

**ELECTRIC POWERED WHEELCHAIR DRIVING OUTDOORS:
THE IDENTIFICATION OF DRIVING OBSTACLES & STRATEGIES
AND THE DEVELOPMENT OF AN ADVANCED CONTROLLER**

by

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THESIS ABSTRACT

When an electric powered wheelchair (EPW) user leaves the confines of their home and ventures into the outdoors, they are confronted with a wide variety of terrain and driving conditions. Very little research has been done in trying to understand the difficulties EPW users face when driving outdoors. The first section describes a focus group study of 31 EPW users with the objective of assessing EPW users' comfort level when driving in various outdoor conditions. Questionnaire and focus group transcripts showed that the EPW user's top concerns were slipping, getting stuck, and tipping. The driving conditions most avoided were in the general themes of soft surfaces, angled surfaces, and adverse conditions.

The second section presents in detail the electronic and mechanical design of an advanced controller for an EPW. A single board computer provides the computational power and storage space needed to execute normal operations, complex safety algorithms, and extensive data logging. Sensors provide feedback on velocity and inertia. A rugged aluminum enclosure protects the electronics. The advanced controller is used to research better ways to provide safety and customization for the EPW user. The outcome of this project was to demonstrate what can be done with an EPW to enhance the mobility and safety of its occupant.

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PREFACE

Wow, so the day has finally come! Working on my projects for the past 3-1/2 years, I wondered if it would ever come sometimes. Mine has been a rather interesting route which has brought me to this day and there are many people who have helped me along my route that deserve my immense gratitude. To start out with, I want to thank Dr. Cooper who has guided me through my thesis development as my adviser and the rest of my thesis committee, Dr. Ding and Dr. Pearlman for their help and advice. Annmarie and Emily, thanks for all your help keeping me straight on the IRB and clinical stuff.

I owe a deep debt of gratitude to my friends and teammates on my projects, Garrett, Wu and Juanjo. We have all put in many long hours (and nights) working on “THE” project and I would never have been able to finally finish my degree without you guys. To the rest of the students and staff at HERL; thanks so much for your friendship and advice on all things school, research, and life. I will miss you all. I must also give a special thanks to Joe Olson for his wonderful friendship and support along my journey to a master’s degree.

And finally, I want to thank my family for their love and support on this crazy journey that is my life. What are families for anyway? ☺ Mom and Dad especially, thanks so much for all your support and encouragement, always helping me push the boundaries of what I can do.

1.0 INTRODUCTION

“The downside of my celebrity is that I cannot go anywhere in the world without being recognized. It is not enough for me to wear dark sunglasses and a wig. The wheelchair gives me away.” With this quote, the renowned astrophysicist Dr. Stephen Hawking makes a point that any wheelchair user completely understands. Their wheelchair is one of the first things many people notice about them. However, in his statement he also shows how far the technology of wheelchairs has progressed over the decades by alluding to his travel all over the world. The increasing sophistication of electric powered wheelchairs, such as the kind Dr. Hawking uses, has greatly enhanced the lives of people with limited mobility by giving them the ability to interact more fully with their environment. There are currently approximately 300,000 people in the United States that use an electric powered wheelchair (EPW) for part or all of their daily mobility [1-2]. Innovations in medical and assistive technologies have helped individuals with serious injuries and severe disabilities live longer, allowing them to participate in their communities in greater numbers. EPW users are most likely to have some form of paralysis, such as quadriplegia, paraplegia, cerebral palsy, ALS (amyotrophic lateral sclerosis), or MD (muscular dystrophy). Approximately 70% of EPW users are non elderly (under 18 - 64) [3] possibly due to these conditions being congenital (CP, ALS, & MD) or caused by traumatic injury (quadriplegia & paraplegia). Therefore the demand to maintain an active lifestyle is very much present among this population and their EPW is integral to maintaining that active life

style. EPW allow their users to enhance their function, increase independence, and have greater accessibility to their home and community. As a result, the EPW is the most important mobility component for this population [4-5], so much so that they consider their wheelchair as an extension of their own body.

1.1 THE ELECTRIC POWERED WHEELCHAIR

The EPW has evolved significantly since it was first patented in the 1950s [6]. Pictured in Figure 1 is Canadian inventor George Klein who invented the world's first truly practical EPW based on an Everest & Jennings manual wheelchair [7].



Figure 1: George Klein and the first practical EPW

Today's EPWs still retain many features of George Klein's wheelchair but have improved in design by the addition of several different drive wheel configurations. The 3 main

configurations available today are rear wheel drive, mid wheel drive and front wheel drive (Figure 2).



Figure 2: Wheelchair Drive Wheel Configurations

The different drive wheel locations change the EPW's maneuverability. Mid wheel drive EPWs, with their drive wheels directly under the center of the chair, turn 360 degrees within their own wheelbase and are the most maneuverable of the three types. The front wheel drive EPW is the second most maneuverable configuration. Both the mid and front wheel drive EPWs are favored for their maneuverability in tight spaces but can become hard to control at higher speeds. Rear wheel drive EPWs on the other hand are the least maneuverable of the three types, but tend to be the most stable at high speeds. Also, they are the easiest to learn how to operate because they steer similarly to a car.

Another advancement in EPW technology has been the development of powered seat functions somewhat similar to the power seat controls in cars. Just as they are used in cars to adjust the driver's position for optimum comfort, so to in EPWs the power seating functions allow the user to adjust their posture to stay comfortable (Figure 3). The seat elevator function is less for comfort and more for increasing the user's workspace. A very important use of the tilt

and recline functions is to allow the user to independently perform pressure relief by shifting their weight onto their back for a period of time. This greatly reduces the chances of the user developing a pressure sore. When driving, the tilt function can be used to add dump, thereby allowing the user to sit more securely in their EPW. When descending a ramp or hill, the tilt function can be used to keep the user level and lessen the chance of them falling forward out of the EPW.



Figure 3: Illustration of Possible Powered Seat Functions

The joystick control that George Klein developed for his wheelchair is still the most common control interface used today. Figure 4 shows 3 common variations of the proportional joystick. The standard joystick is for users with normal hand strength and range of motion. The chin joystick is topped with a rubber cup to allow precise control with the user's chin. The mini joystick has a very small throw and is very sensitive requiring almost no strength to activate.



Figure 4: Common Joystick Controls

When an EPW user cannot control a proportional joystick there are many alternatives. In Figure 5 are 6 possible options. All are currently on the market except for the brain control interface. The wafer switch has large pressure sensitive buttons that would be used by someone without fine motor control. The sip and puff system is used by people with no neck movement and is triggered by blowing or sucking either hard or soft into a tube. The tongue touch keypad is also for use by people with no neck movement but is less conspicuous because the controller is hidden inside the person's mouth. For people with fine control over their neck muscles, the head array uses a combination of switches hidden in the person's headrest to control the wheelchair. The finger steering control is a non-contact proportional control device suitable for people with limited finger strength because zero force is required. The prototype brain control system reads surface brain activity using external electrodes positioned accurately on the user's head with a special cap. Through a series of training exercises the computer learns to interpret certain brain activity as driving control commands.

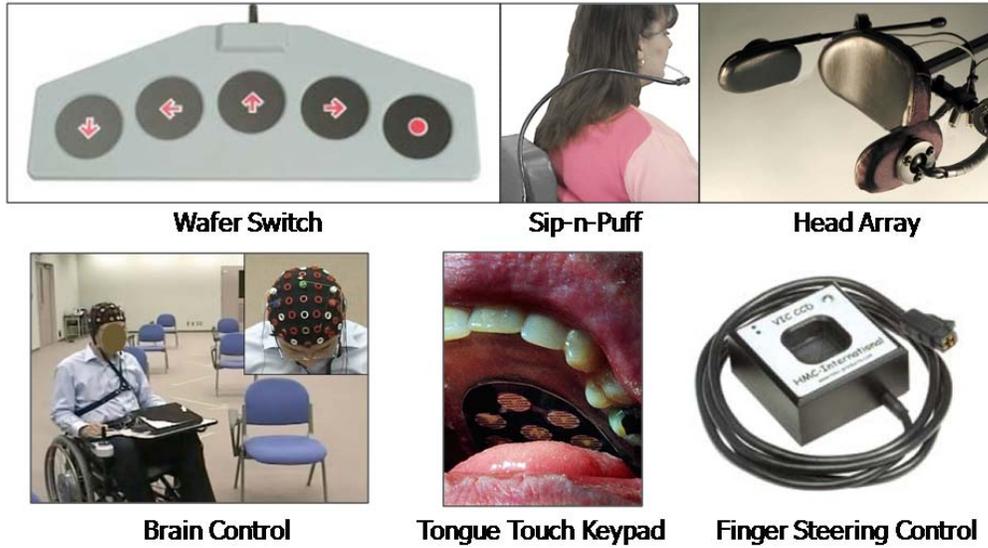


Figure 5: Alternative Controls

Technological advances that have specifically helped to make outdoor driving easier include 4-wheel drive, low pressure tires, link tracks, independent suspension, and gyro stabilized tracking.



Figure 6: All-Terrain Wheelchairs

These technologies are not new, they have existed in the automotive and construction equipment fields for many years and only recently have been applied to EPW design. Independent suspension has become the most widely used of these technologies, being featured as standard now on many mid to high cost EPWs. Gyroscope stabilized tracking, recently offered for the first time as a product by the Invacare Corp, helps to increase driving directional stiffness by resisting veer no matter what type of terrain. This feature can be especially helpful for EPW users that drive with alternative controls such as head arrays, sip-n-puff, or wafer switch systems that must use latched driving modes. Traditional proportional joystick users with impaired hand function, such as tremors, can also benefit from this technology.

Unfortunately, all-terrain EPWs suffer from several significant limitations that keep them from being used more widely. The large tires or link tracks increase the overall footprint of EPW making it difficult to use indoors due to the space constraints. In addition, the large tires, link tracks, and skid steering can damage indoor floor surfaces such as carpet, rugs, and wood. For these reasons, all-terrain EPW users consider them a second chair predominantly for off-road outdoor activities. Another limitation is that because these EPWs are focused almost exclusively toward outdoor driving, Medicare will not pay for them due to an “in home” restriction on funding. The VA does not have this restriction, thus approves all-terrain EPWs on an individual case basis.

In light of the considerable development and incorporation of contemporary electronics, such as the microprocessor, into current EPWs it is surprising that there has been remarkably little research specifically directed to the control of EPWs [2], [8]. All EPWs regardless of drive wheel configuration use essentially the same software while the system dynamics vary considerably. EPW and controller failures are a problem, accounting for about 60% of injuries

each year [9-10]. Most EPW controllers provide a means for tuning simple parameters (e.g., maximum speed, braking limits, acceleration limits, etc.) [8, 11-12]. This level of adjustment is adequate for some highly skilled users. However, most users still have difficulty operating an EPW in environments that they regularly encounter (e.g., grassy surface, hills, snow/ice) [11-12].

1.2 DRIVING OUTDOORS

When an EPW user leaves their home and ventures outdoors, they are confronted with a wide variety of terrain and driving conditions. Indoors, most surfaces are hard and flat with the occasional ramp. Other than space constraints, there are not that many obstacles to driving indoors. When an EPW user ventures outside, they are confronted with uneven terrain such as hills and cross-slopes, soft terrain such as mud, sand, snow, gravel and wet grass, adverse weather such as extreme heat and cold or rain and snow, and driving at night or through a crowd. These are just a few of the things that many wheelchair users have to deal with on a daily basis. Navigating these terrains and driving conditions requires the EPW user to understand the capabilities of their wheelchair and themselves, knowing when it is safe to take chances and when it is not. Being outside is a big part of community participation. It would be impossible to go to work, school, shopping, or social engagements without going outside. Despite all these obstacles, EPW users have learned to navigate the outdoors quite successfully as can be witnessed by the number of EPW users active in our communities.

1.3 ORGANIZATION OF THE THESIS

This thesis reports the results of projects which address the topic of outdoor use of electric powered wheelchairs (EPW). Each project is described in a separate section, and a final section summarizes their results and relationship to each other. The first project is called “The Identification of Driving Obstacles and Strategies”. It describes a mixed methods ethnographic study on the subject of outdoor obstacles to EPW mobility and the driving strategies users developed to overcome these obstacles. The second project is called “Development of an Advanced Controller”. It describes the design and development of an advanced controller for EPWs to help increase their safety and usability.

2.0 PART 1 – THE IDENTIFICATION OF DRIVING OBSTACLES & STRATEGIES

2.1 INTRODUCTION

Although there have been many improvements in EPW design, there has been very little research focused on EPW driving techniques outdoors. Only two reference items were found that focused on outdoor driving, the Power-Mobility Community Driving Assessment (PCDA) published in 1998 [13] and The Powered Wheelchair Training Guide published in 2002 [14]. The identification of these types of techniques for EPW driving could be invaluable, especially for the new driver. These driving techniques would assist both EPW users and researchers. EPW users would have a resource to assist them with learning different driving techniques including how to negotiate different obstacles and when to avoid particular situations [15]. Researchers developing driving control algorithms for EPWs would be able to use the driving techniques to guide the development of their algorithms and potentially develop new algorithms to assist EPW users when driving in difficult terrain. EPW driving training performed by clinicians is usually limited to very basic skills such as turning, stopping, and driving straight. Typically these tasks are only performed indoors and occasionally on very limited outdoor terrain [16-18]. This amount of training does not prepare new EPW users for the multitude of driving situations they will encounter in the real world [19].

The goal of this research project was to conduct focus groups and interviews with experienced EPW users to identify situations that present obstacles to them when driving their EPWs outdoors and the strategies that they use to negotiate these difficult situations. The two primary applications of this data was:

- 1) Updating the current driving education material and the creation of new materials to assist EPW users with learning to drive more safely
- 2) Development of new EPW driving software using an advanced controller to automate driving strategies thereby creating a much safer EPW

2.2 METHODS

2.2.1 Participants

A total of thirty-one EPW users (N=31) participated in this study. Participants were recruited locally in the Pittsburgh area and at two national sporting events for veterans with disabilities. The local participants were recruited through a registry of wheelchair users maintained by the Human Engineering Research Laboratories. All persons in the registry had signed informed consent to be contacted regarding participation in future research. Participants were also recruited at two large veteran only sporting events, the National Disabled Veterans Winter Sports Clinic held in Snowmass Village, Colorado during March 2009 and the National Veterans Wheelchair Games held in Spokane, Washington during July 2009. For both events, the Human Engineering Research Laboratories had a designated research area that displayed information about the laboratories and the research being completed. Persons who inquired about the

research study and indicated an interest in participating were told the details about the study. The participant was then signed up for a focus group that was held then or at a later time. The focus groups were then conducted in a location convenient for the participants.

To gain as diverse of an EPW participant population as possible, the inclusion criteria was broad. The only restriction was that participants had to be active outdoors with their wheelchairs, because we were interested mostly in problems associated with driving outdoors. The inclusion criterion for EPW users was as follows.

- (1) The individual must use an EPW as a primary means of mobility.
- (2) They must actively use their EPW outside of the home which was defined as leaving the home at least three times a week.
- (3) They must be over the age of 18.

An effort was made to recruit an equal number of subjects from the three EPW configurations (front, mid, and rear wheel drive) to have a more balanced sample. The study was not limited to a specific disease condition or disability to widen the pool of participants. No exclusion criterion was based on race, ethnicity, gender, or HIV status.

2.2.2 Data Collection

Questionnaire Layout

The questionnaire [See Appendix A, pg 74] contained the following sections:

- A. Personal Data
- B. Demographics & Self-Assessment
- C. Current Wheelchair Characteristics

D. Power Wheelchair Training

E. Driving Scenarios

The first two sections asked basic demographic questions along with some details about the participant's disability and their length of wheelchair use. Section C was self-explanatory. Section D asked for details about the amount of driving training the participant received when they first received an EPW and how they rated the quality and adequacy of that training. One question in particular asked about accidents that the EPW users had encountered. Section E contained 23 different adverse driving conditions and asked participants to rate each one as to its degree of difficulty. The 23 driving conditions are listed below in Table 1.

Table 1: List of Driving Conditions Evaluated in the Questionnaire

DRIVING CONDITIONS		
Uneven Terrain	Driving Down Steep Hills	Dry Grass
Gravel	Curb Cuts	Hard Sand
Driving Up Steep Hills	Crowds of People	Soft Sand
Mud	Cross slopes	Rain
Wet Grass	Cobblestone	Ramps
Turning on a slope	Severe Cold	Driving at Night
Ice	One Wheel Off Ground	Heavy Carpet
Snow	Severe Heat	

The four levels of difficulty were:

- 1) I can drive through this condition without any difficulty.
- 2) I have encountered this condition and it can be difficult to drive through.
- 3) I try to avoid this condition if I can.
- 4) I have never encountered this condition.

Focus Group Procedure

Ethical approval for this study was obtained from the institutional review board of the Veterans Affairs Pittsburgh Healthcare System. All participants were screened based on the inclusion criteria and asked to provide informed consent prior to enrollment in the study. Focus groups consisted of 2-8 people and were divided into two phases.

- 1) In the first phase the participants were asked to complete a questionnaire [See Appendix A, pg 74] with demographic information, type of EPW used, amount of EPW driving training received, and driving difficulty during specific scenarios.
- 2) During the second phase of the focus group, the participants were asked to discuss the difficult driving situations they had encountered. When needed, the researcher would prompt more discussion by using the scenarios from the questionnaire.

The discussions were recorded (audio only) using an encrypted digital voice recorder. The audio files were later transcribed and stored after being stripped of the 18 HIPPA identifiers. The total time for a focus group varied depending on how many people participated but ranged from 30 minutes to 2 hours.

2.2.3 Data Analysis

Questionnaire

The data collected from the surveys were entered into a Microsoft Excel spreadsheet where it was analyzed with conventional descriptive statistics such as frequencies, means, and standard deviation.

Focus Groups

The transcribed focus group audio data were coded using two different methods so as to gain as much usable data from the material as possible.

- 1) The transcript was broken down into thematically similar paragraphs which were then coded. The author then recruited three researchers which were experts in the field of powered mobility to perform the coding. This was an effort to increase the inter-rater reliability and eliminate any bias caused by prior knowledge of the focus group contents. These three researchers performed the targeted coding using the online Coding Analysis Toolkit (CAT)[20], a free service of the Qualitative Data Analysis Program hosted by the University Center for Social and Urban Research at the University of Pittsburgh and the College of Social and Behavioral Sciences at the University of Massachusetts Amherst. The predetermined codes used were the 23 driving conditions from Section E of the questionnaire (Table 1). To test the inter-rater reliability of the coded data the Krippendorff's Alpha test was used. Krippendorff's alpha coefficient is a statistical measure of the agreement achieved when coding a set of units of analysis in terms of the values of a variable. The coded data was also analyzed for consistency with the results of the questionnaire.
- 2) In-vivo coding was then performed on the transcript by four researchers. The author performed an in-vivo analysis which was then given to the same three researchers which performed the targeted coding. These researchers then performed their own in-vivo analysis while critiquing the author's analysis. Therefore the results of the in-vivo coding consisted of the combined analyses of the four coders.

2.2.4 Data Credibility/Trustworthiness

The researchers used several different methods to establish the credibility of the data and support the overall conclusions presented.

- 1) To check the consistency of the participants' answers to Section E (Driving Scenarios) of the questionnaire, a graph of the conditions rated as Easy and Avoid were overlaid. Through asking the same question in opposite ways, the graphed results showed the results were mirror images of each other (Figure 7), meaning participants' answers were consistent.

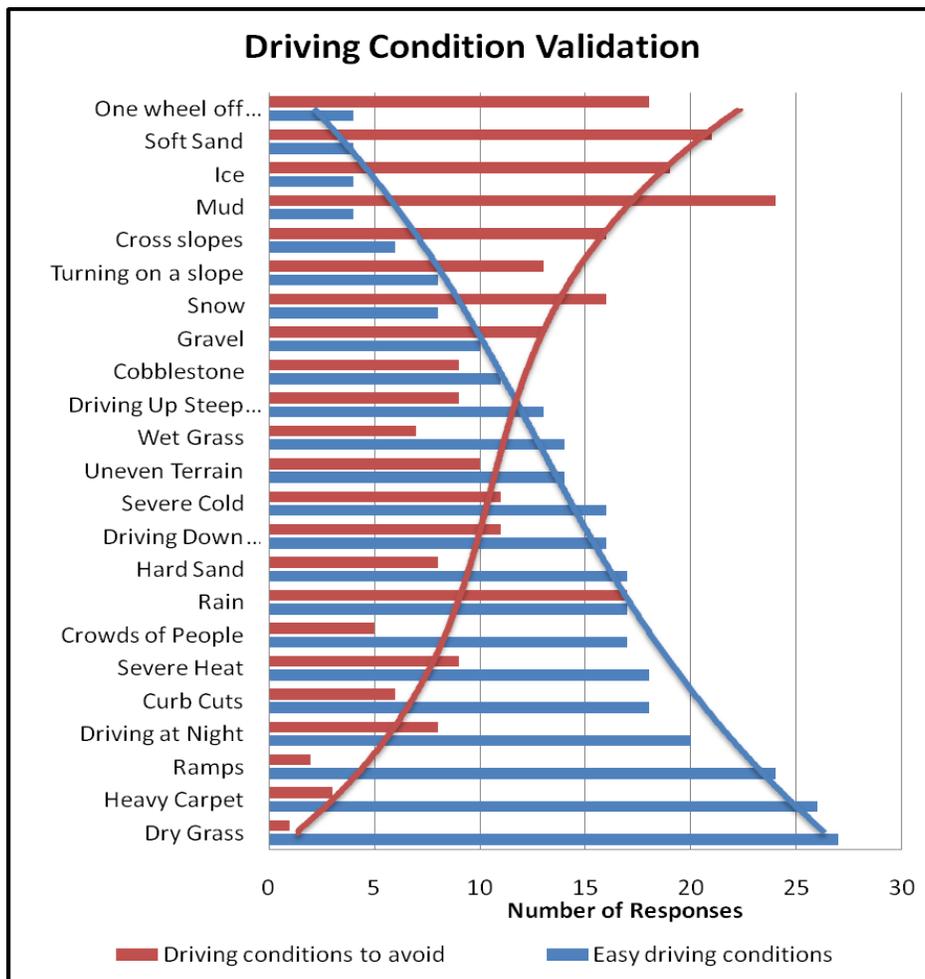


Figure 7: Driving Condition Validation

- 2) The targeted coding on the focus group transcripts was checked using the Krippendorff's Alpha test for inter-rater reliability.
- 3) The in-vivo coding on the focus group transcripts was performed by multiple coders independently who then discussed similarities and differences in their coding.
- 4) Verbatim quotations from the participants are presented in the results to allow readers to judge for themselves the validity of the conclusions.

2.3 RESULTS

2.3.1 Questionnaire

The data from the questionnaire showed that a large majority of the participants were male 84%. By far the disability most cited as the reason for using an EPW was a spinal cord injury (SCI) with 71%. Over half of the subjects had retired due to their disability. About 25% wanted to keep working but could not because their disability prevented them.

Table 2: EPW User Demographics

EPW User Demographics (N=31)			
84% Male	16% Female	Education	
48% Married	42% Single	23% Highschool or GED	
55.8 Age (avg)	9.1 Std Dev	3% Technical School	
Ethnicity		16% Associate Degree	
74% Caucasian		29% Bachelors Degree	
10% African American		16% Masters Degree	
6% Hispanic		3% Doctorate	
3% American Indian		Employment	
3% Other		0% Full time, outside home	
Disability		58% Retired because of disability	
68% SCI		23% Disabled, cannot work	
6% MS		3% Unemployed, cannot find job in field	
6% TBI		13% Other	

The participants were experienced EPW users with an average of 13 years experience driving an EPW. They had been using their current EPW for an average of 3 years and spent about 6 days a week outside their home. The distribution among the three types of EPW was clearly skewed toward rear wheel drive (RWD) and mid wheel drive (MWD) with 42% and 39% of the total respectively. Only 19% of the EPW were front wheel drive (FWD) (Table 3).

Table 3: Wheelchair Use & Style

Wheelchair Use & Style	
13	Years using an EPW (avg)
3	Years using current EPW (avg)
6	Days / week driving EPW outside house (avg)
19%	Front Wheel Drive (FWD)
39%	Mid Wheel Drive (MWD)
42%	Rear Wheel Drive (RWD)

The amount of driving training most of the participants received on their first EPW was less than 30 minutes (32%) to none (41%). Most participants did not take a driving test (62%) or practice

outside (59%) but thought that their training was adequate (4 on 5 point Likert scale). However, they did also agree that an EPW driving skills manual would be beneficial (4 on 5 point Likert scale). The scale used for both measurements equated a score of 1 as strongly disagree and 5 as strongly agree.

Table 4: Wheelchair Driving Training

Wheelchair Driving Training			
Driving Training		Driving test required	
42%	No Training	32%	Yes
32%	Less than 30 min	68%	No
19%	Between 30 & 60 min	Practiced driving outside	
3%	More than an hour	23%	Yes
3%	Do not remember	65%	No
Was training adequate?			
4 = Agree			
EPW driving rules beneficial?			
4 = Agree			

The following three graphs show how participants rated the ease of navigation for the 23 different driving conditions (Figure 8) (Figure 9) (Figure 10). In the Difficult and Avoid graphs (Figure 9) (Figure 10) participants were allowed to mark a condition as fitting into both categories if they wanted. The logic behind this was that certain driving conditions can be very difficult to navigate through but none the less, possible which would lead the EPW user to avoid that condition if at all possible. By allowing both of these categories to be marked, some categories do not necessarily total up to 100% between the three graphs. The red bars on the graphs show which driving conditions were marked by over 50% of the total participants. These

were considered the most important categories for later comparison and analysis of focus group data.

