas (CO_2, N_2, He): 2-16 l/h Cutting gas (O_2, N_2): 500-2000 l/h	Assume a 20 kW pump: Electrical power use: 22-35 kW Water: 10 l/h Abrasive: 36 kg/h Disposal of cutting waste

Precision of process

Subject	CO_2 Laser	Water Jet Cutting
Minimum size of the cutting slit	0.006", depending on cutting speed	0.02"
Cut surface appearance	Cut surface will show a striated structure	The cut surface will appear to have been sand-blasted, depending on the cutting speed
Degree of cut edges to completely parallel	Good; occasionally will demonstrate conical edges	Good; there is a "tailed" effect in curves in the case of thicker materials
Processing tolerance	Approximately 0.002"	Approximately 0.008"
Degree of burring on the cut	Only partial burring occurs	No burring occurs
Thermal stress of material	Deformation, tempering and structural changes may occur in the material	No thermal stress occurs
Forces acting on material in direction of gas or water jet during processing	Gas pressure poses problems with thin work pieces, distance cannot be maintained	High: thin, small parts can thus only be processed to limited degree

Safety considerations and operating environment

Subject	CO_2 Laser	Water Jet Cutting
Personal safety equipment requirements	Laser protection safety glasses are **not** absolutely necessary	Protective safety glasses, ear protection, and protection against contact with high pressure water jet are needed
Production of smoke and dust during processing	Does occur; plastics and some metal alloys may produce toxic gases	Not applicable for water jet cutting
Noise pollution and danger	Very low	Unusually high
Machine cleaning requirements due to process mess	Low clean up	High clean up
Cutting waste produced by the process	Cutting waste is mainly in the form of dust requiring vacuum extraction and filtering	Large quantities of cutting waste occur due to mixing water with abrasives

Appendix B: Machines' Cost

Base Cost of the Different Machines as well as their respective specifications:

Mitsubishi Laser

MACHINE SPECIFICATIONS		Price
Model	3015LVPLUS– 35CFX	$700,000
Machine Unit Dimensions	418.5" (W) x 90.6" (H) x 183.0" (D)	
Rapid Travel Speed	3345 single axis, 4730 simultaneous (inch/min)	
Pallet Changer Drive Mechanism	Chain	
Pallet Change Time	App 25 sec	
Electrical Requirements:	71 KVA	
LASER RESONATOR SPECIFICATIONS		
Resonator unit Dimensions	98.4" (W) x 71.3"(H) x 31.5" (D)	
Rated Output Power (CW) (W)	3500 watts	
Composition CO_2:CO:N_2:He	8:4:60:28	
Consumption amount (liter/Hr)	3	
Gas sealing time (Hr)	24 (during rated continuous oscillation)	
Electrical Requirements:	42 KVA	

MACHINE SPECIFICATIONS		Price
Model	IPE-10010	$12,000
H-Frame Press Dimensions (in)	70.50" (W) x 89.25" (H)	
Press Capacity	30lbs	
Pressing Speed	9.8sec/in	
Pump Model	ZE4320SB-N	
Cylinder Model	RC-10010	
Maximum Operating Pressure	10000 Psi	
Electrical Requirements:	42 KVA	
Manufacturer	ENERPAC	

CNC TURN
DURATURN 2030

MACHINE SPECIFICATIONS		Price
Model	2030	$116,700
Machine Height	66.5in	
Floor Space	72.8 in * 64.2in	
Machine Weight	7700 lbs	
Maximum Spindle Speed	4000 RPM	
Maximum Turning Diameter	13.0 in	
Maximum Turning Length	12.4 in	
Spindle Drive Motor	18 HP	
Electrical Power Supply	20.9 KVA	
Coolant Tank	37.0 gal	

DURATURN 2050 (X 2)

MACHINE SPECIFICATIONS		**Price**
Model	2550	$132,600
Machine Height	69.2in	
Floor Space	92.1in * 68.1in	
Machine Weight	8580 lbs	
Maximum Spindle Speed	3000 RPM	
Maximum Turning Diameter	14.2	
Maximum Turning Length	20.2	
Spindle Drive Motor	34.7/26 HP	
Electrical Power Supply	20.9 KVA	
Coolant Tank	42.2 gal	
	TOTAL	**$265,200.00**

Welding Machine (X 2)

