CHAPTER 17
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THE SMART KART: A RECREATIONAL VEHICLE FOR CHILDREN WITH DISABILITIES

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INTRODUCTION

The Smart-Kart is a recreational vehicle that was designed to provide entertainment and social interaction for an 11-year old boy with spina bifida and other handicaps. This two-seater vehicle (see Figure 17.1) is a gas-powered, joystick-steered device that allows the client to drive the vehicle thus interacting with friends and practicing his motor coordination skills. After device completion, the go-kart was presented to the client and his family to take to their home where they can use it on their extensive property. The client is preparing to transition to an electric wheelchair in which he will have to use a similar electric joystick. This go-kart will allow him to gain extra practice while having fun and enjoying the company of his friends and family. Abundant measures are taken to ensure the safety of our client while using the vehicle.

SUMMARY OF IMPACT

The design of the go-kart was shaped by the client's desire to control an electrical powered vehicle, interact with his friends and family outdoors while keeping safety the priority. Due to the client's manual wheelchair, it is difficult for him to interact with his fellow classmates, especially outdoors. He also cannot enjoy his family estate due to rough terrain. This all-terrain go-kart would allow him to bond with his classmates on much deeper level and allow him to explore the family property. The client's physical therapist and tutor at school expressed that he has made tremendous strides academically, physically and socially. In order to continue on this path, the client needs better means of transportation (electric wheelchair) and socializing with his peers. The Smart-Kart will allow him to do both- bond with his peers while practicing using an electric joystick.

Fig. 17.1. The Smart-Kart.

Fig. 17.2. Linear actuators for throttle (above) and braking (below).

TECHNICAL DESCRIPTION

The chassis of the go-kart is constructed from steel pipes, which assures strength and integrity to the vehicle. A bought chassis was modified in length, width, and sheet metal side panels were installed. This extended chassis makes it a comfortable two-seater and encloses the sides for protective purposes. The go-kart is gas powered and electrically controlled via two controllers: 1) a joystick that the client is able to use to the left of the driver seat and 2) an X-box controller on the passenger side. The control mechanism (joystick versus X-box controller) can be changed on the vehicle's dashboard. Along with these two controllers, there is an additional kill switch on the dashboard, which will turn off all mechanical and electrical components on the go-kart. The vehicle is fully automatic with reverse. Throttle and hydraulic disk breaking is controlled via linear actuators, which are mounted on the back of the go-kart as shown in Figure 17.2. The steering is controlled via a linear potentiometer that receives an input signal from the controller translating the linear motion into rotational motion of the Dayton 1L469 gear motor that is attached to the rack and pinion system. Rotational speed reduction is accomplished with a sprocket and chain system that is added to the rack and pinion system (Figure 17.3).

To start the go-kart, the key on the dashboard must be turned until the engine is in idle mode. An additional switch on the dashboard turns on all electrical components of the go-kart. There is also the switch for type of controller one wishes to use, a kill switch, and a switch for headlights. An alternator is used to constantly charge the 12V-9A deep cycle battery, which powers the electrical components. All software controls use the PIC16F877 microcontroller, which is part of the 16 series 8-bit Microchip controllers. Because there is a need for several PWM output signal pins, three microcontrollers are used to adequately control all system components steering, throttle, and braking. All three microcontrollers are programmed used embedded C language. The microcontrollers take two modes of analog input: the joystick and X-box controller. Depending on the mode chosen on the dashboard, the microcontroller will activate the appropriate output pin to deliver the PWM signal to the speed controller, which then delivers it to the two actuators and steering potentiometer. Due to the client's inexperience with electric joysticks, an ultrasound sensor system monitors objects in front of the vehicle and initiates braking when objects are within an eight-foot range in front of the go-kart. This feature can be deactivated with a switch on the dashboard. The driver's seat supports the client's weak trunk and neck. Additionally, a footrest is mounted onto the floor of the chassis to ensure that the client's feet are kept safely in one place. A five-point harness with a latch-and-link quick release is also used for the driver seat. The passenger seat has a regular backseat belt. Both seats have reclining mechanisms and the driver seat has an additional adjustable armrest upon which the joystick is mounted. All terrain tires and double A-arm independent suspension allows for driving on rough grounds.

The cost of parts/materials was about $4000.

Fig. 17.3. Steering system.

THE ALL-TERRAIN POWER CHAIR

Designers: Prince Alam, Marcus Chapman, and Mathew Kozachek
Client Coordinator: Janice M. Lamb, 142 Barnes Rd., Stonington, CT
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INTRODUCTION

The all-terrain power chair was designed to travel on light trails and other locations that lack pavement and to be operated by Nathan, our client. The all-terrain power chair provides a way for his family and school district to include him in recreational activities without worry about his safety or comfort. All of Nathan's current assisted movement devices serve singular purposes. For example, Nathan's Standing Dani can only be used while standing up, is manually propelled, and can only be used comfortably on perfectly flat surfaces. Also, many of his devices are not intuitive to use. This is essential, so that anyone that helps Nathan into his device does so properly and without damaging the device. With all that said, the design team will also work to make a versatile, safe, and comfortable power chair that can easily be used by Nathan and his family in all sorts of terrain.

It is important to mention that there are other solutions available. However, these solutions are very expensive. A comparable all-terrain power chair retails for about $16,995. To put this into perspective, someone can buy a car for that price, so the high price of such a device makes it cost prohibitive for many hard-working families. In addition, customizations make the commercial products even more expensive Also, the devices that are more reasonable in price have limited capabilities on rough terrain. In addition, Nathan's family has special needs for the purposes of his power chair. Therefore, the all-terrain power chair will be designed to be rugged and ready for rough terrain, all in an easy-to-use package.

SUMMARY OF IMPACT

Our client, Nathan Lamb, is a peaceful, charming, and delightful person to be around. This was reiterated when his parents discussed with the team how he gets a lot of friendly attention at school. It was obvious that he enjoys being outdoors with his family, therefore an all-terrain wheel chair would greatly increase Nathan's mobility and ability to enjoy activities with his family. It was apparent that due to his medical conditions, Nathan tends to fidget a lot when seated. He also has the tendency to keep his right arm high in the air, by his head. Consequently, the family requested that seating have a lot of support and be tilted at the correct angle. The all-terrain power chair is designed to allow him to further enjoy life with his family and friends by allowing him access to more places.

Fig. 17.4. The power chair.

TECHNICAL DESCRIPTION

The overall structure of the all-terrain power chair was made from aluminum square tubing (2 by 2 by .125 inch). This gave the power chair a high strength to weight ratio, which is characteristic of aluminum, provided the necessary structural integrity and low weight requirement needed for a portable device. It was designed so the main structure was welded at 90 degree angles. All other components were fastened to the frame by bolts.

The power chair uses four arms, one for each wheel, as shown in Figure 17.5. Bearings are attached to the lever arm at the top, which are mounted to the upper frame, to allow the arm to rotate. The springs are attached to allow shock absorption from the terrain and have built-in bearings to allow for rotation at each attachment point. The motors are attached to the lever arms via custom-made mounting brackets. Each motor has large wheels directly attached. The wheel diameter is calculated to be optimal based on the maximum speed of 5 miles per hour. There are fully height-adjustable arm rests, a foot plate, and a head rest. The seat is easy to remove for transporting purposes by lifting a latch in the front and unbolting two screws in the back.