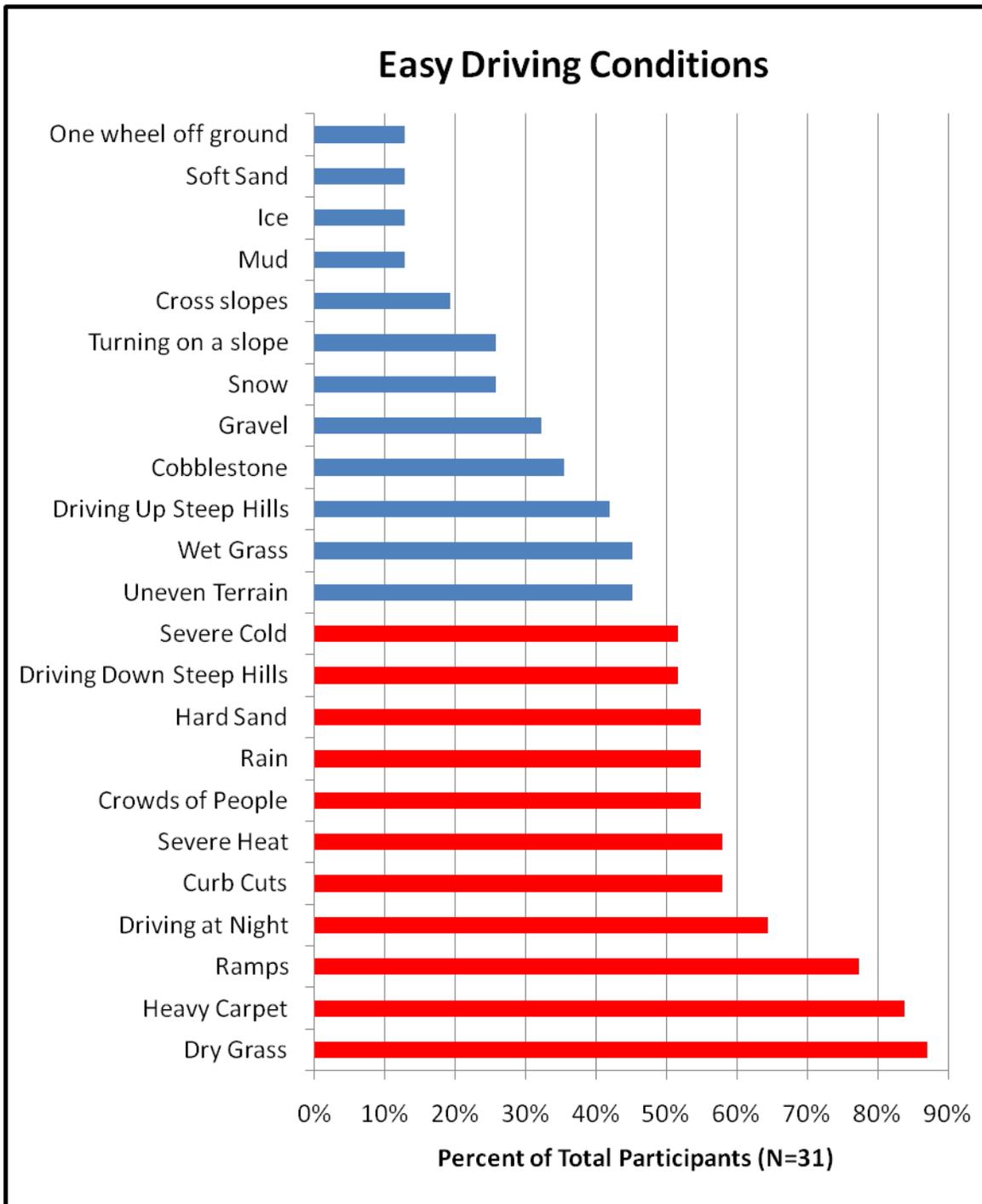


Figure 8: Easy Driving Conditions

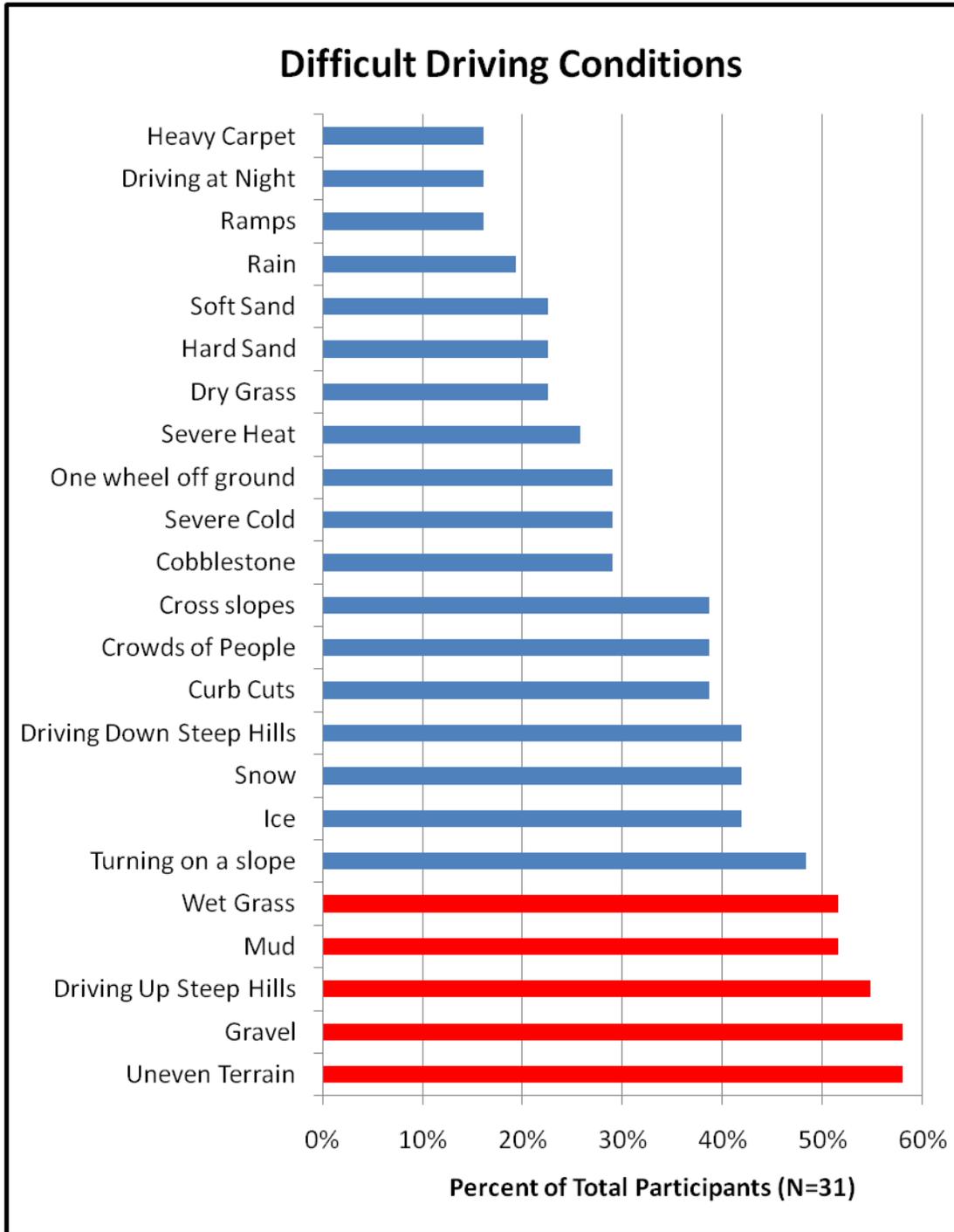


Figure 9: Difficult Driving Conditions

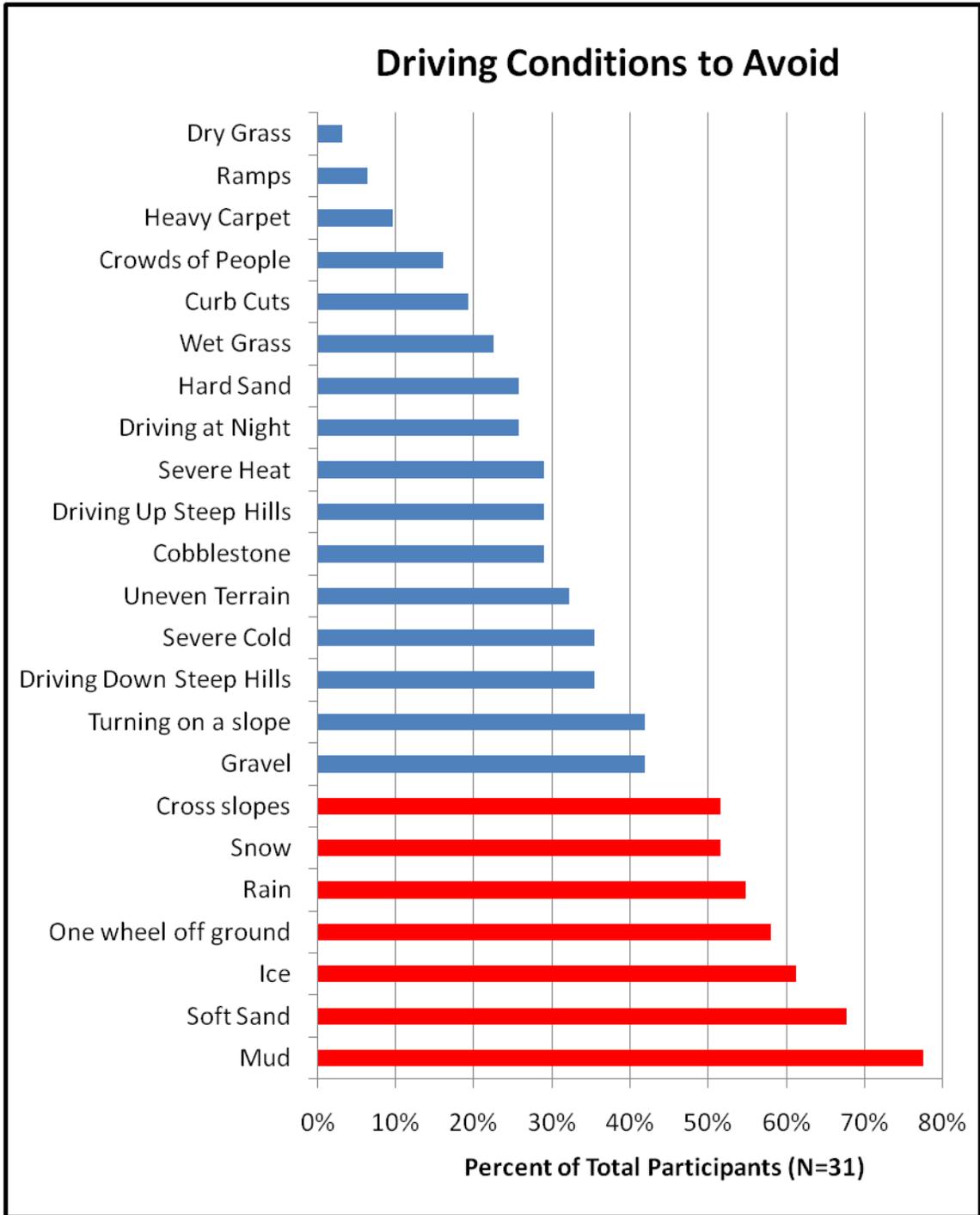


Figure 10: Driving Conditions to Avoid

2.3.2 Targeted Coding (Focus Group Transcript)

The targeted coding was performed by 3 researchers using the following predetermined codes (Table 5) that were obtained from the questionnaire driving condition categories (Appendix A, pg 74). The coders were instructed to code an item when one of the driving condition categories below was referred to as an obstacle in the focus group discussion transcripts (Appendix B-2, p 103).

Table 5: Targeted Codes Used

OBSTACLES	
Uneven Terrain	Sand
Gravel	Cobblestone
Driving Up Steep Hills	Severe Cold
Mud	One wheel off ground
Wet Grass	Severe Heat
Turning on a Slope	Dry Grass
Ice	Rain
Snow	Ramps
Driving Down Steep Hills	Driving at Night
Curb Cuts	Other
Crowds of People	
Cross slopes	IGNORE

In Figure 11 the results of the targeted transcript coding are detailed.

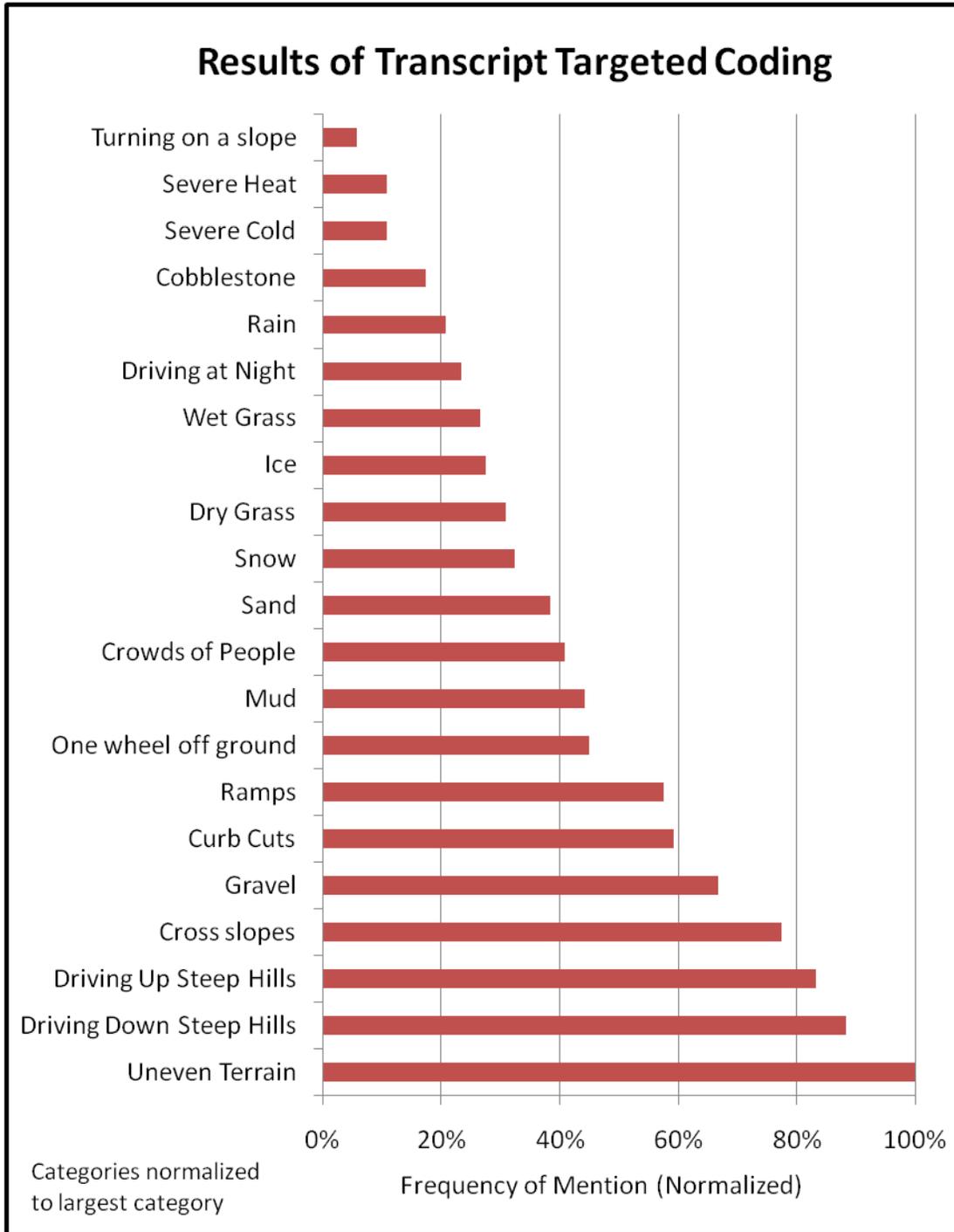


Figure 11: Results of Transcript Targeted Coding

Table 6 shows the text unit counts for each coder. The total count for each coder should be at least 331 since there are 331 text units and each text unit must have at least 1 code assigned to it. On inspection, each coder has a total coded text unit count over 331 so each text unit has been assigned 1 or more codes. Therefore the coding has been performed accurately.

Table 6: Krippendorff's Alpha Test for Coded Categories

Code	Coder 1	Coder 2	Coder 3	Alpha Value
	Coded Text Unit Count	Coded Text Unit Count	Coded Text Unit Count	
Cobblestone	8	5	8	0.854
Cross slopes	15	19	12	0.499
Crowds of People	19	17	13	0.614
Curb Cuts	30	20	21	0.636
Driving at Night	9	8	11	0.780
Driving Down Steep Hills	42	32	32	0.609
Driving Up Steep Hills	36	29	35	0.655
Dry Grass	16	9	12	0.635
Gravel	31	21	28	0.810
Ice	19	16	19	0.687
Mud	11	9	13	0.718
One wheel off ground	8	8	9	0.261
Rain	18	8	13	0.706
Ramps	25	21	23	0.657
Sand	22	11	20	0.761
Severe Cold	3	1	3	0.569
Severe Heat	6	3	4	0.532
Snow	35	26	32	0.786
Turning on a Slope	2	3	2	0.601
Uneven terrain	39	33	48	0.545
Wet Grass	10	13	9	0.451
Other	50	37	107	0.270
IGNORE	81	84	10	0.320
Totals:	533	430	482	0.607

The CAT software used for coding included a statistical test to determine inter-rater reliability. This test was the Krippendorff's Alpha. The last column of Table 6 shows the alpha

values for each of the coded categories and an overall alpha value. To be considered reliable coding with good agreement, Krippendorff Alpha scores should be 0.8 and above. The minimum that is considered acceptable is 0.6 - 0.8. Since the overall alpha score from Table 6 is 0.607 then the inter-rater reliability of the targeted coding can be considered acceptable. If the categories of “Other” and “Ignore” are taken out of the equation then the overall Alpha score rises to 0.634. Therefore the targeted coded data using the predetermined codes can be considered reliable enough to draw conclusions from.

2.3.3 In-Vivo Coding (Focus Group Transcript)

The focus group transcripts were next studied using an inductive analysis technique called in-vivo coding. The author performed an in-vivo analysis which was then given to the same three researchers which performed the targeted coding. These researchers then performed their own in-vivo analysis while critiquing the author’s analysis. The following results are a consensus of these 4 coders.

In-vivo coding is the creation of codes directly from blocks of text as the material is being read and without having any predetermined (targeted) codes. This is a way to summarize a large amount of textual information into the most important points. The in-vivo coding of the transcript resulted in 19 codes. These 19 codes were then grouped into 5 high level categories which better defined their overall themes (Figure 12). In the following pages these five categories will be expanded upon using summaries and quotes from the focus group transcripts.

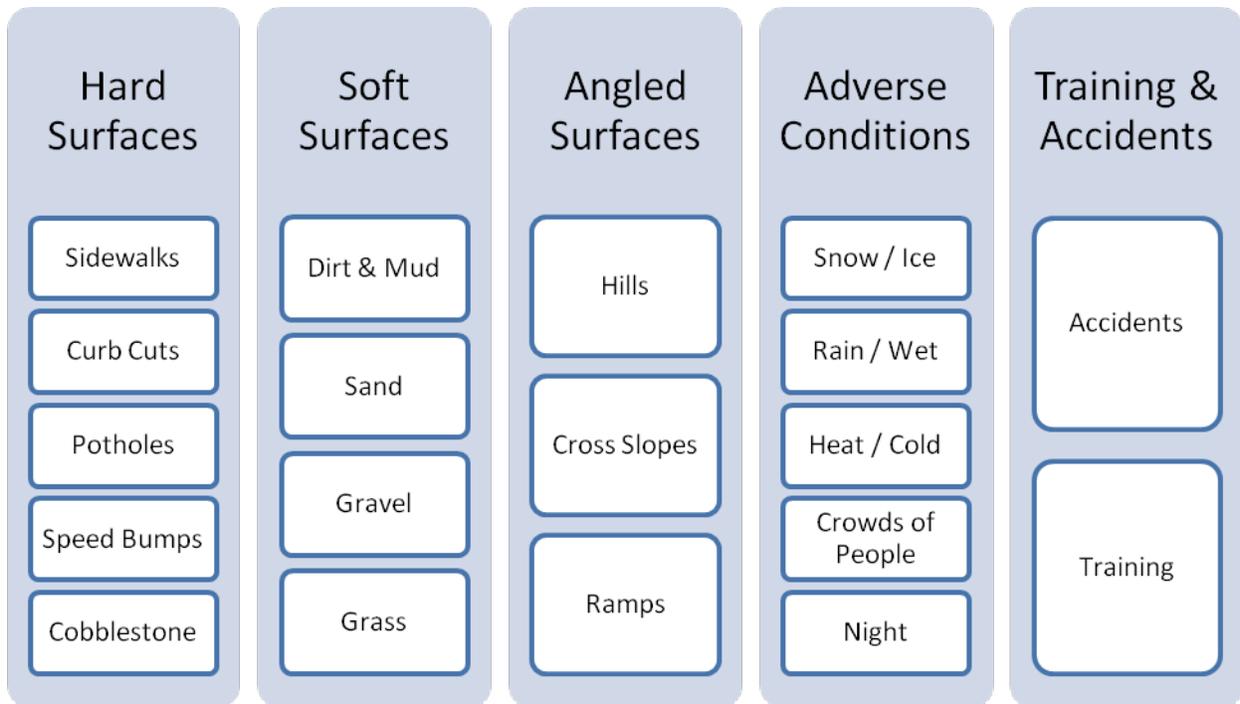


Figure 12: In-Vivo Coded Categories

2.3.3.1 Hard Surfaces

In general hard surfaces are the easiest for wheelchair users to navigate because they do not impair the driving capabilities of their EPW as much as other surfaces. In Table 5 below, the 5 sub categories of hard surfaces are described and EPW user recommended driving strategies are given.

Table 7: Hard Surfaces

Obstacle	Description	Driving Strategy
Sidewalks	Very unsafe when in bad condition (bumps, cracks, potholes, heaving) Jostling can cause painful muscle spasms Dangerous to climb and descend curbs in EPW due to tip risk	Drive in middle of street Do not drive down side of road, harder for cars to see you Climb curb: approaching at an angle helps to lift one wheel at a time, reducing power needed but is more unstable
Curb Cuts	Not enough curb cuts Access can be blocked by cars Too steep (causes foot rests or anti-tippers to catch)	Drive in street to get around that section of sidewalk or blocked access Go slowly to avoid tipping on transitions Watch that nothing catches on transitions Raise foot rests if powered
Potholes	Bumps can trigger spasticity if driving too fast Bounce driver's hand or chin off joystick Risk getting stuck	Must completely focus on driving Slow down & carefully maneuver Stop to readjust
Speed Bumps	Risk of high centering Jars driver uncomfortably Drop items being carried in lap	Drive slowly, find lowest spot, tighten seatbelt, and back up over them if necessary
Cobblestone	Can trigger spasticity if driving too fast (generally painful) Large cobblestones can trap EPW if driving too slowly	Drive fast as possible without causing too much discomfort Avoid all together if possible

One participant commented about curb climbing *“I can do it at an angle but it jars the *&% out of me”*. When climbing the sidewalk was not an option or when the sidewalk was in too bad a condition, the only option was to drive in the street. A participant explained how when he drove in the street, he did not drive along the side of the road because it was hard for drivers to see him and he felt more at risk of being hit by a car pulling into or out of street parking. He instead chose to drive down the center of the road. *“People beep and yell and scream and I get flipped off a lot but the thing about it is if they’re yelling at you, they’re screaming and flipping you off, you know they saw you.”* When talking about potholes, one participant recounted how the road she lived on was full of potholes. *“The road is so steep and full of bad potholes, in the*

rainy season, it turned into a creek bed. My chair started sliding and it hit sideways into one of the potholes. Flipped me over sideways and I broke my arm.” For the unavoidable bumps, one participant said that he just had to “Grin and bear it.”

2.3.3.2 Soft Surfaces

In general soft surfaces are the ones where EPW users get stuck the most because their heavy wheelchairs sink into the surface thereby greatly impairing the EPW’s driving capabilities. In Table 6 below, the 4 sub categories of soft surfaces are described and EPW user recommended driving strategies are given.

Table 8: Soft Surfaces

Obstacle	Description	Strategy
Dirt/Mud	Dry dirt OK Soft dirt, almost instantly bog down and become stuck	Have someone see how deep the mud is Go another way Rock upper body to shift center of gravity & help gain traction if stuck in soft dirt
Sand	Difficult to see hard / soft transition Can bog down very quickly Risk of being thrown out of EPW	Drive fast to maintain momentum and not turn otherwise you will sink in and get stuck Bring a friend to warn about soft sand Find the sand level beach board walks
Gravel	Get stuck easily Can trigger spasticity if driving too fast	Drive as fast as is tolerable to maintain momentum and not turn otherwise you will sink in and get stuck
Grass	Dry dead grass can be slippery Trouble with slipping when one wheel is on the grass and the other is on the concrete	Drive slowly or avoid

Regarding sand, a participant said that “It will stop you dead.” Another participant told about hitting a patch of soft sand and how his wheels instantly became bogged down, bringing his EPW to an almost instant stop. “I’ve been pitched out of my chair and hurt from that.” he said.

One participant said that he “*Can’t go on grass in spring because the ground is so soft I dig right in.*”

2.3.3.3 Angled Surfaces

The two main problems with angled surfaces is the intermittent loss of traction on the drive wheels and the possibility of tipping over. In Table 7 below, the 3 sub categories of hard surfaces are described and EPW user recommended driving strategies are given.

Table 9: Angled Surfaces

Obstacle	Description	Strategy
Hills	Loss of traction Wheelies Will not take chances as much when alone Motors get hot and stop Transitions: EPW can tip forward or backwards if angle is too great	Drive straight up and down a hill to reduced side tipping chances Use tilt feature to level seat Use seat belt or arm hook to hold yourself in Lean forward when going up hills Shift body weight to front or rear to counteract tipping Wait for motors to cool before continuing Raise footrests so they do not catch on the transition when descending a hill In the event of a rearward tip, tuck head forward into chest so the back of the EPW hits first and protects user from the impact.
Cross Slopes	Rear wheel drive EPWs will veer downhill Front wheel drive EPWs will veer uphill Causes torso to lean to side (painful) Hard to keep chin on joystick with head tilted downhill	Lean uphill if possible to reduce tipping Hook arm around backrest cane to control trunk Drive with joystick pointing at an angle away from foreword to keep EPW driving straight across a hill Drive completely down a slope then back up to reach a specific spot instead of driving across the slope
Ramps	Most are too steep Wheelies, anti-tip wheels might not be enough	<i>“I get someone to walk behind to make sure I don’t tip back.”</i> Back-up down the ramp to keep from falling out forwards

When asked, “What slope of hill will you navigate?” users responded with a variety of answers.

“It depends on if it’s grassy and if there is someone to watch me.”

“I won’t take chances as much when I’m alone.”

“It helps if the terrain is familiar.”

“If you’ve gone up the hill then it’s easy to tell if you can come back down.”

“Unfamiliar terrain is much harder to judge.”

2.3.3.4 Adverse Conditions

This category refers to any obstacle to EPW driving that is not a permanent type of terrain itself but a modifier of terrain. In this case, the two types of modifiers are weather and people. Weather has a big influence on peoples’ outdoor activities in general but for people with disabilities that use EPWs, this influence is greatly multiplied because EPW users are much less able to cope with changes in their environment. People can also create drastic changes in the environment through gathering in a crowd or inconsiderately leaving objects in locations that block the mobility of an EPW user. Therefore, weather and people can present formidable obstacles to mobility for EPW users. In Table 8 below, the 5 sub categories of adverse conditions are described and EPW user recommended driving strategies are given.

Table 10: Adverse Conditions

Obstacles	Descriptions	Strategies
Snow & Ice	5 inches of snow max before driving problems Icy slopes almost impossible Curb cuts have icy berm at bottom	Do not turn on ice as it will cause skidding & loss of directional control New snow provided more traction than packed snow Managing momentum is important
Rain / Wet	All surfaces slippery Malfunctions were common when EPW caught in rain	Avoid standing water as it is hard to tell the depth Put plastic bag over controller Slow down and drive more carefully
Heat / Cold	Heatstroke or hypothermia Risk of death	Dress for the weather and have several back up plans
Crowds of People	People step in front of EPW or crowd in from the side Accessing elevators When hit, people yell at EPW user for being bad driver	Have to work extra hard to be noticed, talk more loudly Ask if there is anyone behind before backing up
Night	Worried to travel in unfamiliar areas Not sure what obstacles might be encountered and how dangerous they might be if not seen in time	Bicycle headlamps work great Bicycle lights that clamp to EPW frame

“I just go through and hope I make it.” remarked one participant about snow and ice. Another participant said, *“And there’s the other fact that it’s much more dangerous to be stuck outside in the winter because you might catch hypothermia and die. Little bit bigger issue.”* Then there was the participant from Seattle who said, *“I live in Seattle, so it’s a daily thing. I avoid the puddles, just because I’m afraid of getting water up underneath. But for the most part, if it’s coming down overhead, I don’t really care about it. I get wet all over. When it splashes up underneath, I worry about groundwater.”* One user, referring to driving at night said, *“Darkness is a nightmare.”* Another said, referring to a comment to his wife one evening, *“I’m getting kind of uncomfortable that we’re out here too late.”* *“Lights on a chair would be invaluable.”* said several participants.

2.3.3.5 Training & Accidents

Participants explained how new wheelchair users need to learn their limits but in a safe and controlled manner. They suggested to practice driving outside with an able-bodied friend who could help if needed, carry a mobile phone, and drive a suitable speed for the terrain condition.

Participants were asked about their likes and dislikes for the wheelchair driving training that they had received (Table 9). The answers could be used to better focus improvements in wheelchair driving training taught by clinicians all over the country.

Table 11: Training

Best Aspect	Worst Aspect
<p><i>“Shown how to use it on rocks”</i> <i>“Obstacle course”</i> <i>“Shown how to use the options”</i> <i>“Attention to safety”</i> <i>“Instructed verbally first then therapist walked along next to me once I was in the chair”</i> <i>“The therapist was very patient, constant collaborating / adjusting”</i> <i>“Info on new joystick controls”</i> <i>“Covered fundamentals”</i> <i>“Shown how to use the options”</i> <i>“Showed me how to change driving modes”</i></p>	<p><i>“No outdoor training (especially cross slopes)”</i> <i>“Could have used more”</i> <i>“No training”</i> <i>“Starting in regular hospital hallway to learn sip-n-puff instead of an open area with space.”</i></p>

When asked if a driver’s manual for new EPW users would be helpful, here is what two participants had to say.

- *“Some of the things we learn by trial and error. You can get injured in the trial and error period.”*
- *“I think it would be really good for a new power wheelchair user to have something to peruse through, a book of some sort, not just how to run your EPW, but what you guys*

are doing I think is a really good idea to come up with some teaching for them, and then also to—like scenarios of this is what works, these are danger things, this is another way approach it.”

The study participants liked the idea of creating a driver’s manual using their expert insight. However some suggested that the instructional material be created in video format because it was too difficult to make a traditional paper copy accessible to everyone.

Accidents

The participants reported being involved in a wide variety of accidents during their driving experience. In Table 10 is a list of those accidents, some of which were due to mechanical trouble and others to driver error.

Table 12: Reported Accidents

Accidents
➤ <i>“Warm (moist) air in my sip-n-puff tube froze up so my wheelchair stopped working correctly.”</i>
➤ <i>“I was driving in the latch mode. It’s like cruise control. I hit a bump and it jostled me a little so I couldn’t reach my chin control. It took the back of a Mercedes to stop me.”</i>
➤ <i>“Side guard fell off chair so I fell sideways out of chair.”</i>
➤ <i>“I have twice hit a bump on the sidewalk and ran right into a light pole.”</i>
➤ <i>“Never tip over in a hospital parking lot because they freak out due to liability.”</i>
➤ <i>“A person jumped over my footrests from the side & I hit him because I didn't see him.”</i>
➤ <i>“I was driving on a sidewalk parallel with the street when I ran into an unmarked sidewalk indentation (for entering street level) which caused me to flip over on my side into the street.”</i>
➤ <i>“My speed control always moves forward to high without me realizing it.”</i>
➤ <i>“My first week out of the hospital I crossed the street and ran into a curb on other side cause I assumed there was a curb cut and it was just covered with leaves.”</i>
➤ <i>“I backed up off a curb that was too high and flipped backward.” (rear wheel drive EPW)</i>

The joystick is a particularly vulnerable part of the electronics on a EPW due to its position at the front of the EPW. A very common accident happens when a EPW user approaches a table and misjudges the height of the table, thereby smashing the joystick into the table instead of going under the table. Most times the physical impact to the joystick causes it to malfunction and need servicing. Another problem with the joystick that commonly occurred was that the cable connecting the joystick to the main EPW controller began to break, causing intermittent control problems. This can sometimes be solved by repositioning the cable slightly but in the end it must be replaced.

2.4 DISCUSSION

All the EPW user participants agreed that there were some definite terrains and situations that gave them problems when driving their EPW outdoors. The way they chose to deal with these situations depended on their level of risk taking and that had mostly to do with their level of motor functioning. The less motor functioning they had, the less of a risk taker they were because if they had a problem with their EPW outdoors they would be almost powerless to deal with the situation, thereby increasing the danger associated with having even something small go wrong. If a certain situation was unavoidable, they would bring someone along to help them just in case. Otherwise they would make sure to go only in public areas with lots of people around in case they needed help.

Out of the 23 different driving conditions and scenarios that participants were asked to rate by degree of difficulty, the categories in Table 11 were marked by over 50% of participants as either a condition considered difficult or a condition to avoid. These conditions were

characterized by three major concerns that were reoccurring in the focus group. These concerns, in order of severity were:

- Slip (Loss of traction) - Bad
- Stuck (Immobilized) - Worse
- Tip (Loss of stability) – Worst

Table 13: Questionnaire Categories Over 50%

	Difficult	Avoid
Slip (Loss of Traction)	Wet Grass	Snow Rain Ice
Stuck (Immobilized)	Mud Gravel	Soft Sand Mud
Tip (Loss of Stability)	Driving Up Steep Hills Uneven Terrain	Cross Slopes One Wheel Off Ground

Slipping is the least severe of the concerns because it is relatively easy to recover from this situation if the driver knows the correct techniques. However if the slipping condition is not brought under control, it usually leads to one of the following two concerns happening, getting stuck or tipping. Because of this it is important to prevent slipping to reduce the potential of much worse things happening.

Getting stuck is worse because the driver is completely immobilized, unable to get away from any dangers like rain, cold, or vehicles. If the driver has enough upper body function, it can be possible for them to rock the EPW enough to get enough traction or move the EPW enough to extricate themselves from the stuck position. This is not possible very often though so it is usually necessary for the driver to enlist the help of another person to help them get unstuck. The severity of the situation is determined by how long it will take to get another person to help.

Depending on the situation, this is why the participants chose to bring someone along to help just in case or stay in public areas with a lot of people around.

Tipping is the worst of the concerns because not only is the driver immobilized but they are no longer in their wheelchair anymore. Most wheelchair related injuries are caused when people fall out of their wheelchair in some way. Depending on the disability of the driver, it could take 2 to 3 people to get them back into their wheelchair. If the driver uses accessory equipment such as a ventilator, tipping out of their wheelchair would most likely disconnect it, leading to a possible life threatening situation.

The most common driving strategies were “drive slowly” and “bring a friend to help or ask a stranger” When EPW users were outside, they preferred to drive as fast as possible however this might be too fast for the given conditions, not allowing enough time for the driver to react if there is a problem. This can lead to dangerous situations unless the driver knows when to slow down. This is why the simple strategy “drive slowly” was common among all driving conditions. Another reason is that difficult terrain requires precise control over the wheelchairs movements and this can only be achieved if the user is going slowly. This driving strategy is one that could be implemented into a wheelchair controller that could sense what terrain the wheelchair was driving on and reduce the speed accordingly to a safe level based on the user’s abilities. The second driving strategy was “bring a friend to help or ask a stranger”. The most likely reason for this suggestion is that when driving in difficult terrains outdoors this is the easiest way to solve almost any problem that a wheelchair user might get into. However this strategy is very time and labor intensive so it would be preferable if the wheelchair could automatically help the driver from getting stuck in the first place. Two other driving strategies specifically applied to the “soft surfaces” characteristic and the “angled surfaces” characteristic.

For the different soft surfaces the common driving strategy recommended was to drive quickly across the soft surface to maintain momentum and not sink into the surface too much otherwise the EPW might get stuck. For the angled surfaces the common driving strategy recommended was for the driver to shift their body weight over the drive wheels as much as possible to minimize slipping. This was usually accomplished by tilting the seat using powered seat functions or for users with better trunk control, simply leaning.

In Table 12 below, the common condition categories from the focus group and questionnaire are shown along with the major themes from the in-vivo coding that they fall into. There are only 7 conditions that are not common to both. This shows that the questionnaire conditions matched very closely with the categories derived from the focus group. The themes of “Soft Surfaces” and “Adverse Conditions” contain the most conditions with 8 apiece, followed by “Angled Surfaces” with 6.

Table 14: Comparison of Focus Group Categories to Questionnaire Categories

	Hard Surfaces	Soft Surfaces	Angled Surfaces	Adverse Conditions
Common Categories	Cobblestone Curb Cuts	Mud Gravel Wet Grass Dry Grass Hard Sand Soft Sand	Driving Down Steep Hills Driving Up Steep Hills Ramps Cross slopes Turning on a slope	Ice Snow Crowds of People Driving at Night Rain Severe Cold Severe Heat
Questionnaire Only		Heavy Carpet	Uneven Terrain	One Wheel Off Ground
Focus Group Only	Potholes Speed Bumps Sidewalks	Dirt		

Using only the conditions from the questionnaire which received 50% or more of participants votes, a table was created which grouped the conditions based on the themes developed from the focus group (Table 13). This showed that the conditions rated as difficult mostly fell into the general themes of Soft Surfaces and Angled Surfaces. Whereas, conditions rated as avoid fell mostly into the general theme of Adverse Conditions.

