Team 16 — Snobike

Project Proposal and Feasibility Study

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ENGR 339
December 11, 2009
Executive Summary

Sustainable designs have become a growing trend in our society today. More importance has been placed on protecting and preserving the environment. One of the ways in which this has been demonstrated is through the continued reform in the transportation industry. Biking is an excellent option for those who wish to travel sustainably, but relies heavily on seasonal weather conditions. In order to provide a solution to this problem, the idea for a snow bike was created.

After preliminary design work, research, and analysis, the proposed project is considered to be viable both financially and technically. We believe this project will be completed according to current safety standards and done within the projected timeline.
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1. **Team Description**

Snobike consists of four passionate senior Mechanical Engineering students that came together as a team looking to design a product that would have a practical mechanical application and fill a need in the community. Senior Design is a class in which all of what has been learned during the four years at Calvin College can be brought together into one project. It is an opportunity to exemplify all that has been learned and to test the engineering abilities of the team.

![Team 16: Matthew Milan, Matthew Brouwer, Jen Meneely, Justin Karsten](image)

**Figure 1.1:** Team 16: Matthew Milan, Matthew Brouwer, Jen Meneely, Justin Karsten

1.1 **Matthew Milan**

Matthew was raised in Rockford, Michigan where he graduated from Rockford Senior High School with honors. He is currently working on his Mechanical Engineering degree at Calvin College. After graduation, Matthew plans to either start his career or work on a Master’s degree.

1.2 **Matthew Brouwer**

Matthew was born and raised in Fresno, California and graduated from Fresno Christian High School. He is a senior Mechanical Engineering student with a Mathematics Minor. Matthew has had two internships, both with the Michigan Department of Transportation. After graduation, Mathew plans to continue his education and pursue a master’s degree.
1.3 Jen Meneely

Jen grew up in Pittsburgh, Pennsylvania and graduated from Trinity Christian School. She is a senior Mechanical Engineering student with a Mathematics Minor. Jen had two internships, both with Westinghouse Electric Company, in Pittsburgh and plans to work there after graduation. When not doing homework, Jen enjoys playing volleyball, downhill skiing, and spending time with her family.

1.4 Justin Karsten

Justin grew up in Hudsonville, Michigan and graduated from Hudsonville Public High School. He is currently a senior at Calvin College pursuing a degree in Mechanical Engineering. Justin enjoys playing water polo, hunting, snowmobiling, and spending time with friends and family. Upon graduation, he plans to find a job in Grand Rapids area that fully utilizes his engineering degree.

2. Problem Statement

This design team is proposing to design a bike that will function on both clear and snow-covered trails. The proposed bike will have skis for stability and steering ability and a track that will be powered by the rider. This will allow the bike to be used on roads and trails that are covered in snow. By following a minimal number of easy steps, the rider will be able to convert the bike to be used on dirt trails and paved roads not covered in snow.

The proposed bike will benefit many, especially in the Calvin community. Many in the Calvin community use bikes as their main mode of transportation. By allowing people to ride on snow, more people in the Calvin community will be able to use their bikes during the winter and reduce their dependence on motor vehicles. This will save the rider money over time, as well as contribute to a much cleaner earth.

3. Design Considerations

3.1 Project Objectives

3.1.1 Purpose of Design

The purpose of this senior design project is to design and construct a human powered snowmobile. The design will be based on a mountain bicycle and will allow for safe travel by bicycle when there is snow on the ground.

The specific objectives for this project include several big changes to the mountain bicycle. Most importantly, the design must be safe and allow for safe and reliable transportation in extreme conditions. It also should be easy to convert from snow travel conditions to non-snow travel conditions, and it should be resistant to corrosion. The bicycle should not be more difficult to
pedal than a regular mountain bicycle, should have similar tolerances, and should be comfortable for the rider. Finally, this design must adhere to all standards put forth by the American Society of Testing and Materials (ASTM) as well as standards set by the American Society of Mechanical Engineers (ASME).

3.1.2 Cost

The senior design budget for each team is $300. The team’s goal is to stay under this cost, but in order to make a product that might be considered well built and well designed it might be necessary to obtain more funds. The preliminary prototype will be built as inexpensively as possible, but the goal of the project is to build a model that would compete with current designs on the market that costs about $529.