It is operated by a left-hand mount joystick and powered by 24V DC motors. It uses a rechargeable 12V deep-cycle lead-acid battery capable of supplying the chair with power for up to five hours of continuous use. A commercial motor controller controls the speed and direction of the motors with input from an analog bidirectional joystick.

Overall, the cost of all the parts was about $2100.

Fig. 17.5. An arm of the power chair.

CUSTOM TILT-IN-SPACE WHEELCHAIR

Designers: Katie Guineau, Julia Olczyk, Ben Marcus
Client: Julie Miller, Clinton, Illinois
Supervising Professor: Dr. John D. Enderle
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INTRODUCTION

This custom wheelchair was designed for a 16 year old girl with cerebral palsy, a muscle and development disorder which affects her motor skills and ability to move around. Since she is currently in a wheelchair for the majority of the day, the family asked us to design a custom wheelchair with a tilt-in-space feature to accommodate for Abby's growing needs. Abby's current wheelchair does not support her correctly and the padding needs to be replaced often due to wear. There were many issues that the family had with the current chair that they asked us to address in the new design, for instance 1) functional support for her back 2) larger headrest 3) prevention from slipping forward in the chair 4) uniform solid footrest. The wheelchair frame was donated by NEAT Marketplace in Hartford, CT and modifications were made to this chair to accommodate the family's requests. This wheelchair will ultimately provide comfort and support for Abby and her family. The completed customized wheelchair made for the Miller family is shown in Figure 17.6.

SUMMARY OF IMPACT

This wheelchair was built to maximize comfort for Abby and to also address the support issues with her previous wheelchair. She will now be supported in all directions due to the incorporation of inflatable bladders to maximize support. Her new uniform footplate will allow the family to push her around without the fear of injury. The new larger headrest will prevent her from slipping off and hurting her neck and the new wedged seat cushion and safety harnesses will help the family to keep her in her seat without her standing up or slipping off. All of these customizations to the chair will allow Abby to be comfortable while providing her family with peace of mind that she is safe.

Fig. 17.6. Side view of the custom chair.

TECHNICAL DESCRIPTION

The wheelchair, donated by NEAT, was an older Quickie Tilt-in-Space model that was customized to fit the customer's needs. The chair was stripped and sanded in preparation for powder coating. The powder coating company, Central CT Coatings, chromed the frame and then applied a clear purple coating to achieve the desired purple finish that the Millers requested. The chair was widened to fit the 17" seat so a new seat plate and foot plate had to be fabricated. The seat back was donated also from NEAT in Hartford but it was too narrow so new mounting hardware and brackets had to be designed. Into the seat back, bladders were incorporated to allow the family to adjust the support according to

Abby's changing posture. Two inch memory foam padding was added on top of the bladders to increase comfort. The head rest was mounted on to the center of the seat back. The headrest is fully adjustable to account for Abby's positioning in the chair. A chest harness and safety lap belt was added along with solid urethane tires. Accessories such as cup holders were mounted for both the operator of the chair and for Abby. This chair is built to last and be used daily for many years to come.

Fig. 17.7. Demonstration of the tilt.

THE BICYCLE SIDECAR FOR ABBY MILLER (CP)

Designers: Michael Wieczerzak, Nicholas Ouellete and Elida Babollah
Clients: The Miller family specifically Abby Miller
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INTRODUCTION

The bicycle sidecar was developed for a young girl who struggles with Cerebral Palsy. Since she is unable to ride a bike by herself, the family has asked the team to design and build a sidecar that can attach parallel with a bike. The family had a pull behind attachment for their bike a long time ago, but Abby has outgrown it. The family wanted her next to them when they were riding so that they could talk to her and get her more involved in the experience.

The sidecar's seat was purchased from a company that specializes in chairs to support and keep children with disabilities safe. It was critical that this chair was used since Abby cannot support herself completely. The rest of the project was fabricated by the team to the custom specifications that were given to them. This sidecar will allow Abby to enjoy being on a bicycle and outdoors while still safely supervised by her parents. The sidecar is shown in Figure 17.8.

SUMMARY OF IMPACT

The impact of this project on the family is significant. This sidecar will allow the family to take Abby with them when they go for bike rides. Not only will it make her more a part of their outdoors activities, but it will allow Abby to interact more with them during the experience. Previously, she had little to no interaction while behind them in the previous design, but being directly next to them will allow for communication. This sidecar will make her more mobile outside in a safe, yet enjoyable manner. The seat that was integrated into the project was of the same make, just larger, as the one that was used in the past. Overall this will allow our client to be more active and for her to enjoy being more active.

Fig. 17.8. Bicycle Sidecar.

TECHNICAL DESCRIPTION

The sidecar was created using various parts to create a safe and structurally strong product. The frame of the sidecar, which supports all of the components, was created with 1.5 inch 6016 aluminum tubing. Using this material was key to create a frame that was as lightweight as possible yet had to strength that was needed to support the weight of the project. All of the welds of the aluminum frame were done at a 90-degree angle to ensure that all of the frame's pieces were as precise as possible. For the attachment of the seat, fenders and the footrests, a combination of screws and bolts were used. The attachment of the sidecar to the bike was done using rubberized ring clamps to the frame of the bike and screwed into the frame of the sidecar. The use of the Carrie Tumbleform Seat was essential to making this sidecar safe for Abby. This type of seat provides the necessary support for the back, neck and head, which was very important to her family. This sidecar allows Abby to enjoy riding next to her parents in a safe environment.