Table 15: Analysis of the Top 50% of Conditions

	Difficult	Avoid
Hard Surfaces		
Soft Surfaces	Wet Grass Mud Gravel	Mud Soft Sand
Angled Surfaces	Uneven Terrain Driving Up Steep Hills	Cross Slopes
Adverse Conditions		Snow Ice Rain One Wheel Off Ground

Therefore, clinicians should focus on teaching driving strategies for items in the Difficult theme and researchers should focus on building a better wheelchair for items in the Avoid theme because EPW users simply avoid these things and have not been able to develop reliable driving strategies for them.

2.4.1 Limitations

The main limitation of this study is that of the three groups recruited, most of the participants were from two groups of veterans recruited at wheelchair sporting events. This

could introduce some bias because all participants were very active individuals. Also, the age distribution was skewed toward older adults with an average age of 55.

The focus group part of the study could have been designed better. More effort should have been spent on designing the focus group in consultation with qualitative experts. There was not enough structure in the discussion, leading to a wide variety of data, which was very difficult to draw any specific conclusions from. The open discussion allowed for a lot of talking but much of the discussion was off topic and therefore unusable. One way to improve the structure would be to ask a specific list of questions to every focus group so that the answers across groups could be compared directly.

2.4.2 Application

There are many applications for the driving strategies identified in this study. The two following applications were chosen as the primary focus of the study results.

- 1) Updating the current driving education material and the creation of new materials to assist EPW users with learning to drive more safely.
- 2) Development of new EPW driving control software using an advanced controller to automate driving strategies thereby creating a much safer EPW.

Driving Education Material

The EPW users liked the idea of passing on their knowledge to the next generation in the form of a driving manual for outdoor terrain. They indicated that they would prefer to not learn safe outdoor driving by trial and error. However, the driving training results presented some interesting contradictions. Why would study participants rate their driving training as somewhat

adequate (3.4 out of 5) if 73% of them received little to no training? Firstly, a score of 3.4 is very close to neutral at 3.0 so the opinions are almost evenly split. Secondly, since they are experienced at driving now, when they look back, they may not remember learning on their own to be that difficult. It would be worthwhile to see if less-experienced users that have just been through the experience of learning to drive would respond in the same manner. There is also a contradiction between the participants reporting that their training was somewhat adequate and indicating that having driving rules to teach beginners would be beneficial (4.2 out of 5 point Likert scale). The reason could be that participants thought that beginners today have more to learn.

The data collected from this study can also be used as an added resource to clinicians using such driving reference tools as the Power-Mobility Community Driving Assessment [13] and The Powered Wheelchair Training Guide [14]. All clinicians and new EPW users should be made aware of these tools and their usefulness. New EPW users especially should have access to the book to begin learning the techniques needed for outdoor driving that they most likely will not be taught in the clinic.

The “Power-Mobility Community Driving Assessment” (PCDA) was created in 1998 with a grant from the Canadian Occupational Therapy Foundation. As of 2003, the PCDA has been updated. “The PCDA evaluates the person-environment interaction observed when people drive power-mobility devices in a variety of community settings.” [21] In section C1 of the PCDA called General Driving Skills, there are similar driving condition categories to the ones in this study and also categories not included (Table 14).

Table 16: Driving Skills in PCDA

Similar Categories to Focus Group	Different Categories
Driving on sidewalk	Maintaining a straight course
Driving in parking lot	Intersection with lights
Driving on road	Intersection without lights
Driving in crowds	Accessing crosswalk button
Crosswalks	Crossing streets without lights
	Intersection with lights

In section C4 called “Driving On Varied Surfaces” and section C5 called “Accessing Public Places” the therapist is allowed to specify what surface or environment the EPW user is tested on. This would allow for the inclusion of some of the other 20 categories from this study to be used depending on the community environment of the EPW user.

“The Powered Wheelchair Training Guide” was published in 2002 with funding from the Paralyzed Veterans of America. The goal of the book was to “help increase the independence of wheelchair users, decrease the number of wheelchair accidents caused by the lack of education and training, and limit the frustration caused by those receiving or giving inadequate or improper assistance.” [14] In the book, Chapter 3 - Navigation Skills, Chapter 4 – Emergency Skills, and Chapter 5 – Special Circumstances cover the EPW driving scenarios discussed in this study. There was one driving strategy from this study that directly contradicted a strategy in the book. The book said when climbing a curb independently in the forward direction the driver should always approach perpendicular to the curb and climb with both wheels at the same time to avoid tipping sideways. However, in this study it was recommended that sometimes approaching the curb at an angle was the only way one could successfully climb the curb due to the EPW not having enough power to climb with both wheels at the same time.

The following is a list of obstacles and strategies discovered through the focus groups that are not in the book but are relevant to specific sections in the book.

- Sometimes when stuck in soft ground, an EPW user can extricate themselves by rocking their upper body back and forth to momentarily shift the center of gravity of their EPW to give enough traction to the drive wheels to get unstuck. (Section 3.4 Rough Terrain)
- If you are an EPW user that uses a chin joystick and you are driving on rough terrain, be careful that your chin does not bounce out of the joystick cup as you could push the joystick with another part of your head and cause your EPW to collide with something. (Section 3.4 Rough Terrain)
- EPW users with chin joysticks have a hard time on cross slopes, holding their neck in the right position. (Section 3.6 Cross Slopes)
- When driving in a crowd, work hard to be noticed by speaking up much louder than normal or when outdoors even using a bicycle flag on your EPW. (Section 5.5 Traveling)
- It is easier to drive an EPW in new snow compared to packed snow because the new snow compresses around the tires giving them traction whereas the packed snow is hard and slippery (Section 5.6 Weather)
- Be alert that sip-n-puff tubes can freeze closed in cold weather because of the user's warm moist breath (Section 5.6 Weather)

Multiple focus group participants made the comment that it would be very helpful to them if there was a Youtube video series of EPW driving lessons illustrating the outdoor driving techniques in this book and the ones gleaned from the focus groups. As of yet, no such video series could be found on Youtube. This would provide a much more illustrative and accessible means for clinicians to teach new EPW users the skills they needed for outdoor driving.

EPW Driving Control Software

In 2008, Cooper et al [2] concluded that an area specifically in need of further investigation was the development of wheelchair technology that improved the safety of users during all activities. Focusing on EPW driving control technology, Cooper and Ding [8] recommended robust velocity control, traction control, and stability control as much needed technology in current EPWs. In the following section of this thesis, the design and development of an advanced EPW controller is described. Using the driving strategies identified in this study, control software was developed to reduce the risk of traction and stability problems [22-24].

2.4.3 Future Work

Future work should include conducting more focus groups but with non-veterans that are preferably not as active to gain more insight into their driving strategies and determine how generalizable the current data are. As more is learned about the challenges of driving an EPW in outdoor terrain, the information should be used to continue developing new driving control algorithms such as traction control and anti rollover for EPWs with the goal of creating a higher level of safety and usability for all EPW users [23-25] as well as creating better driver training tools to be used by drivers and clinicians.

2.5 CONCLUSION

This informative study detailed the results of a questionnaire and focus groups whose purpose was to identify situations that present obstacles to EPW users when driving their wheelchairs outdoors and strategies that they use to negotiate these difficult situations. The driving strategies learned should assist new users in learning to drive more safely and help inform researchers' efforts to develop new EPW driving control software. Information gathered in this study may change the way EPW are designed and how individuals are trained to use their EPW.

3.0 PART 2 - DEVELOPMENT OF AN ADVANCED CONTROLLER

3.1 INTRODUCTION

In an EPW review article published in 2005, Ding and Cooper stated that “control algorithms for these EPW have not improved substantially since the early 1980s.”[8]. Incidence of loss of control and injury are far too frequent among EPW users [8] [10]. A substantial fraction of EPW accidents can be directly attributed to the control system and design features of EPWs [8-11]. In 2003 over 100,000 wheelchair related accidents were treated in United States emergency departments with 65-80 percent of the accidents being tips and falls [26]. This agrees with a previous study done in 1997 that interviewed 109 active wheelchair users. Among the users, the largest accident category was tips and falls at 42% [27]. In addition, persons with severe and complex disabilities might find it difficult to steer an EPW under adverse conditions such as slippery or uneven terrain or obstacles. Sometimes, even experienced users may lose control of their chairs under such driving conditions. These actions require hand-eye coordination and fine motor control that for some individuals with high-level spinal cord injury, multiple sclerosis or brain injury may be exceedingly challenging. For some of these people, learning how to safely and effectively use an EPW can take hours or weeks. A survey of 200 clinicians reported that 18% - 26% of their patients who used a manual wheelchair could not safely operate an EPW. The study concluded that for most people with severe or multiple disabilities, “no independent

mobility options exist at this time.” [28] EPW driving could become safer, more effective in a broad array of environments, and functional for more people with the application of a more advanced control system [9-10].

In 2005, a detailed review of ‘smart’ EPW controller research was published that discussed the many efforts to build and test smart controller systems and their varying levels of success. A few notable examples of smart EPW systems included in the review were NavChair from the University of Michigan, Office wheelchair with high Maneuverability and Navigational Intelligence (OMNI) from the University of Hagen, Germany, and Mobility Aid for elderly and disabled people (MAid) from RIAKP, Germany [29]. This previous research focused mainly on navigation and obstacle avoidance.

Control systems research has achieved broad application in other areas, such as telecommunications, robotics, automation, and medicine. The simple proportional-integral (PI) controller used on most EPWs today for velocity control does not perform well when subjected to disturbances, sensor uncertainties and load variation. Most control systems in use today, with the notable exception of EPW, incorporate “uncertainties” or “perturbations”. These “uncertainties” may include: dynamics that are otherwise neglected in order to make the EPW control model tractable; nonlinearities that are too complicated or poorly understood; or parameters that are imprecise because of variations in devices or components. The design of robust control requires the analysis and development of algorithms and methods to address these uncertainties and perturbations.

Related work can be found in the literature about differentially-driven wheeled mobile robots with structures similar to an EPW, where modern control theories (i.e., robust control, adaptive control, neural control) have been applied [30-31]. Wheelchair users usually have

significant difficulty on ice, slippery surfaces and soft ground [32]. However, little research has addressed enhancing traction of an EPW under sub-optimal surface conditions. Work related to traction control are usually found in the literature about automobiles [33-34].

These issues were addressed by investigating the application of advanced control techniques to EPW through a custom designed controller. This section of the thesis describes the design and development of the initial controller prototype. The following design areas were specifically focused on to ensure the outcome of a functional and versatile controller

- Processing Power
- Operating System
- Data Input / Output
- Sensors
- Power Consumption
- Robustness

3.2 METHODS

The surrogate EPW chosen for the first prototype was a Golden Alante wheelchair (Figure 13: Advanced Controller on EPW). It was a very simple EPW with a basic box frame base design which contained the batteries, motors, and control electronics. The seat was mounted on a post in the middle of the base. One nice feature of the wheelchair was that the seat could be rotated 180° so that the wheelchair could be configured as a front-wheel drive EPW or a rear-wheel drive EPW depending on the research study being carried out.



Figure 13: Advanced Controller on EPW

Based on the areas of focus, the design goals for the prototype and the component outcomes are detailed in (Table 15).

Table 17: Design Goals and Outcomes

Area of Focus	Design Goals	Component Outcomes
Processing Power	Must handle complex simultaneous operations Perform data logging	Industrial single board computer 1.6 GHz Pentium M with 1 GB DDR ram
Operating System	Stable and reliable real-time system Provide the same level of safety as a conventional EPW controller	VX Works from Windriver Systems Industrial & aircraft quality real-time system
Input/ Output	Wide variety of connections Must interface with generic peripherals	(48) channels of digital IO (24) channels of A/D (2) analog output channels (6) counters (3) timers
Sensors	Must provide variety of static and dynamic state feedback	500 counts/rev resolution encoders 3 axis gyro 3 axis accelerometer Temperature sensor
Power Consumption	Not use significantly more power than a conventional EPW controller	Industrial quality DC/DC converters, computer, & sensors
Robustness	Reliable during vibration and exposure to the weather	Core components housed in 5"x 17"x 10" aluminum chassis secured to the frame

3.2.1 Mechanical Design

The core components were housed in a 5"x 17"x 10" aluminum chassis, which was secured to the frame of the EPW under the seat (Figure 14). Two industrial servo motor amplifiers were mounted vertically on the inside, front face of the chassis. A layer of thermal joint compound was applied between the amplifiers and the chassis to improve heat dissipation. Fixed to the outside front face was a large aluminum heat sink. The single board computer (SBC) was

mounted to the left side of the floor of the chassis. The PC104 expansion boards stacked on top of the SBC. The DC-DC converter to power the SBC was secured to the inside of the right face with screws and thermal joint compound.

The original wiring harness and the controller connectors were retained from the

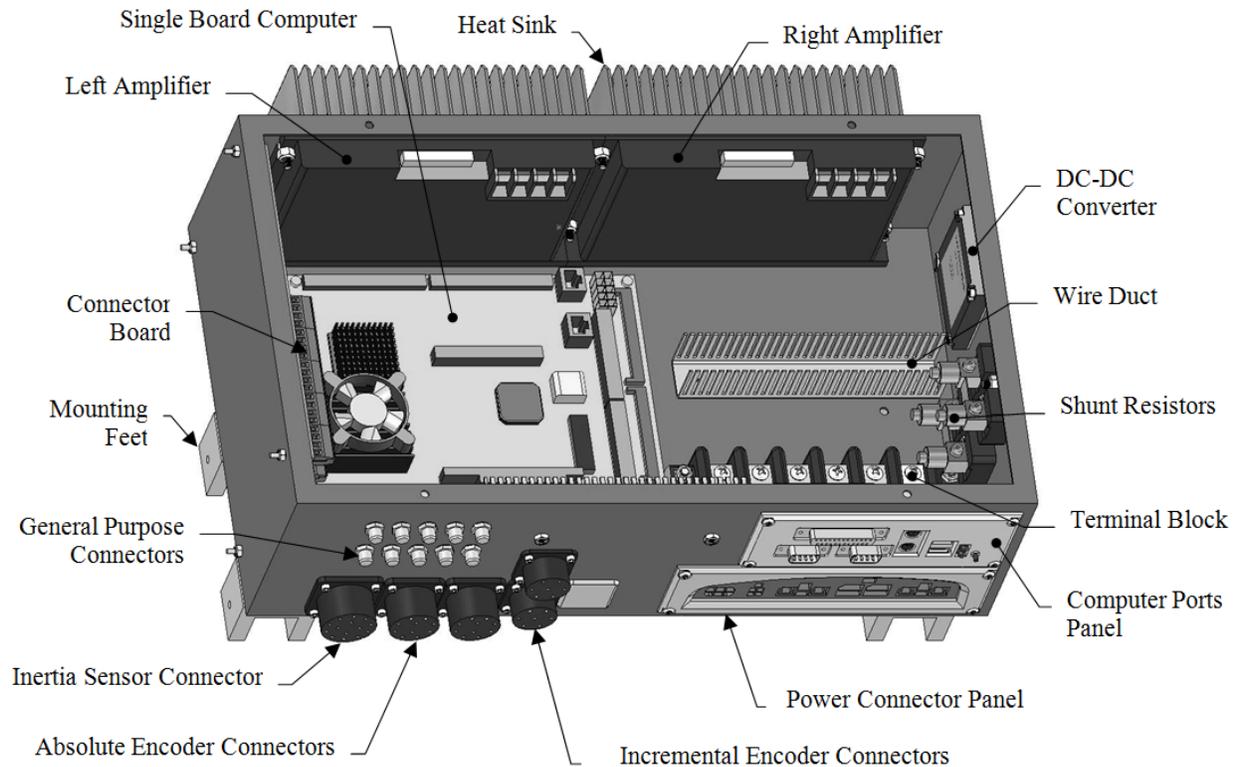


Figure 14: Layout of Components in Chassis

surrogate EPW. The controller connector included connectors for the battery terminals, left and right motor, and the joystick. An opening in the lower left corner of the back face was milled to accommodate the controller connector. The connector was fastened to the chassis using screws and sealed using RTV. Positioned on the floor of the chassis adjacent to the controller connector was a 6 position terminal block rated for 70 amps. The purpose of this connector was to neatly distribute the 24 volt battery supply to the two amplifiers, DC-DC converter, and brake circuit.

A breakout board connected to the SBC via a ribbon cable and provided an interface with several of the computer ports. The ports included a:

- parallel port
- (2) RS-232 ports
- (2) USB ports
- PS2 keyboard port
- PS2 mouse port
- 2 LED indicators

The breakout board was mounted in a cut out directly above the controller connector. A custom made plastic face plate was used to securely fasten the breakout board to the chassis.

In addition to the breakout board, additional connectors were required to interface with the various sensors. For a general purpose connector, 4 position single ended molded cables and matching receptacles were chosen. These cables were designed for industrial environments and featured 24 AWG wire covered with yellow PVC. The 4 positions allowed for a power, ground, and two signal lines, providing enough infrastructure for I2C, USB, CAN, and other serial transmission modes, as well as 2 channel analog sensors. Ten receptacles of this type were mounted on the rear face of the chassis with potential for additional ports in the future. The inertia sensor was mounted in a separate enclosure that was located near the center of mass of the EPW. The wire running from the inertia sensor enclosure terminated to a 12 pin AMP 97 series circular connector in the chassis. The two drive wheel encoder cables terminated to 7 pin AMP 97 series circular connectors. The two absolute encoder cables terminated to 10 pin AMP 97 series circular connectors. All AMP connectors had matching receptacles mounted on the rear face of the chassis.

In order to route the signal wires in an organized fashion, inside the chassis an interconnect board was included. The interconnect board consisted of a solderable prototype board with rows of terminal blocks. The wires from the receptacles terminated on one side of the board, while on the other side; wires terminated from the SBC, DAQ board, and the DC-DC converter. The lines could be connected together by hook up wire from terminal block to terminal block or by solder connection. Permanent connections, such as the digital IO lines used for controlling the brakes were soldered, while sensors used hook up wire connections. The use of terminal blocks allowed incoming signals from the sensors to be routed to the SBC as required for specific applications, while at the same time providing a reliable connection. The prototype board allowed for organized distribution of the 5 volt source, as well as providing a platform for any additional circuits that could be required to utilize a particular sensor or input device.

3.2.2 Electrical Design

The electronic design consisted of a core component group and a peripheral component group. The core group contained components that were required for the EPW to operate as a typical EPW and the infrastructure to interface with a variety of peripheral components. The peripheral group consisted of a variety of sensors and output devices that could be swapped in and out depending on the application.

Core Components

The core components group was divided into high current components and low current electronic components. The high current components consisted of two 12 volt batteries, two 420 watt motors with brakes, two industrial amplifiers, a brake release circuit, a DC-DC converter,

Also included in the high current components was the brake release circuit. The purpose of the brake release circuit was to disengage the brakes when a voltage was applied to the motors. The brakes were applied unless a 24 volt potential was present across the brake terminals. The brake circuit received an input from a digital input-output (IO) pin, boosted the signal strength with a transistor, and passed it to the gate of a power metal-oxide-semiconductor field-effect transistor (MOSFET). The MOSFET was the high current switch that disengaged the brakes.

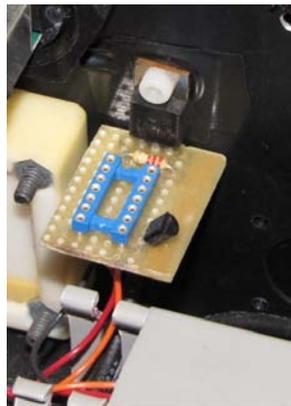
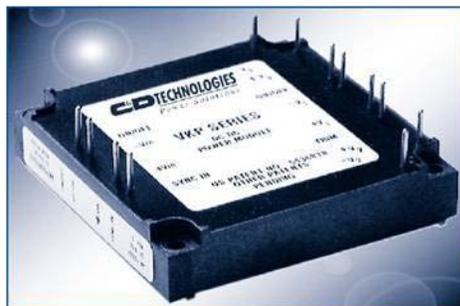


Figure 17: Brake Circuit

The transition from the high current components to the electronics was performed by a DC-DC converter. The converter was required to reduce the 24 volt batteries to 5 volts, 12 volts, and -12 volts, which was required by the single board computer and peripherals. The triple output DC-DC converter was chosen for its compact size, 60 watt output and 18-40 volt input range.



**24 ->5 Volt DC/DC
Converter**



**24 ->12 Volt DC/DC
Converter**

Figure 18: DC/DC Converters

The electronics components in the core group included a SBC, data acquisition board (DAQ), counter board, controller area network (CAN) controller, and connector interface board.



Figure 19: Connector Interface Board

The SBC contained a 1.6 GHz Pentium M processor and 1 GB of DDR RAM. The SBC had numerous external interfaces in addition to the normal ones. These included 8 channels of 12 bit A/D, 32 channels of digital IO, three 16 bit counters, a PC104 bus, and a PC104plus (PCI) bus. The SBC required a supply voltage of 5 volts at 4.6 amps during typical operation. This particular SBC configuration was chosen for its processing power and number of external interface options.

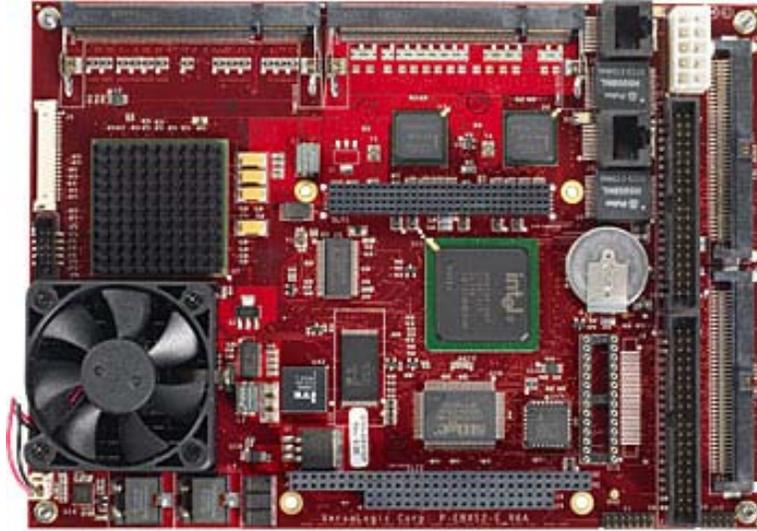


Figure 20: Single Board Computer

The purpose of the SBC was to serve as the “brain” of the system. It was programmed to receive inputs from various sensors, process the inputs and produce appropriate outputs as required by the application. One key output, which was used for all applications, was the two PWM signals, produced using the counters, for controlling the amplifiers. In addition to being a processor for control algorithms, the SBC in combination with a non-volatile storage device was used as a data logger for a large number of driving variables. Initially, the non-volatile storage was a 1 GB Compact Flash card, which provided room for the firmware and many data logging applications. A possible future upgrade was a large capacity solid state hard drive for data logging applications that required large amounts of memory, such as continuous video capture.

The DAQ board was a PC104 analog and digital I/O module. It had 16 channels of 16 bit resolution A/D and could acquire data at a rate of 200k samples/second. It also had 2 channels of 10 bit analog output and 16 lines of digital I/O. The purpose of the DAQ board was to serve as a general data IO peripheral interface.



Figure 21: DAQ Expansion Board

Additional counters were located on a PC104 counter board. The counter board had 3 incremental encoder interfaces and three 8254 Timer/counters, along with some additional I/O lines. The main task of the board was to interface with the 2 drive wheel encoders. It also left resources for the potential addition of PWM controlled motors and additional incremental encoders.

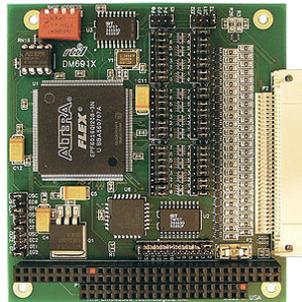


Figure 22: Counter Expansion Board

Peripheral Components

The peripheral components were made up of a variety of sensors, which could be added or removed as required for a particular application.

- Drive Wheel Encoder - Optical encoders were chosen to measure the true speed of the drive wheels. The encoders had 500 counts per revolution resolution, quadrature output, and required a 5 volt supply voltage.



Figure 23: Drive Wheel Encoder

- Caster Wheel Encoder - After initial driving tests with the new controller algorithms, it was decided that the algorithms needed more state information about the wheelchair so as to better recognize when a wheel slip condition existed. To do this, a caster wheel encoder was added which performed the same as the two encoders on the drive wheels but since the caster wheels are not powered, it provided a true ground speed reference point for the algorithm to compare from. The caster wheel encoder was designed from scratch and the caster itself modified. The caster needed to be modified because the normal design of the caster involved a stationary axle with the wheel spinning around it. What was needed was a rotating axle, which could be attached to an encoder on the outside of the caster fork. This was accomplished by moving the bearings in the caster from the wheel itself onto the caster fork, allowing the shaft through the middle of the caster to rotate with the caster and not be stationary (Figure 25) To bring the data from the caster to the main body of the wheelchair a slip ring was used on the caster swivel axis to allow for full 360° movement of the caster. (Figure 24)



Slip Ring for Caster Encoder



Castor Encoder

Figure 24: Castor Encoder

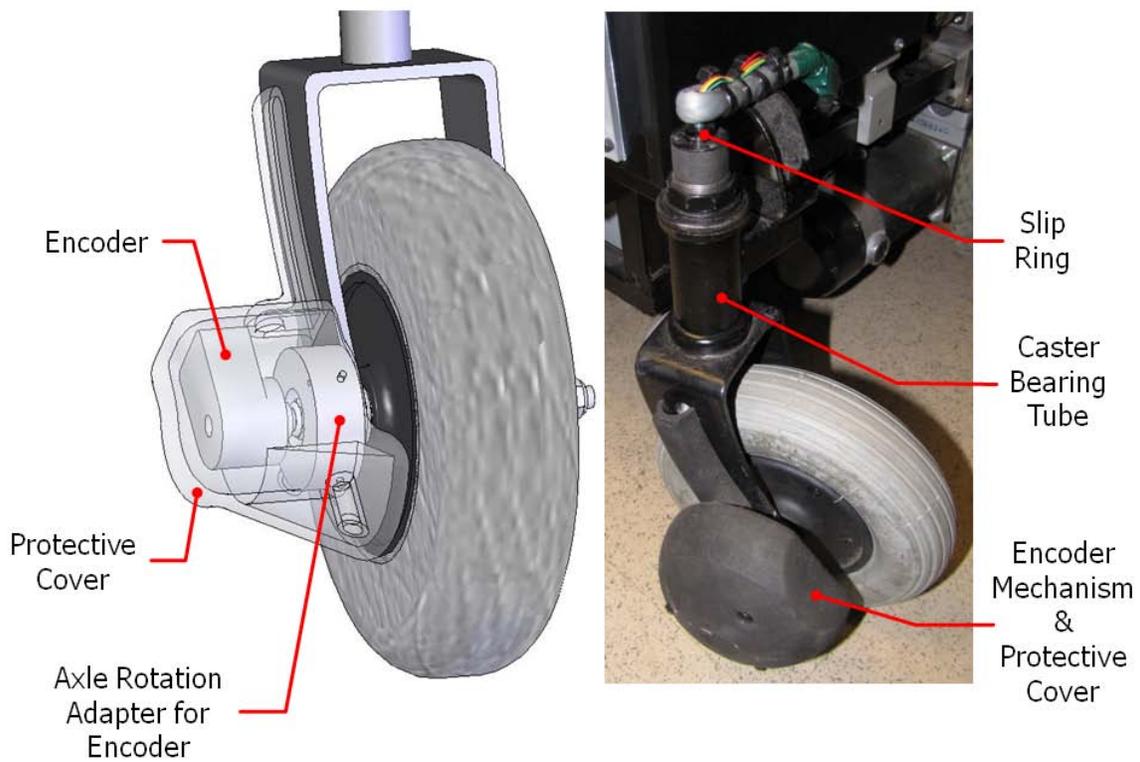


Figure 25: Mechanical Design of Castor Encoder

- 3 Axis Gyro / 3 Axis Accelerometer - The inertia sensing module included a 3 axis gyro, a 3 axis accelerometer, and a temperature sensor. All outputs were analog and required a 5 volt supply voltage. The sensor was used to detect tipping, terrain type, and vibration data.



Figure 26: Inertia Measurement Unit (IMU)

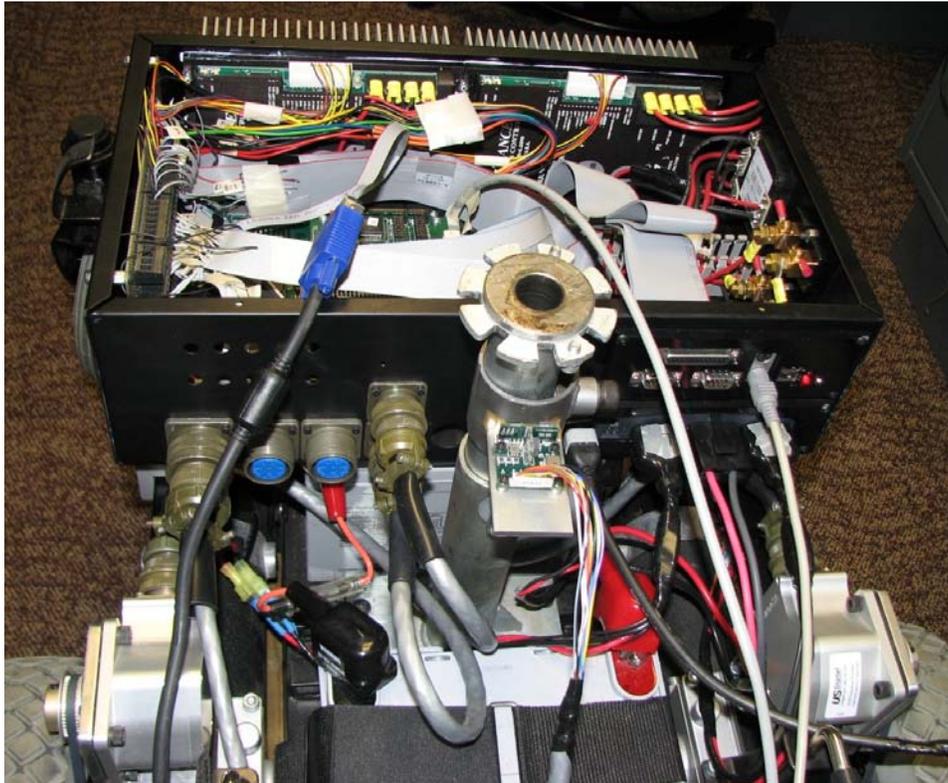


Figure 27: Completed Design with Wiring

3.2.3 Power Consumption Tests

In order to obtain an objective estimate of the power consumed by the controller, the current draw was measured. The test procedure consisted of booting up the EPW controller and executing the driving program which enabled the joystick control. The quiescent power draw was then measured by measuring the voltage across the battery terminals with a Fluke 190C portable oscilloscope/meter while the current was measured using a clamp style ammeter adaptor attached to the oscilloscope/meter. The Golden EPW prototype used two 12 volt nominal, 26.8 amp-hour (5 hour rating) batteries in series to form a 24 volt system.

The Golden Alante surrogate EPW had been previously tested in its factory original condition with the ANSI/RESNA WC-2:2009, Section 4 test titled “Energy Consumption of Electrically Powered Wheelchairs and Scooters for Determination of Theoretical Distance Range”. To allow the comparison of the energy consumption of the original control system to the advanced EPW controller, the Section 4 test was performed on the Golden EPW prototype.

3.3 RESULTS

3.3.1 Power Consumption Tests

The advanced EPW controller power consumption test result showed that at a nominal 24 volt charged battery condition, the controller required 1.88 amps in its quiescent state. A Quickie Rhythm EPW and a Jazzy 1120 EPW were also tested, requiring 0.47 amps and 0.28 amps

respectively in their quiescent state. The results showed that the advanced EPW controller requires 4-6 times more power than conventional EPW controllers.