3.1.3 Reliability

This design is focusing on people who would be interested in using this as a commuter bicycle. In order for this to be possible, it is necessary that the bicycle be reliable and trustworthy for everyday commuting during treacherous winter months. The goal of the design is to be simple and efficient, which will lead to fewer complicated mechanisms and less opportunities for design failure.

3.1.4 Scope

The scope of this design project is a very important objective, which must be defined. Although there are many possibilities for the production capacity of this design, the scope must be limited to something that would be of interest to the average bicycle commuter in Grand Rapids. This means the bicycle needs to be affordable, simple, and efficient.

3.2 Design Norms

Christian engineers are called by God to adhere to higher standards, which must be incorporated into the designs. These designs and the products created by them must be reliable and helpful and do the best to assist with any problems that may occur with the product that they can. People will judge this team based not only on the design produced by them, but based on how they conduct themselves throughout the design process and use that as a representation of the team’s Christianity. The team has decided that in order to accurately portray themselves as Christians, they are going to adhere to the following design norms that they feel best demonstrate what they want the final product to do.

3.2.1 Stewardship

Snobike is committed to stewardship, both financial and environmental. Since the objective of the project is to provide commuters who bike to work in the summer with an option to bike to work in the winter, people will be encouraged to have a way they can bike year round. This option would reduce the number of cars on the road and provide an eco-friendly way to get to work, therefore reducing emissions and promoting sustainability. This is also financially feasible as the
bicycle design will be significantly less expensive than a car, not only in initial price but also in annual maintenance costs, providing the commuter with a considerably large savings from biking.

3.2.2 Transparency

The bicycle must be consistent, reliable, and predictable. Snobike must function in snow and sleet and must keep the rider safe. The easiest way to do this is to make the design understandable and transparent. If the designers have an open communication about the design the user will better understand the concepts behind the work and be able to rely on the consistency and the stability of the bicycle.

3.2.3 Trust

This bicycle design is dependent on the trust of the user. If the user does not trust the design of the bicycle, they will not use it or be interested in purchasing it. The incorporation of trust into a design makes it dependent and reliable. Trust also means avoiding conflicts of interest, no questionable choices or design features that might bring harm to the user.

3.3 Alternative Solutions

There are several alternatives to using a Snobike. One option is to use a regular mountain bike in the winter. The problem with this is that there is not enough traction on the snow to move forward or to turn. Another option is to walk, but this takes much longer and has a longer exposure time to the harsh weather conditions. A third option would be to drive a car. This is more costly and it is more harmful to the environment because it uses fossil fuels. Driving a car is also very dangerous in the winter and the chance of getting in an accident is greatly increased.

4. Project Organization

Planning is extremely important when undertaking any project. As this project spans two semesters it was imperative to create a plan and work from that plan.

4.1 Schedule

A Gantt chart was used throughout the fall semester to schedule work to be completed and can be seen in Appendix. This includes all deliverables required by Senior Design and additional steps required for the preliminary design and feasibility test of the project.
4.1.1 Deadlines

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>September 30</td>
<td>Initial Project Objectives Defined</td>
</tr>
<tr>
<td>October 14</td>
<td>Project Website Startup</td>
</tr>
<tr>
<td>October 21</td>
<td>First Class Presentation</td>
</tr>
<tr>
<td>November 18</td>
<td>Project Proposal and Feasibility Report Draft Due</td>
</tr>
<tr>
<td>December 2</td>
<td>Final Class Presentation</td>
</tr>
<tr>
<td>December 11</td>
<td>Project Proposal and Feasibility Report Due</td>
</tr>
</tbody>
</table>

4.2 Task Breakdown

A detailed breakdown can be seen in the Gantt Chart in Appendix.

4.3 Budget

The specific, preliminary budget only shows estimates of the costs of future parts. The goal of the budget is to keep spending under the $300 given to us by the senior design fund. However, to buy a kit similar to what is being designed costs about $529.