Total Cost of Sidecar = Approx. $1,550

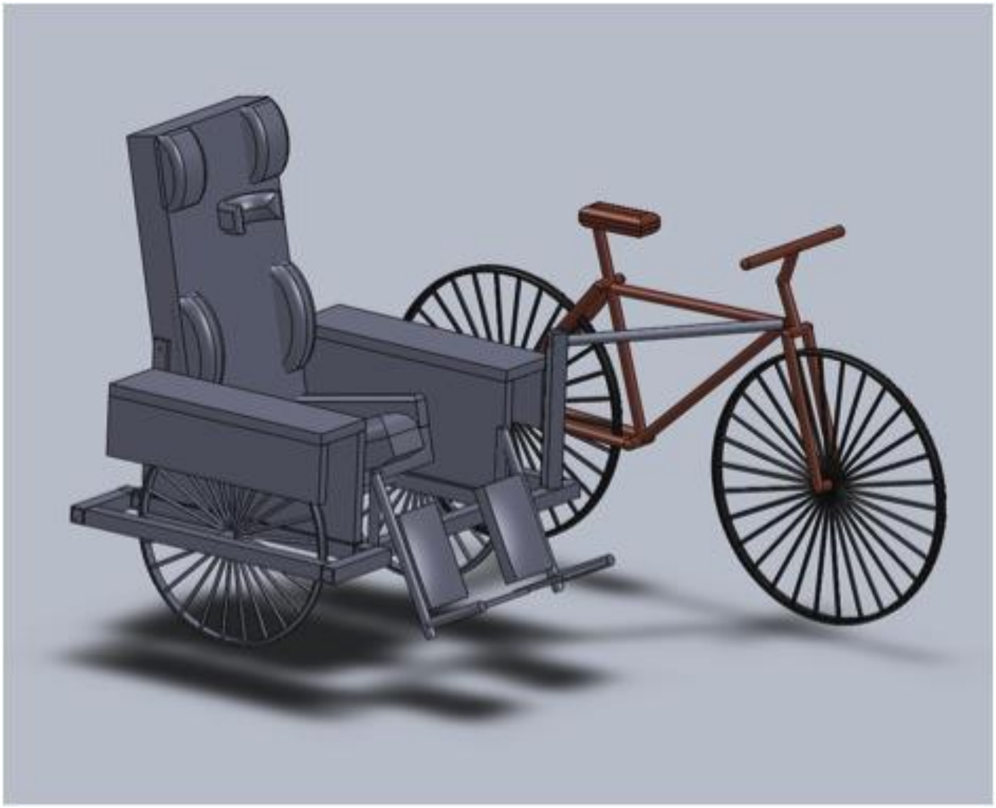

Fig. 17.9. SolidWorks Drawing of the Sidecar

RECLINING BEACH WHEELCHAIR: A CHILDREN'S CHAIR FOR USE ON SAND

Designers: Maya K. Alfonso and Kyle C. O'Brien
Client Coordinator: Marek Wartenberg
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INTRODUCTION

The beach wheelchair was designed to allow a portable and affordable beach transportation option for families with children with disabilities. A youth wheelchair was modified to take large, polyurethane tires, which will help the chair to float on top of sand. A defining characteristic of the chair is its ability to recline on a custom-built leg, attached to the back of the wheelchair. The reclining mechanism allows for the chair user to be tipped back (Figure 17.10), taking pressure off of the lower back and increasing comfort and circulation.

SUMMARY OF IMPACT

The criteria for creating this beach wheelchair were outlined by the Davies family, a family with two twin boys who have spastic cerebral palsy. One of the boys, Jack, uses a wheelchair pushed by his family members to get around. The family vacations in Rhode Island every summer and has trouble getting the boys over the sandy terrain at the beach. Their request was for a portable wheelchair that would allow easy transportation of Jack over the sand, as well as provide the option to recline him to increase comfort and circulation. An additional goal of this project was to design a more affordable reclining mechanism, as many existing options are very expensive and not practical for occasional use.

TECHNICAL DESCRIPTION

To create the structure of the Reclining Beach Wheelchair, a 16.5" youth wheelchair frame was modified. All of the modifications and attachments mentioned were created out of aluminum, which was well suited because it is light and strong.

The first and most important modifications were completed to allow the attachment of large, polyurethane beach tires. The front tires and castors were removed, and replaced with custom-built mounts for the large beach castors. These mounts provided stability as well as a pre-defined distance from the chair frame, allowing near-full rotation of the castors below the chair and optimizing maneuverability of the beach wheelchair. To attach the back tires, two sets of braces were built to house the 1" axels and set the tires far enough away from the frame as to remain unencumbered. The axels were fitted with quick-release pins, allowing the family to remove the large tires when storing or packing the chair.

The reclining mechanism was built using square tubing to create an adjustable-length leg. It was attached to the existing arms of the wheelchair and supported using struts in a triangular shape (Figure 17.11). The arm can be locked close to the wheelchair or out in reclining position using two quick-release pins. The adjustable length of the leg allows for the angle at which the rider is reclined to be changed. A rotating footplate on the bottom of the leg disperses the weight of the rider, keeping the leg from sinking deep into the sand and allowing for the angle to be changed according to the desires of the rider.

The cost of the parts/material was about $900

Fig. 17.10. The Reclining Beach Wheelchair.

Fig. 17.11. Reclining Mechanism.

POSTERIOR BEACH WALKER FOR A CHILD WITH CEREBRAL PALSY

Designers: Matthew Ellis, Danielle Lapointe
Client Contact: Gregg and Laura McClement, Calgary, AB, Canada
Supervising Professor: Dr. John D. Enderle
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INTRODUCTION

The beach posterior walker is designed for a 12 year old boy, Matthew Davies, who suffers from spastic cerebral palsy. The client is receptive, but has limited motor control and requires a walker or quad-canes to move around. Matthew is currently 5 feet tall and weighs just less than 100 pounds. His family goes to the beach often during the summer, so a design that would allow Matthew to use his walker easily over sand and other difficult terrain was requested.

SUMMARY OF IMPACT

The posterior walker is designed for use by the client specifically for the beach. The walker was designed to not only be able to maneuver over sand, but also tough terrain, such as gravel, where commercial walkers would struggle. The walker was designed to expand as our client grows. The posterior beach walker provides our client with freedom to use his walker wherever he wants, especially on the beach and into shallow water.

TECHNICAL DESCRIPTION

The posterior beach walker has a NIMBO youth walker frame. The original height of the NIMBO walker ranged from 23 to 30.5 inches. Our minimum height requirement is 28 inches, which was easily reached since our wheels added to the overall height of the frame.

A seat specially designed for the NIMBO walker frame was installed. This allows our client to be able to safely sit and rest whenever he needs to. Velcro strips were added to either side of the seat to ensure that the seat will stay upright while the client is walking, as seen in Figure 17.13.

Polyurethane balloon wheels were installed to the walker's frame. Two 8.7 inch wheels were installed for the rear wheels of the walker. 11.8 inch wheels

Fig. 17.12. The Posterior Beach Walker

Fig. 17.13. Side View of the Walker.

were mounted to swivel casters using custom made mounts, shown in Figure 17.15.

The front two wheels, along with the swivel casters, were too tall to simply install to the original frame. Clamps were designed and a new, shorter height addition was fabricated and welded to the clamps to ensure that the walker met the client's minimum height need of 28 inches from the handlebars to the ground (Figure 17.14). A cup holder was added to the front of the walker for the client's comfort when on the beach.

Fig. 17.14. Clamps with Height addition.

Fig. 17.15. Fabricated Swivel Caster Mounts.

THE ADAPTIVE POSITION CHAIR

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INTRODUCTION

The Adaptive Position Chair (APC) was designed to add ease to the lives of a family with a child of limited motor and communication skills. In particular, our client is a three-year-old girl diagnosed with Rett Syndrome. Rett Syndrome is a chromosomal mutation characterized by poor motor skills and language reception and expression issues. Onset is usually between 6 and 18 months of age, when a developmental reversal is experienced.

Perhaps the most functional piece of the APC is the tray table. It has three planes of motion to allow for many uses relevant to our client and her family's daily life. The APC also includes support mechanisms to help compensate for her lack of motor control. These mechanisms include a pommel that fits between her legs and a butterfly chest harness. The chair is also adjustable in various ways to allow for growth.