The results of the ANSI/RESNA WC-2:2009, Section 4 test titled “Energy Consumption of Electrically Powered Wheelchairs and Scooters for Determination of Theoretical Distance Range” on the Golden Alante surrogate EPW in the factory original condition and the modified condition, using the advanced controller showed that there was a significant difference, up to 3.5 times, in power consumption between the two controller configurations (Table 16).

Table 18: Results of RESNA WC-2:2009, Sec 4 Test Comparison on the Golden Alante EPW

Brand		Golden Technologies Inc	
Model		Alante	
Serial #		058481	
Mass of Test Driver		100 kg	
	Driving Test	Driving Range	Battery
Factory Original	36.93 Wh/km	17.41 km	12 v Sealed Gel, 26.8 Ah (5hr rating)
Advanced Controller	127.27 Wh/km	5.05 km	12 v Sealed Gel, 26.8 Ah (5hr rating)

3.3.2 Refinement

After building the initial controller prototype and performing the driving tests detailed above in the results section, some modifications were made to the controller to make it more robust and user friendly. In the following list, the controller upgrades are described along with the reason for the upgrade.

- Interface PCB with correct plugs: One of the major redesigns that became obvious after some preliminary driving tests was that over time the wires running to the system interface a board with rows and rows of screw terminals would fatigue from vibration and the wires would break at the screw terminal. The screw terminals also caused some bad

data in some cases due to the connection not being as good as a dedicated plug. The screw terminal design was discarded in favor of creating a custom printed circuit board with dedicated plugs for each component. Originally a custom circuit board was deemed too expensive for the project as it would have had to be made by an outside vendor. However after the first prototype had been built, HERL purchased a printed circuit board rapid prototyping machine which allowed a board to be made for much cheaper at a faster pace. The installation of the new interface board greatly reduced sensor errors and allowed for a much faster disassembly of the controller for maintenance.

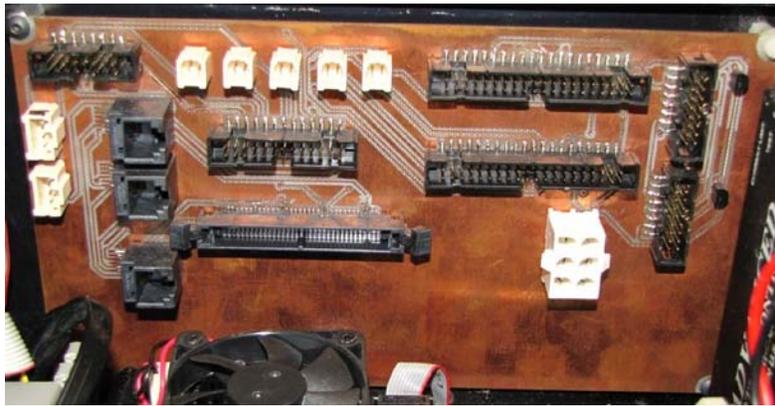


Figure 28: New Interface Board

- Data storage: Originally the controller used a 1GB Compact Flash card as its hard drive but this was deemed to not be enough space for data storage during data logging operations. A 32GB solid state hard drive from Trancend was tried but there were too many compatibility issues with the Cobra SBC so this solution was abandoned. An 8 GB Compact Flash card was then used as the main controller hard drive. The solution provided a size that was large enough to perform some data logging tasks and provided the computer with a very rugged and vibration resistant memory storage medium.
- New on/off switch: When designing the controller the installation of an on/off switch did not seem necessary. During initial system testing the battery was simply unplugged from

the controller to provide the off function. This was however much too cumbersome and contributed to the wear of the connector. An on/off switch was added which turned on the power for the wireless kill switch, which when powered up, engaged the main power relay which supplied power to the rest of the system.

- Wireless kill switch: After a few situations with a runaway EPW during initial algorithm testing, it was decided that safety kill switch was needed. A wireless kill switch designed for ATVs was purchased. The switch controlled a large power relay which provided power to the entire controller. The wireless kill switch itself was powered by its own dedicated DC/DC converter. This allowed the main controller on/off switch to simply control the power to the DC/DC converter which would then turn on the wireless kill switch, turning on the power relay which would provide power to the rest of the controller.



Figure 29: Wireless Kill Switch with Keychain Remote

- Wireless KVM Interface: Originally to access the controller computer, a keyboard and monitor attached by wire was used. The problem was that during testing the user could not see what was on the screen of the controller although it was easy to take the keyboard

on the EPW. This meant that if something went wrong, someone had to go all the way back inside to the lab to plug the monitor back into the controller and see what it was displaying. To fix this problem, a wireless keyboard, video, mouse (KVM) transmitter and receiver combo was purchased and the transmitter mounted on the wheelchair, allowed the user to see and control the wheelchair controller computer from up to 400 feet away. This made testing outdoors much easier since as long as the user did not exceed 400 feet away from the receiver, their colleague could still see on the monitor in the lab what was happening on the controller computer.



Figure 30: Wireless KVM Extender

3.4 DISCUSSION

The advantages of the advanced controller design over conventional controllers were threefold. Firstly, the feedback to the computer provided by the various sensors allowed the EPW to react to the environment dynamically by modifying the output signal sent to the drive wheel motors. This made the EPW safer by allowing it to sense and react to its environment with minimal user input. This ability was featured in the driving software developed to improve traction control and stability control. Secondly, the programmability of the control computer allowed a high degree of customization possibilities for the joystick such as different axis, a

larger center dead zone, and damping of user hand tremors. Lastly, the solid state memory storage capability of the computer allowed for extensive data logging of a wide variety of parameters which allowed the researchers to better understand the dynamics of driving.

The limitations of the advanced controller design over conventional controllers were threefold. Firstly, the system required much more power to run. With a full computer and peripheral sensors to run, there was about a 300% increase in power consumption over a standard EPW controller. While a limitation for full scale clinical testing, the battery did allow up to 5 km of range which was sufficient for most testing. Secondly, the prototype controller enclosure was rather large and would not fit well on most wheelchairs. Also, space would have to be found to fit all the sensors onto the EPW. Eventually though, the system would become smaller as the design and parts evolve. Lastly, the controller was more expensive owing to its much higher level of complexity.

Future work with the advanced EPW controller should involve its continued use as a test platform for new driving control algorithms. The controller should also be used to introduce students to the concepts of EPW control since it is a completely open controller system, able to be manipulated in any way, making it a good learning tool.

3.4.1 Application

Driving control software for the advanced EPW controller was developed by Hongwu Wang which focused on the top concerns of EPW users, loss of traction and loss of stability. Below are the abstracts from the 3 published studies he has performed to date.

Real-Time Model Based Electrical Powered Wheelchair Control [23]

The purpose of this study was to evaluate the effects of three different control methods on driving speed variation and wheel slip of an electric-powered wheelchair (EPW). A kinematic model as well as 3D dynamic model was developed to control the velocity and traction of the wheelchair. A smart wheelchair platform was designed and built with a computerized controller and encoders to record wheel speeds and to detect the slip. A model based, a proportional-integral-derivative (PID) and an open-loop controller were applied with the EPW driving on four different surfaces at three specified speeds. The speed errors, variation, rise time, settling time and slip coefficient were calculated and compared for a speed step response input. Experimental results showed that model based control performed best on all surfaces across the speeds.

Real-Time Slip Detection and Traction Control of Electrical Powered Wheelchairs [24]

The purpose of this study was to develop an electrical powered wheelchair (EPW) control system with the ability to detect and compensate for wheel-slip in real-time. A smart EPW platform was designed and built with a real-time computerized controller that records wheel speeds as a means to detect slip. The slip coefficient was defined by the difference in the rotational velocity of the caster and driven wheel. To evaluate a simple wheel slip controller, our EPW was driven over five different surfaces at three speeds. Paired t-tests showed that with anti-slip control, there was significant ($p < 0.001$) lower slip coefficient than without anti-slip control. Experimental results showed that the performance of anti-slip control was consistent on the varying surfaces at different speeds.

Real-Time Forwarding Tipping Detection and Prevention of a Front Wheel Drive Electric Powered Wheelchair [22]

The purpose of this study was to develop a front wheelchair drive electrical powered wheelchair (FWD-EPW) control system with the ability to detect and compensate for forward tipping in real-time. A smart EPW platform was designed and built with a real-time computerized controller that records wheelchair accelerations and angular speeds as a means to detect forwarding tipping. The tipping rate was defined by the pitch direction angular velocity of the wheelchair. To evaluate a simple wheelchair tipping control strategy, our EPW was driven over a ramp at different speeds. Experimental results showed that the tipping could be accurately detected as it was happening and the performance of the tipping prevention strategy was consistent on the slope across different speeds.

In addition to the advanced controller being used as a test platform for advanced driving algorithm research, it has been replicated in a slightly modified form for use in a second project called the Personal Mobility and Manipulation Appliance (PerMMA). PerMMA was a large project whose goal was to develop a complete mobility and manipulation system for people with upper extremity impairments. As designed, the first generation prototype was built using an off the shelf Permobil C500 wheelchair with the addition of two ARM robotic arms. The OEM control electronics in the Permobil C500 were completely removed and replaced with a custom designed controller. The only difference electrically between the two controllers was that the Permobil controller used much more of its digital I/O connections because it had to control four

seat functions and manipulate two carriages for moving the two robotic arms. The mechanical design of the controller however was much different because it had to be incorporated into a specific space in the chassis of the Permobil C500. Figure 31 shows a 3D model of the controller used to determine the placement of all the components in the chassis before it was constructed.

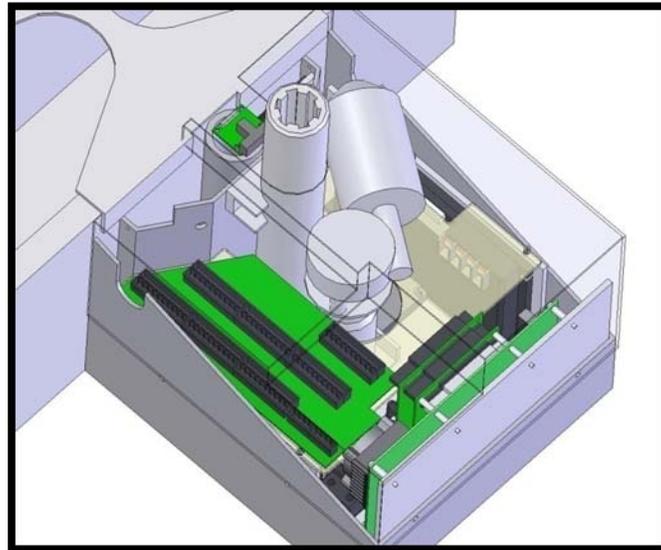


Figure 31: 3D Model of PerMMA Controller

The main goal of the mechanical design for the PerMMA controller was that it must look clean and integrated into the wheelchair such that people would not notice that anything was different. To help make participants more comfortable during clinical testing, the design needed to look very professional, as close to an actual product as possible. The aesthetics of the current design (Figure 32) were successful to that end as many people remarked how the wheelchair looks like a commercial product to them. The PerMMA wheelchair has begun clinical testing and preliminary results show that participants are quite happy with its capabilities [35-36]. As the project continues on, the second generation of PerMMA could use a very similar controller

based on the overall system design from generation 1 but with updated electronics which would make it faster and smaller.



Figure 32: PerMMA Generation 1

3.5 CONCLUSION

The design of an advanced controller for EPW was detailed in this section. The details included specifications of the electronic and mechanical design. The advanced controller was used to research better ways to provide safety and customization for the EPW user. The goal of this project was to demonstrate what can be done with an EPW to enhance the mobility and safety of its occupant.

4.0 FINAL CONCLUSION

When it comes to learning about driving outdoors, unfortunately new EPW users normally receive little to no outdoor driving training, leaving them to learn the necessary driving techniques by themselves, through a lot of trial and error. What training is performed by the clinician is usually limited to very basic skills such as turning, stopping, and driving straight. This amount of training does not prepare new EPW users for the multitude of driving situations they will encounter in the real world [19]. Although there have been many improvements in EPW design, there has been very little research focused on EPW driving techniques outdoors. Ding and Cooper stated that “control algorithms for EPW have not improved substantially since the early 1980s.”[8]. Incidence of loss of control and injury are far too frequent among EPW users [8] [10]. Control systems research has achieved broad application in other areas of technology but most EPW are still using simple controllers that do not perform well when subjected to disturbances, sensor uncertainties and load variation. Most control systems in use today, incorporate “uncertainties” or “perturbations”. The design of a robust EPW control required the analysis and development of algorithms and methods to address these uncertainties and perturbations.

All the EPW user participants agreed that there were some definite terrains and situations that gave them problems when driving their EPW outdoors. The three major concerns which were reoccurring in the focus group were: Slip (Loss of traction) – Bad; Stuck (Immobilized) –

Worse; Tip (Loss of stability) – Worst. The EPW users liked the idea of passing on their knowledge to the next generation in the form of a driving manual for outdoor terrain. They wished that they would not have had to learn outdoor driving by trial and error. By learning proper driving techniques through training and accidents, an EPW user can develop the ability to successfully navigate hard, soft and angled surfaces along with adverse driving conditions. The focus of the advanced controller was features related specifically to safe driving such as traction control, stability control, and robust velocity control with rejection of external disturbances.

All new EPW users should be made aware of the best learning tool there currently is, “The Powered Wheelchair Training Guide” [14]. New EPW users especially should have access to the book to begin learning the techniques needed for outdoor driving that they most likely will not be taught in the clinic. Study participants really wanted to see a Youtube video series created of EPW driving lessons illustrating outdoor driving techniques. This would provide a much more illustrative and accessible means for clinicians to teach new EPW users the skills they need for outdoor driving. And through the use of an advanced EPW controller, it could be much easier to learn these techniques. A traction control algorithm could be applied which would work to counteract a detected slip condition and keep it from getting worse or a stability control algorithm could be applied which would detect the roll rate of the EPW would immediately drive the wheels to counteract the tip and keep it from getting worse.

This study affects EPW users in a most personal and immediate manner. The information presented in this thesis should help change how individuals are trained to use their EPW and the way EPW are designed. These two projects represent an important step towards creating the next generation of EPW training and controls.

APPENDIX A

FOCUS GROUP QUESTIONNAIRE

The following questionnaire was made for evaluating EPW user feelings about driving on unfavorable terrain.

Questionnaire Packet Wheelchair Users

Power Wheelchair Driving Strategies on Unfavorable Terrains

COMPLETION LOG:	DATE:	INITIALS:	TIME:
Subject ID#: _____			
Data Collection	/ /		
Data Entry	/ /		
Verification	/ /		

PART A - Personal Data

Gender: _____ Male (0)
_____ Female (1)

Age: _____

Ethnic Origin: _____ African-American (1) _____ Caucasian (4)
_____ American Indian (2) _____ Hispanic (5)
_____ Asian-American (3) _____ Other (6): _____

PART B - Demographics & Self-Assessment

We are interested in the relation of disability and assistive technology to other factors in your life. The following questions deal with these factors. Please check the responses that best describe you:

1. What is your impairment/disability? _____

2. Date of onset or injury: ____/____/____

3. What is the highest degree you received?

- _____ (0) High School Diploma or GED
- _____ (1) Associate Degree
- _____ (2) Vocational/Technical School
- _____ (3) Bachelors Degree
- _____ (4) Masters Degree
- _____ (5) Doctorate, etc.

3. Which statement best describes your **CURRENT** work status?

- (0) Working full-time, outside the home
- (1) Working part-time, outside the home
- (2) Working full-time, inside the home
- (3) Working part-time, inside the home
- (4) Retired because of disability
- (5) Retired, but not because of disability
- (6) Housekeeper, homemaker
- (7) Disabled: unable to work because of disability
- (8) Unemployed: not able to find a job in the field that I was trained in
- (9) Other: please specify _____

4. Please indicate which best describes your marital status:

- (0) Single
- (1) Married
- (2) Living with someone as if married

5. How long have you been using a power wheelchair? _____ years

6. How long have you been using your current power wheelchair? _____ years

7. How many days of the week are you driving your wheelchair outside your house?

_____ days per week

Part C: Current Wheelchair Characteristics

1. Model	
2. Manufacturer	
3. Date received	
4. Other Characteristics	
5. Control Method (i.e. joystick, head array, etc.)	
6. Additional Equipment (i.e. seat elevator, elevating leg rests, tilt-in-space)	
7. Front-wheel, mid-wheel, or rear-wheel drive?	

Part D: Power Wheelchair Training

1. How much training did you receive when you obtained your current power wheelchair?

- less than a 30 minutes between 30 and 60 minutes
 more than an hour do not remember
 no training

2. Did you have to take any kind of driving test to see if you could safely drive a power wheelchair?

- yes no

3. Did you practice driving outside at all during your training at the clinic?

- yes no N/A

1. Did your supplier or your clinician come to your home to make sure your new wheelchair would fit in your house?

____ yes ____ no

2. Do you feel the training you received was adequate?

1. Strongly disagree
2. Disagree
3. Neither agree nor disagree
4. Agree
5. Strongly Agree

3. What did you like the best about your training?

4. What did you like the least about your training?

5. Do you think a manual which described outdoor power wheelchair driving strategies that was developed from talking with experts like you would be beneficial to new power wheelchair users?

1. Strongly disagree
2. Disagree
3. Neither agree nor disagree
4. Agree
5. Strongly Agree

1. Why or why not?

2. Have you had any accidents with your wheelchair before? What caused these accidents? Please mark as many items below that apply.

- (0) Your wheelchair slipped and ran into something
- (1) Your wheelchair tipped over forward or backward
- (2) Your wheelchair tipped over sideways
- (3) It was too dark to see well and you ran into something
- (4) You ran into a person in a crowded public place
- (5) You became stuck because your wheels lost traction
- (6) Other experiences, Please specify

3. If you would like, please give a short description of any of your accidents and what you learned from it.

Part E: Driving Scenarios

Please put a check in the box describing your experience with the listed driving conditions. (You may check more than one experience for each condition.)

Driving Condition	I can drive through this condition without any difficulty	I have encountered this condition and it can be difficult to drive through	I try to avoid this condition if I can	I have never encountered this condition
Mud				
Ice				
Uneven Terrain				
Curb Cuts				
Gravel				
Sand				
Snow				
Ramps				
Crowds of People				
Cobblestone				
Driving at Night				
Rain				
Driving up steep hills				

Driving Condition	I can drive through this condition without any difficulty	I have encountered this condition and it can be difficult to drive through	I try to avoid this condition if I can	I have never encountered this condition
Driving down steep hills				
Dry Grass				
Wet Grass				
Heavy Carpet				
Severe Heat				
Severe Cold				
Cross slopes				
Hard Sand				
Soft Sand				
Turning on a slope				
Driving while one wheel is off the ground				

☺ Thank you for taking the time to complete this questionnaire ☺
 We appreciate your participation!

APPENDIX B

B.1 FOCUS GROUP SUMMARY

The following transcript summary was generated from several focus groups and interviews held during the time period of September 2008 to July 2009.

Hard Surfaces

Sidewalk

- Can be very unsafe to drive on sidewalk cause bad condition of sidewalk
- Pittsburgh sidewalks notoriously bad because large temperature differences cause massive amounts of heaving
 - Hardly any sidewalk is level with flat joints between sections
 - Potholes in sidewalks are common place
 - Up to several inches in height difference between sections of sidewalk
- Bumps, cracks and chairs
- Most chairs can't climb curbs
 - Don't have enough ground clearance either
- Jostling is very painful for some people
 - "I can do it at an angle but it jars the shit out of me."
- Drove off edge while avoiding light pole. Flipped on side
- Get off sidewalk into grass, get stuck, high center on edge of sidewalk
- Putting new Walgreens in and not including sidewalk
- When people aren't doing what their supposed to do like clean off sidewalks
- Sidewalk paved with gravel (bike path) instead of concrete cause bike path isn't required to have snow cleaned off
- On bike paths, sometimes people say "Get off here. It's only for bicycles."
- STRATEGY
 - Approaching curb at an angle helps by lifting one wheel at a time
 - If bad, must drive in street to get around

- Drive in middle of street cause sidewalk is rough & curb cuts too steep
 - Don't drive down side of road
 - It's harder for cars to see you
 - Right down the double yellow line
 - "People beep and yell and scream and I get flipped off a lot but the thing about it is if they're yelling at you, they're screaming and flipping you off, you know they saw you."

Curb cuts

- Limited number along sidewalks sometimes
 - Drive quite a distance to find one
- No curb cuts
 - So have to go off side of curb
 - Almost tipped chair over once
- Many times they are very steep
 - Can try going backwards but then anti-tippers catch
 - Footrests drag at bottom of cut at transition
- People park in front of them
 - Must backtrack to get around
 - Drive in street to get around

Potholes

- Must focus more on driving to avoid the potholes
- Bumpiness causes bladder spasticity which is quite uncomfortable

- Inconsistently bumpy surfaces are a bigger problem than constantly bumpy surfaces
 - Throw off your concentration
 - Throw hand off joystick
 - Must stop and get readjusted
- “Road so steep and full of bad potholes, in the rainy season, it turned into a creek bed. My chair started sliding and it hit sideways into one of the potholes. Flipped me over sideways and I broke my arm.” Page 35
- STRATEGY
 - “Grin and bear it.”
 - Weave around road to avoid potholes
 - Must slow way down

Speed bumps

- “Some so high you get stuck on them.” Page 33
- Jars person out of chair
- Makes person drop what they’re carrying
- Going up and down (getting tossed around)
- STRATEGY
 - Go real slow, try to find the lowest spot
 - Tighten Seat Belt
 - Back up over them

- Will throw you back into the chair instead of forward

Cobblestone

- Too bumpy, jarring hurts
- Small stone
 - not too bad
 - Don't usually get stuck
- Large stone
 - Tosses user around a lot
 - Can be very uncomfortable because it sets off spasms
- Most difficult to drive on

Soft Surfaces

Dirt / Mud

- Dirt is a problem
- Will bog you down
 - Take someone with you to see how deep the mud is
 - If not sure, just avoid it
- Got stuck in dirt at the bottom of a ramp in a city park
 - Got out by driving forward and rocking upper body to change center of gravity which gave more traction to drive tires

Sand

- “Will stop you dead.”
- deep sand, easy to get stuck
- Hard to see transitions from hard to soft sand
 - Have someone walk ahead to spot soft sand
- “I’ve been pitched out of my chair and hurt from that.”
- Can’t go to the beach because of it
 - Possible to use beach boardwalk to water (not that many around)
- On sandy trails, drive up on grass to side of trail
 - Go as fast as you dare
 - Don’t turn and maintain speed

Grass

- Tendency to spin especially if wet
- Can get stuck even if not wet, some EPW don’t have much torque
- Dry grass immediately after being cut can be slippery
- Dry dead grass can be slippery like straw
- “Can’t go on grass in spring cause ground is so soft I dig right in.”
- Trouble with slipping when one wheel is on the grass and the other is on the concrete
- STRATEGY
 - Go slowly to get through
 - Back up and go another direction (avoid problem)

Gravel

- Gravel a big problem
- Get stuck easily
- Larger gravel is easy to get stuck
- Large gravel tosses you around (uncomfortable)
- The smaller the gravel, the more a problem of sinking in
- STRATEGY
 - Want chains for tires to increase traction
 - Must maintain momentum otherwise will sink in and get stuck
 - Get out of chair and push with help from others
 - Get out of chair if possible & drive it by standing next to it
 - Less weight will allow it to get unstuck
 - If looks solid enough, hit full speed and hope for best
 - Stopping will cause you to bog down quickly
 - Go as fast as you dare

Angled Surfaces

Hills

- If too steep, might not be able to slow down at bottom
- Will back down hill if hill is too steep
- Pop wheelie when starting on hill
- Much more comfortable going up hill than down

- Feet hang off pedals, could get stuck under chair, BAD
- Chance of tilting over
- Tilt seat back a little to stay level
 - If too much tilt, safety lock out will slow speed of EPW
- Be more careful out in country where there's fewer people to help if there's a problem
- In transitions
 - Tendency in FWD to roll forward when hitting the flat
 - Can push back on foot rests and lean back in seat to keep weight to the rear
- What slope of hill will you navigate?
 - Depends on if it's grassy and if there is someone to watch me
 - Won't take chances as much when alone
 - Helps if terrain is familiar
 - If you've gone up the hill then it's easy to tell if you can come back down
 - Unfamiliar terrain is much harder to judge
- Mid wheel drive WC does well with spring loaded front casters
 - Use seat function to tilt seat back when descending a hill
 - Front casters don't catch on stuff
- Sometimes motor heats up
 - Wheelchair slows way down
 - Stop for a few seconds to cool off
- STRATEGIES
 - Go straight up and down or switchback

- Raise footrests so they don't catch on the transition when descending a hill
- Have wife or one of their kids stand next to him
- Always someone nearby
- Hook arm around backrest to keep from sliding out of chair when descending hill
- When tilting over backwards, tuck head into chest so back of chair hits first and protects you if you roll over
- Lean forward when going up hills
 - Make sure to have a seat belt on or you might fall out forward due to no trunk control

Cross Slopes

- Scarred about tipping over
- Never had a wheel come up but sure felt like it
- Need dynamic method to feel true tipping
- Need help with traction on uphill wheel
- Not comfortable with you're body flopping off on the side
- Chair handles just fine but it's hard to keep chin in chin control cause head wants to tilt downhill
- Controller has feature to reduce fishtailing
- Turning on a hill
 - Front wheel drive chairs will always swing your front end down the hill

- Rear wheel drive chairs will always swing your back end down the hill which will point you up the hill
 - Might be able to climb hill at an angle because you can kinda tack up it like a switch back.
 - Making corner turn could be possibly cause a flip
- STRATEGY
 - Lean torso to one side when approaching a hill or else it feels like you will flip over
 - Must lean into the hill
 - Hooks arm around backrest cane to control trunk
 - Rather go completely down slope then back up to correct spot than traversing across cross slope
 - Use seat tilt to keep user level when descending a hill
- It was mentioned that when driving across a steep side slope, the tilting of the EPW causes the center of gravity to shift more over the downhill drive wheel causing the lighter uphill drive wheel to slip making the wheelchair veer up or down the hill depending on whether it is a front wheel drive EPW or rear wheel drive EPW. This necessitated the EPW user to drive with their joystick pointing at an angle away from foreword just to keep their EPW driving straight across the hill.

Ramps

- A lot of places have very steep ramps that no one should attempt
 - Seat tilt angle can be adjusted to keep user level while going down the ramp

- Seat tilt will also move the center of gravity somewhat
- Sometimes ramps are built directly on top of steps
 - Much too steep to be safe
 - Impossible for manual WC users to get up
- Get someone to walk behind to make sure I don't tip back
- Back-up to go up the ramp
- Transitions at the bottom of ramps can cause a front wheel drive PWC to tip forward if the transition angle is great enough

Adverse Conditions

Snow & Ice

- Little bit OK
- “It really doesn’t bother me that much.”
- “I’m OK in slush or hard packed ice.”

- With 4-5 inches, EPW sinks in
- EPW won’t turn properly
- Mud can cause similar problems
- “It just stops dead.”
- Can get hung up in hard snow drift

- Small amount of snow improves traction compared to ice
 - Fresh untouched snow easier to drive in
- Ice is too slippery
 - Don’t have any traction on ice
 - Icy side slopes are tricky because either uphill or downhill wheel is slipping
 - Try to slide you into the snow bank at the bottom
- Covers up pavement markings which show where handicap parking is
 - Snow removal people put snow in handicap parking spaces maybe because they are not used as much in winter
- Sidewalks

- If snow on sidewalk is well trampled down then there are different densities of snow (hard and soft). This is because people don't shovel their sidewalk right away.
 - Creates very bumpy surface which are uncomfortable to drive on
 - Slowing down helps a little
 - Too much though will get you stuck
 - Frozen ruts on sidewalk
 - Impassable to EPW
 - Where snow is compacted it is much slipperier than other areas with new snow
- Sidewalks heave and buckle in winter so they are no longer flat but have large cracks with up to several inches in height difference between sections of sidewalk
- When streets are plowed, snow is piled on sidewalk so must drive EPW in street
- Sometimes can't see edge of sidewalk due to snow coverage
 - Try to stay close to building side so don't get too close to the edge.
- Went down to mailbox in snow and get stuck in curb cut
- Curb cuts are not plowed most of the time
- Sidewalks and street get plowed and this leaves a berm of hard sticky snow stuck in the curb cut

- Can slide and bounce across berm in curb cut if moving fast enough other half of time get stuck
- Consequences of getting stranded outside in winter can be hypothermia or death (not good)
- STRATEGY
 - Just go slowly on ice
 - Don't turn on ice, let inertia carry you over
 - When going out, take someone along if possible or go places with lots of people so can call for help if get stuck
 - "I just go through and hope I make it."

Heat

- Wear shorts and loose shirts
- Cooling vest
- MS & SCI and heat don't mix
- Easy for people with SCI to get overheated since they don't sweat

Rain / Wet

- Sometimes causes electronics to short out which can cause dangerous situations
 - Seat reclined and chair stopped while crossing road
- Water from top is OK (live in Seattle) but worry about water splashing up from underneath

- Chin control gets nasty really easily
- Be careful of puddles, they can be deeper than you think
- Any surface that is wet causes a lot of sliding
- If you get caught in thunderstorm chair still needs to work
- STRATEGIES
 - Put plastic bag over controller
 - Controller should be more water proof
 - Slow down and drive more carefully

Crowds of people

- Will step right in front of you
- “Piss me off”
- Run over toes
- They don’t notice an EPW user as well since they’re sitting down
- People generally are very nice and open doors and move out of way
 - Driving around a lot of people (mall) is difficult
- Getting in and out of elevators
 - Hard to watch out for peoples’ toes
 - Hate backing up cause afraid of hitting people
- STRATEGIES
 - Work hard to be noticed
 - Make some noise so that people notice you
 - Use a flag like some bicycles have

- Ask if there is anyone behind before backing up
- Use your horn to warn people

Night

- Darkness is nightmare
- Nearly impossible
- Low lighting conditions at night
- Traveling down unfamiliar sidewalks is worrisome
- Not sure what obstacles you might encounter and how dangerous it will be if you don't see them in time
- "I'm getting kind of uncomfortable that we're out here too late."
- Lights on Wheelchair
 - Some like using only natural night
 - Some use bicycle lights
 - Want bicycle flasher
 - "Lights on chair would be invaluable"
 - Clamp bicycle light on wheelchair (can't find clamp anymore)

Parking Lot Etiquette

- People parking in the lines where the ramp goes down
 - Inconsiderate people, Not observing the law
- People often leave shopping carts in front of ramps

- There's a new McDonald's out there and there's a sign that says no parking next to the ramp. Oftentimes people think, "Well, I have a handicap plate so I can park there." And there you can't.
- If can't get handicap spot then take up 2 parking spots so no one can park next to you so there's room for the ramp

Training & Accidents

EPW driving training

- People must learn their limits
 - Take someone with you till you know your limits
 - Bring a phone
 - Drive a suitable speed for the condition
- "Because some of the things we learn by trial and error, you can get injured in the trial and error period."
- "I've got OJT."
- Make up an outdoor obstacle course
- Driving instructional material
 - Make a DVD of driving examples
 - For high level quad a book is nightmare
 - "I think it would be really good for a new power wheelchair user to have something to peruse through, a book of some sort, not just how to run your wheelchair, but what you guys are doing I think is a really

good idea to come up with some teaching for them, and then also to—
like scenarios of this is what works, these are danger things, this is
another way approach it.”

- What did you like the best about your training?
 - “Instructed verbally first then therapist walked along next to me once I was in the chair”
 - “Obstacle course”
 - “Shown how to use it on rocks”
 - “The therapist was very patient, constant collaborating / adjusting”
 - “Info on new joystick controls”
 - “Covered fundamentals”
 - “Shown how to use the options”
 - “Showed me how to change driving modes”
 - “Attention to safety”
- What did you like least about your training?
 - Starting in regular hospital hallway to learn sip-n-puff instead of an open area with space
 - “Not everything covered”
 - “No outdoor training (especially cross slopes)”

Accidents

Accidents from Questionnaire & Focus Groups

- “Warm air in my sip-n-puff tube froze up so my wheelchair stopped working correctly.”

