Deliverable C

# Design Criteria

The wheelchair skis must possess the following features:

* Easily driven in winter condition: This system will either allow the client or the assistant of the client to easily move the wheelchair to any destination in any type of winter road or path, including snowy and icy pathways.
* Regular braking system and emergency braking system: This system will either allow the client or the assistant of the client to stop the wheelchair for any type of danger, and this system is one of the most important system because a braking system will save a person’s life.
* Minimize force of friction: This system will allow the wheelchair to move faster in the winter, so the client can reach his/her destination in a shorter amount of time.
* Push away snow: This system will push away as much snow as possible while the wheelchair is in motion, so snow does not build up in the skis or under the wheelchair. This system will ensure smooth traveling and will have less traveling problems.
* Move on hard surfaces: This system will allow the wheelchair to move in hard surfaces such as concrete sidewalks and pavement because cities, such as Ottawa, had construction on roads where sidewalks will be blocked for access. Also, this system can not cause damage to the overall product.
* Safety reflectors: This system will notify anyone in cars or anyone in other vehicles that the client, who is in the wheelchair, is passing by, and this system will provide safety to both the client and anyone else.
* Simple installation: This system has to be easily installed on the wheelchair without any assistance of a chair lift, and this system will independently be used by one person and nothing else.

# Design Teams’ Product Concepts

Julian Marra

***Product Concept No. 1 - Wheelchair Skis (Attachable)***

Wheelchair skis are designed and operate as simple as the name makes it out to be. The concept of this design includes the client being able to easily attach a ski apparatus that will allow the wheelchair to move efficiently in thick snow or icy conditions. The material of the skis will be a lightweight durable plastic, with a smooth gloss coating (like downhill skis) to minimize the friction of the snow/ice on the skis, making it easier to push the wheelchair. Moreover, the skis design will be oriented in a way to minimize the amount of snow build up under the wheelchair which eventually causes it to get stuck. This setup will either attach to the bottom frame of the wheelchair and will have a lever mechanism that will lift the wheels from the ground and place all the weight on the ski system, and will provide a locking mechanism for safety. This design, like all of our design ideas will have reflectors installed for roadside safety of the patrons being pushed and pushing the wheelchair on the sidewalk. This system will also be equipped with a braking system which will involve a metal piece with teeth to be gradually placed into the ground to allow the wheelchair to come to a stop. Extra braking mechanisms will be put in place for emergency stops which will allow the wheelchair to come to a complete stop in a shorter distance. The only issue we face with this solution is that it will have to be configured differently for different types of chairs (manual and electric). We are expecting the cost to build this product to be low, which makes it one of our favourable ideas.

***Product Concept No. 2 - Wheelchair Track System***

This product concept tends more to our clients who have electric chairs. The reason being is that an electric chair is automatically moved by a joystick on the armrest of the chair, and therefore would have a better possibility of being mobile through snow and ice on rubber tracks. The concept of this idea is to orient the rubber tracks onto the wheels of the chair, to allow the automatic motion of the wheels to rotate the tracks backwards and forwards. This will be a very productive system for automatic chairs as there will be no need for a staff member to push them as the chair will be fully mobile on its own, as well as we won’t have to design a braking system for the chair as it will already be able to stop when the wheels stop rotating. The rubber tracks are super effective in snow and ice given that they will be designed similar to the tracks on a snowmobile. There will be no need to try and minimize the friction from the tracks to the terrain, as the tracks will be fully rotational. The only downside to this concept which we have to research is the steering. Currently electric chairs are steered by their front 2 wheels (out of 6 total wheels) and if there is a track attached to the wheels, the front 2 will not be able to rotate and turn the chair. Although the track system may be more efficient for electric chairs, we suspect that it won’t be as sufficient for manual chairs which means we would need two completely different products, ultimately increasing the costs of production.

***Product Concept No. 3 - Wheelchair Skis (Drivable)***

This product concept is extremely similar to the ***Product Concept No. 1***, except that instead of having to attach the skis onto the bottom frame or wheels, our clients will be able to drive their wheelchairs directly onto the skis and then lock them in place. For this concept, we plan on leaving an insert towards the back of the skis in order for the wheel to still rotate while the skis do a fraction of the work through snow and ice. For the electric chair especially, this insert in the skis will allow the moving wheels to help move the wheelchair forwards. The ski design will be the same as in the attachable skis as in they will be oriented in a convex shape that will minimize the snow build-up under the chair or around the wheels. Braking for this system will be much easier because of the wheels contact with the ground, which will minimize the amount of braking mechanisms we need which will also minimize weight and cost of the apparatus. In sum, the main difference between these skis and the attachable skis is the ability to drive right onto them and be able to lock in place at a specific location on the wheelchair.