Model	XMT 456 CC/CV	**Price**
Quantity	2 machines	$5,655
Power	3 phase power	
	450 A at 38 VDC	
	565 A at 43 VDC	
Welding Amperage Range	5-600 A, in CC mode	
	10-38 V in CV mode	
Floor Space	4 * 4	
Weight	118 lb	
	TOTAL	**$11,310**

Grand Total Equipment costs	**$1,105,210**
Cost of Installation and testing for all other equipment	$110,521.00
Powder Coating Costs	**$60,000**
Cost of Installation of Powder Coating Machine	$10,000
GRAND TOTAL	**$1,285,731**

Appendix C: Material Costs

Material Cost Quotes for the Steel for the Prototype caster:
Quotes obtained from Napco Steel Inc.
Sales Representative: Brian Miller (Phone: 630-293-1900)

1018 C.R.S

1" Diameter (Used to Manufacture the Pin)
Sold in 12ft Lengths Order Quantity 10 Price Each $24.77 Total Cost $247.70

Tubing 2 ¾" O.D / 2" I.D (Used to Manufacture the Bearing Housing)
Sold in 12ft Lengths Order Quantity 10 Price Each $181.00 Total Cost $1,810.00

¼" X 4" Flat Stock (Used to Manufacture the Base Plate)
Sold in 12ft Lengths Order Quantity 10 Price Each $49.98 Total Cost $499.80

¼" X 5" Flat Stock (Used to Manufacture the Base Plate)
Sold in 12ft Lengths Order Quantity 10 Price Each $62.95 Total Cost $629.50

¼" X 6" Flat Stock (Used to Manufacture the Base Plate)
Sold in 12ft Lengths Order Quantity 10 Price Each $84.90 Total Cost $849.00

932 BRONZE TUBING

1 ½" O.D / 5/8" I.D (Used to Manufacture the Bronze Bushing)
Sold in 105" Lengths Order Quantity 10 Price Each $324.80 Total Cost $3,248.00

1018 H.R.S

4ft X 8ft Sheet 1/8 Thickness (Used to Manufacture the Fork)
Order Quantity 10 Price Each $88.80 Total Cost $888.00

4ft X 8ft Sheet 3/16 Thickness (Used to Manufacture the Fork)
Order Quantity 10 Price Each $134.86 Total Cost $1,348.60

4ft X 8ft Sheet 1/4 Thickness (Used to Manufacture the Fork)
Order Quantity 10 Price Each $176.31 Total Cost $1,763.10

Appendix D: Labor Costs

Labor Costs for the Facility Personnel per shift.

Indirect # of hours in a shift=8

Title	#	wages/hr	$ Total/hr	
Manufacturing Engineer	1	$25.00	$25.00	
Shift Supervisor	1	$20.00	$20.00	
Receptionist/Administrative Assistant	1	$15.00	$15.00	
Business/Sales/Marketing	1	$20.00	$20.00	
	4		$80.00	/hour
			$640.00	/day
			$12,800.00	/month
			$153,600.00	**/year**
Total (including benefits and vacation & everything else)			**$230,400.00**	**/year**

Direct

Title	#	wages/hr	$ Total/hr	
Professional Welders	2	$20.00	$40.00	
Main Machine Operator/Programmer	2	$25.00	$50.00	
Product Finishing Professionals	2	$15.00	$30.00	
Product Assembly Personnel	1	$12.00	$12.00	
Assembly/Ship/Cart/General Factory Worker	1	$12.00	$12.00	
	8		$144.00	/hour
			$1,152.00	/day
			$23,040.00	/month
			$276,480.00	**/year**

TOTAL COST TO COMPANY : SALARIES **$506,880.00 /year**

(Assumi20 days a month of work)

TOTAL COST TO COMPANY:SALARIES/caster **$8.80**

Appendix E: Manufacturing Capacity

Caster Manufacturing Capacity for an 8 hour shift.

Shift Capacity (Calculated by time for each caster)							
		minutes	simult.	Mins 8hr			
Laser Cutter	Base plate	0.5		480			
	Forks	1					
	changeover	0				volume	volume/month
		1.5	1		# of casters	320.0	6400.0
CNC Lathe #1	King Pin	2					
	changeover	0					
		2	1		# of casters	240.0	4800.0
CNC Lathe #2	Bearing Housing	1.5					
	changeover	0					
		1.5	1		# of casters	320.0	6400.0
CNC Lathe #3	Fork Base (Yoke)	2					
	changeover	0					
		2	1		# of casters	240.0	4800.0
Hydraulic Press	Fork	2					
	changeover	0					
		2	1		# of casters	240.0	4800.0
Welder # 1	Base Plate and Bearing Housing	2					
	changeover	0					
		2	1		# of casters	240.0	4800.0
Welder #2	Forks and Fork Base	2					
	changeover	0					
		2	1		# of casters	240.0	4800.0
Finishing	All parts of the caster	30	150		# of parts	2400.0	48000.0
Assembly	total caster including nut and wheels	2					
	changeover	0					
		2	1		# of casters	240.0	
			Maximum shift capacity			**240.0**	**Casters**
			# of shifts in a month			20.0	
			# of casters in a month			**4800.0**	**Casters**