- “I was driving in the latch mode. It’s like cruise control. I hit a bump and it jostled me a little so I couldn’t reach my chin control. It took the back of a Mercedes to stop me.”
- “Side guard fell off chair so I fell sideways out of chair.”
- “I have twice hit a bump on the sidewalk and ran right into a light pole.”
- “Never tip over in a hospital parking lot because they freak out due to liability.”
- “A person jumped over my footrests from the side & I hit him because I didn't see him.”
- “I was driving on a sidewalk parallel with the street when I ran into an unmarked sidewalk indentation (for entering street level) which caused me to flip over on my side into the street.”
- “My speed control always moves forward to high without me realizing it.”
- “My first week out of the hospital I crossed the street and ran into a curb on other side cause I assumed there was a curb cut and it was just covered with leaves.”
- “I backed up off a curb that was too high and flipped backward.” (rear wheel drive EPW)
 - Caught in a downpour on the sidewalk
 - Wheelchair stopped working
 - Someone rescued wheelchair user
 - Watch your speed
 - If too fast, you could run into walls when turning or tip over
 - Joystick / Controller
 - Messed up controller by pulling up to a table and mashing the joystick into the table
 - Cable to joystick began to break so control became intermittent

- Was able to move cable so it worked and then get home
- Joystick shorted out
 - got soaked during rainstorm and began turning on and off unexpectedly
- Burnt out a drive motor
 - WC would only go in a circle
 - Motor began to smoke
- Flying
 - EPWs are treated very badly by airlines
 - Many people mentioned this as a big reason they drive everywhere
 - For most, every time they fly, something on their chair gets broken
 - Antiquated regulation about disconnecting battery (based on liquid acid batteries)
 - Usually wires get destroyed in process
 - Airline broke joystick controller, when turned on the WC would start moving forward and not stop

B.2 INSTRUCTION SHEET FOR TARGETED CODING

The following instruction sheet was giving to the researchers as a how to guide for performing the targeted coding on the transcripts.

How to do Targeted Coding of the Focus Group Transcript for Obstacles

Setting up your account at the Coding Analysis Toolkit (CAT)

1. You will receive an email with the subject line "Coding Analysis Toolkit - New Account"
2. Click the link in the email to verify your account and set up your password.
3. You will be taken to the Main Menu.

Logging into your account at the Coding Analysis Toolkit (CAT)

1. Go to <http://cat.ucsur.pitt.edu/>
2. Log in with the username given in the new account email you received. It should be the first part of your email address before the @pitt.edu
3. You will now be looking at the Main Menu

Coding Instructions (see example on next page)

1. On the Main Menu, click "Code Datasets"
2. Click on the only dataset available to code called "EPW_Driving_Obstacles"
3. You will then see a screen like the figure on the following page. All the codes are listed at the top of the page with check boxes next to them.
4. Read the text block and mark the categories that apply to it. As you can see in the example below, I have marked the obstacle category as "Driving Up Steep Hills. If there are multiple obstacles mentioned in the text unit, then check off multiple check boxes.
5. If none of the categories describe the specific situation mentioned in a particular text block, then chose the "Other" category.
6. If the text block does not mention an obstacle then mark it as IGNORE and move on.
7. When you are done selecting codes, click the "Code Item" button to save your choices and move on to the next text block. There is 331 text blocks in all.
8. If you would like to take a break, just click "Stop Coding" which is on the left underneath the codes. This will save your place so when you log back in and start coding again, it will take you right back to that page.

Note:

The interview/focus groups consisted of from 1 to 5 participants so in some of the transcripts the transcriber has not been able to differentiate among all the participants with P1, P2, etc. Therefore some of the comments might seem contradictory so in that case, I would assume they are from 2 different people.

I have already gone through the transcript and culled out the text that I deemed irrelevant to this study, shortening it from 300 pages to 100. So you should not have that many text blocks coded as IGNORE.

The categories are the same categories used in the questionnaire we used for the other half of the study. The outcome of this coding will be used for a direct comparison to the outcome of the questionnaire data to check the agreement between the questionnaire and the focus group results.

*Thank you very much for your help 😊
If I can ever repay the favor, just ask.*

Coding Example

[Coding Analysis Toolkit] - Code Dataset - Windows Internet Explorer

http://cat.ucsur.pitt.edu/app/codeDataset.aspx?id=5505

You are logged on as: Benjamin Salatin (bas90)

CAT CODING ANALYSIS TOOLKIT

Select one or more:

- Severe Cold
- Ramps
- Turning on a slope
- One wheel off ground
- Dry Grass
- Curb Cuts
- Cobblestone
- Rain
- Crowds of People
- Cross slopes
- Mud
- Driving Down Steep Hills
- Sand
- Wet Grass
- Ice
- Severe Heat
- Driving Up Steep Hills
- Snow
- Driving at Night
- Uneven terrain
- (t) IGNORE
- Other
- Gravel

Code Item

1 item left [Stop Coding] [Jump to...] [Bookmark] [View Memos] Sort: Alphabetical # columns: 3 [Show Descriptions] Next >

Interviewer: What about – if you're you know on a side-slope, you're like this or you know going up and down hill, you know I guess if you're in rear-wheel drive going up a hill, if you stop and then you start again, you'll probably do a wheel you know going up the hill, but... It doesn't? **You could call this a hill or cross-slope.**

I try to avoid, I completely avoid slopes. If I'm going downhill, I have no problems.

When you're on a slope the best way for you--

And not stop.

Is to--when you are in a chair is to lean forward.

Interviewer: **Going up the hill?** = Obstacle

Yes. You know put the weight [indecipherable].

Interviewer: OK.

But if you're going to lean forward, you better have a seatbelt on. Because I've done that before and whoop! [laughs] Right. Well that would be--you know some people, they are capable of you know handling the wheel chair.

Yeah.

If the wheel chair has the capability of moving the weight. **Weight shifting strategy to balance EPW**

But you've got the quad people who can't.

Yeah. See I have no muscle from here down. So if I'm [indecipherable], I can't even – I've got to do this to pull myself.

That sucks.

Right. **?my EPW?**

That's why I can't wait to get back into [indecipherable].

The [indecipherable] automatically adjusts for the hill.

?EPW?

B.3 FOCUS GROUP TRANSCRIPTS

The following full length transcripts were generated from several focus groups and interviews held during the time period of September 2008 to July 2009.

Subjects DS01, DS02, DS03

DS03: 05:06

The only problem I really encounter is with the speed bumps. It ya know, for example at the airport or in (name) park.

Ben: 05:16

Right

DS03: 05:17

Ya know, that limitation. Lack of curb cuts.

DD: 05:22

Can you be a little specific, ya?

DS03: 05:24

As far as being able to get my wheelchair from the road onto the curb and inside the building. Sometimes I'll hafta go quite a distance out of the way to get to a curb cut. That has really no bearing on the wheelchair.

Ben: 06:07

Well. Ya I guess we're looking at environmental. I mean like we said, driving, ya know hills, cross, ya know like going along the side of a hill, slippery spots, I mean that's environmental stuff but you have to drive on it so how do you, how do you work, I guess, in that cause, ya know, with the speed bump ya know being a good example. What's your problem with that and how do you get around it? How do you deal with a speed bump?

DS03: 06:37

How do I deal with speed bumps? I usually tighten the seat belt.

DS03-B: 06:54

You have me stand next to you when you're on a hill. I or one of the kids stands next to you.

DS03-B: 07:04

So he doesn't tilt and if he does tilt then there's someone right there that can help him. He's fortunate to have family around that can help him.

DS03: 07:11

And again, it's my lack of upper body strength that causes me to fall.

DD: 07:19

See but you never have that situation because like when they discover that you are under the risk and they prevent it just by

DS03: 07:30

They're usually there all the time.

Ben: 07:33

Like with the speed bump, the problem there would just be going up and coming back down and getting tossed around.

DS03: 07:42

Exactly

Ben: 07:45

So that means you'd just go really slowly over that

DS03: 07:50

Or go backwards cause that will throw you back into the chair instead of forward

DS01: 08:10

(Paraphrased) When I drive over gravel, my wheels sometime get stuck because they sink too far into it.

Ben: 08:35

Gravel, Right. Are you talking about big gravel or the really small stuff.

DS01: 08:40

(Paraphrased) Small stuff. If you stop moving you sink in and then I can't go through

DS03: 09:07

Ya, I've experienced the same problem. When my kids were young and they'd play ball, I'd get caught in the gravel.

Ben: 09:16

Right, and sometimes if you're moving in some cases you can get through but if you slow down to much or stop then you can't get through.

DD: 09:26

You lose the momentum

Ben: 09:27

You get stuck and you can't start up again.

DS03: 09:31

And the large gravel tosses ya.

Ben: 09:35

Right, throws ya around, the bigger chunks, the rockier stuff

DS01: 09:40

(Paraphrased) And then wet grass is a problem. When I have one wheel on the grass and one on the concrete? then I have trouble with slipping.

Ben: 11:51

One thing we have been looking at is the slipping thing. Like what you were talking about on whether it's grass ya know after it's wet or when it's muddy or icy or whatever. Just keeping the chair under control. So if you're on the grass in the park and you start to slip. What do you do? Do you just stop or do you go really slow.

DS01: 12:20

Well, I can go slow or I back up and go another direction.

DD: 12:37

Oh, avoid it.

DS02: 12:55

Um, I think that at least my version of the Permobil C500 doesn't have very good low end torque and so if you are out in some sort of soft soil it gets stuck really easy. Sometimes it gets stuck and you can't move your wheels which is pretty ridiculous because there should be enough power to move your wheels regardless of whether you're stuck or not. I think that's been a complaint that they've fixed with the next version of the C500 but it's definitely an issue. I guess that might even be a programming thing or a motor gearing thing. I'm not sure which. Because I have the speed package on my chair and I'm not sure why they neglected the low end torque.

Ben: 13:57

So if you do get stuck, you can't dig your way out.

DS02: 14:02

No

DD: 14:03

Do you know if that's only this chair or like other chairs?

DS02: 14:06

I was talking to the Permobil reps at RESNA and they said that was one of the issues and they were working on that. Or they said they fixed it but cut down the top speed so I don't know if that's actually a fix.

DD: 14:20

You have to get a speed and torque balance.

DS02: 14:30

Let's see, So ya, like one of my major issues is because I'm kinda tall and I don't have any power options for my legrests. I have a lot of problems with my footrests grinding on bumps and like I'll get hung up on my footrests quite frequently depending on what it is. If you got like a quick.. Um if you're going into a quick transition up an incline. I'll get my footrest caught or like on curb cuts or anything will pretty much catch em or even the difference between like going into a bus or whatever. One of the things that I found that I can do to go over stuff that I couldn't be able to go over otherwise is by leading with the left, leading with one of my wheels because if your wheel can go over it then your footrests will go over it. But if you hit it with the footrests before you go over it with your wheel, you're gonna end up gettin caught.

DS03: 15:45

Were you able to get an adjustable footrest on it?

DS02: 15:50

Yes, but I don't have one because I'm afraid I'm gonna bust it.

DS03-B: 15:55

So you're not able to cross over any curbs at all?

DS02: 15:58

Um, I can back over curbs sometimes. Depends on how big they are. It also has seat elevation where a ...

DS02: 16:10

Right, we'll you have much better ground clearance than I do. I have maybe a couple inches.

DS03: 06:23

I can go all the way up. (unintelligible)

DD: 16:45

If you have an adgjustable one, this problem gonna be gone?

DS02: 16:49

Yes, it would be.

Ben: 16:52

Then your feet would stick out in front more.

DS02: 16:55

Yes, there are trade offs.

Ben: 16:58

But you didn't wanna get the adjustable kind cause you're too hard on the chair and you figured that'd break.

DS02: 17:08

Yah. Especially because the first swingway, I'm the first ones I've seen with the swingway types instead of the center post. Like a swingway leg rests break all the time.

DS02: 19:25

Like another issue is like side slope stability. Especially when you're coming down a large hill or something and then you're coming into a sideslope like this. I've never had a wheel come up on me but a lot of times it feels like it would've but um like because I hook my arm around the backrest upright I can control my trunk through that. A lot of times when I see a big side slope coming I lean all the way over here before I come up. I pull myself this way before I come up the (?) on the otherside, otherwise it feels like, besides throughing my trunk to the side, otherwise it feels like it's gonna flip the chair a lot. I don't know, maybe a dynamic method of feeling that. And it might also help with traction issues on the uphill wheel

Ben: 20:28

Right, like if you're going along the side, it wants ta, with rear wheel drive it would wanna point ya

DS02: 20:38

Besides that, it's just not comfortable with you're body floppin off on the side.

Wu: 20:45

What's your strategy to drive through that? Whether you use the same method you use on the flat surface or you need to do something different with the joystick?

DS02: 20:56

Um, I think that the way the controller works on this chair, it has something that keeps you from fishtailing, but usually most front wheel drive chairs will always try, your front end tries to swing down the hill and then the rear wheel drive chair, you're back end will swing down the hill which will point you up the hill. I think that you can make the slope less steep of a slope if you go at an angle than if you go straight at it. So you're chair might be able to climb a hill at a slight side slope because you can kinda tack up it like a switch back. But making a corner on a side slope is really kinda scary.

Ben: 22:00

Yah, so you just turn a hill into a switchback and go up it that way.

DS02: 22:05

But making that corner around there before the switchback

Ben: 22:43

What do you guys do in the wintertime when you go out? Do you just make sure you don't go out until the sidewalk been cleared? How do you deal with snow and ice and stuff?

DS03: 23:06

It really doesn't bother me that much. It's when I get home and mess up the carpet.

DS01: 23:16

I just go through it and hope I make it. (paraphrase: It's kinda like the gravel)

Ben: 23:50

I guess most of the time if you're going on the sidewalk anyhow, the snow that was there probably already been pretty packed down.

DS01: 23:59

Yah

DS02: 24:00

I don't have any problems with snow.

DD: 24:05

So you not feel scared when it snowed and you have to go outside? I guess raining doesn't really matter to you guys.

Wu: 24:22

Do you guys have any experience driving through a crowd of people, a lot of people? Do you have any experience with that?

DS03: 24:30

That's why they make a horn.

DS03-B: 24:38

Remember that time at Disneyworld? People are generally very nice. They'll generally move out of the way, open doors. He really doesn't have any problems.

Wu: 24:52

But if you have some situation and you have to back up? Do you have any problem in this situation?

DS03-B: 25:02

No, he usually asks somebody if there is anyone behind him before he backs up. He doesn't just back up. He always asks somebody.

Wu: 25:09

OK

DS01: 25:10

Yah, I do to.

DS03-B: 25:17

I think the most problem is people parking in the lines where the ramp goes down. It's more the things like that (unintelligible)

DS03: 25:30

Inconsiderate people. Not observing laws.

Ben: 25:35

Like the part where they got it X'ed out because that's where you go up the ramp. People will park right in that spot.

DS03: 25:41

Exactly. What I'd seen an excellent situation on Rt 8, there's a new McDonald's out there and there's a sign that says not parking next to the ramp. Oftentimes people think, "Well, I have a handicap plate so I can park there." And there you can't.

Ben: 26:10

Right. It's on either side not in the middle.

DS03: 26:17

Or people leave shopping carts there.

DS03: 26:29

That's probably the largest issue.

DS02: 26:38

I don't know about the snow issue. I've probably seen a lot more snow than anyone would ever want to see. Like you're issue with the lines on the sidewalk, like when it snows heavily, like where I'm from they don't take the snow down to the asphalt. You can't even find the lines so no one knows if it's a handicap parking space.

DS03: 27:09

Or people will put the snow right there.

DS02: 27:18

And like a lot of times, they don't plow out curb cuts. They'll come along and do the side walk then they'll come back and plow the street again. Then you got these big chunks of really hard sticky snow stuck in the curb cut like a lot of times, I mean most of the time I'm not very frightened about going out by myself but if I know it's just snow, a lot of times I'll try to take somebody with me or try to go someplace where there's a lot of other people that could push me out. A lot of the curb cuts if you go really fast at them, you can kinda slide and bounce over whatever snow is there and get out but then the other half of the time you get stuck. And also sideslopes when it's icy is really tricky because like either you're uphill or downhill wheel is slipping. It'll try to slide you off the slideslope into the snowbank. And I also find that sometimes, if nobody's walked on the sidewalk before it's actually easier and more comfortable to travel over than if people have been going over it for like a couple days. Because then you get like um different densities of snow where people have been stepping and when you go over it, it just rattles you. And also where they stepped it's much slipperier than where they didn't step so um that's a pretty big issue when it comes to snow. And there's the other fact that it's much more dangerous to be stuck outside in the winter than it is when it's raining out because you might catch hypothermia and die. Little bit bigger issue.

Garrett: 29:31

So when the sidewalk's kind of half trampled down snow and half not trampled down snow, is it difficult to keep the direction, you're directional kind of stability of your chair going? What takes up your focus when you're driving?

DS02: 29:50

The biggest issue, for me at least when I go over stuff like that is um, it's really bumpy. Like you are just rattling the whole time you're going over it. And um if you slow down it's a little bit better sometimes but at the same time you might not make it through if you slow down. So you have to keep your speed up and it's really uncomfortable. And a lot of times when it's cold out the sidewalks heave at the same time. So like the cracks in between the sidewalks you'll have, like during the summertime there'll be no bump there but during the winter time you got this 3 inch gap between the edge of the sidewalk.

DS03: 30:40

Another issue I've had in freshly fallen snow is where's the sidewalk end and where does it begin? You really can't distinguish between them.

Garrett: 30:55

So what happens when you actually run off the sidewalk and you get a drop off? What's your course of action at that point?

DS03: 31:03

Fortunately I haven't. I guess the next question is (?). That's just like falling off a curb, it is falling off a curb.

Garrett: 31:15

It is, yah.

DS03: 31:20

So you try to stay as close to the building as you can.

Hongwu: 31:30

So did you have any experience when you drive on the sidewalk and there are small stones or such things and suddenly you drive on that and it will affect your drive?

DS03: 31:44

Not a lot. (Unintelligible)

DS02: 31:52

I also found that when my tires are wet when I just come out from the snow or something and I'm inside and you come around the corner and you're trying to make the corner and you're chair keeps going straight. Not really an outdoor issue I know.

Ben: 32:16

It's usually squealing like crazy on the floor.

DS01: 32:18

Yah, I know what you're talking about.

DS03: 32:24

Yah know what? When I get inside the mall or other place, I just ride around in circles on the mat to dry my wheels off.

Garrett: 32:52

So I guess we're not completely focused on outdoor terrains. What about some indoor terrains? Ya'll have chair that are pretty well suited for outdoors but what about heavier carpets or loose carpets?

DS01: 33:10

(Paraphrase) I have loose carpet, runner or large piece of carpet, when one wheel is on the carpet and the other is on the floor my chair won't move

Ben: 33:42

Yah right, when the one wheel tries to spin and it pushes the carpet and then pushes the whole rug out.

DS02: 34:08

Also there are places with real steep ramps on the side if you go to the wrong place like Garrett's old apartment. Sometimes you go to a place where they'll give you a ramp that nobody should ever attempt going down. Then they have like really bad transitions on the bottom. I don't know if you guys do anything about that.

DS03: 34:38

Actually I adjust my chair. I had to do that just today at Arby's.

DS02: 34:55

You should try that one at the Sixth Street Grill down in the non smoking section. Like they just put a ramp down over a flight of steps.

DS03: 35:26

They had a nice ramp up to the shoe department and some genius decided the ramp is unsightly so let's just cover up these steps instead with a slab of plywood. Uh, that's not gonna work. Fortunately I was there while they were doing it and I went to the district manager and said "Come on. Let me show you something." And they immediately put the ramp back how it was.

DS02: 36:05

Another big issue with me in outdoor stuff is in low lighting conditions. So like if you're traveling at night and you're going down a sidewalk you don't know. That's can be a problem.

DS03: 36:23

I never really experienced that.

DS03: 36:35

Another outdoor thing where I have problems is real pretty slightly brick sidewalks. In Pittsburgh, give it about 4 years of winter where all of the sudden the bricks become yah know, not longer level. And you go down there and that causes some serious problems.

DS02: 37:10

How does your chair do on cobblestone?

DS03: 37:16

Sometimes I get stuck and sometimes I don't. Yah know, I'm better with the smaller cobblestones than I am with the large ones. With the larger, I just get tossed around in the chair whereas if I keep going in the small stuff, I'm alright.

DS02: 37:45

For me it's just so uncomfortable the rattling like that. Sets my spasms off.

DS02: 37:56

Yah know, with those brick sidewalks, that's nasty.

Ben: 38:01

Even just the normal sidewalks around here yah know. In the city here there's a lot of cracks and pieces that are all every which way. It's not like a level sidewalk at all.

DS03: 38:26

For example if you go to Disney world in the Animal Kingdom. Someone in their infinite "wisdom" tried to make it authentic looking. Cracks in the walkway. Unbelievable. I know Dr. Cooper said he was talking with the people down there and that their plans are in the future to have a level wheelchair type of path. But if you go down to Animal Kingdom, it's unreal. It's unlevel. It's just bad.

Ben: 39:07

It's like you're in the jungle.

DS03: 39:10

That's exactly what they were going for, the authenticity.

Ben: 39:15

Right. It's like I didn't come there to go to the jungle.

DS03: 39:23

But that's a prime example of, yah know, form over function.

DS03-B: 39:32

I also think wheelchair seat belts should be made better.

DS03: 39:36

Yes, wheelchair seatbelts should be made to restrain you in the seat. After a period of time this will slip and ya know, I'll slide forward. In a car, you're seat belts aren't giving on you. They give on the wheelchair.

Ben: 40:00

Where is the slip coming from?

DS03: 40:04

I don't know. After a period of time when I ride just during normal riding my seatbelt will become loose. This isn't the first seatbelt that I've experienced this in.

Ben: 40:21

So it actually gets, you set the distance and it expands and gets bigger.

DS03: 40:26

Correct, and I slide forward.

Ben: 40:28

Huh, so something in the adjustment of it isn't ...

DS03: 40:32

There is no adjustment.

Ben: 40:38

So it shouldn't be doing that?

DS03: 40:39

Exactly but it does.

Have you experienced that?

DS02: 40:45

Yah, a little bit. Obviously my seatbelt isn't very tight. Gives me room to grow. But also because my chair has a little bit of fake dump in it. Because I put a towel in the front of my cushion. It keeps my butt back a little bit better. It's little like if you were to ride with a little bit of tilt all the time. And like with the recline. I had a chair with a reclining back on it when I was first injured and as the day went on, I kept sliding out the front of my chair. And there's really no way to pull yourself back up if you get out from there. So that's part of the reason I got rid of it. Besides I couldn't reach into my backpack.

Garrett: 42:23

So (unintelligible) talked a lot about rough surfaces or bumpy surfaces being a problem. So when you're on thoughts types of surfaces, is it a lot harder to keep control of the direction you're going? Or does it take more of your focus to do that?

DS03: 42:48

Probably focus, just to try to avoid the larger potholes, shall we say.

DS02: 43:00

For me, like I have a little bit of bladder spasticity and going over really bumpy things really makes me quite uncomfortable. And ah like if I go over cobblestones or something I have to slow way down so it doesn't rattle me too much.

DS02: 43:33

And ah, ya it's really uncomfortable. I don't know if it's so much difficult to maneuver over like consistently bumpy surfaces. I'd say stuff that's bumpy in some places is going to throw you off more than something that's always bumpy. And of course it's even worse at night.

DS03-B: 44:00

Bumpy surfaces do throw you're hand off your joystick and then you have to stop and get yourself readjusted.

DS02: 44:20

Um, another interesting thing that happened the spring of this year was I was going down by the river and they hadn't cleared all the mud and dirt off the river trail yet. And I was gonna go up the ramp and I got stuck in this huge pile of dirt at the bottom of this ramp but I was able to get out my driving my chair and rocking it at the same time. And I was able to actually, by changing the amount of traction on my tires, by shifting the weight, I was able to get out. I don't know if that's a conceivably useful thing for your chair. I don't know but maybe someway of shifting the center of gravity over the wheels maybe could help you out.

DD: 45:25

What about speed? Do you need more speed outdoors and then change to indoors and you want to slow down? Or are you constantly adjusting?

DS02: 45:35

Ya, I think that um, especially when you're outside on a road. You want to have as much speed as you can. You have cars going by and I don't expect to be going as fast as a car but it makes you feel very uncomfortable when you're driving alongside the road and you got cars. It happens. They're whipping by you really fast. And also, you probably wanna get off the road as fast as you can. And a lot of time when you're going that fast, you feel pretty unstable being so tall. Because like when you're going as fast as you can go, it feels really kinda top heavy even though my chair weighs even more than I do. I mean together, we probably weigh about 450-500 lbs. But it kinda feels unstable, especially if I was to go any faster and start turning. I don't know if I would feel comfortable being so tall.

Ben: 47:00

But if you had something like a stability control that would keep you from swerving or something like that would become dangerous. Would it be, I don't know maybe it'd be more of a mental thing. You knew you could keep going straight and go faster without accidentally swerving too much that you would become unstable.

DS02: 47:30

Well, like recently about 2 days ago, I went to Bridgevalle which is probably... I'm never gonna go there again. They let me off at a bus stop which of course had no curb cut and then I had to drive my chair about a half a mile up this rode which on Google maps looked fine with wide shoulders. And then I got there and first of all, it's like this giant (?) hill with this blind corner so no one can see anyone coming up or down the hill and then the sidewalk at first you can't get onto it and then after that, it's just the shoulder of the road but the shoulder of the road is slanted so much that you feel like you're chair is gonna dive off the side of the thing and I mean I think if my chair was shorter I would feel a bit more stable on something like that. I mean still, like

my chair if you stop quickly going down a large hill the back end is gonna try to raise up. You can do an endo with it if you're not careful.

DS02: 48:51

Ya, um. I probably over exaggerated that problem. Like if you're coming down the hill from up, the Peterson Events Center on the way down, ya know. You stop and it'll try to rock forward on you.

DS03: 49:08

That's where I'll use the tilt to tip my chair back.

DS02: 49:18

It tries to rotate around the large tire. So ya, I think either readjusting the center of gravity in thoughts situations or readjusting whatever control you need to get it to me more stable when you're stopping going down large hills or when you're coming down slanted large hills where big trucks can't see you. I don't know, something that could be done I think.

DS02: 50:06

So have any of you guys ever broken you're chair? While riding in it.

DS03: 50:23

The only thing I've done is screwed up the controller by pulling straight in to a table or something else.

Garrett: 50:32

So how'd you break your chair while you where driving?

Ben: 50:57

just going down the side of the street? (Yes)

And what happened? Did it just start working again after awhile or did someone have to help you.

So after awhile, you were able to get the cable to work long enough to get back home.

Ben: 52:00

What about, have you ever had problems with getting water or anything inside the chair when you're out when it's wet outside or it's rained or something? You haven't had it break down because of that have you?

DS02: 52:18

I've had my joystick short out. I was at the (?). I used to live in East Lansing, which it rains about as much as it rains in Pittsburgh. It probably doesn't rain as often but it rains harder. And so I pretty much soaked my joystick and it would turn on and off by itself.

DS01: 52:42

Downpour, Craig in middle of day, and my wheelchair stopped and I couldn't go anywhere, and someone rescued me

DS02: 53:15

I burnt out one motor once. Then my chair would only make circles to one side. And it was smoking and I'm like, I'm strapped into this thing.

DS03-B: 53:36

The airline broke his joystick. Then when we turned it on, it just went and we couldn't stop it.

DS03: 53:55

Oh, one more thing. What happened DS03-B when it would only go in a circle?

DS03-B: 54:02

Oh, one of your clutches wasn't engaged.

Garrett: 54:15

So we've talked a bit about some like down slopes. I know it's hard to put a number to these things but about how steep a slope will you try to go down. I mean how adventurous are you guys about going down steep slopes?

DS02: 54:36

I'd say it depends on if it's grassy and if I have someone around me to watch. Because if I'm by myself I won't necessarily take the chances that I would if I was with someone else.

DS02: 54:56

And it definitely helps if it's familiar. Like if you go up the hill first and then you go like oh, I can probably come back down the hill. It's different if it's totally unfamiliar.

DS01: 55:06

You got that right.

Ben: 55:35

Whatever doesn't throw you out forward on the ground. With the mid wheel drive chairs you've got the casters in the front with the springs on them to keep you from tipping forward. Does that work pretty good when you're coming down?

DS03: 56:01

Yes, as long as I angle my seat back. I don't have any problem.

Ben: 56:05

And having the smaller wheels in the front like that being the first thing that hit. You've never had them catch on anything? Or something like that?

DS03: 56:14

No.

Ben: 56:49

OK, so it's the little bumper wheels.

DS01: 56:52

Ya. I don't like them.

Ben: 57:03

Ya, I've seen that before and I've kinda wondered if that keeps you from hitting it with your drive wheels first.

DS01: 57:10

Without it I couldn't drive

Ben: 57:17

Have you always driven a front wheel drive chair?

DS01: 57:22

Ya. Always (?) Permobil.

Ben: 57:40

How about you DS03? Have you always used mid wheel drive?

DS03: 57:44

I had this um Invacare Action XT and I equate the tires that were on it like a moon rover. Ya, that was very difficult to control. I believe it was made by Invacare. It was made just for a short period of time. That was extremely difficult. Since that period, I've had mid wheel and I've had no problems.

Ben: 58:23

And that Invacare one was rear wheel drive?

DS03: 58:29

What was that? Each wheel worked independently. It was extremely difficult.

DS03: 59:22

Yep, they were the same size. They were like small volleyball size wheels. And they didn't work together.

Ben: 1:01:39

But that one. Each tire had a motor and for the steering, you used the joystick but it steered like a car.

DS03-B: 1:01:55

You actually had another controller that had to be programmed to your driving. There was another piece you had to plug in to set the settings like speed I was just awful. He used to have to back up all the way to the other side of the basement in order to get up the ramp up into the van.

DS03: 1:03:29

And since then I've used a Jazzy midwheel drive chair. It's been great.

DD: 1:03:36

How long have you had this?

DS03: 1:03:37

I've had Jazzys for 10 - 15 ten years.

DS03: 1:04:00

This chair's been great for me. Again, the only problem is the seatbelt.

Ben: 1:04:07

Do you use the tilt feature to help keep you seated and not slide forward like that?

DS03: 1:04:16

Yes, I could.

Ben: 1:04:25

DS02, you've said you driven all three kinds haven't you.

DS02: 1:04:40

Yah, I've driven a front wheel, mid wheel, and rear wheel drive. I'm progressing forward. I started off with a rear wheel then mid wheel and now I'm in a front wheel. I think that the midwheel drive chair seemed to do a lot better on side slopes than either the front or the rear wheel. With this chair you can kind of feel you're tail end moving down the hill, tries to point you up the hill. Whereas with a rear wheel drive chair when you're on a side slope it tries to drive you a little bit up the hill because is always tries to swing you out that way. I think that rear wheel drive is the most intuitive to drive. In the midwheel drive chair, you can do pretty much everything. But it's tricky to figure out how to pull up alongside something really close at first but after awhile you get the hang of it. But I think that my front wheel drive chair is the

most comfortable when going over really small bumps out of all the chairs I had because the small front caster don't go first. I think the suspension in all my chairs was only mediocre. But with the Permobil, it seems like a much smoother ride.

Subject DS09

Interviewer: Okay I'm going to start recording. Just ask you a couple, a few questions here. So I'm here with [name] and so basically I want to know from you what are the most difficult driving situations you encounter? If you can just think of a few.

Probably the biggest, the most difficult is getting on and off a city bus.

Interviewer: On and off a city bus. Okay.

It's just real tight maneuvering, being on a larger power chair trying to get around the corners.

Interviewer: Gotcha.

For one, you're backing on, can't look behind you trying to wiggle around the corners.

Interviewer: Visibility. Okay.

It's a pretty tight situation.

Interviewer: Okay.

Interviewer2: How long have you been in this chair?

