Adaptive Equipment Designed and Constructed for Samantha Gillard

By

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Project for Client #14: Samantha Gillard

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Executive Summary

Jane Gillard contacted the University of Connecticut hoping to be connected to a team of engineering students willing to design adaptive equipment for her 2 ½ year old granddaughter, Samantha. Samantha was born with a MECP2 chromosomal mutation more commonly known as Rett Syndrome. Essentially all of Samantha’s muscle motor function is affected by the disease, which has had a tremendous impact on the quality of life for her and her family.

While there may be many aspects of Samantha’s day-to-day routine that could use a little assistance from adaptive equipment, we’ve chosen to focus primarily on her most immediate need: Samantha needs an adaptive position chair at which she can carry out activities such as eating, reading, and learning the Boardmaker® created language found in her PODD (Pragmatic Organized Dynamic Display).

Samantha’s second need is to be a little kid and have fun with her family. The Gillards are ski-enthusiasts who would love for Samantha to join in on their winter activities. Getting Samantha on the slopes will be no small feat and will require a specially designed adaptive ski sled to ensure her safety at all times. For the warmer months, we will develop another way for Samantha to enjoy herself under her parents’ close supervision; for this we intend to retrofit a Power Wheels® battery powered, ride-on car with a remote control and a custom safety system.

1 Introduction

1.1 Background

Samantha Gillard is a two and a half year old girl who has been diagnosed with Rett Syndrome. Rett Syndrome is a chromosomal abnormality (MECP2 mutation on the X chromosome) that usually onset’s between 6 and 18 months of age, and only afflicts females. Males suffering from the same MECP2 mutation typically do not survive to term. Rett Syndrome’s affects on the nervous system range from mild to severe, and typically consist of developmental reversal after about six months, poor motor skills, and language reception and expression issues.
What Samantha lacks in motor control, she makes up for with her sunny disposition and the love and support of her parents Geoff and Jenny Gillard, and her grandmother Jane Gillard. Samantha’s family has requested our assistance to improve their quality of life by creating equipment to aide in Samantha’s day to day activities. Samantha’s only current means of communication is through the use of a Pragmatic Organized Dynamic Display (PODD). The PODD consists of a binder that has small cartoon-like pictures that each have an associated meaning, and are organized in a logical way that would allow the user (person helping Samantha) to flip through them until the desired action is reached. As the user points to different illustrations in the PODD, Samantha can use her left and right hands to indicate “Yes” by pressing a large green button, and “No” by pressing a large red button. Ultimately, the red and green buttons will be USB-port-compatible and can be connected to a computer to perform mouse-clicking actions. The buttons also provide Samantha the ability to advance the pages in online books as the story is being read aloud to her (by a pre-recorded voice) via a reading program that can be run on a laptop. Reading, looking at pictures in books, and having books read aloud to her are a few of Samantha’s favorite activities.

At this time Samantha is unable to walk, crawl, speak, or feed herself.

1.2 Purpose

Our purpose is to design and construct equipment that will help Samantha carry out day-to-day activities, such as eating, reading, using the laptop, and using her Pragmatic Organization Dynamic Display. To meet this requirement we will engineer an Adaptive Position Chair unique to the needs of Samantha and her parents. The chair must be adjustable to fit Samantha as she continues to grow.

In addition, we have also set out to design and construct equipment that will allow Samantha and her parents to have fun and enjoy time together as a family. Geoff and Jenny have informed us that they are both avid skiers, and Samantha loves to go fast. By developing an Assisted Skiing Device for Samantha, it will allow her to hit the slopes and participate in a favorite family activity that she would otherwise need to sit out on.

Lastly, so that Samantha might be able to have some fun outside in the
warmer months, we will acquire and modify a battery powered, ride-on car for Samantha, similar to the Fisher Price® brand Power Wheels® products. In order to best suit Samantha’s safety needs, we plan develop a Ride-On Remote Controlled Car by installing a remote control system and five point restraint harness among other modifications.

1.3 Previous Work Done by Others

1.3.1 Products

There are numerous adaptive chairs for children available for purchase with prices ranging from $300.00 to $2,000.00. The designs, materials used, features, and functions vary greatly from one manufacturer to another and even from model to model within the same manufacturer. One that is close to what our device will be is called the Adaptive Anti-Tipping Chair and is available from a company called Achievement Products for Children. The price of this particular chair ranges from $379.00 to $484.00, and is available for both children and adolescents. Similar to our proposed device, it has a tray and is adjustable to accommodate growth. However, it is not collapsible as Samantha’s chair will be.