Mihir Jakhi

***Product Concept No. 1 - Wheelchair skis only for flywheels***

This product concept is only a slight improvement on the current wheelchair design as it simply adds skis onto the flywheels. This would make traversing through the snow easier and provide a greater degree of control over maneuvering in general. This would be ideal to only glide over the snow instead of through it.

***Product Concept No. 2 - Wheelchair skis for both flywheels and the main wheels***

This product concept would improve on product concept 1 in the sense that this would be applied to both the main wheels and the flywheels. The flywheel skis would remain largely the same, however the main difference would be on the skis for the main wheels. These skis would be wider than typical skis in order to more evenly distribute the weight of the wheelchair and the client. These skis would ideally lock and latch onto the wheelchair wheel, preventing it from moving completely. This would mean that the client would have to be propelled by an external force, such as a push from someone else. This concept would also glide over snow rather than through it but would do with a greater degree of efficiency because in this case both sets of wheels have a larger surface area to distribute the weight over. In design concept 1, the main wheels would sink into the snow and decrease traversing speed as well as maneuverability.

***Product Concept No. 3 - Wheelchair skis for powered chairs***

This product concept would be similar to product concept 2 in the sense that it would install skis onto all available wheels on the wheelchair but different when it comes to the main wheel. The skis for the main powered wheels would have a hatch cut into them in order allow the chair to largely propel itself. The skis on the flywheels would only allow for gliding and more mobility.

Leo

***Product Concept No. 1 - Wheelchair skis with a cover***

This product concept is very similar to the first wheelchair design which is at the top of the list, but for this design, the skis will have an additional “cover” attachment onto the two smaller wheels of the manual wheelchair, unlike a traditional type of ski. This cover attachment is just a cover that attaches on top of the skis such that the snow will almost never touch the smaller wheels (except the ground snow) and will allow the wheelchair to move faster in the snow. This cover design is similar to how a car travels through air because a car is built to have an aerodynamic shape to easily move through the air. Essentially, this cover design will be built to the shape that is similar to the shape of an aerodynamic car, and this will help the wheelchair move through the snow efficiently. Moreover, the skis themselves and the cover will be made from the materials that have been mentioned in the first wheelchair design. Furthermore, this concept can be applied to electric wheelchairs as well. Finally, the wheelchair will have an included emergency braking system such that two sharp hoe-like objects, that is facing parallel to the ground and facing in the opposite direction of where the client is facing, will turn 90 degrees clockwise when the client or the assistant presses a mechanical button. The two sharp hoe-like objects will be attached to compressed springs, and the springs will be decompressed when a mechanical button is pressed.

***Product Concept No. 2 - Wheelchair skis with a larger cover***

This product concept is similar to the above product concept, but for this concept, the cover will cover over all of the wheels of the wheelchair, including the two large wheels. This concept will still have the same aerodynamic properties as the above product concept. Since this design will have a larger cover, the wheelchair will technically move faster in the snow because the wheels of the wheelchair will almost never touch the snow (except the ground snow), and the wheelchair will overall have less friction. Lastly, this concept will also include the same emergency brake system and materials as the above product design.

***Product Concept No. 3 - Wheelchair skis with a pointy plow***

This product concept is to have two snow plow that will attached to the front of the wheelchair, so the two snow plows form a pointy tip in the front wheelchair. Since the wheelchair has two separate snow plows, one of the snow plows will have a couple of latches that lock onto the other snow plow; therefore, the two snow plows will be joined together, and they will be in static. The wheelchair will also have skis that attaches to the two smaller wheels of the wheelchair, so this enables the wheelchair to easily move in the snow. With these two combinations, the wheelchair will curve a path and push away any incoming snow, and it also has the ability to move freely in the snow due to the attachment of the skis that are clinged to the two smaller wheels of the wheelchair. Lastly, this concept will also include the same emergency brake system and materials as the above product design.