5. Preliminary Design Method

5.1 Project Requirements

The following requirements were determined by Team Snobike, but all are desirable for a customer who would be interested in using a Snobike.

- The vehicle must be able to transverse snow-covered paths
- Users should be able to operate it safely
- The vehicle should be easy to pedal, similar to a regular mountain bike
- There should be an easy conversion between using the front tire and the skis
- Keep the additions to the bike to a minimum so it remains lightweight.

5.2 Economic Feasibility

Products similar to the one being designed sell for about $529. The estimated manufacturing cost for these products is $150. The future goal is to be able to manufacture the Snobike kit at a competitive cost and quality. Prototyping costs are typically much higher. The senior design budget is $300, which will be used for design and prototyping. Several significant donations have been made to the project to help reduce the prototype cost. From the Snowmobile Expo, the team was given a back tread that can be cut into several smaller treads; snowmobile skis were also donated and will be used on the prototype. Calvin College Student Senate was also gracious
enough to donate two mountain bikes for prototyping and testing. All of these donations will make a significant impact on the cost of the project. The team is anticipating other costs will come once more testing is complete. Other costs, such as production cost, will also be anticipated. The team will be constructing as much of the design as possible without any outside assistance to keep cost down.

5.3 **Technical Feasibility**

The proposed project has already been done by a company called Ktrak, meaning it is a viable project. The challenges for this team will be keeping the cost within the design budget and creating a better design. The bicycle Ktrak offers is not reversible between front tire and ski, this would be an additional design challenge for this team, but would make the overall bicycle more useful to the user.

6. **Design Parts**

6.1 **Adjustable Skis**

6.1.1 Coefficient of Friction Analysis

The coefficient of friction for the skis is expected to be very low. This will aid in allowing the bike to slide on the snow without getting stuck. Most skis have a coefficient of friction of around 0.01 to 0.31.

6.1.2 Ski Analysis

The basic ability of the skis to turn the bike is not in question. This is because the skis will be of the same design as snowmobile skis and their ability to cut through and grip the snow will not be adjusted.

6.1.3 Collapsible Design

One of the constraints of the Snobike is to be able to lift the skis and use the front tire in case there is no snow or ice present. The design for the adjustability of the skis can be tackled in many ways. In order to change the skis as little as possible, it was decided that the skis would not be collapsible. The skis will instead be quickly removable and have a safe and convenient storage area. In order to facilitate this, several main components were added. These can be seen in Figure 5.1. A sturdy tube, with a diameter of 2 inches, will be attached to the ski at a steep angle. A tube with a diameter of 1 inch will be mounted to the top of this tube. When the skis are being used, this small tube will slide into a hollow tube that also has a diameter of 2 inches. The weight of the bike and rider will be supported through the cross sectional area of the larger tubes. If the skis come off of the ground at any point a latch prevents them from sliding out. The skis are stored in much the same way when the tire is being used. The skis will be flipped over and will slide into a vertical hollow tube. They will then be secured by the latch. This entire apparatus will be attached to the front shocks by a clamp.

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1 From: http://jjap.ipap.jp/link?JJAP/37/720/
This is an initial prototype design. Other things need to be considered in the design process. The path may be intermittently blanketed in snow. The skis will need to be able to adjust quickly without much effort and this could drastically alter the final ski design.

6.2 Gearing System

6.2.1 Size Selection

One of the main concerns with this project is the difficulty in peddling. The Snobike needs to be able to be peddled just as easily as a normal mountain bike. This is achievable with the current gearing technology. Modern mountain bikes have twenty-one gears and the low gears have a very small amount of resistance.

6.2.2 Design Style

The integration of this system will be simple because it is a design for a kit. The tread system will incorporate the original rear axle and the rear tire. These constraints and adjustments will make the development and integration of a Snobike gearing system smooth and efficient.
6.3 Back Tread

6.3.1 Material and Tread Selection

The tread material used in the Snobike will be made of rubber. The rubber tread will need to be cut to length, so a durable yet workable tread will be used. The starting tread from which the final tread will be cut was made by Polaris, and has a U.S. patent number of 3,830,551. This tread is made of durable rubber and has ribs that will allow the tread to work on both pavement and snow.