In this chair? Probably 4 years.

Interviewer: Any other situations?

Eh, stuff likes curb cuts.

Interviewer: Curb cuts.

So to speak. When I lived in San Diego which was probably more adaptive than any place and still their curb cuts when you get to the bottom of them, you know, you'd be, the footrest would drag. I had more trouble with my footrest than any other part of the chair.

Interviewer: Okay. Other situations? Well, we'll present you with other situations that we've come up with but we want to know from you personally anything you can come up with. So those two are great.

Generally, very rarely you get a steep ramp but that's not really a problem in this chair.

Interviewer: Occasionally but not, okay. Let's actually, I can help you with this. This is kind of more detailed stuff about daily activity and the chair you use.

Instruction first and the job training so to speak?

Interviewer2: What did you like least about your training?

Probably starting just in a regular environment rather than in an open room where you got space. Those 8 foot hallways got narrow. I started in a [unintelligible – chair type] chair. It's a whole different challenge.

Interviewer: Hey, in that city, city bus condition, would you say that's the most difficult thing you encounter the most frequently as well?

Yeah it's probably the most frequent. Yeah. Just getting in and out of the bus.

Interviewer2: Do you think a manual which describes outdoor power driving strategies that was developed from a talking with experts like you would be beneficial to new power chair users?

Probably a video would be better than a manual. I would agree that training would work but a video would be more functional than a manual.

Interviewer2: Especially for a high level quad who can't turn the pages.

Anytime you get to a power chair or book is their biggest nightmare.

Interviewer: I can imagine.

Interviewer2: Have you had any accidents with your chair before? What caused these accidents? Wheelchair slipped and ran into something?

Yes.

Interviewer2: Your wheelchair tipped over forward or backwards?

Sideways.

Interviewer2: Tipped sideways? Forward you just ran off the ramp of a van. It was too dark to see well and you ran into something?

No. Darkness is definitely a nightmare.

Interviewer2: You ran into a person in a crowded public place? Check, check, check, check,

Interviewer: All of them? [Laughter]

Interviewer2: You've become stuck because you're wheelchair lost function?

Yeah.

Interviewer2: Other experiences, be specific.

Uh... well I've had problems with it getting wet before. Driving when it was wet.

Interviewer: Any traction issues?

Eh the only traction issues would be in the dirt. Gravel is a big problem.

Interviewer: Yeah we'll get to that in a second. I jumped the gun I think actually. I've got to be quiet for a second.

Interviewer2: If you would like, please give a short description of any accident and what you've learned from it.

Um... whenever I was driving in the latch position I hit a bump and then couldn't reach my (chin?) control. It was kind of a bad, that was the day I came home after running into a car.

Interviewer2: In latch position?

Yeah, latch mode. It's like cruise control. Hit a bump, jostled me a little. Took the back of a Mercedes to stop me.

Interviewer: [laughs] you picked a good one. ... Great thanks. Alright so now we've got a few scenarios that we've come up that we kind of want to get your input on. It'll just take a second. So, please put a check in the box describing your experience with the listed driving conditions. So the first condition would be mud and the choices are "I can drive through this condition without any difficulty," "I've encountered this condition and it can be difficult to drive through," "I try to avoid this condition if I can," or "I've never encountered this condition."

I try to avoid it.

Interviewer: Try to avoid it. Okay. How about ice?

I fully avoid that one.

Interviewer: Fully avoid.

I don't see any in California.

Interviewer: Okay.

Of course I guess that doesn't count.

Interviewer: Right, right. Uneven terrain?

I have no problem with uneven terrain.

Interviewer: No problem, okay.

If it's all uneven, but.

Interviewer: Yeah. Uh, curb cuts? We talked a little bit about that.

Curb cuts, yeah, the biggest problem there is just like I said, the footrest or out far enough that whenever you come out the footrest will drag.

Interviewer: Okay. And gravel?

Yeah, gravel you tend to bury down there pretty readily.

Interviewer: So you'd say, "I can drive through this condition," that's actually no.

Depends on how deep the gravel is. If it's a light gravel thrown over a driveway that's possible.

If it's landscaping rocks generally you're not going to get very far before you're stuck.

Interviewer: Right. Okay. How about sand?

Very avoidable. You know I get into it occasionally but I try to avoid it.

Interviewer: You'd say you'd try to avoid it.

Yeah. Deep, deep sand you're definitely going to get stuck.

Interviewer: Right. Snow?

Very little experience with it. When I've been in it, you know, it has to be pretty shallow if I'm going anywhere.

Interviewer: Um, ramps? Just generally speaking?

Ramps are no problem.

Interviewer: Not a problem, okay. Crowds of people?

Be patient.

Interviewer2: You can do it!

Interviewer: Um, cobblestone?

No fun.

Interviewer: No fun.

You bounce around a lot but you get through it.

Interviewer: Okay. Driving at night?

Lights on the chair would be invaluable. I do it all the time but I definitely will adapt, when I do have a new chair I will adapt some sort of lighting system.

Interviewer: Gotcha. And rain?

Try to avoid it. Don't really have a problem, chin control gets real nasty pretty quick.

Interviewer: Okay. Driving up steep hills?

Chair powers out, you know, steep hills don't work. Would be nice to have a chair that had a low torque and a high torque ability. Now this chair's got, it's considered a performance chair and has four different programs but it doesn't really change the level of torque.

Interviewer: Okay.

So it's got number that you can program. I guess you can go down but you can't go up.

Interviewer: Right. That's something you can't do on the fly though?

No, well no you can't change gears on the fly.

Interviewer: Right.

And you don't really need to change it on the fly, you know, you can stop and go through gears and that would be okay if you were coming to a hill and knew that you could stop and shift down into a more torque type situation and, you know, going back and forth to school I could be a couple miles down the road and it would be real nice to be able to switch them to a low torque, high speed situation like that.

Interviewer: Right, right. Okay. Just a few more. Driving down steep hills?

Not a problem.

Interviewer: No problem. Dry grass?

That's not.

Interviewer: Wet grass?

No problems.

Interviewer: Heavy carpet?

Guess not.

Interviewer: Severe heat?

No problem, chair handles it.

Interviewer: Cool. Severe cold?

Chair doesn't have any problems.

Interviewer: Cross slopes?

Not a real problem.

Interviewer: So it can be a problem but-

It's more trouble than me trying to stay where I can reach the chin control than it is the chair handle it.

Interviewer: Okay. Hard sand?

No, no sweat.

Interviewer: Soft sand?

Doesn't work.

Interviewer: Doesn't work.

Going to get stuck.

Interviewer: Okay, turning on a slope?

No problem.

Interviewer: And driving while one wheel is off the ground?

No sweat.

P2: And you would know these things.

Interviewer: Alright that's it. That's all we got. Is there anything else you can think of that we didn't mention that you haven't mentioned already?

No, not really. Like I said the big, the big advantage would be to have a low-speed, high-torque and then low-torque, high-speed capabilities so when you do get the steeper hill you could go on up the hill or-

Interviewer: Right.

My original chair had a lot more torque than this one and then this one's got more speed and I'd like to combine those two capabilities.

Interviewer: Gotcha. Okay.

I know that snow mobiles, what always comes to mind because they go from idle to full-throttle with no gears.

Interviewer: Yeah that makes sense.

0 to 80 or 90 miles an hour with just the push of a throttle. Seems like you should be able to adapt some sort of a gear system or speed system.

Interviewer: Okay.

If you get the right engineer involved.

Interviewer: Yeah, that's what we're trying to do Yeah, cool. Well thank you so much for your time.

You bet. Not a problem.

Subject DS10

Interviewer: So, basically kind of as it reads, so please put a check in the box, I'll put the checks in, please put a check in the box describing your experience with the listed driving conditions. So, and you can say whatever you want to add about these tips so like when you encounter mud. I can drive through this condition without any difficulty. I've encountered this condition and it can be difficult to drive through. I try to avoid it. Or, I've never encountered it.

I've encountered it.

Interviewer: Right here. How about for ice? Uneven terrain?

That's always [unintelligible].

Interviewer: Curb cuts?

Always.

Interviewer: Gravel?

What's that? Gravel.. that'd go over here.

Interviewer: Over here. Actually I can let you, you want to mark them, go faster?

Yeah. Actually here it'd be both.

Interviewer: You can do both.

I try to avoid that shit if I can help it.

Interviewer: Snow?

It don't faze me. Ramps don't faze me. Crowds of people? They piss me off is what they do.

Interviewer: It's just annoying?

Yeah, I can drive through them. I'd rather avoid them. Cobble stones. Definitely avoid the bastards. Night driving.

Interviewer: One more page.

That don't bother me. I've been in a chair so long, you know?

Interviewer: Yeah.

[unintelligible] but you'll see the mud on it. I've got a mile driveway [unintelligible] The only way to drive through it is to put it to the wall and just push. Thing is I can handle it but they need a book to teach some of the guys. Wet grass. Sand. Heavy carpet. I just don't like being shocked. Severe heat? Don't matter. Don't matter. Hard sand. I like driving with no wheels. Do jumps.

Interviewer: Alright so you're basically done but I do want to get your input on like anything you haven't seen so far. Like what you think is the most difficult driving encounter?

For me or what I think it would be for a new guy to be put in a chair?

Interviewer: For you.

The most difficult would actually be the cobblestones.

Interviewer: Cobblestone. Okay.

With this chair it's no problem but if you get a chair that's center drive, the cobble stones are going to grab those and you will get knocked out of it.

Interviewer: Right. So you would recommend rear-wheel drive.

Rear-wheel drive, yeah. If you got cobblestones, it's rear-wheel drive. You get mud or something, rear-wheel drive.

Interviewer: Okay. What about, I don't know, like navigating like city buses or did you ever try taking buses things like that?

Oh yeah, it don't-

Interviewer: Not a problem?

Not a problem.

Interviewer: Not a problem. Okay.

I think rear-wheel drive's easier but that's my opinion 'cause my wife has center-drive and even though that turns on a dime, on a bus that could be up front 'cause you have to pull so far forward before you turn.

Interviewer: Right, right, right. Anything else you can think of?

Wish they made traction devices for these for ice.

Interviewer: Traction? That's not (fair?).

You know. Someone could come up with a design like for [unintelligible] chains.

Interviewer: Right, like chain link things for the tires. Okay. Anything else?

No.

Interviewer: Cool. That should do it. Thanks for you time. That went fast. We'll send you a check for 40 in the mail.

Subject DS11

Interviewer: What did you like least about the training?

Least about the training? Probably just it wasn't enough.

Interviewer: Not enough. Do you think the manual which described outdoor power wheelchair driving strategies that was developed from talking with experts like, oh, too late, hold on. This is not for you.

What manual? [laughs]

Interviewer: Yeah this is...

Sorry about that.

Interviewer: Yeah exactly. Have you had any accidents with your wheel chair before? What caused these accidents? Please mark as many items as, below, that apply. So I'll have you do that right there. ... I can, I can fill that out for you if you want?

That's alright.

Interviewer: Okay.

If you don't mind me picking it up so I can read it.

Interviewer: Not at all. ... Okay let me go back to a question that I missed. So, do you think a manual which describe outdoor power wheelchair driving strategies that was developed from talking with experts like you would be beneficial to new users?

Could be.

Interviewer: Could be. So would you say agree or strongly disagree or?

I'd go with agree.

Interviewer: Why or why not?

Well it fits in between, it depends on how the book is, the manual is developed.

Interviewer: Kind of how good it is?

And what it says that more manuals deal with, I can do it.

Interviewer: Right, right.

They're not worth the paper they're written in.

Interviewer: Right, right.

You see the number of pages it took time to get printed. And then, this one here, other than that one, the worse one, is driving on, driving into unmarked steps.

Interviewer: Okay.

You know, what do I do? Correct it now? I carry a white cane.

Interviewer: Right okay.

Some people think of stupid but that's alright.

Interviewer: Gotta survive.

It doesn't take much to go a couple of steps before you realize you got to do something else.

Interviewer: Yeah, yeah. Okay so this is going to be kind of an open discussion part. I just want you to describe one of the most challenging for you, the most challenging kind of driving situations that you can think of, that you encounter.

I generally, generally it's where people are not doing what they're supposed to do. They're cleaning sidewalks, cleaning snow off of sidewalks, kind of stuff and I end up getting stuck where the curb, where the street comes to the curb right at my mailbox. You can go into the mailbox but can't get out. I have to carry a snow shovel. Probably look like a nut driving down the street carrying a snow shovel.

Interviewer: Yeah, yeah, wow. Anything else you can think of.

That kind of, that kind of-

Interviewer: That type of thing.

Or I've got a (City Father's) group, you know, the city politicians that are unwilling to enforce ADA regulations. So they let a brand new Walgreens go in with no sidewalks and no curb cuts.

Interviewer: Right. Okay. Anything else you can think of? I just want to get as much as you want.

And they're putting in a new sidewalk on the street and then decided not to pave it but to put it in in gravel so it would be a bike path rather than a paved sidewalk because in that town if you have a sidewalk on your property, you have to be responsible to clean the snow off.

Interviewer: Right. Right.

So why, we're not going to make those people clean the snow off so just put in a bike path instead.

Interviewer: Right, kind of convenient right?
Thanks guys. Now I'm sitting in the gravel and I can't go anywhere.
Interviewer: Okay so this next set-
Hello!

Interviewer: That's going to make it more difficult. So, this next section I'm going to go through different driving conditions and basically your response is going to be either "I can drive through this condition without any difficulty," "I've encountered the condition and it can be difficult to drive through," "I try to avoid it all together," or "I never even touch it, I never go near it." So the first condition would be mud.

I avoid it.

Interviewer: Avoid it. Okay. Ice?

I would try to avoid that too.

Interviewer: Avoid it. Uneven terrain?

Oh I go right on through it.

Interviewer: Alright. Curb cuts?

I find that's the biggest problem. Hello!

Interviewer: Jeez. Um, gravel?

Gravel's a bitch.

Interviewer: Yeah.

And I dutifully mark this down.

Interviewer: So would you say you try to avoid gravel?

Yeah I try to because usually it's not packed low enough to give you a firm foundation to make it.

Interviewer: Right. Sand?

I've been on sand. It depends whether wet or dry.

Interviewer: Okay.

Wet sand is alright, not too bad. The dry sand is a real bitch but.

Interviewer: Snow?

Snow's not too bad. I got out in the snow. It's when I hit the ice that's in it or underneath it.

Interviewer: What about ramps?

Ramps, generally are pretty good. It's the lack of ramps that's a bigger problem.

Interviewer: Right. Crowds of people?

I try to avoid it.

Interviewer: Try to avoid. Cobblestone?

Difficult.

Interviewer: Okay. Driving at night?

Nearly impossible.

Interviewer: Okay.

Years ago when I was a kid, used to go when I was a kid, they used to make clamps that fit on handle bars of a bicycle that you could clamp a flashlight into and I can't find it anywhere because I have a, like I could clip it.

Interviewer: Yeah that would be perfect, huh?

It would give me a light out in front.

Interviewer: A headlight, yeah, yeah. What about rain?
Rain?
Interviewer: Yeah.
Well it's hard to avoid that.
Interviewer: Well you try to avoid it, yeah.
Not really, no I'll go out in it.
Interviewer: Okay. What about driving up steep hills?
As long as I have enough battery. I mean there's all sorts of reasons why things go to hell in a hand basket.
Interviewer: Right, right, right. What about driving down steep hills?
No that's alright.
Interviewer: Not a problem. Dry grass?
That's alright.
Interviewer: Wet grass.
Still alright.
Interviewer: Heavy carpet?
Ooh, hate that.
Interviewer: Okay. Try to avoid?
Try to avoid.
Interviewer: Severe heat?
Doesn't make any difference.
Interviewer: Severe cold?
No difference.
Interviewer: Cross slopes?
Cross slopes?
Interviewer: Yeah.
Well I'd do it anyway if I had to get there.
Interviewer: Okay. Hard sand?
That's alright.
Interviewer: Soft sand?
That's bad. I try to avoid that 'cause I get stuck.
Interviewer: What about turning on a slope?
Well if you pay attention to what you're doing you do it anyway.
Interviewer: Right. How about driving while one's wheel is off the ground?
Yeah, I've done that.
Interviewer: Do it but difficult?
Do it but difficult. [unintelligible] you can do it. You run into the same thing.
Interviewer: Absolutely.
The difference is, your chair can be pushed.
Interviewer: Right.
They can't get onto my and push it.

Interviewer: I think we're about done. These lights are killing me, huh. Yeah so that should do it. We'll send you 40 in the mail and thank your so much for your time.

Subject DS13

Interviewer: Okay. This is subject #5. So basically I want to, I want to know from you like what you think are the most difficult situations to drive over.

Trying to get on city buses.

Interviewer: City bus.

Um, especially in the mall, lot of people, I can't see good. I need a flash.

Interviewer: Right. Right.

Usually people pretty good about but lots, like I said, malls or crowded areas, people don't see you, just step out in front of you and that scares you. Do something to hurt you.

Interviewer: Yeah. Those are good. Any other situations you can think of that are kind of tricky? Um, in this type of material you can't get on a side slant. You have to be level. I've had it bounce with me and I want to stop going down a hill, lot of stuff are down the hill, and the front wheels are plowed forward and it hits you but you better have your seat belt on you or you'd be on the ground.

Interviewer: Right. Right. Alright sounds good. Which one of these things happens the most frequently?

The side and the city bus.

Interviewer: Okay.

You know when you cross a street a lot of them have a little slant to them. I live in Raleigh and the chair is pretty wide and you have to--everybody's nice but you have to wait. Which I don't mind.

Interviewer: Right. Okay. Um,

Subject DS14

Interviewer: So subject #6. So basically, I know this is going to sound kind of redundant because you've already talked about all this but I just want you to describe, like, what are the most challenging sort of situations you can think of in terms of using a power chair.

The most challenging for me is going through snow, like, I can get through like a couple inches but if it gets like 4 or 5 inches of snow then a heavy chair just sinks down and it doesn't turn the way it's supposed to and so then it just, I just get stuck. So, yeah mud is basically the same way because we have, basically Mud March we call it after the snow's melting, so that gets pretty ugly too.

Interviewer: Okay. What about, what about maybe like city buses or anything?

No. We don't have any. I have a pickup truck that has a lift in it.

Interviewer: Any other, any other environmental situations you can think of that are problematic or annoying?

I find going on, like on slopes, if I am on asphalt going on slopes then I feel like I'm tilting forward 'cause the front casters are up higher, I'll tilt forward and it feels like I'm falling out of this chair.

Interviewer: A slope? What kind of a slope exactly?

A downslope.

Interviewer: Down slope. So really just kind of a balance/security kind of thing.
Right.

Interviewer: Okay that's pretty good. Anything else?

Um, trying to think like in crowds, like going in and out of elevators and stuff. It's always hard because trying to turn and see people so you don't crunch toes. So that's, I hate backing up because, you know, just being able to turn and see them. So.

Interviewer: That's a pretty good list. Anything else you can think of?

No. I don't think so.

Interviewer: And, so in terms of like, which one, of the ones you mentioned, which one do you think is most problematic, most frequently? Would you say like the snow and mud, weather conditions?

Yeah weather conditions would be the biggest one for me.

Interviewer: And the rest, like, like slopes, crowds, backing up, probably equal?

Yeah those would all be.

Interviewer: Alright cool. That's it.

Oh okay.

Subject DS15

Interviewer: Subject #7. Okay if you could describe kind of what are the most difficult, and I know we've already kind of talked about a lot of stuff but what are the most difficult situations that you encounter in your chair?

Probably is driving on gravel.

Interviewer: Gravel?

I live on a farm.

Interviewer: Okay. Okay do you get caught up basically or what's the-
If it's loose gravel it bogs down and doesn't seem to want to go.

Interviewer: Okay. Another situation you can think of?

No.

Interviewer: Do you ever, like, take city buses or anything like that?

No, I live out in the country.

Interviewer: Out in the country, so that takes care of that.

I drive my own vans.

Interviewer: Perfect. How about maneuvering in your van? How's that work out?

The front wheel, it spins sometimes.

Interviewer: Is that getting into the van or while you're?

Getting out.

Interviewer: Getting out, okay. Let's see, anything else you can think, I'm trying to think of other scenarios. Anything else around the farm?

Um, no. Just try to avoid it.

Interviewer: Just try to avoid danger at all cost. But you'd say probably gravel is the number one?

Yeah.

Interviewer: Alright I think that should do it. Fill this out and we'll send you a check in the mail.

Subject DS16

Interviewer: Subject #8. Okay. Just want you to describe sort of the most difficult or the scariest situation you can think of or inconvenient with your chair, with this current chair, that you encounter pretty regularly.

Well you could be going down the yard to the street and all of a sudden they don't have any curb cuts so you have to go off the side.

Interviewer: No curbs, okay, curb cuts.

And only one time did I almost hit the chair on the side. It was too high.

Interviewer: Okay. Anything else that you can think of?

Just probably stay away from anything that has an incline.

Interviewer: Anything with a pretty steep incline?

Yeah. Especially out in the country. Like mowing the lawn, make sure you, go down hill before you go up.

Interviewer: Anything else?

Not that I can think of.

Interviewer: Do you ever try to get on city buses or anything like that?

No because I have a special ramp, UVL, in my van.

Interviewer: Right, right, so you've got that all covered.

Yeah I've got a 15-passenger Econoline.

Interviewer: Uh... trying to think of anything else. Anything else that you can think of that's an inconvenience or little tricky or?

Well if I take this shopping, grocery stores aisles sometimes can be a problem especially after the 4th shelf. You have to hope somebody's around that will help you.

Interviewer: So that, they're, so not only are the aisles sometimes a little bit narrow but then just reaching up.

The other thing is they need somebody in a wheelchair designing the bathrooms because you could get--when you have to go straight in, you can't shut the door and also it's not, a lot of them aren't built with the idea that there are bigger chairs around than a (normal?) chair.

Interviewer: Right, right. Okay. Okay so out of all the things you mentioned, you mentioned, you know, issues with curb cuts, you mentioned incline, grocery store issues, bathrooms that are too tight. Which one would you say is the worse for you?

Grocery.

Interviewer: Grocery. What would you say is number 2?

Bathrooms.

Interviewer: Bathrooms.

And then the first one. Unless you're outdoors you don't do the others as much.

Interviewer: Okay great. Well that should do it. Thanks so much for your time.

No problem.

Interviewer: We'll send that check in the mail. Thank you so much.

Subject DS17

Interviewer: Okay subject #9. Okay so what are the, what obstacles do you think are most severe or give you the most?

Something I don't think they addressed was in stores. They never leave enough room in the aisle ways.

Interviewer: Okay stores.

I always avoid clutter, you know, with the racks. I'm always knocking stuff off racks. The other thing is bathroom does.

Interviewer: Bathroom doors.

I think they should set bathroom doors where they open, you know, swing inwards and swing out, the swinging door instead of the open to go in and-

Interviewer: Oh okay.

It's easier to push it to go in than to get out 'cause you have to grab the handle then back up. If the door went both ways, that would be perfect for a lot of places.

Interviewer: I agree.

A lot of your hotels, airplane tickets, bus, plane tickets and stuff, they always have these high counters. Nobody ever has a low counter for wheelchairs.

Interviewer: Right, right.

And... I can't really think of anything else.

Interviewer: Anything else outside or-

Parking.

Interviewer: Parking?

Parking is always a big problem because people don't park in the stall right and then trying to get out and get back in.

Interviewer: What do you usually do to kind of, you know, combat that? Do you ever take up multiple spots or kind of?

If I can't get into a handicap stall, then I take 2 spots. I find somewhere so nobody can park beside me so my ramp can drop down.

Interviewer: Gotcha. Anything else you can think of? Do you ever take city buses or anything like that?

No I've never been on a city bus.

Interviewer: Okay.

And the ones that I've gone on have all been pretty well acceptable. It's just that I don't think they have enough room for [unintelligible].

Interviewer: Alright, um, unless you can think of anything else.

That's all I can think of.

Interviewer: No, that's really good, that's very good.

Subject DS18

Interviewer: Alright subject #10. Okay so I just want to, we've gone through many situations sort of that have been presented to you. I was wondering if you could bring up any situations that we haven't discussed yet that you find to be difficult with the chair. Difficult or scary.

I don't have anything in this chair that are difficult or scary. I'm very happy with the way it runs and I'm very impressed with the handling of it.

Interviewer: Okay.

I was nervous at first about coming up a bump like this. This is great. Coming in at an angle or going straight.

Interviewer: Okay. What about, I don't know, do you ever get on city buses, things like that?

I've got on a city bus and it works great.

Interviewer: Okay.

And it turns on a dime which is really good. I use what they call a caravan to travel with everyday to and from work and school and I'm able to go in and out and turn on a dime and fit it with, it will fit 2 wheelchairs side-by-side real easily.

Interviewer: Great, great, great. Let's see... Any close calls on, like, hills ever or ramps or you just try to avoid kind of dangerous situations?

I don't think I've ever had to worry about any difficult situations like that. If it looks too dangerous I will avoid it.

Interviewer: Fair enough. So you're not a risk seeker.

No.

Interviewer: Which is smart. I'm trying to think if there is anything else. What did we cover... Alright I think that, unless you can think of anything else you'd like to mention about the chair, your experience in your chair?

No. I do want to say that I think that if you were training for working on a chair, learning the speeds is important. You want to be able to walk, move quickly at a speed of 3 or 4 but you try to turn at those speeds and you're going to run into walls or make yourself fall over.

Interviewer: Gotcha. So just learning how to control the chair.

Control it. Yeah. I've used, with my controller on the left side for a couple years and I could control it going at a fast speed well and then I moved it recently, just 6 months ago to this side and I'm not quite as good at controlling it at higher speeds so I make sure I walk the line, move slowly.

Interviewer: Okay. Alright. What about transferring in and out of the chair? Is that ever?

Well it's not difficult for me since I can stand and I can use my leg. For anyone who cannot it works really well because you can...

Interviewer: Because of the elevator and you can also move the arms.

Well yeah you can move the arms, take the arms off and you need to just slide directly off of it and that way, for people that don't have usage or watch their balance or anything. I do not have balance, I'd be careful from this point.

Interviewer: Great then I guess that will do it.

Thank you very much.

Subject DS19

Interviewer: Subject #11. Okay if you'd like, please give a short description of any of your accidents and what you learned from them. Anything that kind of comes to mind. I know you did already a little bit but.

What I've learned is, depending on the chair model, definitely dictates the terrain you could go over and the tipping ability on the chair.

Interviewer: Okay so just.

Yeah. Repeat the question again?

Interviewer: Um, basically a short description of any accidents or situations.

Yeah, well calibrating the stopping on the chairs, they're all different. So, where I might have to sip 3 or 4 times to get a quick stop, with this chair, my other chair, I could just sip once and it would stop. So there's a learning factor-

Interviewer: Learning curve there, alright.

If the sip and puff tube ever gets away from me, I'm gone and pretty much at the, at the whim of the chair.

Interviewer: Right, right. Scary. Okay, independent of calibration and settings, wheelchair settings, can you think of other environmental situations that you consider to be scary for you? Ramps, curbs, curb cuts?

Yeah, ramps, curbs because I-

Interviewer: Well what do you put at the top of the list?

Ramps.

Interviewer: Ramps.

Ramps are always scary. I got to get someone to walk behind me if it's too steep or backup the ramp. Yeah I would say that's the big one.

Interviewer: Okay. What about, I don't know, maneuvering, like, going through stores or grocery stores or things like that?

Yeah, you know, I have a mid-wheel drive is definitely designed better for navigating through tight areas, office spaces, grocery stores. Rear-wheel or front-wheel drive is a little different swinging either the front or the back around.

Interviewer: Any other environmental situations that come to mind that?

Yeah, I just had one yesterday getting outside in the freezing weather with the sip and puff. Early morning, when the hot air goes in the tube it builds up condensation and then the condensation froze up so I couldn't, and I couldn't figure out what was wrong with the chair. It was just not operating. We found out there was ice chunks inside the tube.

Interviewer: Wow. Unbelievable. Alright I'll stop this for now.

Some of the questions were, do it but it's difficult. What makes it easier is if I have someone with me to walk behind me up the steep ramp to make sure I don't tip back. With the chair I have in the tilt feature on it, going down hills I'm able to tip to kind of counter-balance that so those are little tricks I've learned.

Interviewer: Any other tricks you can think of?

Um... not off hand.

Interviewer: No that's great. Great information.

Subject DS20

Interviewer: Subject #12. So basically I just want you to maybe bring up any situations that are difficult that we haven't already talked about that you find could, can be challenging and maybe how you deal with them, strategies, things like that.

Mostly in tight spots.

Interviewer: Tight spots, okay.

Small houses, stuff like that. Bathrooms. The only major problem I have is with airlines.

Interviewer: Airlines, yeah. The way that they treat your chair or-

The way they treat my chair. I drive just about everywhere because of that.

Interviewer: Right. What about, you ever try to get onto buses, city buses? Anything like that?

I've never had to do that, no.

Interviewer: Okay. Any other weather conditions that you really try to avoid or that are giving you problems?

No, there's no weather that I try to avoid. I will try to avoid getting out in a real muddy area but, sure, there's some places that I don't want to get bogged down.

Interviewer: Right. Sure. What is it that you mentioned about going up steep hills?

Yeah, when I go up steep hills, sometimes I have to stop because the motor heats up.

Interviewer: Oh okay.

I have to cool off then start again.

Interviewer: How long do you usually let it cool off for?

Couple seconds.

Interviewer: Couple seconds. Okay. How do you know when the motor strains?

It slows way down.

Interviewer: It just slows down, okay. Um... okay. Anything else you can think of that I?

No.

Interviewer: Alright.

The ADA doesn't work.

[laughs]

Interviewer: The ADA, yeah.

An ADA doesn't necessarily mean you can get into it with your wheelchairs.

Interviewer: Right, right, absolutely. Alright. I think that should do it. Thank you very much for your time. Appreciate it.

Subject DS21

Interviewer: Okay, subject #13. Okay so basically just want to get your input on any conditions that we haven't talked about. Situations that you think are difficult, scary, and how you may or

may not kind of deal with those situations. So like rolling over, rolling, trying to get into a city bus, trying to navigate through bathrooms or other types.

Yeah. Just trying to get around houses you get scared because you can hit the walls and scratch people's paint. They don't have wide stuff. Bathroom's not a problem. I've been finding that concerts, those are a little bit difficult because running over, it's dark and rolling over people's toes and stuff.

Interviewer: Right. Right.

Bus is not a problem. Airplanes, the way they treat your chair, that's probably the biggest thing I can think of.

Interviewer: What about, I don't know, maybe stores or something like that. Store aisles or grocery stores or something like that? Not so much?

Most major ones are okay but you go into some of the smaller like Hot Topic clothing stores and it gets a little bit close in there. You can't turn. Around you have to back up.

Interviewer: Right.

But I'm pretty forceful, I just tell them to move out of the way.

Interviewer: Any other weather conditions or surfaces?

No but I'm always tentative like today, I went out skiing and I had to put my chair out there in the snow. That was a little bit like, I hope it, I hope it's still working when I get back.

Interviewer: Right, right, right.

Like the electronics basically.

Interviewer: Yeah.

That's why I try to keep it as simple as possible. They've got all these new ones with add-ons and I really don't like that myself.

Interviewer: What about like if you get caught in the rain? Do you ever have problems with the rain kind of shorting your chair out?

Never.

Interviewer: No. Okay that's good.

It always works. I don't know how but they always did so far.

Interviewer: Cool, cool.

Mainly it's airlines.

Interviewer: Airlines, so that would be kind of your number one.

Exactly. They're not, they're not universal in the way they take care of and there's too many moving parts for them to handle. I haven't had a trip where it didn't get destroyed.

Interviewer: Right, right. Okay. Yeah that's a big one. Alright that sounds really good. Anything else you can think of?

No. For myself? No.

Interviewer: Thanks a lot, man. Thanks for your time. I appreciate it. Helps us-

Subject DS22 and DS24

Interviewer: Okay. Um, so any of these categories, or any other ones that, you know, you thought of when you were filling stuff out? Um, as far as driving outside, what things tend to be

obstacles, you find to be obstacles and do you just completely avoid stuff or have you found, you know like, work around ways to still go where you want but maybe in a little bit different way? Ways to handle different terrain?