Kieran Moynihan

***Product Concept No. 1 - Wheelchair Sled***

Product Concept No. 1 is similar to Product Concept No. 2 in that it is a static, fixed, mechanism which allows the wheelchair to slide over the slow, rather than force through it. The sled would be made of a lightweight material, like plastic or a light metal, which would not encumber the individual pushing the sled, but not so light as to be bent or warped by uneven ground. The bottom of the sled would be flat, so as not to tip the wheelchair to one side or the other, with the sides curved upwards so that snow does not pile atop the sled, weighing it down. The sled would be attached to the wheelchair by fixing straps around the front and back wheels, securing the sled in place, and preventing the wheelchair from slipping off. Because of the unspecific shape of the straps, and the fact that their length would be adjustable, this design could fit many different shapes and sizes of wheelchair, provided that the wheelchairs in question fit within the bounds of the sled.

***Product Concept No. 2 - Wheelchair Wheel Plows***

Unlike Product Concepts No. 1 and 3, the wheel plows of Product Concept No. 2 would not have the wheelchair gliding over the snow, but rather plowing a path through the snow. This mechanism would be attached only to the front wheels of the wheelchair, and would force the oncoming snow to either side, forming a trench that would allow the back wheels to pass easily. The plows would have a flat bottom in which the front wheels would sit, and high outer walls, with a wedge on the front to divide the snow being “plowed”, and convex walls on either side. The side walls would serve a dual purpose of keeping snow off the front wheels, and packing down the snow that is forced to either side, preventing it from falling back into the path of the back wheels? The advantage of this design is that it is relatively simple to both design and attach, as it does not need to be designed for the entirety of the wheelchair. A disadvantage of this design is that if the snow is particularly deep, the plows may not be able to clear a trench, as any snow above the height of the plows would simply fall in behind the plows as they passed.

***Product Concept No. 3 - Wheelchair Skis***

Like Product Concept No.1, the wheelchair skis are fixed surfaces that would allow the wheelchair to glide on top of the snow more easily. Unlike the sled described above, however, this design would consist of four separate skis, each of which would be attached to separate wheels. The rear skis would be smaller, as they are simply guide skis, while the back skis (attached to the back wheels) would be larger, as they bear most of the load of the individual sitting in the wheelchair. An advantage of this design is that it is lightweight (compared to the sled design), and is easily maneuverable, as the front skis can move independently of the back skis, allowing for the wheelchair to be easily turned while moving. A disadvantage of this design is that it may take more time to attach this mechanism to the wheelchair, given that each piece of the skis has to be attached separately to their respective wheels, making it slightly more awkward to put on/take off.

# Solution Analysis

\*Note: Solution Analysis is in order from most preferable to least preferable

\*Note: Further analysis and prototyping will be required for product efficiency and testing

1. ***Wheelchair Skis (Drivable)***

The drivable wheelchair skis offer a wide range of benefits that satisfy our clients’ needs, including portability of the system, lightweight design, efficient and easy installation and effectiveness through snow and ice.

**Design variables:**

* *Skis*

The skis for this system will be 3D printed in portions which will include ‘dominos’ to easily connect one piece to the other, without having a protruding crease at the bottom. Once all connected, the skis will be ground down to a smooth finish and waxed the same way downhill skis are. The skis will be oriented in a convex shape to minimize friction through the snow and ice and to minimize the amount of snow that collects under and around the wheelchair. For this setup, the skis will also include rubber spiked rollers at the front and rear of the ski so that they’re not damaged if it comes into contact with ice or ashphalt. The top of the ski will be fitted to the thickness of the wheel, with a little bit of wiggle room to allow the wheel to still rotate on the ground through the inserts. We also plan for the skis to have two sections of ‘teeth’ that will allow the ski to move like a track along the y-axis. By doing this, the skis will make for less work while trying to turn and will also minimize the risk of getting stuck in heavy snow.

* *Locking Mechanism*

The locking mechanism will be mounted to the top of the ski and will grip the side frame of the wheelchair firmly. It will be a solid metal locking bracket with rubber padding within the grip to disallow damage to the wheelchairs exterior finish. We are not able to attach the mount to the wheel in this solution because we would like for the wheel to rotate freely through the insert in the ski. Exact mounting locations are still to be determined.

* *Rubber Spiked Rollers*

The rubber rollers will be mounted on a 360 degree rotating axle with 50% of the roller exposed at the bottom of the skis. These rollers will be mounted towards the front and rear sections of the skis, with the purpose of providing protection and extra traction to the skis on hard surfaces and through heavy snow. The tread pattern of the rubber rollers will be that of an all terrain car tire.

* *Emergency Braking System*

Two lockable metal plates will be installed to the rear of both skis which, with the step of a foot can be locked down into the ground. This system is for the staff member pushing from the rear to be able to step on a pedal in the middle of the chair that will cause both plates to be pushed into the ground, stopping the wheelchair. Additionally, depending on costs we plan on being able to use the rubber rollers as brakes to add to the braking power.