Appendix F: Facility Locations

Location Comparison between Chicago and Arkansas

Chicago

EDGE (Economic Development for a Growing Economy)

- Involves at least 5 million investment in capital improvements places in service in Illinois and employs at least 25 new full time employees

Property Tax Incentives

- Class 6B, 6C and 7: Rehabbing existing facility or area in need of commercial development. Property receives 16% assessment level for first 8 years, then 23% in the 9th year, then 30% in the 10th, and then back up to full 36% in 11th year

Enterprise Zone Program

Exempt from state and city sales tax on building materials purchased in the city.

- 6.25% sales tax exemption for machinery
- exempt from state tax on gas and electricity
- exemption from real estate title transfer tax
- $500 income tax credits for each job created for disadvantaged workers
- investment tax credits

Empowerment Zone Program

- Employer wage credits of up to $3,000 for wages and certain training expenses for employees living within Empowerment Zones
- Tax deductions of up to $37,500 of the cost to Empowerment Zone Property
- Employer wage credits of up to $2,100 for hiring at risk youth

TIF (Tax Increment Funding)

- There are over 70 TIF district in Chicago Area
- Expenses eligible
  - Land acquisition, clearance and site prep
  - Certain environmental remediation measures
  - Building rehabilitation
  - Signs and awnings
  - Streets and streetscaping
  - Professional fees related to development
  - Job training and welfare to work
  - Up to 30% of applicants construction period interest costs

In quarter 1 of ’05:

- Manufacturing average salary : $50,405
- Machinists hourly wage $24.28
- Miscellaneous Machine Operators $14.92
- Welders and Cutters $18.80

- Assemblers $10.75
- Production Inspectors $10.50

15% of Chicago's workforce is in manufacturing

Major transportation hub

Strong with suppliers and buyers

Good quality of life, healthcare, school systems, Public Transportation and Arts and Culture

ARKANSAS

Jonesboro:

- 60,000 residents, 5th largest city in Arkansas
- Jonesboro MSA recently recognized as 7th strongest in the nation for manufacturing
- More than 100 industrial plants and facilities
- Manufacturing makes up 22.9% of labor market
- High quality transportation infrastructure
- 2 railroads and 42 trucking companies

Most Tax incentives in Arkansas are technology and information sciences based. (ArkPlus Tax Incentives, Targeted businesses, Motion Picture Production, Tourism)

Average Industrial Bills

Electricity
- 5,000kW, monthly 2,920,000, typical bill would be $103,328.90
- 10,000kW, monthly 5,840,000, $206,657.00

Wastewater
- First 2,000 gallons, $3.00
- Next 12,000, $1.30 per thousand gallons
- Over 14,000, $.70 per thousand gallons

Water
- First 1,000 - $3.00 min
- Next 19,000 - $1 per thousand gallons
- Next 180,000 - $.95 per thousand gallons
- Over 200,000 - $.60 per thousand gallons

Building Cost Estimates

Total sq. ft. of building	**16200**
Lower half sf. Cost	$ 41.50
Median sf. Cost	**$ 55.50**
Upper sf. Cost	$ 74.50
Rough Estimate:	**$ 899,100.00**
MEANS spec. building size	25000
Cost Modifier	1.05
Size modifier factor	0.648
Cost Modifier	1.05
(refer to Building Construction Cost Data 2006)	
Total (including size factor)	**$ 944,055.00**
Location factors	
Little Rock, AK	**81.2**
Fayetteville, AK	**71.8**
AK average	**75.1**
Chicago, IL	**111.6**
Total Estimated Building Cost	
Little Rock, AK	**$ 766,572.66**
Fayetteville, AK	**$ 677,831.49**
AK average	**$ 708,985.31**
Chicago, IL	**$1,053,565.38**

Business Analysis of the proposed facility:

Being one of the objectives of this IPRO, the team developed an appropriate business model based on the new process design. Factoring in details such as cost of materials, cost of facility, cost of equipment, and cost of utilities, e.t.c., and the team was able to design such a model, the results of which are shown below.
With limited resources as compared to seasoned professionals, we naturally had to make some assumptions when designing this model, some of which are listed below.