SUMMARY OF IMPACT

In order to communicate, our client uses a Tobii Eye-Gaze System to navigate a Pragmatic Organized Dynamic Display (PODD). She also uses the family laptop to read interactive children's books online. We hope that the APC will provide a place that she can comfortably eat and do these and other activities. The most important feature of the APC, in terms of its range of uses, is the acrylic tray table. The adjustability of the angle of the tray contributes to its versatility. Also important are the various supports, which are customized to the client. They provide safety as well as vital trunk stability. The legs of the APC are adjustable, allowing the client to be at a normal chair height or at eye level with an adult. We hope that the device will make the lives of our client and her family easier by providing a personalized space to perform day-to-day activities.

TECHNICAL DESCRIPTION

The frame of the chair is fabricated out of low carbon steel tubing that is primed, painted, and coated with rust-proof paint. There are sections of frame made out of square tubing and others made out of round tubing. The decision to use which tubing was based on functionality; for example, the seat back and bottom are square so that the components fit. The legs are telescoping to allow for height adjustability. This function was made possible by smaller tubes with a series of systematically drilled holes that fit snugly but smoothly into large diameter tubes. Clevis pins and cotter rings hold the legs at the desired height. Extra stability is made possible with leveling feet on the bottom of the legs. This compensates for any variability in ground that the chair is situated on, should this be an issue. By a similar telescoping mechanism, the platform for the client's feet is also adjustable. The adjustability in this case allows for the client's growth and will hopefully allow use of the chair for multiple years. The platform itself is sheet steel with a piece of acrylic on top. Chair back and bottom pads are mounted on plywood and consist of foam padding upholstered in vinyl. Another important component of the APC is the padded pommel that sits between the client's legs to provide trunk support. This pommel is also upholstered in vinyl, and slides back and forth along a slotted track cut into the steel frame from the bottom of the chair seat. The pommel folds down from the upright position when a button is pressed. This allows for ease of placing the client in and out of the chair. The armrests are also padded again with vinyl covered foam. They are detachable so that the steel frame can be easily cleaned if necessary.

In terms of design analysis, there are some improvements that could have been made had we had more time. Though functional, the tray table becomes a bit off-kilter in certain positions. Slight adjustments in the tubing structure would fix this problem, though after completing construction it was too late time-wise and money-wise to go back to redo this. Also, the steel frame means that portability of the chair is limited by weight and size. This is something that we might reconsider if we were to make another APC. That being said, the APC that we constructed is fully functional and we hope that it will be useful to our client's family.

The total cost of the project was approximately $380.00.

Fig. 17.16. The Adaptive Position Chair.

THE ASSISTED SKIING DEVICE

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INTRODUCTION

The Assisted Skiing Device (ASD) was designed and fabricated for Samantha Gillard and her family. Samantha Gillard is a 3 year old girl who has been diagnosed with Rett Syndrome. Rett Syndrome is a neurological disorder that negatively affects muscle motor control as well as expressive language skills and physical development. Samantha's parents Geoff and Jenny Gillard are avid skiers, who frequently visit Samantha's grandparents who live at the base of a ski mountain in New Hampshire. While Samantha is physically incapable of skiing on her own, with the assistance of a skilled skier and the Assisted Skiing Device, she will have the ability to get outside and hit the slopes.

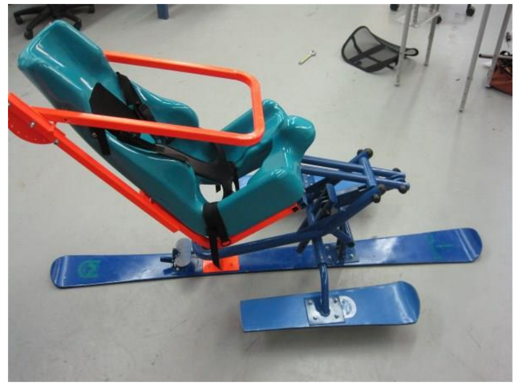

Fig. 17.17. The Assisted Skiing Device.

SUMMARY OF IMPACT

While Samantha has difficulty conveying her thoughts and feelings, her parents have informed us that she likes to be outside, and she likes to "go fast". In addition to this, with mountain access, and a family of skiers, the ASD seemed a perfect fit. The integration of the ASD into their lives will allow the Gillard's the opportunity to spend time together as a family, while doing something that they love that would not be possible for Samantha to participate in otherwise. The ASD will always require a "pilot" to drive from the rear position, but allows Samantha a small amount of control through leaning side to side, this will help to provide her with exercise and motivation to move while strengthening her core.

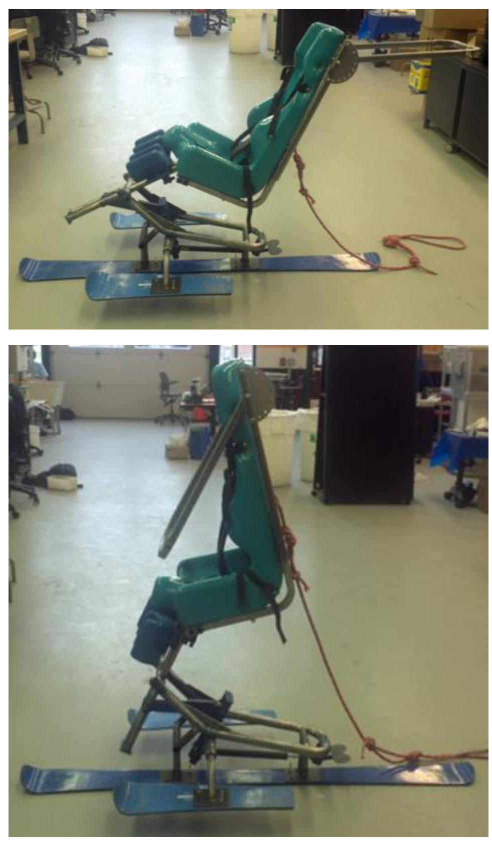

Fig. 17.18. Lowered piston riding position (top) and raised piston chair lift position (bottom).

TECHNICAL DESCRIPTION

Prior to beginning design of the ASD, we spent time researching existing assisted skiing equipment. In addition to learning that most of the equipment on the market came with an astronomical price tag, many included either two skis acting in tandem, or a single main ski with outriggers for balance and turning control, as well as suspension systems, and in some cases, hydraulic assisted mechanisms for getting the rider on and off of ski lifts.

We were able to obtain a TumbleForms® TriStander from NEAT Marketplace. The piston assembly in the TriStander closely resembled the pistons used to provide comfort through passive suspension as well as maneuverability to adjust the ski sled to be ski lift accessible. The core of the TriStander became the basis for our design, and was quickly incorporated into the early CAD model.

We were also able to obtain a donation of two Teleboards® and a snowboard to use in conjunction with the TumbleForms® TriStander. One of the Teleboards® was cut in half and became outriggers for stability and balance. The remaining Teleboard® and snowboard were both retrofitted to fit the frame of the stander to allow the future operator(s) to switch between boards to alter the performance capabilities of the ASD.

Similarly, the outriggers can be adjusted to four different operating positions, or removed entirely, this way, as the pilot (person driving the ASD) improves their level of skill in the operation of the device, they will be able to increase the angle of lean during turns, and ski faster.