* *Safety Reflectors*

Safety reflectors will be installed onto the system for maximum roadside safety and to provide a far visual for oncoming traffic.

1. ***Wheelchair Skis And Variations(Attachable)***

*\*\**Note: this is section is the culmination of all similar ideas stated in this document

The attachable wheelchair skis provide the client with increased maneuverability and control while also being quite simple in their design and implementation.

* *Skis*

The skis for this concept would also be largely 3-D printed because this allows for maximum design flexibility. These skis would look largely the same as normal skis except for being slightly wider to accommodate for the increased load they would have to bear. This would allow for maximum weight dispersion and thus prevent sinkage. These skis would also be shaped in a convex shape in order to push snow out of the way.

* *Locking Mechanism*

Each of the skis would lock the the wheels by use of two solid metal arms, one on each side, with rubber grips on the ends. The arms would be flipped up and locked into place by the person attaching the skis, and the rubber grips on the arms would firmly hold the wheel in place and prevent it from sliding out or away from the skis.

* *Emergency Braking System*

The braking system is similar to that of the drivable wheelchair skis. A metal plate would be installed at the rear of each back ski, and when the person pushing the wheelchair steps on the provided foot pedal, the plate would be locked in a downwards position, pushing against the snow and ground underneath the skis and stopping the wheelchair in its tracks.

1. ***Wheelchair Sled***

The Wheelchair Sled is a simple design, compared to some of the others, but it’s in its simplicity that it gets its advantage. A sled, unlike skis, is a singular piece of equipment that is not finicky or awkward to attach/detach, and, while it might be bulky to carry around detached from the wheelchair, it is easy to keep all of it together, as it exists only as a single piece.

* *Sled*

The sled would consists of a single, continuous 3-D printed design (though it may be printed in multiple pieces and then attached). The sled would be wide enough to fit completely around the wheelbase of the wheelchair, and long enough to protrude with a slight up-slope in front of the wheelchair, allowing the wheelchair to mount rises in the snow. The front of the sled would be formed into a wedge, with the sides forming convex walls protecting the wheelchair from snow and forcing snow beneath and to the side of the sled.

* *Attachment System*

The sled would be attached to the wheelchair by use of straps and buckles. Ideally there would be four straps in place to secure the wheelchair. The first running from the back of the sled around the front wheels, the second running from the front of the sled around the back wheels. The last two would run from the back of the sled around the back wheels and from the front of the sled around the front wheels. This would prevent the wheelchair from sliding either forward or backwards, as well as reducing unnecessary forces pulling the wheels and potentially breaking the wheelchair.

* *Braking System*

The braking system for this design will consist of a metal plate fixed to the back of the sled and attached by an axle to a foot pedal. When the person pushing the wheelchair presses their foot down on the pedal, the metal plate will swing down and dig into the ground and snow, slowing the progress of the sled and stopping it quickly.

* *Safety Reflectors*

The sled will have reflectors fixed upon the upper rim of the design. This will give oncoming cars an additional visual cue that there is someone ahead of them and protect the safety of the individuals pushing and riding the wheelchair.

1. ***Wheelchair Wheel Plows***

Wheelchair plows are different from all the other design concepts because their strategy is not moving the wheelchair over the snow, but rather moving it *through* the snow. This may be effective to some degree, but it has some drawbacks.

* *Plows*

The plow would be made from a 3-D printed plastic waxed bottom, to allow it to easily slide over snow, and either *hard* plastic or metal high walls around it. The walls would be shaped such that it forms a wedge at the front of each plow, with walls around it. On each side of the plow, the walls would initially run up at around a 60° angle to the ground, and then curve upwards. The initial flat surface would compact and snow being forced around the plow, and the upper curve would serve to protect the front wheel from snow falling over the the top of the wall.

* *Attachment System*

The plows would be attached by metal clips which would protrude upwards from the base of plows and connect across the top of the front wheels, on either side of the wheel’s attachment point. This would prevent the wheelchair from sliding forward or backwards in the plow, and from jumping up out of the plows due to a sudden bump in the surface.

* *Emergency Braking System*

The braking system is similar to that of the drivable wheelchair skis. A metal plate would be installed at the rear of each back ski, and when the person pushing the wheelchair steps on the provided foot pedal, the plate would be locked in a downwards position, pushing against the snow and ground underneath the skis and stopping the wheelchair in its tracks.