Assumptions
No. of casters manufactured per month: 4,800
No. of casters manufactured per year: 57,600

Basic Costs

Estimated Manufacturing Cost per caster	$ 13.11
Total cost to company (Labor)	$ 506,880.00
Estimated Labor Cost per caster	$ 8.80
Estimated Cost of Goods sold per caster	$ 40.00
Total year 1 cost of goods sold	$ 2,275,776.00
Total year 1 Overhead costs	$ 1,520,640.00

Table - Initial Capital Expenses

Buildings	$709,000
Land	250,000
Property Tax	57,540
Facility Maintenance	$35,450.00
Machinery and equipment	1,285,731
Net property/equipment	*$2,337,721*

Year One Data

Total year 1 depreciation expenses	$ 410,454.00
Total year 1 Maintenance, repair, and overhaul expenses	$ 192,860.00
Total year 1 other miscellaneous expenses	$ 4,000.00

1. Year-one revenue expectancy	
	<Custom Series>
Number of casters sold annually	**57,600**
Average sales price per caster	**$70.21**
Annual revenue	*$4,044,096*
Total year 1 revenue	*$4,044,096*
2. Year 1 cost of goods sold	
	<Custom Series>
Cost of goods sold per caster	*$40.12*
Total year 1 cost of goods sold	**-** *$2,310,912*

Amortization Schedule

Annual interest rate	5.0%
Monthly rate	0.41%
Loan amount	$2,337,721
Term of loan (months)	60
Payment	($43,996.84)

