

Innovation: The Four Season Vehicle

1 Objective

The Olin human powered vehicle team has never previously designed a vehicle with weather in mind. This year, the team took a revolutionary shift in mindset and decided to build *Cheryl*, a more practical vehicle that is safe, stable, and comfortable to use all year round. The ASME HPVC notwithstanding, the vehicle's focus was on the daily function and adaptability of our vehicle to a riders everyday needs. The design of *Cheryl* focuses on safe operation in rain and wintry conditions, the most common weather challenges faced by human powered vehicle owners in New England. This focus prompted the creation of a fully-faired vehicle with modular outboard wheels, ensuring that the rider remains dry and balanced in any commute. Furthermore, *Cheryl's* separate fairing compartments for both the side front wheels and the single back wheel prevent splash from the road. Finally, the vehicle's front wheels can be swapped for studded tires, skis or skates for transportation or recreation across a variety of surfaces.



Figure 1: Prototype vehicle during snow testing.

2 Need

Rain reduces road traction, lowers visibility, causes riders discomfort and is the most common of the adverse weather conditions presented to HPV operators in New England. It makes the roads slick, reducing a coefficient of friction between the wheels and the road by anywhere between 16% and 72%[5], which, especially on turns or at high speeds, can cause collisions or crashes. Most of the rain splashed upon a rider in the rain is not from the falling rain itself, but from the wheel splashing up water and sediments from the street surface. A vehicle with a more stable system with more traction and protection from the elements than a standard bicycle is needed.

In addition to rain, human powered vehicle operation is impeded by winter weather, which includes snow, slush, extreme cold and icy road conditions. Like rain, active snow storms have a reduced visibility issue, but the key issues necessary in dealing with winter weather are the extreme cold and the icy road conditions. The roads can have their friction reduced by up to 74%[1]), which increases the likelihood of falls and crashes. The extreme cold of the winter can also be a hazard on its own. The cold air can cause runny noses, trigger asthma, cause exposure, or possibly even frostbite [3]. This is especially an issue with biking, as the faster you move the stronger the wind chill effect (also a cause of frostbite) due to the air movement from biking.

Other conditions considered included strong wind and sun. Strong wind can push upon a rider, causing them to swerve or fall. It can also sweep and carry debris around a rider, which could shock the rider and cloud their vision. Strong sun can cause a vehicle to overheat if left long outside and can cause glare on the window. These conditions were deemed to be less critical than rain and winter weather.

3 Description

Cheryl reflects an intentional system design for a more weatherproof system. The vehicle features a high traction, more stable three-wheel configuration, a fully enclosed fairing with separate wheel pods, a wide window, the possibility of replacing wheels with skis or skates, and space for bike lights. The application of these innovations gives *Cheryl* the ability to function in many weather conditions, allowing a person to travel by human power all year round.

The vehicle's three-wheel configuration is inherently more stable than a bicycle. This is of great advantage in low traction situations like the slick roads caused by rain and ice. When handling turns, the two front wheels provide a wide support patch and prevent tipping. If one were to hit a patch of ice in this vehicle, one wheel could pass over, potentially lose grip, but instead of swerving and falling as one would in a two-wheeled vehicle, the trike stays upright.

The tricycle configuration also allows for higher visibility, both in terms of being seen and seeing out. Its increased width is easier for cars sharing the road to see and allows for the mounting of several standard bicycle lights. Lights can be mounted on each wheel hub, which makes for a wider base for the lights, something that cars are expecting to see on other cars, causing them to notice and take care around our vehicle. Lights on the wheel shells can be both front and rear facing, and an additional back light could be mounted to the back of the central fairing.

In addition to the tricycle configuration, *Cheryl* has a fully enclosed aerodynamic and structural carbon fiber fairing in which the rider sits. This fairing isolates the rider in a separate compartment from the wheels, eliminating splash from the road. Furthermore, the fairing is an insulated shell, protecting the rider from wind chill in the winter. In the summer, the front portion of the fairing can be removed to maximize comfort of the rider. Additionally, the fairing shields the rider from the glares of the sun, rain and flying objects. Finally, the fairing is designed to cut through the wind and avoid lateral swing in strong winds.

Finally, *Cheryl* is designed with modular front wheels that can be quickly detached and replaced with skis or skates for harsh condition or recreational riding. The rear wheel can be swapped out for a studded tire for additional control on icy surfaces.

4 Literature Review

Careful review of the Leitra velomobile (UK) indicates successful attempts at a partially fared non-motorized commuter vehicles. This vehicle offers full weather protection although it does have ventilation problems in hot weather. They do not currently have a winter skate-trike adaptation, which is possible as a bolt-on addition to *Cheryl*. Furthermore,

their winter bikes are also unfared. Our design incorporates many aspects of the Leitra velomobile with improved rideability.

5 Testing and Evaluation

Although *Cheryl* is not yet complete, the team has tested its prototype tricycle in a variety of winter Massachusetts weather conditions. On snow (Figure 1), the prototype was agile, maneuverable and did not skid. Furthermore, during testing on a nearby hockey rink with slick road tires, the vehicle was completely stable, even during tight turns and slides (Figure 2). Additionally, in casual and aggressive street riding, the vehicle handles intermittent patches of ice and crusty snow with ease. Finally, testing with past fared vehicles has demonstrated the impressive wind-shielding advantages of fairings. Increased stability and protection from the elements has a dramatically positive effect on rider confidence and places *Cheryl* in a class of its own.



Figure 2: On ice, the vehicle was completely stable during tight turns and slides.

6 Conclusions and Recommendations

Cheryl is built with all-weather capability, complete protection against the elements and the multi-terrain capability with front ski and skate attachments. Although we did not explore this option, attachments for riding on sand or other surfaces is a promising area to develop in. *Cheryl* is truly a novel vehicle for commuting or recreation any time of the year in New England.

References

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