* *Safety Reflectors*

The sled will have reflectors fixed upon the upper rim of the design. This will give oncoming cars an additional visual cue that there is someone ahead of them and protect the safety of the individuals pushing and riding the wheelchair.

The table below tallies each component on a scale of 1-3, 1 being satisfactory and 3 being excellent

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Design** | **Portability** | **Cost** | **Weight** | **Meets Needs** | **Total**  **/12** | | | | |
| No. 1 | 3 | 2 | 2 | 3 | 10 | | | | |
| No. 2 | 2 | 1 | 1 | 2 | 6 | | | | |
| No. 3 | 1 | 3 | 1 | 2 | 7 | | | | |
| No. 4 | 2 | 3 | 3 | 1 | 9 | | | | |

Table 1 - Overall design

# Prefered Solution

Based on the analysis of all the different types of solutions, a consensus has been achieved in moving forward and further developing the *drivable wheelchair skis.* This design exceeds the needs/wants and expectations of our clients, and if developed correctly will be an extremely effective product not only for our clients at the LIFE program, but every person who is confined to a wheelchair.

Additionally, prototypes will be developed and tests will be conducted to expand our knowledge based on the design specifications we have already come up with and to improve the product as a whole.

# Group Design Concept

For our group design concept, we plan on using the drivable wheelchair ski idea as the base of our concept while adding improvements and changes based on the ideas presented in this report.

***5.1*** ***Ski Design and Features***

Adapting the idea of the wheelchair sled and wheelchair plow, the two seperate skis will be designed wider than originally planned to be able to fit our mounting and braking components onto it, and to even out the weight distribution on the skis. Making the skis wider than original will also allow for more of a curvature in the skis convex shape, helping with the management of snow build up, like that of a plow.

Merging the wheelchair tracks and wheelchair skis will be done by adding two rubber rolling wheels per ski, with a tread pattern similar to an all terrain tire. This will minimize damage to the skis if there is a rough patch of ice or a patch of concrete exposed on the sidewalk and will provide extra traction to the skis to tackle heavy amounts of snow. Additionally, we will be incorporating a rigid transmission belt approximately 3 inches in front of the wheelchairs main wheel on the ski to allow track like movement out of the rigid skis. These connectors are similar to that of a heavy duty conveyor belt connector and act like teeth that allow the ski to fluctuate up and down in the y-axis. This improvement will allow for smoother transitions into different terrain, better steering and stability and will allow the skis to be folded in half for portability off the wheelchair.

The skis will be 3D printed in parts and will be assembled using ‘dominos’ to avoid having protruding creases at the bottom of the ski, and visually looks like an individual ski. Once the entire ski is assembled, it will be sanded to a smooth finish and waxed like a downhill ski for minimal friction. Skis will have to modified and adjusted for the difference in the manual and electric wheelchairs.

***5.2 Locking Bracket***

The locking bracket will be directly mounted to the skis and attached firmly to the frame bar directly behind the wheel. The attachment piece to the bar will be of cylindrical shape that opens in half and clamps down and locks the skis in their proper place. The inside of the cylindrical clamp will be padded with rubber so that there is no damage to the exterior finish of the wheelchair. For this design, we **cannot** lock the skis in place onto the wheel as we would like for the main wheels to rotate freely.

***5.3 Safety Reflectors***

3M stickable reflectors will be added to the system for maximum roadside safety.

***5.4 Braking System***

The braking system adapted for this design concept will be that of the braking system mentioned by each group member in their solution ideas. There will be a foot pedal in the middle of the wheelchair which will be fixed to an axle that will engage a metal plate at the rear of each ski down into the ground, allowing the wheelchair to come to a full and complete stop. Through tests and prototyping, if this is not efficient enough then we will add a braking apparatus to the rubber rollers. Since the main wheel of the chair is in contact with the ground, the client will be able to add to the braking power by grabbing hold of the wheel and stopping it from rotating.

This design concept will have to be integrated differently for electric wheelchairs, and the process of prototyping and testing will allow us to do that efficiently.