6.3.2 Coefficient of Friction Analysis

Friction forces between the tread and snow or pavement are key in designing a reliable and functioning bike. Without enough friction, the bike will not be able to move along the road or snow covered path. In order to accomplish this, the coefficient of friction for rubber on various surfaces needed to be calculated. Table 5.1 contains the coefficient of friction for rubber on various surfaces.

<table>
<thead>
<tr>
<th>Surface</th>
<th>Low Value</th>
<th>High Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snow (Wet)</td>
<td>0.30</td>
<td>0.60</td>
</tr>
<tr>
<td>Pavement (Dry)</td>
<td>0.50</td>
<td>0.85</td>
</tr>
<tr>
<td>Pavement (Wet)</td>
<td>0.25</td>
<td>0.75</td>
</tr>
</tbody>
</table>

By comparing the coefficient of friction for dry pavement against wet pavement and snow, the relative efficiency of the tread on the above mentioned surfaces can be determined. It would seem that the rubber tread would work on snow nearly as well as a normal bike tire would work on wet pavement, as they have similar coefficients of friction. This analysis only shows only how effective the rubber is at pushing off of the surface and not the friction within the bike to move the tread. The force required to move the tread will be greater than that of a normal bike tire. This will be discussed in greater detail in the design section.

6.3.3 Design

The design of the back tread will encompass much of the original bike design. The rear wheel, for example, will remain intact and act as a functioning part of the tread propulsion system. The basic design layout can be seen in Figure 5.2. The tread will be propelled by the back wheel, which will remain connected to the current pedal-chain gearing system. There will be a large support bar that extends from the back wheel away from the back of the bike that will connect to a gear-wheel. This gear-wheel will allow for the tread to stay tight and remain lined up with the system as well as keep a maximum amount of the tread surface in contact with the ground. In order to keep the tread against the ground the entire time, there will be a shock that extends from

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2 Data obtained from:
the seat support. This will give the appropriate downward force. This will allow for better propulsion of the bike. There will also be two smaller wheels that will come off of the support bar. These wheels will help to keep the tread lined up with the system and allow for tension to be kept within the tread.

![Back Tread Design](image)

**Figure 6.2:** Back Tread Design

### 6.4 Braking System

#### 6.4.1 Current Braking System

Currently the bike is installed with rim brakes, more specifically linear-pull brakes. These are quite common for mountain bikes as they are cheaper than other braking options and function well under standard weather conditions. As the cable is tightened, the brake arms are pulled together putting pressure on the rim causing the wheel to slow.

![Linear-pull Brakes](image)

**Figure 6.3:** Linear-pull Brakes

6.4.2 Brake Design

The front brake is only useful when the skis are not in use. There is no form of braking for skis other than angling the skis toward each other which is not in the scope of the project. Therefore, the front braking system will be left as is and not used while the skis are engaged. The rear brakes will also be left as is. Some minor modifications may need to be made in order to allow clearance for the tread system. The linear-pull calipers are cheaper while still having sufficient stopping performance. They are also the lightest option which helps the riding ability.

6.4.3 Design Alternatives

A design alternative considered was disc brakes. These brakes were not chosen because of the cost. The brakes have a higher initial cost and typically a compatible wheel would also need to be purchased in order to allow the disc brakes to be installed. Also the disc brakes add undesired weight to the bike.

![Disc Brake](image4)

**Figure 6.4:** Disc Brake

Another design alternative considered was a drum brake. This brake is typically even heavier because of the bulky fixture added to the axle. It is also expensive to install. There is little maintenance because the braking system is self contained in the shell but lacks the stopping performance needed.

![Drum Brake](image5)

**Figure 6.5:** Drum Brake

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6.5 Seat Adjustment

6.5.1 Seat Sizing

In the best interest of the rider, the proposed seat will be the same standard seat that is currently on most bicycles. This will allow the rider to feel like they are riding the average street or mountain bike. This will also reduce the cost of the overall project.