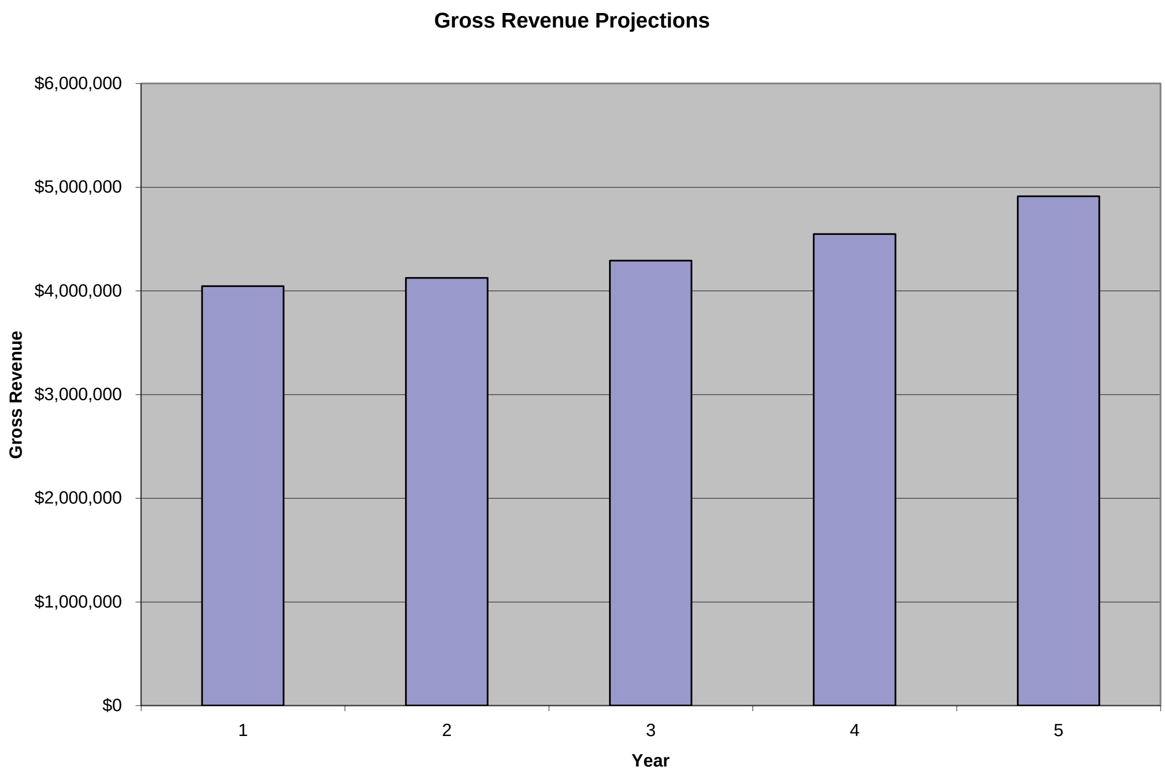
Return on Investment

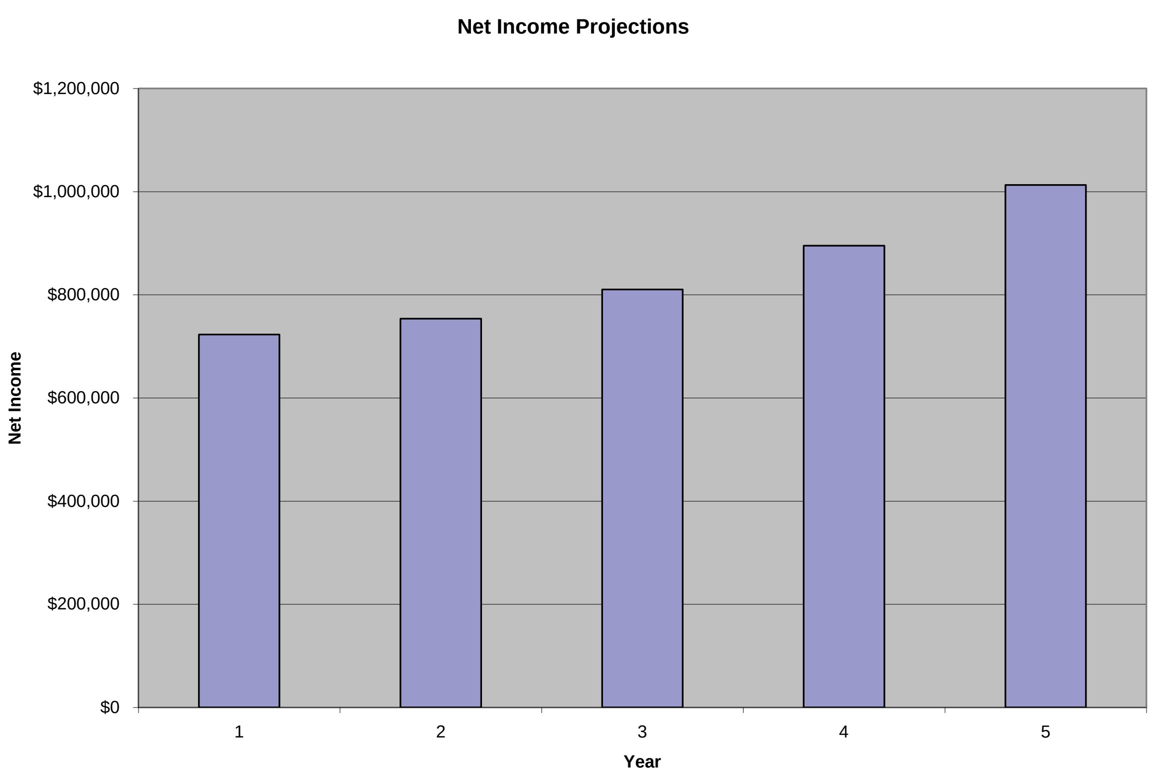
ROI = Net Income / Book Value of Assets

	Year 1	Year 2	Year 3	Year 4	Year 5
ROI	*37%*	*49%*	*73%*	*129%*	*385%*

Total Year 1 Profit & Loss projections

		Year 1
Revenue		
Gross revenue		*$4,044,096*
Cost of goods sold		*2,310,912*
Gross margin		*$1,733,184*
Total revenue		*$1,733,184*
Operating expenses		
Depreciation		*398,946*
Maintenance, repair, and overhaul		*192,860*
Other		4,000
Total operating expenses		*$595,806*
Operating income		*$1,137,378*
Interest expense on long-term debt		*104,893*
Operating income before other items		*$1,032,485*
Loss (gain) on sale of assets		0
Other unusual expenses (income)		0
Earnings before taxes		*$1,032,485*
Taxes on income	*30%*	*309,745*
Net income (loss)		*$722,739*





Our data is quite promising, with a payback period of less than four years.

Appendix G: Acknowledgement and References

Acknowledgement:

Project Sponsors:
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Faculty Advisors:
Professor Will Maurer
Professor Keith McKee

External Resources:
Mr. Joe Arvin, President of Arrow Gear Inc.
Mr. Chuck Harris, Colson Associates

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