Once the ski sled was assembled, the piston would adequately allow the operator to raise and lower the seat, with the lowered position intended for decent down the mountain, and the raised position intended for access to a chair lift to ascend the mountain.

Fig. 17.19. TumbleForms TriStander after having the piston assembly isolated out.

The ASD also features a polyurethane foam TumbleForms® potty chair, for comfort, and durability, as well as resistance to the elements. The potty chair was adapted to fit the frame, and fit with a four point safety restraint harness. At the head of the of the chair attachment frame, we attached a semi-circular piece of aluminum with holes drilled at nine different fixation points for the pilot handle bars. At the base of the chair frame a steel loop was welded into place to attach a rope. The rope is then attached to a climbing harness worn by the pilot. As a last resort safety measure, it is intended to act as a tether and prevent the ASD from getting away from the pilot in the event of a fall.

THE RIDE-ON REMOTE-CONTROLLER CAR

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INDRODUCTION

The ride-on remote-controlled car (RRC) was constructed to give a child with limited or no mobility the freedom movement without another person directly propagating their movements. The client is a three year old girl who was diagnosed with Rett Syndrome. Rett Syndrome affects the development of the nervous system. Symptoms usually consist of developmental reversal around six months of age resulting in poor motor skills and language expression issues. The client is unable to walk, crawl, speak, or feed herself. The client's family requested our assistance in providing a means for her to enjoy the outdoors. She lacks the motor skills to explore and enjoy the outdoors on her own.

SUMMARY OF IMPACT

To give the client a sense of mobility and freedom, the ride-on remote-controlled car was constructed. The vehicle would not be controlled by the client but would allow her to be mobile without someone immediately next to her propagating and sustaining her movements; a freedom she was not able to enjoy until the RRC. With the client strapped into the RRC, her parent or guardian can drive the vehicle using a standard RC radio controller. Children with an immobilizing disability don't experience any independence from their care givers. The RRC provides a means of transportation into nature and the surrounding environment giving the client a new sense of freedom.

TECHNICAL DESRIPTION

To construct a ride-on remote-controlled car, a Fisher Price® brand Power Wheels® was acquired and modified to be remote control, more rugged and safer. Structurally, the Power Wheels® remained unaltered. The battery, battery connector plug and electric motors were left unaltered. The manual switch transmission and all associated wires were removed. The remote control (RC) system was purchased separately and installed into the Power Wheels®.

Fig. 17.20. The Ride-On Remote-Controlled Car.

The RC system has several key components: a radio transmitter and receiver, battery elimination circuit, an electronic speed controller, and a steering servo.

The radio transmitter broadcasts the desired movements of the RRC via two channel communications, one for forward or reverse and one for steering left or right. The transmitter uses multiple pulse width modulation (PWM) signals to communicate with the radio receiver. The radio receiver deciphers the transmitter's communications and divides the signals for each channel into separate channels outputting a standard RC signal. A standard RC signal uses pulse width modulation for communication. Typically, signal duration is 10ms. A pulse of 1ms indicates low, 1.5ms neutral and 2ms high.

The battery elimination circuit functions as a power supply for the radio receiver, eliminating the need for a separate battery for the receiver. The battery elimination circuit also functions to provide sufficient current to the steering servo motor. Using a battery elimination circuit built into a speed controller may not provide sufficient current for the steering servo to achieve the maximum amount of torque possible.

The electronic speed controller receives the PWM signal and translates it from low, neutral, high to reverse, stopped, forward. The electronic speed controller feeds the proportional amount of voltage from the Power Wheels® battery to the electric motors, establishing the drive system for the RRC.

The steering servo receives the PWM signal and translates it from low, neutral, high to -45° rotation (left), 0° rotation (center), 45° rotation (right). The steering servo is an electric motor with a potentiometer to measure the degree of rotation of the motor shaft. The servo receives the RC PWM and moves the servo to the appropriate degree of rotation using the potentiometer's position feedback and returns to center when the signal received is neutral. The servo acquired was a 5:1 gear ratio high torque servo. The motor shaft had a servo horn mounted on it. The servo horn was attached to the existing rack and pinion steering system. The servo replaced the function of the pinion, pulling the rack from side to side.

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The approximate cost of all parts including the Power Wheels® was $575

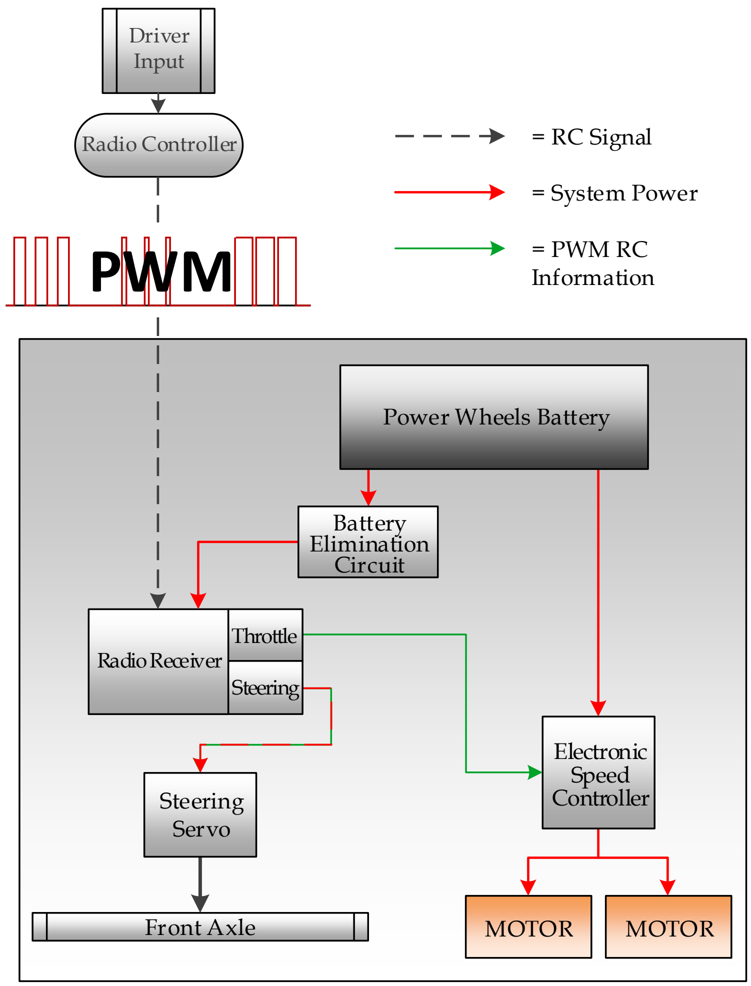

Fig. 17.21. Electronic Setup.