6.5.2 Seat Adjustment

Instead of having a standard seat adjuster, a quick release seat adjuster will be used. This will allow the rider to easily adjust the seat height without using any tools or following a complicated process. The adjuster will also allow for seat adjustments to be made much more quickly, reducing setup time and making the bike more user friendly.

6.6 Pedal Redesign

6.6.1 Proposed Design

The proposed pedal design for the bike will include straps to secure the riders feet to the pedals. Each pedal will have a single adjustable strap that will reach from one side of the pedal to the other, placing the rider’s foot between the strap and pedal. This is a necessary addition, as wet winter weather can cause the riders feet to slip off of the pedal, reducing the effectiveness and safety of the bike. The straps were chosen for their effectiveness, safety, and low cost.

6.6.2 Alternatives

There were a few alternatives to adding a single strap to the existing pedal. One alternative was to purchase specially designed strap and toe clip pedals. This would secure the rider’s foot as well as the single strap. The problem with this option was that it was much more expensive and was less safe because the users foot could get stuck during an accident.

6.7 Corrosion Resistance

6.7.1 Material Selection

The main way corrosion is reduced is through an enclosure that will house the gearing system. The component of the bike that is most vulnerable to corrosion is the chain and gearing system. The cover will be made of a durable plastic. The design of the cover is discussed further in the section below.
6.7.2 Design

The plastic casing that will cover the gearing system and chain will be designed specifically to encase the current gearing system. The casing will allow for easy removal and replacement of the chain and other components. It will also be designed to eliminate moisture around the chain and gearing system, thereby reducing rust. The casing will be produced using an injection molding process. Since this is expensive and the shield is not a vital component of the bike, the shield will not be employed on the prototype. However, this component will be very important on the final product.

7. Budget

7.1 Prototype Cost Estimates

As of now the prototypes do not cost anything. Aluminum and other raw materials are given to the team by Calvin College’s metal shop. Two mountain bikes have been given to team Snobike by Student senate. Also, some snowmobile skis and tread have been generously donated to us by Charlie Vallier.

7.2 Business Plan

Currently, the business plan is to sell the Snobike parts in a kit. A full version of the business plan is currently being developed. The business plan is being created with the help of Professor Medema from the Business Department at Calvin College.

8. Future Work

8.1 Product Testing

Initial prototype designs need to be finalized. These designs will then be prototyped and tested. Through this testing, adjustments will need to be made in order to optimize the design. With these adjustments, new prototypes will be made, and this process will be repeated until a model that satisfies the project requirements has been fabricated.

8.2 Product Expansion

Snobike is being designed as a kit to be put on average mountain bikes. In the future, work could be done to expand this. One option is that the kit could be adapted to different bike types. This could include road bikes and children’s bikes. Another option is that Snobike could become a full bike instead of a kit. There is a possibility to make a product that could be sold at a competitive price with normal bikes depending on the design changes.

9. Conclusion

9.1 Christian Perspective
This project incorporates many of the values that the team, as Christians, hold in high regard. One of the ideals that was strived for is to put others first. Snobike was created with the user in mind and it is designed to keep the user safe. Another ideal is to help people in need. Some people completely rely on their bikes for transportation. Snobike helps them to be able to do this year round despite the winter conditions.

9.2 Stewardship

One of the most important parts of this project is the idea of stewardship, both financially and environmentally. In Genesis God gave man dominion over the earth. This means that people can use the earth, but they are responsible for its keeping and wellbeing. Part of this includes depleting the earth of resources. Snobike incorporates stewardship in its design because it is manually powered and does not use any fossil fuels. Stewardship is also incorporated financially because the Snobike is much less expensive than a car. The initial and annual costs are both significantly lower for a Snobike.

9.3 Trust

This bicycle design is dependent on the trust of the user. If the user does not trust the design of the bicycle, they will not use it or be interested in purchasing it. The incorporation of trust into a design makes it dependent and reliable. Trust also means avoiding conflicts of interest, no questionable choices or design features that might bring harm to the user.

9.4 Feasibility Conclusions

After preliminary design work, research, and analysis, the proposed project is considered to be viable both financially and technically. We believe this project will be completed according to current safety standards and done within the projected timeline.
Appendix: Project Gantt Chart and Task Breakdown