![Figure 1. Adaptive Anti-Tipping Chair](image)

Similarly, there are also many assisted skiing device design concepts available for purchase; these devices are designed to meet the needs of individuals with a wide variety of handicaps. Prices range in the thousands. A Downhill Sit-N-Ski is available from the company Mountain Man for $2,900 to $7,500. This product is comprised of a seat within a reinforced plastic shell that is mounted on two ski blades. It has a push
bar attached for assistance when the skier is not going downhill, and is available in both adult and child sizes. However, it differs from our proposed device because the push bar is not intended for a companion skier directing the sled down the slope. Also, the chair lift compatibility is different in that two people are required to lift the shell whereas ours will be able to be done easier. A product a bit closer to our device is a Piloted Dualski made by a French company called Tessier. This is a product designed for someone who is unable to ski independently and so needs to be steered by a companion. There is a hinged bucket seat, similar in concept to that of the device mentioned above. When at the bottom of the mountain, the companion need only push a button to help the seated skier into a more upright position so that he or she can get on the chairlift with little delay. At the top, the bucket seat clicks back into position.

![Figure 2. Piloted Dualski](image)

Finally, Power Wheels® manufactures and sells over 1,000,000 battery powered, ride-on cars for children every year; they even have models that will operate under remote control and only cost a few hundred dollars. The most prevalent models — those that are not remote controlled — cost about $250.00 new from Wal-Mart®. These vehicles are powered by a 12V battery. Charging time is 18 to 30 hours, with a run time of 1 to 3 hours. They have two child-sized seats, and go both forward and in reverse. The respective speeds are 2.5 and 5 mph, and 2.5 mph. Our device will be able to go faster than this because the operator will be an adult using a remote control, and the whole system will have more safety features and fail-safes.

### 1.3.2 Patent Search Results

The patent for an adaptive mobile chair with removable rear wheels is listed under US Patent number 4,643,446. This chair has a tray, large back
wheels, and small front wheels. The back wheel assembly is detachable so that the chair can sit on top of a car seat or a couch.

The patent for a Sit-Ski device is US Patent number 6,036,202. This device is intended for an unassisted user, who has two ski poles with short blades on the bottom. The seat is mounted on a pivot and a shock absorber, and the contraption has one ski blade rather than the two ours will have.

The patent for a Children’s Ride-On Vehicle with an Auxiliary Control Mechanism is listed under US Patent number 5,845,724. This design has an electric motor and a drive system intended for use by a child operator. The child can also steer via the primary steering system, which is connected to at least one of the wheels. The patent also outlines secondary steering and motor control systems that can be controlled by someone not in the vehicle. The Adjustable Speed Control for Children’s Ride-On Vehicle is listed separately under number 5,859,509. This is a switch assembly located between the vehicle’s motor and battery that connects to multiple user-selected speed configurations.

### 2 Project Description

#### 2.1 Objective

The Adaptive Position Chair will be designed with the intentions of meeting Samantha’s needs for a location to learn and practice using her Pragmatic Organized Dynamic Display (PODD). Additionally, Samantha will be able to use the Adaptive Position Chair for eating, reading, and using a laptop in conjunction with her red and green buttons to read children’s books online. For this reason the Adaptive Position Chair will require a tray table located conveniently for each hand. It is also required that the chair be able to adjust so that it can grow with Samantha. It’s also necessary that the chair be able to safely provide support for Samantha’s core, as she has difficulty holding herself upright. Arm and leg restraints are an additional requirement, as Samantha’s lack of motor control often causes her to move in ways that she doesn’t intend. This is especially a concern when it comes to her eating, as she has an involuntary tick that causes her to continually place her hands in her mouth. The chair will also have features to allow for Samantha’s parents’ ease of use. In order for them to be able to use the chair in places other than their apartment, the
design will be such that it folds into a smaller form that can be placed in the car.

The Assisted Skiing Device will allow Samantha to go skiing with her parents. The importance of being able to have family activities such as this allows the family to live as normal a life as possible. Shared experiences are at the core of any family’s most fond memories, after all. In concept, the device will be a sort of stroller on skis guided by the adult skier behind the child. Samantha will be strapped in using a five-point safety harness. For practical use at any local ski slope, the device will be able to be unfolded from its position of function so that Samantha can sit on the chair lift while still harnessed into the device. After getting off of the lift, the device can be returned to Samantha’s skiing position by clipping certain safety clasps back into place.