DESIGN OF SWIMMING HOT TUB LIFT

Designers: Katelyn Burkhart, Martin Collier, Isis Curtis, Eileen Molloy, and Victor Nguyen
Client: Mr. Ronald Hiller, Ashford, CT
Supervising Professor: Dr. John Enderle
Biomedical Engineering Department
University of Connecticut at Storrs,
Storrs, CT 06269

INTRODUCTION:

Ronald Hiller is a 56 year old man who was diagnosed with multiple sclerosis, also known as MS, when he was 16 years old. Over time, as a result of this disease, leisure activities such as swimming became a challenge for Mr. Hiller. Though he has been living with MS for decades, only within the past ten years has it affected him enough to require him to use a wheelchair. With this challenge, came about the need for an assistance device; something to allow the task of going into water. When asked to construct a lift for Mr. Hiller, several factors had to be taken into consideration when approaching the project: weight requirements, weather conditions, and stress and strain and so on.

While there are lifts available on the market for hot tubs, many are very expensive, costing upwards of $1000, and most are designed for indoor hot tubs with cement decks surrounding them. Mr. Hiller has an outdoor hot tub on top of a deck behind his house, so the lift needed to be cost effective as well as customized for an outdoor hot tub.

SUMMARY OF IMPACT:

Those with disabilities are often left at a disadvantage in society today, with a loss of accessibility to certain activities which bring them joy. For our client, Ronald Hiller, we were able to bring some of that enjoyment back into his life by constructing a lift for his hot tub. Diagnosed with multiple sclerosis, Mr. Hiller found it to be a challenge when trying to relax in his hot tub. Moreso, Mr. Hiller's neurologist recommended use of his hot tub to him as a way to try to reactivate some of his nerves. However, he currently cannot get in or out of his hot tub. This leisure activity became more of a hassle for him and we needed to make it fun again. Over a year and several challenges, we were able to construct a lift which can be used for Mr. Hiller to get into and out of his hot tub which is beneficial for therapeutic purposes. It makes it possible to have friends over or to just relax with ease.

Fig. 17.22. Hot tub lift.

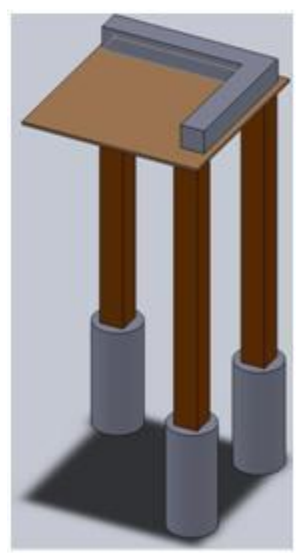

Fig. 17.23. Schematic of Pylons and Supports.

Mr. Hiller has let us know on multiple occasions how truly grateful he is that we built this project.

TECHNICAL DESCRIPTION:

This project incorporated previously used Bruno scooter lifts which were scrapped for parts and then put back together. They were modified to be 55 inches in height, compared to the original 32 inches in height, and are compact enough to avoid creating a hazard around the hot tub. The lift has two motors: one at the base for rotation, and another at the top of the boom for movement in the axial direction. The lifts are connected to 12V Marine Deep Cycle batteries, which can be charged after extended use. The circuitries of the lifts were waterproofed with an acrylic conformal coating. This non-conductive material prevents corrosion and moisture buildup. The entire lift is coated in a corrosion- and water-proof spray-paint to protect from the effects of the chlorine it is exposed to and weather effects. There are also plastic protective covers over the motor and rotational gears to protect from weather effects. The rope used is a polypropylene material that does not expand when wet and has a strength that can hold 400 pounds. The rope extends 2 feet below the base of the lift, so there is ample room to be lowered into the hot tub. The seat is mesh and weight rated for 600 pounds. This will allow the seat to dry between uses and avoid buildup of mildew or other bacteria. The seat will be attached using two carabineers and a metal hoop to allow ease of use for Mr. Hiller. This also allows easy exit once he is in the hot tub.

Under the lift, below the hot tub deck, are a set of pylons held in sonotubes filled with cement. These sonotubes and pylons are inserted 42” into the ground to comply with Connecticut State Building regulations. A schematic of the pylons is shown in Figure 17.22. The silver L on top of the deck represents the base of the lift.

The total costs of the lift and its parts was approximately $300. The contractor for the pylons and supports cost about $600 for material and labor, giving a total project cost of $900 dollars.

DESIGN OF SWIMMING POOL LIFT

Designers: Katelyn Burkhart, Martin Collier, Isis Curtis, Eileen Molloy, and Victor Nguyen
Client: Mr. Ronald Hiller, Ashford, CT
Supervising Professor: Dr. John Enderle
Biomedical Engineering Department
University of Connecticut at Storrs,
Storrs, CT 06269

INTRODUCTION:

Ronald Hiller is a 56 year old man who was diagnosed with multiple sclerosis, also known as MS, when he was 16 years old. Over time as a result of this disease, leisure activities such as swimming became a challenge for Mr. Hiller. Though he has been living with MS for decades, only within the past ten years has it affected him enough to require him to use a wheelchair. With this challenge, came about the need for an assistance device; something to allow the task of going into water. When asked to construct a lift for Mr. Hiller, several factors had to be taken into consideration when approaching the project: weight requirements, weather conditions, and stress and strain and so on.

While there are lifts available on the market for pools, many are very expensive, costing upwards of $1000, and most are designed for in ground pools with cement decks surrounding them. Mr. Hiller has an above ground pool, so the design for the lift needed to be cost effective as well as customized for an above ground pool.

SUMMARY OF IMPACT:

Those with disabilities are often left at a disadvantage in society today, with a loss of accessibility to certain activities which bring them joy. For our client, Ronald Hiller, we were able to bring some of that enjoyment back into his life by constructing a lift for his pool. Diagnosed with multiple sclerosis, Mr. Hiller found it to be a challenge when trying to go swimming or simply relax in his hot tub. This leisure activity became more of a hassle for him and we needed to make it fun again. Over a year and several challenges, we were able to construct a lift which can be used for Mr. Hiller to get into and out of his pool which is beneficial for therapeutic purposes. It makes it possible to have family over and go for a swim, or just relax on a hot day with ease. Mr. Hiller has let us know on multiple occasions how truly grateful he is that we built this project.

Fig. 17.24. Swimming pool lift.

TECHNICAL DESCRIPTION:

This project incorporated previously used Bruno scooter lifts which were scrapped for parts and then put back together. They were modified to be 55 inches in height, compared to the original 32 inches in height, and are compact enough to avoid creating a hazard around the pool. The lift has two motors: one at the base for rotation, and another at the top of the boom for movement in the axial direction. The lifts are connected to 12V Marine Deep Cycle batteries, which can be charged after extended use. The circuitries of the lifts were waterproofed with an acrylic conformal coating. This non-conductive material prevents corrosion and moisture buildup. The entire lift is coated in a corrosion- and water-proof spray-paint to protect from the effects of the chlorine it is exposed to and weather effects. There are also plastic protective covers over the motor and rotational gears to protect from weather effects. The rope used is a polypropylene material that does not expand when wet and has a strength that can hold 400 pounds. The rope extends 2 feet below the base of the lift, so there is ample room to be lowered into the pool. The seat is mesh and weight rated for 600 pounds. This will allow the seat to dry between uses and avoid buildup of mildew or other bacteria. The seat will be attached using two carabineers and a metal hoop to allow ease of use for Mr. Hiller. This also allows easy exit once he is in the pool.