Well, where I live, the majority of our roads are dirt.

Interviewer: Dirt roads, okay.

With big potholes and if you're going to go outside, you can't avoid it. [Laughing]

Interviewer: Right, okay.

So you have to just –

Grin and bear it.

Grin and bear it, yeah.

Interviewer: Does the bumpy bother you, or?

Oh –

Interviewer: Well maybe it's –

You know, plus you hit a pothole or something or a gopher hole – I've gotten stuck in gopher holes [laughing].

Interviewer: You know, I live on a farm back in Virginia. I know, I've stepped in a few gopher holes. Yeah. Okay.

I use a combination of both; I either avoid certain [unintelligible] or you know go--find a way around.

Interviewer: Yeah.

The street that I live on, um, I've turned it into an obstacle course. I mean, my neighbors get a kick out of watching me because I'm from one side of the road to the other trying to get from the main road to home.

[Unintelligible] has speed bumps, so that sucks.

I hate speed bumps. I'll go around them –

In my case, I can't go around them.

Interviewer: So you just gotta go over them real slow? Or [unintelligible] forward or something – They're some that are so high that you can actually get stuck on them.

Interviewer: Oh wow.

I have one that is so steep that every time I roll over it I pop up out of the chair. And if I'm carrying anything I drop it.

Interviewer: Drop it, yeah. Okay. Huh.

So what I do with that was I go real slow, try to find the lowest spot.

Interviewer: The lowest spot, yeah.

And what was funny was we had just put some curbs in downtown. First time we've had curbs –

Interviewer: Wow, okay.

And we'll work with one blinking light in our town [laughing].

[Talking over each other]

Interviewer: Okay.

[Unintelligible] Park, it's up in the mountains, four seasons, snow in the winter.

Interviewer: Oh.

In California?

Yeah, in southern California. We're halfway between Bakersfield and LA.

Interviewer: Huh.

But, uh –

Four seasons [laughing], hot and hotter.

But, uh, the people in town weren't used to the curbs yet and they didn't – they don't look for the wheelchair cuts. And I got tired of having to backtrack and then go out into traffic to get around a vehicle.

Interviewer: 'Cause they park right in front.

Right.

Interviewer: Oh, okay.

And so I – just as I got started to go around, a cop came by, and I said, "Isn't that against the law?" And they said, "It sure is." That gal got a 250 dollar ticket [laughing]. And she put the notice in the newspaper, in our little newspaper –

Interviewer: Yeah, right.

In our weekly. "Watch out for the –" [laughing] and now we don't have the problem, except 250 dollars.

Interviewer: Yeah, okay.

In Miami actually right now, they're in the process of creating all new curb cuts.

Interviewer: Oh wow.

They got some money from the federal government.

Interviewer: Right, yeah. So they're making – I mean, they had them before, but they weren't that nice.

They have like, a yellow rubber –

Interviewer: The bumpy stuff, where they –

Non slip thing.

Interviewer: Yeah, okay.

That's what we've got. But before, we had to actually drive in traffic in the bike lane or whatever. But now it's nice having the sidewalks.

Interviewer: I bet, wow.

Most of the drivers don't know respect, at least in Miami. No respect.

Well like I said, we have one blinking light in town, and to get to the post office, you have to go across a busy, busy main street. And that's where the blinking light is. And there's no way –

Interviewer: And there's no crosswalk there or anything.

Yeah, there is a crosswalk.

Interviewer: Okay.

And I was in the crosswalk coming back from the post office. I stopped, I waited my turn and started in. Some gal ran the light, and I mean she missed me by that much. It scared the daylights out of me. I slammed into (reverse?).

Interviewer: Right, wow.

I've had close calls. I think it's the drivers –

I've slipped on ice, you know. I won't go out in snow because it's just too –

Interviewer: Too slippery?

Well no. This chair is steady, it just stops dead.

Interviewer: Oh, okay.

I haven't encountered that problem. I don't think I will.

Interviewer: Yeah, probably not, probably not. Okay, so no snow, don't do ice 'cause it's slipping around too much.

And having mud will bog you down. And sand will stop you dead, too. If it's sand, it will stop you dead. And I've been pitched out of my chair and hurt from that.

Interviewer: 'Cause were you on hard sand and then it –

No, we were on dirt and the gate to the park was sand. And I hit that soft sand. And my chair stopped dead, and I didn't.

Interviewer: Oh my.

Were you seatbelted in?

I don't – this chair doesn't have a seatbelt.

Because I fell off – I was getting off a bus one time, and I fell off the ramp, and I didn't come out of the wheelchair because I had my seatbelt on. So I was like hanging from – you know, on the down--on the sidewalk, hanging from my wheelchair.

The road we used to live on –

Interviewer: Oh my.

Is so steep that to get from East End, down Texas trail to my house, it was so steep and so full of bad potholes, in the rainy season, it turned into a creek. A creek bed. And it had big potholes, and my chair started sliding, and it hit sideways into one of the potholes. Flipped me over sideways, and I broke my arm.

Interviewer: That's a pretty steep hill, yeah, wow.

I've fallen off the sidewalk –

Interviewer: Like, gotten a wheel off the sidewalk?

When I first got the wheelchair, since I didn't have any training, as I was avoiding the light pole, I went off the curb right there in front of the VA and fell over and a bunch of guys helped me to get up.

Interviewer: Just took you right over sideways. Yeah. Oh man. So –

Is that manual you're talking about?

Interviewer: Manual, or like a video – video, something like that. Would that?

That would be great.

Interviewer: Okay.

That would really be great.

Interviewer: That's what, pretty much everyone we've talked to said they don't – they didn't get no training, or when it comes to outside training, they don't get it, any instruction on –

I've got like, OJT, you know? On the job training.

Yeah, that's what everybody gets.

Interviewer: Yeah, yeah. Okay. Well, um, let's see. Alright. Where were we at, here? Uh, you guys have any trouble, like with gravel, or, you know, in the park or something, you know? Like if it's too deep or something you get stuck in it?

On the grass, you have a tendency to spin, especially if the grass is at all wet.

Interviewer: Okay, yeah. That's what we've heard as well, okay.

And then you have to dodge moles and gophers.

Interviewer: Okay, alright. Um –

That's an obstacle course, too.

Interviewer: Right, definitely. So the two main things we're looking at, or the new control we're designing is stability, like tipping stuff, and traction. So like, slipping, ice, wet grass, stuff like that, and seeing if by adding sensors to the wheelchair, that the wheelchair could actually sense when you're starting to slip or start to tip over and correct it, like faster than you'd even have to think about.

What would be nice is a video or something –

Interviewer: Okay.

Would be, you know, warnings of things to avoid.

Interviewer: Things to watch out for.

Like [unintelligible] sand.

Interviewer: Yeah.

The snow, you know, things that are going to stop you dead in [unintelligible].

Interviewer: Alright. She had to run to get stuff for the charger. Any other observations from that? I mean, do you live like smack in Miami kind of thing? In the city? Any like, city driving issues? Like you said, the drivers don't seem to be very attentive?

They're attentive, but not –

Interviewer: They don't respect – so even though they see you, they still – okay. Kind of get a little too close for comfort.

I guess, you know, it's partly my fault. I cannot stand the sidewalk.

Interviewer: Oh, okay. Is that just 'cause there's not –

Because there's a lot of little bumps. You know, the cracks and the chairs, like –

Interviewer: Oh, okay. So the road's just smoother. You go on the road.

Yeah, definitely.

Interviewer: Okay, alright. Good reason, just kind of unfortunate. Do you ever, like, instead of the road, the bike path or something like that if there is one? Or is it –

I have used a bike path, under the metro rail. But that's – when I want to get to the bike path, I have to some gravel and that's when I get stuck.

Interviewer: Okay. Alright.

And the bike path has potholes, also. It's not maintained well.

Interviewer: Oh really? It's not like – is it paved, or not?

Yeah. is, but it's got potholes and stuff in it.

Interviewer: Okay. Like with the gravel, did you try – how did you get yourself unstuck when you got stuck the first time?

I had to get off the chair and push it.

Interviewer: Oh, yourself? Oh wow. Okay.

Between me and another guy.

Interviewer: Okay.

‘Cause he saw I was having problems and saw I needed some help.

Interviewer: Right, okay.

And I’ve gotten stuck on the grass on my walkway to get into my townhouse. If I get off the walkway and I get stuck. And then I have no power, no torque. [Unintelligible] like teeter-totter on the edge of the walkway and the grass and I’ve had to ask neighbors to help me, ‘cause I get stuck there.

Interviewer: Yeah, okay. Huh. Now is that, like, you’ve got one wheel on the sidewalk and one wheel in the grass kind of thing, and you’re stuck on that edge right there?

Yeah, well sometimes both wheels will be on the grass, and I can’t get up –

Interviewer: Can’t get up on the sidewalk, okay.

It’s one of the main reasons [unintelligible]change my chair. Plus when we went to practice at park the other day for a game I got stuck in the chair--in the grass.

Interviewer: Wow, okay. Well, I guess since you won’t be playing on grass here, you should be alright then. Huh. Alright.

What they did was, they can’t speed up anymore, so what they did was they tried to add some torque to it, and they got it torqued to the max.

Interviewer: Okay. So they – still not enough, okay.

But my chair wasn’t ready for the game, so I would have had it.

Interviewer: Alright, well, yeah. Hopefully.

The guy that works the chair stuff went off to vacation in Hawaii.

Interviewer: Okay, well. I guess people have to take a break sometime, you know.

He’s good, though.

Interviewer: He’s good. Good deal. Treat you well. This is the guy at the VA you’re dealing with?

He deals with veterans.

Interviewer: Yeah.

He has a company, him and two other guys.

Interviewer: Oh okay. Okay.

I call him “Triple A.”

Interviewer: Triple A [laughing].

I ran out of juice one time and I called him, you know, I called “Triple A,” his name was [name] and he said he’d be there in a few hours.

Interviewer: Uh huh.

I fell asleep by a propane tank at a gas station, and some elderly gentleman came and offered me three dollars like if I was a bum. And I said, “No, Sir,” and I explained to him what happened. And the attendant showed me an outlet, and luckily I had my cord with me, and I was able to

plug in to the [unintelligible] for a half hour until the bus came along and I was able to get back in the bus.

Interviewer: Okay.

I went down a lot closer to the VA, called [name] back, and said, “[Name], I’m now in such and such a place.” And he said, “I’ll be there in ten minutes.”

Interviewer: Okay.

So he came, and I had just – my wheelchair was still under warranty at that time, I was within the first year. And my batteries had been changed. But he came and gave me two new batteries, because he told me he didn’t know how long those other batteries had been on the shelf.

Interviewer: Yeah, oh yeah.

And he had an external charger.

Interviewer: Nice, okay.

[Unintelligible] big box that you were referring to.

Interviewer: Right, so when you charged up the first time, you had like, an internal charge.

Yeah, just a thing that I put in a cord. And then after I had that incident, he gave me the external charger. Because I tell you, I came with just a cord.

Interviewer: Mm hm. Alright. Is there – let me think. Is there any places, just in getting around, you know, during the days that you’d like to go, but because your chair can’t go there, you can’t? The beach.

Interviewer: The beach? Okay.

‘Cause of the sand.

Interviewer: Right. Okay, well that’s definitely a big one.

I live very close to the beach. I love the water.

Interviewer: Okay. It’s probably – it’s just, the sand’s not – it’s too dry.

It’s just too soft.

Interviewer: Yeah, okay.

The chair’s too heavy. Because I don’t weight--I lost 75 pounds.

Interviewer: Mm hm. Okay. Have you ever tried, like on the – out closer to the water? Like the harder sand, where it’s packed down out by the water? You can’t – they don’t have any, like, boardwalks that go out there? Okay.

Not as of yet.

Interviewer: Okay.

Unfortunately.

Interviewer: I’ve seen some of those before, something like where it’s level with the sand, and it kind of goes out almost to the water.

I’ve heard that there is one on the beach, but one of my--my son is a lifeguard for the fire rescue department. And his friend’s a lifeguard for the city of Miami Beach. And I asked one of his friends, the lifeguard, he doesn’t know where it’s at, but I know there’s one –

Interviewer: There is one, okay.

And I have--you know MS and the heat don’t mix. So I can’t be out there looking for it.

Interviewer: Yeah, yeah. Right. So if you’re going to go out, you go out in the evening or something like that?

I'm a morning person.

Interviewer: Oh, you're morning? Okay. Early morning? That's cool.

I try to stay out of the midday sun.

Interviewer: Right, right.

I also wear shorts most of the time, and (loose?) shirts.

Interviewer: Yeah, that definitely will keep you cool.

Plus, I have a cooling vest and all that kind of gear.

Interviewer: Oh you do? Okay. Like with the water, it goes through it and stuff? Yeah.

Those gel packs that you freeze?

Interviewer: Yeah.

It has pockets and you slip them in. Cooling wristbands, cooling scarf, I have a cooling hat; all that stuff.

Interviewer: Wow, okay. It's like your own air conditioner kind of thing. Yeah, with all the humidity down there, it gets pretty hot, I bet. Oh boy. Alright. Well, I think that's pretty much it, hit pretty much everything. Tipping over, slipping – I've got a friend I work with at the lab, and he's from like, way up north in Michigan. And he said, "When I get done with college, I'm moving somewhere warm, you know, where it's – I won't have to deal with snow and ice and all that kind of stuff," you know?

Subject DS23

Interviewer: Um, do you have any other observations, like through... any of these, or stuff you would want to elaborate on, I guess, could be – the idea A, like I said, the training materials is one thing we're trying to develop, and the other one with our power chair controller, we're looking at – the two main things we were wanting to focus on was stability, control somehow, like if you are in a slope situation, or if maybe you're coming down a slope and you're stopping two quickly and you might tip over kind of thing, that the chair could react on its own in some of those circumstances to help keep the person from tipping over. That and slipping, I guess, mainly with concerns in like, winter time conditions, snow, ice, stuff like that. Uh, those are the two things we are starting to look at now. Do you have any other, like, driving outside, gravel, dirt, mud, all that kind of stuff? Do you?

The biggest thing is driving outside. If it's muddy, trying to get someone with you to find out how deep the mud is.

Interviewer: Okay.

If you're not sure, I'd say avoid it.

Interviewer: Right, okay.

And with sand, snow – snow hasn't been a problem, because unless you get into a real hard snow drift, and then it'd be like any other vehicle, you get hung up.

Interviewer: Right. You – I know we're talking with one guy, and he was saying how, like on a sidewalk or something, he finds sometimes that if the sidewalk's been trampled--packed down, that it's actually a lot slipperier than if it was just like new snow, and he was kind of plowing his own trail to start with. Um, that it was – he got better traction that way.

Yeah, overall. Yeah, 'cause he'd be making his own trail, he wouldn't be trying to go over packed –

Interviewer: And it wasn't nearly as bumpy, either. Uh, is what he said, so is that –
Um, never... encountered it, where I had to go over sidewalks that weren't shoveled.
Interviewer: Okay, alright.

I guess the only thing there is if they don't shovel a light enough path and get off the edges of the sidewalk.

Interviewer: Oh, okay.

So you have to be aware of what the sidewalk is like.

Interviewer: Right, right, okay.

Uh, gravel, gravel usually isn't too bad if you're careful.

Interviewer: Okay.

Sand is the worst, because you never know when it's going to go from hard sand to soft.

Interviewer: Okay.

You could be going along on what looks like good, solid sand –

Interviewer: Right.

And the next thing you know, you're sitting – you're digging yourself in and you're burying yourself. It went from hard to soft all at once.

Interviewer: Okay.

The only thing I can think of on that is you gotta have someone with you, preferably maybe walk ahead.

Interviewer: Right.

And they may hit soft sand and warn you.

Interviewer: Okay.

Or, now I go hunting up at Camp Ripley, and I know what some of the different trails are like, so I know when I see soft, I see the sand there, I know when it's soft and when it isn't. If it's soft, then I try and head up onto the grassy area beside the trail.

Interviewer: Okay.

Usually works.

Interviewer: Okay, alright.

I've had where I dropped through there, too.

Interviewer: Where the grass is like, just above the sand kind of thing and you can't really tell.

Yeah, just the stupid easy lock bolt catching the grass, pulls a little harder. You end up digging yourself down.

Interviewer: How much clearance do you have with the easy lock? Like a couple –

About three quarters of an inch.

Interviewer: Wow, okay.

Yeah. Garden hoses are fun.

Interviewer: [Laughing] I bet. You'd drag it half way across the yard. Huh. Okay. Do you ever, like with gravel though, do you ever run into a problem where it was deeper than you thought and it kind of – if you slowed down at all, you kind of bogged down into yet? Have you ever run into that?

Uh, I look at gravel, and if it looks like it should be okay, I just hit it full speed –

Interviewer: Full speed, okay. Right –
Hope for the best, and so far I've gotten lucky on gravel.

Interviewer: Okay.

Unless it's a gravel road, and they're pretty firm.

Interviewer: Yeah, oh yeah. Yeah, those are. Okay. Yeah, 'cause we had a few people say, "You know, you gotta keep moving or else if you slow down, you might get stuck" kind of thing.

Yeah, kind of a "don't stop" type thing.

Interviewer: Right, right. Okay. Alright, let's see.

One of the problems that I find with this newest chair is the anti-tips stick out farther. And they're real low to the ground. They'll hang me up when I get up –

Interviewer: Really?

Get up in the backyard and try to turn, if there's tree roots close to the surface, they'll hang up on the tree root when you try and turn.

Interviewer: Turn, okay, right. 'Cause you're – they can't move at all side to side.

Right. So you're really – with the newer chairs now, you really have to be aware of the ground wherever you go.

Interviewer: Mm hmm, okay. Have you always driven – have all your chairs been rear-wheel drive, or have you done –

I've always been a rear-wheel guy.

Interviewer: And that's just your preference? You'd never want to try, like a front-wheel drive or anything?

Uh, front-wheel drive, I don't like the way they – the wheels in the back stick out so far to turn.

Interviewer: Yeah, okay.

You have to have much more awareness of where the back of the chair is.

Interviewer: Okay. Yeah.

Looks to me like it'd be a real hazard in the house, for tearing things up.

Interviewer: Yeah, I suppose they could be.

And the mid-wheel drive, I always looked at those like a good way to get hung up on ramps or some of the curb cuts, where there's not a level end, where you've got an inch or two drop.

Interviewer: Okay.

I always thought, and you know, even out on the grassy areas. A couple of years ago, I talked to one guy and he said he tried to go up sidewalk and get out onto the grass in some of the parks, and got hung up with his drive wheels hanging where he couldn't get any traction.

Interviewer: Oh, okay. Yeah, 'cause those have, usually, four caster wheels on those.

Yeah.

Interviewer: Yeah. I'm wondering that myself, with people, you know, how they – they got twice as many little wheels to get hung up on.

Yeah, and they don't have near the give that they should have. But then they keep you from tipping over, I guess.

Interviewer: Right, right.

And if you're involved in any kind of wheelchair sports, the rear-wheel drive is the only way to go.

Interviewer: Okay, yeah. That's what I've – I haven't actually gotten to watch power soccer, but from what I've watched online, it seems like everybody uses the real-wheel drive chairs. Is that 'cause they, are they faster than any of the other chairs, I'm thinking?

Uh, when you do spin kicks, you get a lot more spin. Speed, you can hit the ball a lot harder. A little better for maneuvering, sometimes.

Interviewer: Okay, hm.

I don't know how they'd be with some of the other sports. Never been in any of the other type wheelchair sports.

Interviewer: Right, right, okay. I wonder if power chair soccer continues to grow in popularity, if you know, there will be – they'll come out with, like, wheelchairs with that in mind. You know, kind of custom design, like you get a basketball chair or something like that. If they'll actually have –

A lot of guys – a lot of the people that can transfer or that have a disability where they can stand up and move from one chair to another, I know several of them. They have their chair that they use around home, and then they've got the one that they use for soccer.

Interviewer: Oh, okay.

And soccer's always the rear-wheel drive, and the one they use around home is usually a center wheel.

Interviewer: Yeah, okay. So even in that case, you have your sports chair.

Yeah.

Interviewer: Okay.

In my case, trying to transfer from one to the other, uh, I get one chair for all purposes.

Interviewer: Right, right. Okay. I would agree, plus it's one less thing to bring with you.

Yeah, and where do you store a power wheelchair?

Interviewer: Yeah.

They take a room themselves.

Interviewer: Pretty much. Hmm, okay.

Yeah, moving in crowds, you've gotta watch out for people stepping in front of you. State fair's always a fun one to maneuver. People will walk along and they'll actually step right up into the side of the chair and stick their foot out, and you run over their foot with your rail.

Interviewer: And they probably have sandals on too, because it's –

Yeah.

Interviewer: It's during the summer, yeah. It's one thing--

You hear a few words as you – you tend to ignore them.

Interviewer: And just keep going, yeah, like I didn't hear that. Okay.

If you're dumb enough to walk into me, that's your problem.

Interviewer: Uh huh.

Once in awhile, they're not paying attention and they'll walk in front of you. Usually I can avoid them; once in awhile I'll get an ankle.

Interviewer: Uh huh. Yeah. People just don't think about, you know, it takes a little while to stop, or something. You know, you can't just stop up like, you know, a person can or something.

Interviewer: Uh, yeah, so you talked about driving up hills is easier than going down. Now if you have to come down a hill, you usually just come straight down it? Or do you kind of see if you can switch back down it or anything like that?

I usually will go straight down, depending on – if it looks like it's real steep, I might try going a switchback and keeping the speed downhill.

Interviewer: Right, okay.

If it gets to be too steep, you might not be able to slow down when you get towards the bottom.

Interviewer: Right, okay. You ever try backing down something that's too steep, or not?

Mm... no, I haven't done anything real steep now for the last couple of years.

Interviewer: Okay.

Of course, having to get around here –

Interviewer: Maybe you will, okay. Do you ever find, like, if you're going up a steep hill and then you have to stop and then you restart again, do you ever kind of like, pop a little wheelie there? When you start out going up?

Yeah.

Interviewer: Okay.

Yeah, my tips get a checkout every once in awhile.

Interviewer: Right. Okay.

That's where – in power chair soccer, I've learn to trust the anti-tips because –

Interviewer: You've got enough to work there if you –

Play goalie and you're backing up, and you have to go forward to block a ball.

Interviewer: Right.

So you're moving backwards and forwards, and I've hit the anti-tips hard enough that I've gotten slammed into the chair back.

Interviewer: Oh, okay. Well I guess they're doing their job, then, if you haven't gone over backwards. Okay. Alright.

But it's not something I'd recommend that anybody try.

Interviewer: We've gone through most of this... so you'd said earlier, at night you'd prefer to just use night – use, let your eyes get accustomed to the dark and –

Yeah.

Interviewer: You drive like that, instead of using any kind of light, yeah.

Yeah. I prefer not to use any extra lights.

Interviewer: Uh huh. You live in an area where there's, like, street lighting and stuff like that? Or?

Yeah, there's some street lighting. Uh, I've been out in some of the parks where there isn't the street lighting, and I still prefer just what natural light there is.

Interviewer: Yeah, okay. Alright. Yeah, I've been working with one of my friends at the lab on trying to make some lights for a chair, 'cause he's always out in town all the time at night, and stuff like that. So we're trying to see what we can come up with, 'cause he didn't like any of the ones that are available, like on [unintelligible] mobile or whatever. He didn't think they were powerful enough, so. But, he does without now just fine, so, I don't know, maybe he would say the same thing if he actually tried – you know, got a flashlight out or something.

Yeah.

Interviewer: I guess you could use, like, red ones, right? Because that doesn't mess with your night vision, does it?

Never tried those.

Interviewer: Well I've heard, like, for reading, people using to read maps or something. If it's at night and you don't want to – you need a light but you don't want to hurt your night vision, the red color doesn't –

Yeah, like in the military.

Interviewer: Right, yeah. So if you had, like, red headlights at night.

[Laughing] don't know how well they'd light up too far ahead on the path.

Interviewer: Let's see... oh, you had said, don't – with standing water and stuff, be careful, find out how deep it is before you go trying to drive across it.

Right.

Interviewer: Okay. You said the creeks or even some--some puddles can be deceiving, I suppose. Yeah. Well the one that was deceiving was the one – we were crossing a creek that was – an old bridge had fallen down.

Interviewer: Okay.

So it was only about a foot of water, except it was a little dirty and you couldn't see the bottom real well. And part of the bridge decking had fallen away, so we got down into about a couple of feet of water.

Interviewer: Uh oh.

Didn't short anything.

Interviewer: Wow, okay.

The older chairs were well built.

Interviewer: Yeah, huh. That's cool. Have you ever had, like gotten caught out in the rain or something, and gotten the control, like on your previous chairs? You know, any issues with that, or?

Nope.

Interviewer: Never really had any water trouble?

Never had any water trouble.

Interviewer: Okay. Well that's nice.

The way they design them now, I think a guy could probably take one in the shower.

Interviewer: Really, okay.

They don't recommend it, but I think a guy could maybe get away with it.

Interviewer: Well, they're supposed to be making them that water-resistant. I wonder sometimes about, you know, some of the dials and the buttons and stuff on the controller, how water resistant those really are. But maybe... hopefully, though, they're making that easier.

Yeah, well everything's pretty well covered up.

Interviewer: Yeah, okay. Yeah, I hadn't talked to anybody that has been in – I mean, maybe an inch or two of water, but I hadn't heard, you know, a foot of water or something like that. Yeah, that's – if you were in something a foot deep, that's pretty good. I guess the motors would be underwater, but they still work alright.

Yeah that was--on that one, the motors were positioned differently.

Interviewer: Oh, okay.

Yeah, with these I don't know.

Interviewer: Yeah, oh on that one they were up higher a little bit?

Yeah, they stood vertical.

Interviewer: Oh, okay, alright. I guess, yeah, I have seen one of those before. Vertical, hmm.

The old Invacare 3P – it's about 30 years old.

Interviewer: Okay.

All the electronics on those was right under the seat, and the motors, the way they were designed, they were way up. The base of the electronics was way up high, so.

Interviewer: Right, okay.

Yeah, you got a foot of water and all the electronics was still high and dry.

Interviewer: Nice, okay. Is there any – from seeing wheelchairs kind of evolve over time, is there anything you think that they're still missing, you know, in the more modern ones that could be added to that? That you'd like to see on it, or not?

I understand that Permobil has designed a lockdown system that works strictly with theirs, where they have – the pin actually retracts up into the wheelchair.

Interviewer: Oh, okay. So you're not dragging anymore.

So you don't lose your ground clearance.

Interviewer: Huh. Okay, yeah I think I have heard that before.

I had a guy tell me that this spring.

Interviewer: Okay. 'Cause Permobil is here, we could stop by and ask.

And Invacare needs to do something like that. They need to get together with EZ Lock, or else develop their own system.

Interviewer: Right, okay. So a retractable vehicle lock.

Yeah, and when you're not going to lock in to the vehicle, you – the pin retracts up out of the way and when you're going to lock in, the pin drops down so you can lock into place.

Interviewer: Yeah, okay. Makes sense, makes sense. Alright.

Other than that, the improvements and stuff they've made over the years, everything – I don't know what they can do more.

Interviewer: Uh huh. Probably better batteries and more powerful motors. And electronics are – electronics are probably smoother, aren't they?

Uh, at points they're a lot smoother and they're really reliable.

Interviewer: Uh huh.

The last chair I had five, six years; I never had any trouble with it.

Interviewer: Wow. Okay. Wonderful. I guess that's how long they're supposed to work, right?

'Cause you can get a new one about every five years, right?

Yeah. They say –

Interviewer: That's the cycle? A kind of life cycle?

Yeah, I think about – they make the same model about seven years, and then they quit making it, so they make it obsolete. You can't get parts anymore, so you buy a new chair.

Interviewer: Okay. That's the racket. Alright.

They took a lesson from the auto industry.

Interviewer: [Laughing] You gotta get repeat customers somehow.

Yeah, yeah.

Interviewer: Okay. Alright, well. Do you feel like this chair, like what you got is a pretty good cost between something that works well outside and something that works well inside, or?

Yeah, it's – I'm not sure what they could come up with that would be better.

Interviewer: Uh huh.

Anything they come up with that would be better, then you start taking up more space.

Interviewer: Right, right. Okay, that's true. With as much as you do, like trails and things like that, what – I wondered about if you could make the tires, so you could actually like adjust the air pressure of the tires. So outside, you know, if you're on a trail, you could have like, four low pressure tires, like a four-wheeler would have. But if you're indoors or something, or on smooth ground, you could pump them up tight so you could get more mileage out of your battery and stuff like that. I'm not sure exactly how I'd do it, but I was kind of – 'cause it would give you a more cushioned ride, as well, with the lower pressure tires.

Yeah. I don't know how that would work, 'cause these, they've got – well, the front casters are solid and –

Interviewer: Okay.

The back ones, now they use a foam –

Interviewer: Oh, you've got the foam gel kind of tire? Okay, so they don't – so you can't get a flat tire.

Yeah.

Interviewer: Yeah. That's pretty good, pretty important. Okay. Yeah, well I guess in that case, that wouldn't apply. You have to have air tires to go and do that.

I used to be good at spotting thumbtacks in the hallways [laughing].

Interviewer: You hear the little "Shhhh," right, yeah I think that is something they've gotten better at, is the making the gel and the foam so that it feels like an actual air tire.

Yeah, along with the individual suspension on all four wheels now.

Interviewer: Okay. Oh, you have it on – do you have suspension on the casters?

No.

Interviewer: Or just the back tires?

No –

Interviewer: The front ones have it?

The front ones have some suspension built in, too.

Interviewer: Oh, okay. Very cool, okay. I didn't realize that. I knew they had it on back, but I thought most of the power chairs, the front casters didn't have any suspension on them.

I'm not sure on this one.

Interviewer: This one?

The other one –

Interviewer: The other one did?

The way it was designed, it did.

Interviewer: It did? Oh, okay. Alright. Yeah, this one looks like the casters are pretty much directly attached to the front.

There might be a little spring inside.

Interviewer: Yeah, could be. Yeah. Maybe inside that barrel.

Yeah, inside.

Interviewer: Okay.

There's a spring inside there.

Subject DS25, DS26, DS29, DS30, and DS31

Just run over them once, and I guarantee you, they won't do it again.

OK. Well, they can't power chairs can't stop quick enough. Mine can.

Well, some they can.

Well, I stop you know.

Mine stops pretty quick, but I don't, you know some of them don't give a shit. [laughs]

Some of them stop in front of me--stop and turn around on me, and it's like they walk right into me

You know what's bad, the fact that we're down low. [indecipherable] from the chest up and we're below them.

Interviewer: So if you had any experiences that you wanted to elaborate on, or ideas you have for how you would make your power chair – what you would add to a power chair.

I've got one for you.

Interviewer: OK.

They should have some kind of an adjustment for stopping. I don't know; maybe some chairs do. I know mine doesn't. Like mine, if I'm hauling ass and I let go man, errp, if I don't have my seatbelt on I'm out of the chair. [laughs]

Interviewer: OK. OK.

I mean some chairs may have an adjustment for that, but mine doesn't.

Right. You're talking about an ABS brake system so it doesn't stop you so fast.

Well, no. No, now they have this new system out now they're going to put in automobiles where it can – I think maybe cars even have it already, some of them – that they can tell if there's a car in front of you.

Interviewer: They use a radar [indecipherable] on cars.

It's a sensor they've got.

But some kind of super sensor...

You get in congested with [indecipherable].

And another thing we'd always be stopping.

I don't think it kicks in– I was reading on the Internet last night about it. It's a – I think that you have to be going a certain amount of miles per hour or more before it even, that sensor thing even kicks in.

Interviewer: A better horn, a better horn, OK?

Mine I can reach with my finger when I'm running. [beeps]

See I don't have that finger dexterity.

Interviewer: So it would almost be better if you had a horn built into the joystick. So you could just like [talking over each other]--

Yeah it would be nice, yeah.