Samantha will be able to satisfy her desire to go fast during the warmer months with her Ride-On Remote Controlled Car. She will not be left out of having her very own Power Wheels®, but rather will have one specially created to fit her needs. Samantha will have a five-point safety harness attached to her padded “driver’s” seat. By retro-fitting a remote control to the car, her parents will be able to control Samantha’s speed and direction as she rides along. The remote will have various safety features, including that of stopping if the remote user gets out of range of the vehicle, and having a slower top speed than market. The range itself will not be too large, because Samantha should not be too far away from the person driving the car in case there is trouble.

2.2 Methods

To fabricate the Adaptive Position Chair, we will start with a frame of steel tubing. The entire device will be 40 inches tall. There will be a lap tray made of acrylic that will fold in such a way to allow for Samantha to be placed into and removed from the chair with ease. Also, there will be two push buttons affixed to the tray – red on one side, and green on the other. These buttons will be able to connect to a computer via USB port. The armrests will have nylon straps in order to prevent the nervous tick (described previously) associated with Rett Syndrome while Samantha eats. There will be a platform attached to the chair legs on which she can rest her feet. The seat itself will be padded with nylon-covered foam so that it is comfortable for the duration of Samantha’s activities.
To make the chair collapsible, the following measures will be taken. The legs of the chair will telescope down, and the seat back will fold onto the tray via hinges. This will make the whole device less than two feet tall to allow for a comfortable fit in the trunk of a car.

In order for Samantha’s growth to be taken into account, the back of the seat will telescope up. Also, the foot rest will be able to move down.

During actual construction of the chair the general purpose steel tubing can be accurately cut to length using a chop saw, bent to the desired orientation using a tubing bender, and attached securely and permanently with welds. In order to get the legs and back of the chair to telescope we can use tubing with a larger I.D. (inner diameter) traveling outside of tubing with a smaller O.D. (outer diameter) symmetrical, uniformly spaced holes and the use of spring pins for easy adjustment, and stowing capacity. The tray tables will slide on and off the of the arm supports using a similar tubing system and set screws. Polyurethane foam pads will be attached to the chair frame and serve as seat bottom and seat back cushions, as well as arm, and leg cushions. A nylon safety harness will be secured to the frame to hold Samantha to the seat. Similarly, nylon restraints will be located at the arm and leg locations, to prevent any unwanted or undesired movements. Finally, a couple coats of spray paint will keep the chair looking nice and prevent rust and corrosion.

Figure 3. Adaptive Position Chair
The second device will allow Sam to ski with her family. The device will consist of a booster seat mounted to a tube steel frame that is capable of rising and lowering. The frame’s articulates using a Z lift type frame design. The lift will allow Sam and the ski sled to board chair lifts. The use of chair lifts is essential for successful implementation of the design. Several existing models do not feature a means of boarding the chair lift without stopping the lift entirely. Creating a way to board a moving chair lift will ensure the product’s practicality.

The ski sled will consist of four assemblies of parts: the frame and lift, the chair and harness, the mounting assembly, and the skis and bindings. The frame and lift will be made from tube steel. The frame will serve as the base of the ski sled design for the other assemblies to be mounted onto. The frame will consist of a handle for the driver to hold, a base for the passenger to sit on, and a lift. The handle will fold in two for boarding the chair lift and transportation of the device. The lift will allow the base frame of the ski sled to be hoisted up to a height that will sled to board a chair lift. At this time the lift will be passive and require the driver to lift the rider up onto the chair lift seat. Investigation is being made into the feasibility and necessity of a pneumatic piston to assist the driver with lifting. The addition complexity of the piston appears to be greater than the necessity. The chair and harness will consist of an existing car booster seat that will have a restraint harness mounted to it. The harness and booster seat will be mounted to the frame. The mounting assembly will attach the frame to the bindings of the skis. The assembly will connect to the bindings like any other ski boot allowing for the skis to be switched out as desired and removed for transport. The assembly will give each ski on degree of motion only. The skis will be able to raise and lower while staying parallel each other and the base of the seat. This will allow both skis to stay in contact with the ground and orientated so that they will resemble a normal skier’s style. The skis and bindings will be purchased commercially and mount to the device just as they would mount to a ski boot.
The Ride-On Remote Controlled Car will essentially be a retrofitted Power Wheels. We will take the existing steering, braking, and acceleration mechanisms and make them able to be controlled remotely by adding the appropriate number of additional servo motors. We will also change the seat that Samantha sits in to provide the necessary support and safety. A five-point harness will be added to keep Samantha in her seat.