Under the lift, below the pool deck, are a set of pylons held in sonotubes filled with cement. These sonotubes and pylons are inserted 42" into the ground to comply with Connecticut State Building regulations. A schematic of the pylons is shown in Figure 17.24. The silver L on top of the deck represents the base of the lift.

The total costs of the lift and its parts was approximately $300. The contractor for the pylons and supports cost about $600 for material and labor, giving a total project cost of $900 dollars.

THE L.A.D. ELECTRIC WHEELCHAIR TO RIDING LAWNMOWER ASSIST DEVICE

Designers: Michael Chen, Matthew Desch and Joshua Aferzon
Supervising Professor: Dr. John Enderle
Biomedical Engineering Department
University of Connecticut
Storrs, CT 06269

INTRODUCTION

The L.A.D. was designed to allow mount and dismount of a riding lawnmower without the need for lower body input. After the L.A.D was completely built and ready to be operated, it was presented to Ronald Hiller of Ashford, Connecticut. Mr. Hiller has Multiple Sclerosis which has progressed over the past four years and limits his lower body mobility and confines him to a power wheel chair. He does however possess full upper body functionality. It is his wish to be able to care for his lawn as he did before his aliment worsened, and therefore it is necessary to have a safe and effective lift for him to mount and dismount his riding lawnmower without needing to use his lower body. The ultimate intention of the L.A.D is to enable Mr. Hiller to mow his lawn, specifically to mount and dismount his mower, safely whenever he chooses.

SUMMARY OF IMPACT

The design criteria for the L.A.D were requested by Mr. Hiller and his wife. The device needed to safely displace the distance between his power wheelchair and the seat of the lawnmower. In order to achieve this, a barber chair pump was utilized. An attachment mechanism to connect the L.A.D to the lawnmower would allow for transfer from the lift to the chair. Mobility was required in order for the lift to be positioned next to the lawnmower regardless of lawnmower position. In addition, the wheels would require independent breaking systems to hold the lift in place as Mr. Hiller transferred himself to the lawnmower seat. For safety purposes, safety belts would be required on both the L.A.D and lawnmower. Comfort in the seat was provided by dual layers of egg crate cushioning.

TECHNICAL DESCRIPTION

The L.A.D was made from many smaller subunits that join together to allow proper function. Mechanical parts include the seat which was cushioned using a dual layer of egg crate cushioning. The seat was made to a length of 16 inches, width of 15½ inches, 1½ inches in height without back support and 18 inches in height with back support. The hydraulic pump was a Keller Int. NGI Hydraulic Pump model. The wheels used were ¾ inches wide Coolcasters Medical/Industrial grade model with a built-in breaking mechanism. The base of the L.A.D was taken from a standard 5-point base office chair. To connect these components together, custom connectors were fabricated (see Figure 17.26). The connector between the seat and the hydraulic pump was constructed using steel and connected to the seat

Fig. 17.25. The L.A.D Electric Wheelchair to Riding Lawnmower Assist Device.

via a shoulder bolt to allow the seat to swivel 360 degrees. The connector between the hydraulic pump and the base was constructed using aluminum and attached to the pump via four 8 mm screws.

The total cost of the L.A.D, including fully paid for, discounted, and free parts for use in a senior design project, was $833.33, which was under our allotted budget of $1000. This system is much cheaper than other similar lifts which range from $6650-7150.

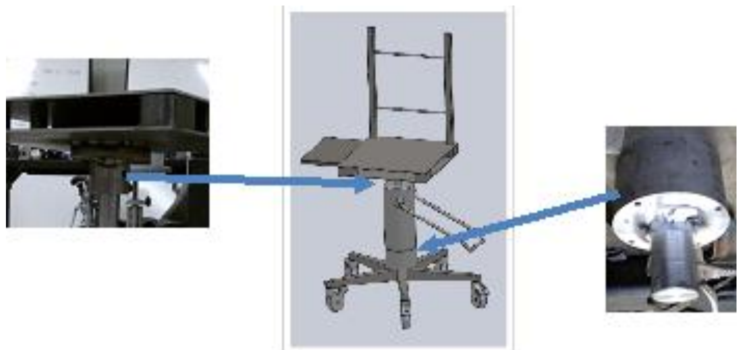

Fig. 17.26. Custom connectors, incl. pump to chair (L) and pump to base (R).

A MOTORIZED ASSISTIVE JUMPING DEVICE

Designers: Michael Ballintyn, Elyssa Polomski, Tianyi Xu
Supervising Professor: Dr. John Enderle
Biomedical Engineering Department
University of Connecticut
Storrs, CT 0626

INTRODUCTION

The motorized assistive jumping device was designed for a child with cerebral palsy so that the child would have more freedom to stand and jump. Due to the cerebral palsy, the child's ability to stand is limited and therefore requires assistance to be held in that position for long periods of time. This device allows for the child to be fully supported in an upright position, independent of any assistance from parents or caretakers. This device also has a motorized component that will allow for the device to be remotely controlled by both the child and the parents. The use of a joystick by the child will help to prepare for the use of a motorized wheelchair. The device will not operate unless under the supervision of a parent. This device will increase the quality of life of the child by allowing them to remain in an upright, standing position for an extended period of time, allowing the child to enjoy an experience they do not normally have while also strengthening the muscles of the lower body.

SUMMARY OF IMPACT

Because the child is described as one hundred percent dependent and wheelchair bound, physical therapy must be conducted to maintain the muscle tone and strength of the lower body. For this, the child receives therapy sessions to assist in strengthening physical and cognitive abilities. To strengthen the lower body, the child must be removed from the wheelchair and held in an upright, standing position. When this happens, the child becomes very excited and happy because of the opportunity to work muscles that are not normally active. This device will facilitate this type of therapy by allowing the child to remain in an upright position for extended periods of time without assistance from others. The child will be able to strengthen leg muscles that are normally dormant due to inactivity when the child is in the wheelchair. This device will improve the child's overall quality of life as well as help with the child's physical therapy. Also, due to the dual controller system, the child will be able to gain experience using a joystick in preparation for use of a motorized wheelchair.

Fig. 17.27. The Completed Motorized Assistive Jumping Device.

TECHNICAL DESCRIPTION

The structure of this device is composed of 80/20 T-Slotted Aluminum. The aluminum pieces were constructed to create a rectangular frame that could support and suspend the child from various bungees attached to the frame. The dimensions of the frame are 31" by 34" by 72". This particular frame was selected because the material is strong, lightweight and vibration proof, and components can be attached easily using the T-slots.

To suspend the child, a SafetyWaze construction harness was customized to fit the child's small frame. Once placed in this harness, a series of six Keeper and Knot bone bungee cords are attached to the D-rings located on the hips and back of the harness. The bungees are adjustable and can be moved to provide the child with the best fit while in the device. The bungees are attached to the frame via eye hooks and bolts that are fitted for the T-slots.