# Visuals

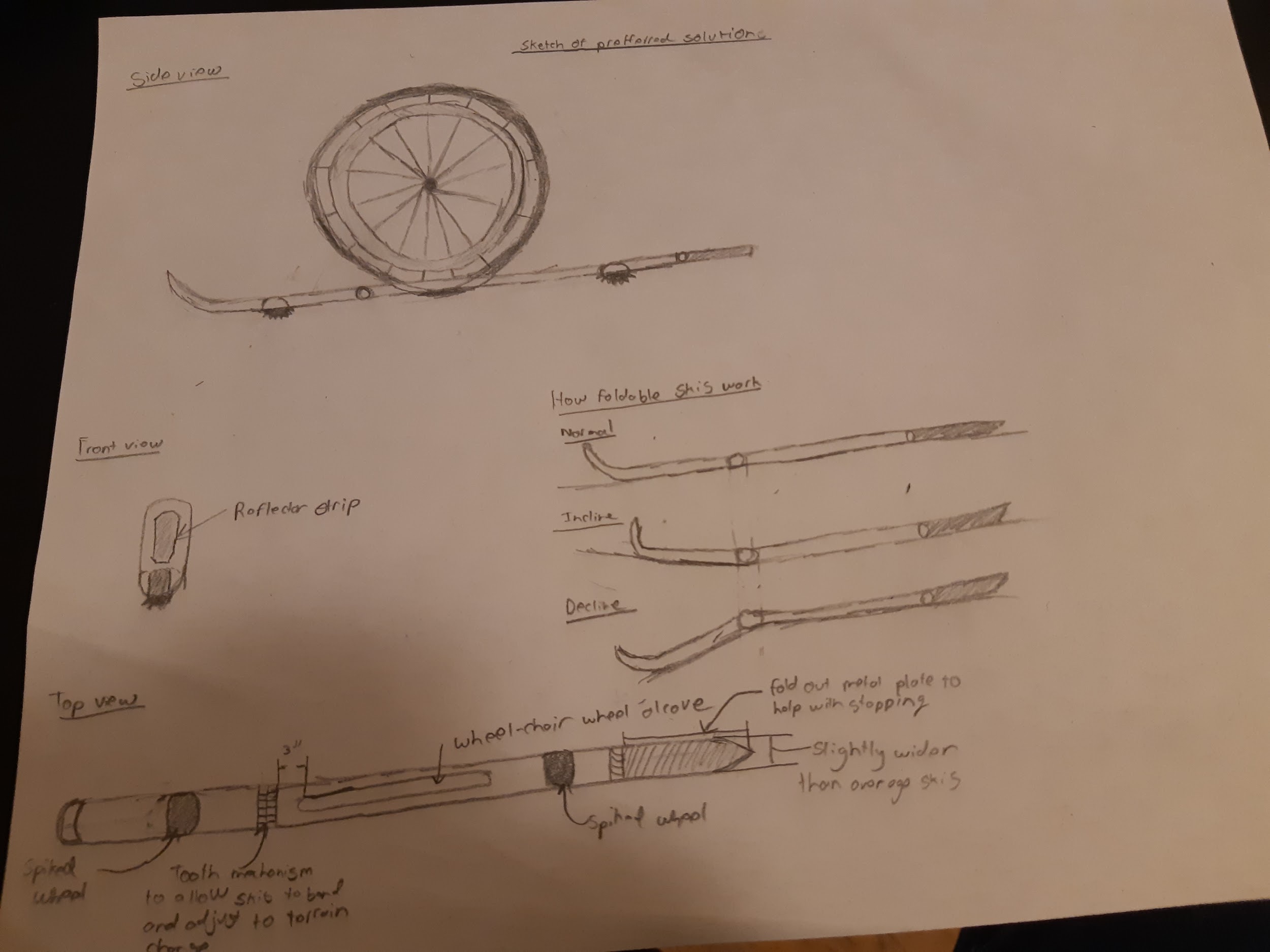


Figure 1 - Drawing and design specs

# Core Functionality of Group Concept

The core functionality of our group concept is to provide a flexible, simple solution to the problem at hand. The design presented in the group concept section fulfills these requirements by being able to adapt to the type of terrain it is facing through use of its foldable half of the skis. This makes the ski more flexible over all types of surfaces, flats, inclines, and declines. The rubber wheels further improve this aspect by allowing easy and efficient transferral between ground and snow conditions by being very wide as well as protruding very little. The braking system at the back provides extra safety because it can stop the wheelchair from running off/moving into danger when not needed. In addition to this theme of safety, reflectors will make the user far more visible to oncoming traffic. The benefit to this design is that it is quite versatile and able to meet all the requirements of the client, while also fulfilling a few extra and finer goals. The major drawback to this design is that it is not quite as simple as some other designs presented in this document. It is this designs versatility that makes it slightly more complicated. Despite the complications, this design resides well within the realm of possibility, and can be brought to fruition with careful planning, development, and testing.