The modification of the Power Wheels® car will begin with the disconnecting of the steering wheel and pedals. Next, a roll cage in the form of two U-shaped steel tubes will be attached to the frame of the car. If the frame is not sufficient currently, it will be reinforced using the same general purpose carbon steel. A servo motor will be attached to the existing steering column to control the directional orientation of the two front wheels. If necessary, the steering concept will be rethought, and rebuilt in order to accommodate the potential steering design ideas. The radio controller receiver will be wired to the servo motor that handles the steering, as well as the existing Power Wheels® motor that handles the acceleration and direction (forward/backward) of acceleration. A failsafe will be incorporated so that if the Ride-On Remote Controlled Car ever loses signal from the radio frequency transmitter, a killsnow will be
trip and the car will cease to operate. Lastly, a five-point nylon safety harness will be attached firmly to the frame and roll cage.

Figure 5. Power Wheels ®

3 Budget

The expected budget at this time is $1,300 for all three projects.

Table 1. Adaptive Position Chair

<table>
<thead>
<tr>
<th>Component</th>
<th>Material</th>
<th>Estimated Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seat</td>
<td>Nylon, polyurethane foam</td>
<td>$100.00</td>
</tr>
<tr>
<td>Tray(s), Foot Rest</td>
<td>1-1.5” Acrylic</td>
<td>$100.00</td>
</tr>
<tr>
<td>Frame</td>
<td>Steel Tubing</td>
<td>$150.00</td>
</tr>
<tr>
<td>Harness</td>
<td>Nylon</td>
<td>$50.00</td>
</tr>
<tr>
<td>Hardware</td>
<td>Misc.</td>
<td>$50.00</td>
</tr>
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</table>

**Estimated Total: $450.00**

This total is about the same as the chairs that are available commercially. This is due to the modifications we will make specific to Samantha.
### Table 2. Assisted Skiing Device

<table>
<thead>
<tr>
<th>Component</th>
<th>Material</th>
<th>Estimated Cost</th>
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</thead>
<tbody>
<tr>
<td>Seat</td>
<td>Commercial booster seat</td>
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<tr>
<td>Frame</td>
<td>Steel Tubing</td>
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<tr>
<td>Harness</td>
<td>Nylon</td>
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</tr>
<tr>
<td>Skis and Bindings</td>
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</tr>
<tr>
<td>Hardware</td>
<td>Misc.</td>
<td>$50.00</td>
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</tbody>
</table>

**Estimated Total: $550.00**

This total is about 16% of the cost for a similar device currently on the market.

### Table 3. Ride-On Remote Controlled Car

<table>
<thead>
<tr>
<th>Component</th>
<th>Material</th>
<th>Estimated Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car</td>
<td>Commercial Power Wheels ®</td>
<td>$200.00</td>
</tr>
<tr>
<td>RF Controller</td>
<td>Commercial</td>
<td>$50.00</td>
</tr>
<tr>
<td>6 Channel Micro Receiver</td>
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</tr>
<tr>
<td>Stepper Motors and Controllers</td>
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<tr>
<td>Harness</td>
<td>Nylon</td>
<td>$50.00</td>
</tr>
<tr>
<td>Roll Bar</td>
<td>Steel Tubing</td>
<td>$50.00</td>
</tr>
</tbody>
</table>

**Estimated Total: $700.00**

**Total for three projects: $1700.00**
Even the ride-on remote controlled cars on the market currently do not have the capabilities that the device we are making will have, so it is difficult to compare this estimated price to anything available commercially.

4 Conclusion

Ultimately, the Gillards want Samantha to have the most ‘normal’ childhood possible. She has wants and desires similar to any other toddler – she loves to read, go fast, and spend time with her family. We want to help make and keep these activities part of her world; along with making things such as skiing accessible, we will also help the family with some of their everyday activities.

Samantha’s Adaptive Position Chair will provide a place where she can communicate via her PODD, eat, and enjoy her online books. It will be able to both grow with Samantha, and fold to a smaller size for ease of transportation. The restraints and seat construction will provide the support she needs to stay upright.

Her Assisted Skiing Device will allow her to enjoy going fast down the slopes with her parents while staying safe. The sled-like device will be controlled by an experienced adult skier, and the seat itself will have safety features like the harness. The device will be able to go on the chair lift with ease, so the family does not have to deal with the extra hassle sometimes associated with such products.

The Ride-On Remote Controlled Car means that Samantha will be able to enjoy speed during the summer as well. She will remain safe in her padded seat via the harness while an adult controls the operation of the vehicle. Should the signal from the remote be lost, fail-safes will be in place to prevent harm to Samantha.

Hopefully the devices described above help Samantha and her family with everyday activities, as well as provide some enjoyment and fun memories doing activities previously inaccessible.