This device is also motorized and able to be moved through the use of a remote control. A dual transmitter system was implemented. One simple transmitter was custom made for the child and only contained a joystick, indicator LED and a power switch. Similarly, the parental controls contained these same features as well as an emergency stop button and an override feature that would allow their controller to override any movement of the child's joystick. These transmitters send a signal to the programmable receiver which in turn converts the movement of the joystick into a pulse-width modulation (PWM) signal. From here, the signal is then transmitted to two separate speed controllers. A differential steering system was implemented using two identical speed controllers and motors. The PWM signal from the receiver is then split and sent to each of the two speed controllers. The speed controllers then adjust the amount of output voltage to each of the motors which drive the system.

Also connected in parallel with the speed controller is a relay. This component acts as a safety mechanism for the system. The relay cuts all power going to the speed controllers and motors if certain actions take place. If the emergency stop button is pushed, or if one of the two receivers is not powered on, the relay will not allow any voltage from the battery to pass to the rest of the system. This is an important safety measure that ensures that there is parental supervision at all times when the device is in motion.

To power the entire system, a 12V automotive battery was used and wired into the system. The parental controls also require the use of D cell batteries. All of the motor components were then mounted to the bottom platform of the device and the motors were mounted using a custom-welded plate attached to the 80/20 frame. Once the motor system was completed, it was housed in the lower portion of the device. Small caster wheels were attached to the front of the frame while larger 12 inch wheels were attached to the motor shafts via customized couplers. All of the remaining components were mounted to the device and made operational before donating the project to the child.

The cost of the parts and materials was approximately $1700.

PROJECT FOR STEVEN MACARY: MODIFIED ALL TERRAIN VEHICLE (ATV) OR BARNEY MOBILE

Designers: Joseph Yi, Savio Chris, Judy Kachittavong
Client Coordinator: June Macary
Supervising Professor: Dr. John Enderle
Biomedical Engineering Department
University of Connecticut
Storrs, CT 06269

INTRODUCTION

The modified ATV or quad was designed to provide a child with a better and improved device that is user-friendly. This device is a typical battery-operated vehicle that integrates a joystick mechanism and remote control system, along with lumbar support, as seen in Figure 17.28. Upon completion, the modified ATV will be given to Steven Macary, who is an enthusiastic 12 year old boy with cerebral palsy. His speech is impaired and limited to making noises. Also, his motor skills lack muscle control and coordination to do daily tasks, such as opening and closing doorknobs and applying adequate pressure on his feet. Steven cannot use his quad independently in its original state. He does not have enough muscle strength in his leg to push down the pedal, neither does he have sufficient arm strength to control the manual steering, and the quad does not provide proper support for his back. Finally, the modified ATV is intended to improve Steven's quality of life and access to normal childhood activities.

SUMMARY OF IMPACT

The design criteria for the modified ATV were defined by the need for independence.

Previously, Steven could not ride his quad independently, even though he enjoyed riding it. Although his parents help him ride the vehicle, they cannot always be there to help him ride it. The impact of this project will provide more convenience for Steven and his parents, while also successfully increasing his happiness quotient. In the end, the modified ATV will help Steven become more active and free, while enjoying the outdoors in a vehicle.

TECHNICAL DESCRIPTION

The overall structure of the modified ATV was based on the Peg Perego Polaris Sportsman 700. A seat was mounted onto the base of the ATV, using Aluminum

Fig. 17.28. The Modified ATV.

plates. These plates were necessary to provide stability and support to mount the seat onto the vehicle. Egg grate was used for cushion to pad bolted area and covered with a seat cover to add comfort.

A steering servo power gearbox from ServoCity was used for the steering mechanism which provides a powerful and accurate rotation that handles tremendous loads. The pistol grip transmitter was chosen for better comfort and user friendly steering, with a compatible receiver. The 2 servo joystick was essential in our electrical components, since it can simply plug in a power supply and connect the servos to control them via the joystick. The Traxxas EVX-2 features 2 motor connection terminals; along with a high burst amperage on the motor needed for the system. Two single-pole-double-throw (SPDT) switches, with a center-off mode, were implemented for the pulse-width modulation (PWM) signal wires coming from the joystick and receiver – one for the steering servo and the other for the electronic speed control (ESC). This allows the user to switch modes of control from the joystick to remote control. A dashboard was created from a sheet of aluminum which was bent accordingly and mounted onto the ATV. This is to create a flat surface, where the joystick will be mounted, along with switches. All the wires and electrical components are secured on the inside of the ATV with wire ties and Velcro tape, respectively. Finally, the vehicle is painted green and purple— the color scheme of Barney. Figure 17.29 illustrates the electrical wiring assembled in the modified ATV. This schematic consists of all the components mentioned above.

Total Cost of Modified ATV was approximately $1117.

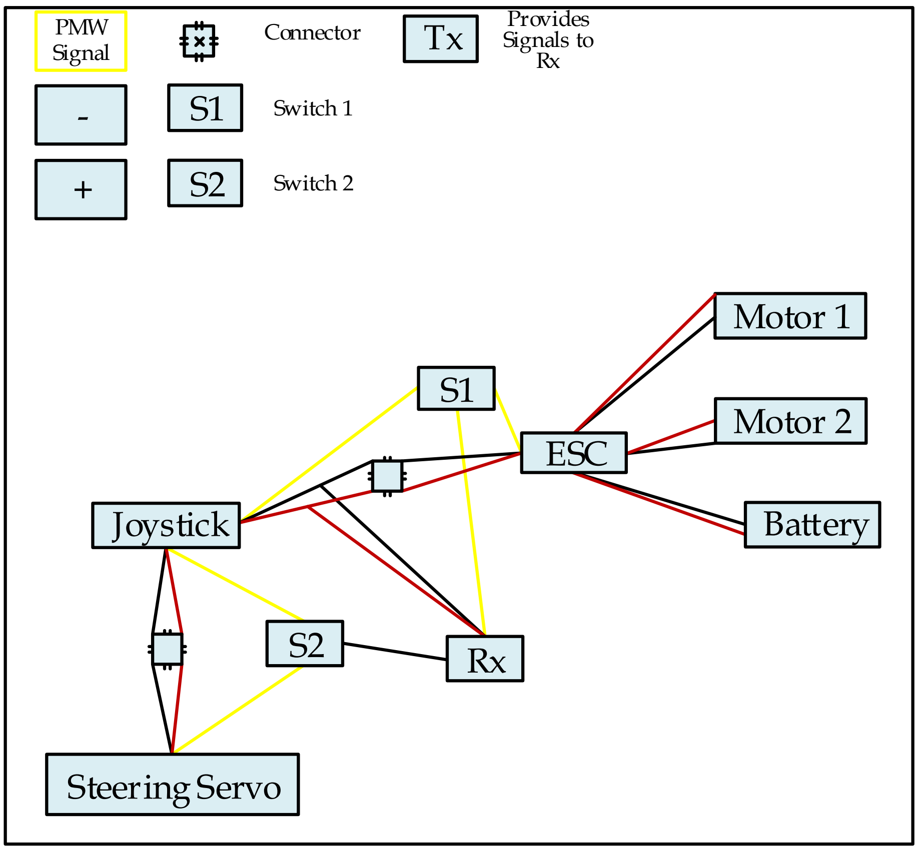

Fig. 17.29. Electrical Wiring Diagram.