Years ago you could get them with handle bars and you'd have a button right here.

Interviewer: OK. What about – I know two of the things we're looking at in the controller we're designing, that were focusing on – is like slipping and sliding traction control and tipping like when you're on hills and cross-slopes and you know sideways, and so, is there anything...?

Just stuck in sand and gravel and stuff like that, that might come in handy.

Like if I'm angled that way, I'm this way.

You have to adjust yourself to it. But like you would use a riding lawnmower where you were going down the hill, you got to lean.

Interviewer: Yeah, you got to lean to one side.

You got to do it with the wheelchair, too, a lot of times.

You have to be aerodynamic.

It's fortunate that my arms come up, but I also participate in bowling.

Interviewer: Right, OK.

So in bowling--

That helps.

--It helps -- but for people like him, his arm rest doesn't come up.

Yeah.

Interviewer: Right.

I've never seen [indecipherable] If they don't come up they come off.

[indecipherable] You get the [indecipherable].

Yeah.

Interviewer: Oh, and you got to stick it back in.

Make sure it goes back in.

Interviewer: Right, right... So then they're saying that a good thing to have the arm--

And a lot of time when you put it back in--

[unintelligible] it's a good feature because I can shoot 9-ball and go bowling and things like that.

Right.

Interviewer: Bowling, yeah. When, in like--

Sometimes it's like it doesn't [indecipherable].

Like with this chair.

Interviewer: Right.

My other chairs don't have this you know.

Interviewer: OK. What do you find be like the hardest stuff about driving outside?

Mud.

Interviewer: Mud, OK.

Anything, whether it's grass, or dirt or cement if it's wet--

Interviewer: Yeah, you'll be sliding all over the place.

[indecipherable] one way or the other way.

Yeah, certain grass you can drive on; certain grass you can't.

Right.

Interviewer: Yeah, you probably don't have that problem. [laughs]

Damn I think he can go across that damn river.

They look like floater tires.

He's got one better, yet. You know had it special made for him.

Interviewer: Oh, yeah. I saw that one. That was a beast.

Oh, that one that's like a stainless steel?

Yeah, yeah.

That's the one with six wheels on it.

With all aluminum wheels on, aluminum...

Aluminum, yeah.

Yeah, like anodized aluminum.

Interviewer: So when you're slipping you know around outside, do you just slow down?

Interviewer: Or just slow down and go really slow.

This chair is--they told me, the manufacturer told me, and the book told me when you are in sand or stuff like that and you're slipping to actually put it in 3rd to 5th gear and go.

Interviewer: To go faster, right.

You've got to get out as quick as you can.

Interviewer: Well, I've had -- you know in other discussions I've had, people talk about gravel, where they're saying you know you've got to keep moving. Or else you sink down in it and you'll get stuck.

Yeah, you'll sink down into it.

Interviewer: Right.

It's best if you go in a kind of zigzag angle. That you don't be going straight [unintelligible]

Interviewer: OK, you've got angle a little bit, OK.

[indecipherable] and what I find really annoying and [indecipherable] design, too, won't help, is get on the sidewalk, there's no way to get off it. So you've got to backtrack.

Yeah.

Interviewer: You get on it on one curb cut. You go down the other end and there's no curb cut.

There's no curb cut. You've got to come back and go back--get out in the street--

And sometimes drive on the street.

Right.

Well, they've got newer treads where the wheels adjust to the curb and everything else.

Well, this one does. It'll jump up a five inch curb.

But not all, not all the chairs do that.

My manual says it will go up a [unintelligible] curb. I ain't got it to go up a half inch curb yet.

Interviewer: Oh, yeah.

I can't get bounced around too much though, because like all of my [indecipherable] and I can't take the banging.

If that curb is that high there's no way, but if it's down here, I could probably get up.

Right.

I could bleed internally with [indecipherable]. [laughs]

Interviewer: Yeah.

But I would have to go in a certain angle to get that wheel and then--

Interviewer: To get up on the curb, yeah. You got to get it at an angle a little bit.

Here's another one, why--

When you [unintelligible] it up the front wheels jump off the ground?

Interviewer: Oh, it kind of rears back on you a little bit? But you've got wheels in the back, too. So you...

[indecipherable] you did have wheels in the back too--

That's what I wanted to talk about the wheelie part like on this model these wheelie bars are completely non-functional, I mean there's no way in the world...

Yeah, that's non-functional. [laughs] That is--that's I'm not going to say on tape what with that. That's more than nonfunctional. [laughs]

Yeah, see those...

[indecipherable] my chair.

Look at how high mine are. They wouldn't be no good for nobody.

[indecipherable] over the curb.

They don't [indecipherable]

Interviewer: Yeah.

See I've got a different type, I've got the [indecipherable].

Interviewer: Right.

And that [indecipherable] trying to go up over a curb, at certain places, stores and stuff, you gotta get into. I can't get into it [unintelligible]

Like the [unintelligible] says it'll go over a 3 inch curb, I can't get it to go over a half inch curb.

I mean unless I get bounced around, but I can't [unintelligible]

A lot of chairs are built too low to the ground.

Interviewer: They don't have enough ground clearance. OK.

Right.

I can do it at an angle, but it jars the shit out of me.

There's got to be a better way to ease up to a curb [indecipherable]

Interviewer: OK.

Unless you have like that there; there are places that you want to go and you can't get there.

Interviewer: Because it's too low down, and you get stuck.

It's too low down, you've got a boat, you've got a boat under there. It hinders you from going different places.

Interviewer: OK, like the EZ Lock thing. Yeah, yeah, I've had people mention that.

If I had my way I would make an all-power wheel chair – all wheel drive.

If you need it, you just need it.

Like my – these wheelie bars, because one time he – the Permobil rep he (lifted?) up and them wheelie bars, if I would have--If [indecipherable] on my back those wheelie bars would not have done anything.

No, they wouldn't.

All they do now is punch holes in the plaster walls where they stick out so damn far.

Right, yeah.

Interviewer: Huh, OK.

And then I took the wheelie bars off, and Jesus Christ, the VA went through the roof. "You put them on right now." I had them in my pouch, and they went and got the – a socket set and put them right back on while I was volunteering.

Interviewer: Yeah. They wouldn't let you do that.

I was – good thing I – I was – I was going to cut the whole thing off with the dremel tool. [laughs] Good thing I didn't. Like I said hopefully--you know within a few months I'm hoping to be out of this.

Interviewer: Yeah. Wow, OK.

I'm having 2 of the 4 surgeries done to get back in the [unintelligible] And the other two, I can get the injections instead of surgery. [laughs]

Interviewer: What about – if you're you know on a side-slope, you're like this or you know going up and down hill, you know I guess if you're in rear-wheel drive going up a hill, if you stop and then you start again, you'll probably do a wheel you know going up the hill, but... It doesn't?

I try to avoid, I completely avoid slopes. If I'm going downhill, I have no problems.

When you're on a slope the best way for you--

And not stop.

Is to--when you are in a chair is to lean forward.

Interviewer: Going up the hill?

Yes. You know put the weight [indecipherable].

Interviewer: OK.

But if you're going to lean forward, you better have a seatbelt on. Because I've done that before and whoop! [laughs]

Right. Well that would be--you know some people, they are capable of you know handling the wheel chair.

Yeah.

If the wheel chair has the capability of moving the weight.

But you've got the quad people who can't.

Yeah. See I have no muscle from here down. So if I'm [indecipherable], I can't even – I've got to do this to pull myself. That sucks.

Right.

That's why I can't wait to get back into [indecipherable].

The [indecipherable] automatically adjusts for the hill.

Interviewer: Right, right. Yeah, I've kind of wondered that, if – and another guy had mentioned he was getting stuck that – you know he'd kind of like you know rock around and try to get the center of gravity kind of moving around so his wheels could get traction and he could get unstuck. And you know if he could make a chair that you could move the seat forward or back with relation to the wheel, you could change that center of gravity that you know maybe he could just...

Well, Permobil has got that new chair out where you can press the button and the front end of it goes out longer, and then it come back in shorter.

Interviewer: Oh, really?

Yeah. They had it on the expo yesterday. Because I--

Interviewer: OK, I'm sorry I missed that.

I didn't drive it or nothing, but I sat in it, and then he showed me how the--and you can just sit there and you press the button, and the thing just goes out. The front tires go out, or they can come back in.

Well, that would throw your center of gravity off.

Well, and like he said if you're going to be on a long--it's mostly for like long outside basically even surfaces. But he said it will handle the, you know, inclines and declines and slopes and that. But he says the longer the wheel base, the more comfortable.

Interviewer: Oh, yeah. Yeah, definitely.

And that's why they do it, and they've got a – it's a lock-down thing that when you get to where you like it, you can lock it down. And then click another button to unlock it and move it again. And they have a cutoff feature where you can't – you know it disengages all your motors and everything except for that one that's moving the front end of it back and forth so you don't – you can't be driving [indecipherable] at the same time.

Interviewer: [indecipherable] OK. All right.

Yeah that was pretty sweet.

I wouldn't trade this chair.

But then it looks more like a scooter, though.

Interviewer: I would agree with you. I've watched some online videos, but I've never gotten to see one up close, so.

Interviewer: One of them chairs like he's got.

Yeah. A monster, I call it the monster truck chair [laughs]

Interviewer: Right. It will go anywhere.

Oh hell yeah, you can do a lot of stuff.

Well this one [indecipherable].

Interviewer: Right. Right. Do you use that in your house, or do you just use something else in the house?

My apartment is too small. I use it a little bit, but I'm able to ambulate once – yeah.

Interviewer: Right. OK.

As long as there's a wall or something's near me, I can handle that.

Interviewer: OK.

Except me, I got a – I have to transfer to either a manual chair or I have got the little, small power chair.

Interviewer: OK.

I can get this into my bedroom, and all my doorways are 36 inches and that, but you know it's...

Yeah, it's a tight squeeze.

Interviewer: It's a lot to move around.

Yeah. It's not an overly large chair, but the way you have to turn it you know.

Interviewer: OK.

What I like about this chair is it's got this center wheel, so it turns right around in a small...

Circle...

Interviewer: Yeah. OK. Yeah, I've definitely got different you know opinions on front wheel drive, rear wheel drive, mid-wheel drive, you know.

I think they should get rid of front wheel drive, I'm sorry. I'm sorry.

Don't be sorry, I'm don't like front wheel drive.

I got trained in a rear wheel drive, and I just...

Now mid-wheel drive is not bad, but...

Mid, I like mid-wheel.

Mid-wheel ain't so bad, but the front wheel...

Interviewer: The front wheel doesn't make any sense to you.

Because everybody pretends to forget they've got an extremely long piece of equipment behind them, and you'll see chunks of cement and plaster ripped off.

Interviewer: Right.

And people, and people, when they turn around, they don't realize what your turn radius is.
[indecipherable] You run [indecipherable] people.

Yeah, it seems like with me – now see here, my turning radius, I have to, I have to watch myself and you know the people around me. You know like getting into like the elevators over there. You can't see the back of you, so it's hard for you to judge.

Interviewer: Yeah.

Put some mirror's on it or something you know so you can see, you know.

Yeah.

There you go.

They need to design different types of mirror systems so we can see; a lot of us can't turn our heads.

Interviewer: Right, yeah.

Well, like they do on the cars, they got this you know...

Interviewer: The little camera...

A camera...

Or bicycle mirrors, I bought the ones that you put on your eyeglasses.

Something so you can see--

They weren't bad, but then you know if you like two big old dimples on your nose for a week. You know they should come up with something so that you can see behind you, even a little LCD thing or something.

Interviewer: Right, right, OK.

I probably hit ten people--I go, "Is there anybody behind me?" That's the only choice I've got, and nobody talks. They go, "Hey, hey, what the hell you doing?"

Well, the way they make cameras now really, really small.

Interviewer: Oh, yeah, yeah. They can definitely do that.

They could mount them on the back and that.

Then you're trying to move up, move up, and you can't move up.

Interviewer: I know in Europe, like I was in Europe one summer and over there, they're required to have headlights and taillights and turn signals on all their power chairs.

Like a bicycle. Do they have licenses for bicycles? You have to have a license for bicycles.

Interviewer: Yeah, well, that's good to hear.

No, you know they got certain areas for bikes. They should have certain areas for chairs.

Right.

Interviewer: There you go.

They have the bike trails and the lanes on the road.

Interviewer: Yeah.

They should have the same thing for wheelchairs.

Yeah, like right back here, [indecipherable] "Hey, hey, get out of the way."

Interviewer: On the edge of the road?

And I was on the bicycle walk. Why am I not – you've got two tires, I've got four. Why aren't I allowed on that? I mean this guy yelled and screamed at me, "Get the hell off of there. That's for bicycles." "Well, I'm sorry. I can't ride a bicycle." [laughs]

Yeah. This is our bicycle you know.

Interviewer: Right, yeah.

These are my legs, this is my bicycle.

Right.

Interviewer: That's bad. I mean.

My ass warmer, everything. [laughs]

Subject DS27

Interviewer: Okay. Cobble stone?

They're bumpier and so I try to avoid them if I can.

Interviewer: Is that, is cobble stone, does that hurt when you go across and you're bumping or is it just annoying?

Just hurts.

Interviewer: Hurts. Okay.

It jars me.

Interviewer: Okay, what about, just for the record-

I work for a living so when it's 90 degrees I'm sitting out in the sun [unintelligible] in this.

Interviewer: Oh my!

Because I like outside. It don't bother me.

Interviewer: It doesn't bother. Okay, good deal. Oh yeah if you're doing roofing.

You know, how the hell could you sit out there all day? Well, look at my arms, you know. I can [unintelligible] myself and watch traffic go by. It's very cold. I've been was living out in Montana, I've been out in the winter when I--you know never [unintelligible] when it's really cold, it's never... it affects my hands because, you know.

Interviewer: It makes your hands stiff probably.

Yeah.

Interviewer: Yeah okay.

So, let's see... anything, anything else that comes to mind on your experience with driving outdoors and stuff you've learned, you know, that you wish you would have known in the beginning kind of thing on driving on gravel or dirt, sand?

Well, I know danger situations when I see them so I find some other alternative you know.

Interviewer: If you can't go around.

Yeah you know like ramps, all I had was a, I had a long ramp and I put carpet on it.

Interviewer: Okay.

But as soon as it snowed, it turned to slush.

Interviewer: Ooh yeah, 'cause the carpet held the snow down.

So I ripped the carpet off and tried sand paper but when you shovel sand paper all the grit, torn sand paper, and everything so it's better to have some sort of [unintelligible], you know, with sides so you can go up around it. Cork maybe with holes in it. That worked very good.

Interviewer: Oooh okay. So you can like push the snow through the ramp, like through the holes and clean it off better.

And it gives you grip.

Interviewer: Okay. Do you ever find being in Montana driving snow in ice and stuff like that, what do you, do you find it easier, do you go out in the snow much or not really?

No.

Interviewer: Not really?

Not much at all because if you get stuck you're screwed.

Interviewer: Yeah. Okay. So no ice probably at all. I mean do you ever, have you done it accidentally you know gotten caught in a little ice patch or something sliding around?

Well you're going to get stuck, and you don't go nowhere, and I just spin and I'm sitting there like an idiot going nowhere.

Interviewer: Okay so in that case you get somebody, you know, somebody has to come help you to get off the ice?

Yeah.

Interviewer: Yeah okay. What about in other tough situations like gravel and stuff like that if you've gotten, have you ever tried like rocking your wheel chair if you got a little hung up?

Well, I just do it like this [unintelligible].

Interviewer: More hurt.

I've been stuck [unintelligible]

Interviewer: Okay and did that help at all kind of like-

Well this thing is so light it ain't like [unintelligible] This is real light. This only weighs 206 pounds. Yeah 178, about 380 with me in it.

Interviewer: But you can kind of wiggle it and get it unstuck if you need to. 'Cause that's one thing we're thinking about was if, you know, if you could design a chair where the seat could move above the wheels like forward or backwards 'cause sometimes it would help if there was more of less weight on the drive wheels to help them get unstuck or something like that or help you when you're driving up and down hills to kind of shift your weight one way or the other so that you're more stable and don't have a chance of tilting over as much.

I wish they'd make a rubber track like that would go around this wheel and see the back wheel and-

Interviewer: Oh like a tank track.

Yeah.

Interviewer: Yeah there's one chair like that.

Because this, this is like a tank,

Interviewer: The way it drives, exactly, exactly, it is kind of similar to that. So you said pretty much the hills and stuff like that, you just, if it's too steep you just stay away from there.

Well, if I have to go up, you know.

Interviewer: But is it in the hills you do go up and down like in a park or whatever, is it easier you think to go up a hill or to go down it just in how stable you feel?

I think it's easier to go up a hill unless you have some sort of brace. If you don't where a seat belt which I don't, you're leaning forward and you're balancing.

Interviewer: When you're going down and you might fall out forward.

You have to stop and keep that momentum down.

Interviewer: Oh yeah. Right right. Okay. You ever have, uh, have you ever had any problems with feeling like you were about to tip over in some situations or even-

No.

Interviewer: You haven't?

No.

Interviewer: Okay. This is-

Most of the weight is down, low to the ground and it takes quite a bit to get that flip.

Interviewer: So this is a pretty good platform. Pretty solid base there.

Yeah. They should have something like the weight, like if it tips this way the weight goes this way.

Interviewer: Kind of like a sail boat or something. Yeah it goes off to the other side.

Interviewer: A weight would like slide over to the other side?

It defies gravity. You know.

Interviewer: So the cars tipping this way, the weight goes up so that it helps pull it back down.

Yeah.

Interviewer: Oh I get it, I like that.

Run by [unintelligible].

Interviewer: Alright.

It takes a little [unintelligible] magnet type thing, pull it over so you wouldn't fall over.

Interviewer: What about like with gravel and stuff like that? Have you been on it that much?

Oh well my driveway's made out of gravel and I have a long driveway. I lived in the trailer court.

Interviewer: Alright. Did you... how does that work with a chair? Do you find if you slow down too much you kind of sink down in it?

No.

Interviewer: Okay, is it pretty thin?

Yeah it's pretty-

Interviewer: It's not like deep gravel.

Even the big rock gravel you'll, you'll spin out if you sit but if you go slow you can get traction, sorry, you peel out, you sink at all, it's hard to get out.

Interviewer: Okay. So have you ever encountered like the deeper gravel where, 'cause I've had guys telling me for that they just got to keep moving. If you slow down you just get stuck. You know, you got to just keep moving through it. Is that, have you had that experience?

Yeah and that these wheels are front wheels. They kind of, I don't know, you can't go over a bump that's just more than that big.

Interviewer: Okay. 'Cause it'll dig into it. Or it'll stop, it'll stop your chair. Yeah. Okay.

Not enough shocks to get it up.

Interviewer: Yeah, you can't climb over curbs or nothing like that. Alright. See if I have anything else.

Interviewer: Have you ever got caught in the rain or driven through any big puddles after it's rained or something and had any problems? Does it bother it?

I usually put a plastic bag over it, you know.

Interviewer: And water getting up underneath doesn't really bother it. Well that's good. Okay. Good deal.

Interviewer: You ever, I don't know, what an example would be, maybe if you were on a sidewalk and then you had to get around somebody or whatever and so you kind of drove off the sidewalk a little bit so maybe you had one tire in the grass, on the side, you know, next to the

sidewalk and one's still on the sidewalk. Have you ever had that one happened and like started to slide around because you had one wheel on a different surface or not really?

Usually I just pull over and stop.

Interviewer: Stop, alright.

Oh I yell, Look out! No.

Interviewer: Move over! Passing on the left!

Coming behind you... just turn around and see me and usually move out of the way.

Interviewer: That was pretty much it. I mean, yeah, this was, I mean we wanted to do the whole thing just like discussion style 'cause that, you know, then people can talk about whatever and it's easier and usually when you've got a group of 3 or 4 people you kind of feed, you know, one person has a story and they're like, "Oh yeah, I remember this situation," you know but we needed the questionnaire so we actually had some, so we could get some numbers to make some graphs and stuff and so.

One thing I would like to get is a seat upper and lower.

Interviewer: Oh, the seat elevator?

Yeah.

Interviewer: They do have that one some chairs, just you didn't get it on this one. Yeah.

Because it-

Interviewer: Helps you reach stuff up higher.

Well, at the table, you know, table we eat at it's this high so I had to, you know.

We ate upstairs instead of coming down.

Interviewer: Oh okay, alright.

But you know it's just like, food up at the bar it'd been alright I could, you know.

Subject DS28

Interviewer: Um... is there anything else as far as your experiences, like I said, stuff you've learned since driving that you wish you'd known in the beginning kind of ways you've learned to get around outside, techniques and things like that? It would help new time wheel chairs users as well as help us, techniques 'cause with our controller what we're trying to look for are techniques, stuff that maybe you do because you've learned how to do that over the years kind of thing when you get in certain jams. If we could actually put that into a controller so that the controller did it and the person driving didn't even need to think about it, that's the kind of stuff we're looking for. So, related to-

Obstacle course. A way of training. In other words, you could make up like an obstacle like with sand, with snow, with ice, with uneven terrain, dry grass, all those kinds of things and then maybe someday in the future have it that you have to pass your test on one before you're able to drive and run somebody over to the hospital with your chair at age 96.

Interviewer: Right. Right. Right. Okay. Well I know stuff like that exists like there's been some develop of that for driving indoors but I don't, as far as I know, there hasn't been too much that's been developed for outdoors especially more for power chairs. So, yeah.

People just gotta fundamentally learn their, what's the word I'm looking for-

Interviewer: Limits?

Yeah.

Interviewer: Kind of thing.

Yep. 'Cause the first time, in other words, I will attempt a steep hill but if it's a steep hill that I don't think I'm going to make it to the top if I'm not in the mood to get stuck I won't attempt it but if I do have somebody with me there that if I do get stuck they can help me one way or the other then I'll take that chance maybe. So that's one thing you've got to learn. If you have somebody with you you can take a little bit more chance than you can instead of when you're by yourself because you don't want stuck. If you have a phone that might make it a little easier. If you don't have a phone, you're shit out of luck.

Interviewer: Right, right, right.

'Cause I have gotten stuck before like at our house we had the water main dug up before and they messed up my sidewalks and ramps and stuff and I ended up getting stuck and flipping over. The City came by and plowed my macadam ramp that needs the cement, the sidewalks and my macadam was like this in the air and I tried to go over it and anyway I got stuck. And another time I went over, there was a guy drove by and saw me actually got out, picked me up and threw me in my chair.

Interviewer: Oh wow. Okay.

Kind of amazed me, you know, that he was capable of doing that.

Interviewer: Okay.

So if you're with somebody, it's always better to be with somebody than not be with somebody.

Interviewer: Right. Right, definitely.

Depending whether you can take that chance if you've got somebody to help back you up plus the power of your chair it's better to get out of sticky situations.

Interviewer: And once you learn, learn what to expect in that situation you're probably more- Know when to eliminate something all together because you don't want to be upside down looking up wondering how you're getting back in your chair.

Interviewer: Yeah exactly. Okay. Living, you know with the winter time and stuff like that, what's been your experience with driving on sidewalks that are, you know, have packed snow on them or new snow and stuff like that. Are you find some, I mean, what's, what do you avoid and you know what do you, are you okay with in driving around in the winter?

If the snow is within 1 ½ something like that you can sort of deal with it as long as you ain't got anything so it's such and such slow. But if you've got something that's more like 2 ½ or more inches then you might not want to try the same thing unless you're with somebody, again.

Interviewer: Right.

And they can back you up if need be. But I usually avoid anything of, like, 2 or more inches. These don't get great traction and I just push them to their limits.

Interviewer: And with, you know, probably avoid, avoid ice as much as, you know, you might hit a patch that you didn't notice or something like that but other than that.

Yeah ice with snow on top is tricky.

Interviewer: Oh I bet.

Treacherous kind of thing because you've got 2 different things to deal with. So you've even got to be more careful of like maybe staying under an inch if you have like an ice and then it snows. So if you have like ice and 2 inches then forget it because you're going to push your body to death.

Interviewer: Yeah, sliding around, definitely. What have you found, I guess what we've really found in talking with people is there's kind of 2 scenarios people do. Like, if you're getting in a sticky situation they either slow down and kind of, you know, if it's traction or something like that, you know, sliding around, slow down, that seems to be kind of the key there. Get traction, you know, and get through it. And then you see, I've seen the reverse talked about with stuff like maybe a little bit of sand or gravel or something where it's like, people say you've got to keep moving through it because if you don't you'll kind of sink down in it and if you stop you get stuck. So they're like, in that case, you know, I almost like the faster the better.

Yeah and I got to be careful. My lockdown bolt in the back, I don't know if you can see that, you can see that in the back?

Interviewer: Uh.. let me look here. Oh is it more up underneath? No, I can't really see it. Right, I mean you don't get probably more than what, about an inch of, inch off the ground there? Ground clearance?

[unintelligible] Once you get stuck you're stuck for good.

Interviewer: Oh wow, look at that. Yeah, yeah that is really low to the ground.

See what kind of clearance I've got there, like about an inch?

Interviewer: That or a little bit under, probably $\frac{3}{4}$ to an inch.

So you got to worry about that. If it's bumpy terrain you've got to worry about digging in because if that sucker digs it's like getting stuck with your frame pushing, snow pushing your frame up off the ground. Then you're just going to zip-zip.

Interviewer: Exactly.

So you've got to be careful with that if it's, you know, clipped their lock down [unintelligible].

Interviewer: Yeah, yeah, well that's, that's the gripe I think most people have had is when you do have that feature on, it really limits you on terrain and stuff.

Right because then you can't boogey as fast to get through something because, you know, if I end up looking up at the sky you're probably going to be stuck-

Interviewer: Right, right.

2 mooses to dig you out.

Interviewer: Okay. What about, I mean if you, do you feel like you're starting to get stuck, can you shift your weight around a little bit to kind of get, change the traction on your tires to get, help keep going through.

Not too much.

Interviewer: Not too much.

I can try but it's, you know.

Interviewer: It doesn't really help.

And when he comes down off the bus, the ramp there, it's like his feet just hit the ground. He just starts to go down.

Starts to, you know, push forward, so I have to be careful on that.

Interviewer: Right. Okay.

So when I have a choice, like, they have both ramps set down on the bus. One in the back it's more like this and then the one up where the driver is more like that. I'll take the driver.

The one in the front.

And it tends to come over onto the feet.

Interviewer: Right, right. When you're, like with hills and stuff since you do have all the seat functions do you ever when you're coming down a hill let's say, do you ever tilt back, tilt your seat back?

A little bit.

Interviewer: So that you're not like facing, you know, down the hill?

What I got to worry about though is the ready to drive part. That's when I was sitting there I was trying to show you the lock down bolt but I couldn't move because-

Interviewer: It won't let you drive if you're too tilted back.

Yeah, it'll lock itself out and I had to work with it to get it back out of that mode.

Interviewer: Got it.

They need to make the change up.

Interviewer: That way so that when you're coming down the hill you're actually sitting more level if you tilt back a little bit.

But if I go back too far then it'll lock out on me. It's a safety precaution actually.

Interviewer: Yeah. Okay.

Technically when you're, you know, in other words, if I start sitting back it'll lock out where it won't move and you've seen people drive around with them all practically upside down, that's unsafe.

Interviewer: Stay away from that. Yeah. Like when you drive along, you're like-

If you're somebody that only wears about 150 or 200 pounds you can take a little more chance but this chair doesn't weight that much more than I do.

Interviewer: Okay.

I got about 355. This chair weighs about 450.

Interviewer: Okay. Have you ever driven anything besides the mid-wheel drive?

Yeah. I've had the, what was that one buggy I had? That big monstrous one that [name] has trouble with?

Interviewer: Was it a rear wheel or front wheel drive?

No it was front wheel.

Interviewer: Front wheel, okay.

So you've got rear wheel, you've got mid-wheel, and you've got front wheel. They're all different.

Interviewer: Oh yeah, yeah.

And some of them are set up to turn out this, they're like a bus in a sense where like wheels are like behind you so the wheels are like in front of you, you can turn with the turn but if the wheels are right behind you, you've got to turn a little late.

Interviewer: Yeah, do you... so have you just tried the front wheel drive and the mid-wheel drive? Have you ever done rear wheel?

Yeah.

Interviewer: You've done all three? Okay.

Yeah.

Interviewer: What, what's your preference and why on those? I mean what's your observation on driving the three different kinds of these.

Uh... it's hard to say. It sort of almost depends on I think that you get used to in the beginning. You know, what you're accustomed to. Like if you first drive with a rear wheel you sort of don't

want to change because then you go from like a great driver or super driver to a flounder. Know what I mean?

Interviewer: Yeah.

You're just not as good when you first switch because you're going into buildings and you like smack your arm or run into somebody's arm or whatever. That tends to be negative.

Interviewer: True. True. Okay. So... which is your first one? Is that, you definitely agree that you-

I'm thinking the, one of the first ones I had I think was an Invacare Storm.

Interviewer: Okay.

Tried to take a bat at it, a newer model back then or not. About '94.

Interviewer: Okay and that was rear wheel, right?

Right.

Interviewer: So was that-

The one that was mid wheel is one that I can't think of the name.

Interviewer: Okay. And then the, yeah, and then the front wheel.

It's kind of a bigger, heavier set frame structure on this one I'm thinking of.

Interviewer: Did you, did you find that the rear wheel drive one tended to go faster? Did you get more speed out of it and such than say the front wheel drive?

I think the other thing is that you can put together on a relativity is the fact that if you're used to, if you're a driver of a car or was a driver of a car, most cars are rear drive and that's what you're accustomed to so you sort of like that when you go to a chair.

Interviewer: Good point. I hadn't thought about that before.

See what I mean? If you learned how to drive when you were 16, that's the car you learn how to spin and do a doughnut with kind of first whereas it's totally different with a front or mid-wheel drive trying to do a doughnut but if it's same as what you're accustomed to in your car, you know, and then you've got a, cars that are front wheel drive too that are different.

Interviewer: What about like just weather, rain, stuff like that? Have you ever gotten got caught out in the rain or driven through any big puddles that caused any problems kind of thing?

Yeah at different times I got caught in the rain and what happens is you, I started shorting out and I was laying out in the middle of the road, well not laying out in the road but-

Interviewer: Stuck in the middle of the road.

Yeah. In a reclined position and people look at you like, what's wrong with this guy?

Interviewer: Exactly.

He's out there taking a siesta and I'm trying to drive by and get to work, you know? So they look at you a little strange and get irritated with you. But I was sitting there and it's going [screeching noise]-

Interviewer: Oh jeeze! [laughs]

So the rain you try to avoid because you don't want to dice up your electrical.

Interviewer: Exactly. Right. Okay.

And one time I was on the elevator at the VA in Altoona and I was sitting like now, like I am, in the elevator and all of a sudden I start to recline and laying down and they look at your strange like, Why are you reclining? How you going to get out the elevator laying down? I got stuck in

the rain that day. So usually you got to wait awhile, a day or so 'til it dries out, turn up the heater in your house and set it over the heater to dry it out.

Interviewer: Right, let it dry out.

So you got to kind of avoid that. A light shower ain't bad, you know, you can handle that with an umbrella or something but if it's rain raining, you better skip on that.

Interviewer: Right, right, don't want to get caught in that.

[name] always thinks that I should be able to see behind me like I have a cover girl mirror in it or something.

I'm, not the one on there. I glued the, stuck it to his head rest.

Interviewer: Or you can wear those ones on the glasses like what the biker's have.

I've never seen, I've seen them but-

Interviewer: It's like a little rear view mirror that hands, I think it's actually on a helmet. It hangs off the brim of the helmet.

Yeah I've seen those.

Interviewer: But yeah those just look kind of dorky. Look kind of weird but, you don't want to be wearing one of those all the time. I don't know, I kind of like the back up camera idea. Yeah. I don't know.

Interviewer: What, just find, like driving in groups of people, people assume you can maneuver just as well as a person walking can and so they stop all of a sudden right in front of you or cut in front of you and they assume you're going to stop or get out of their way and you can't.

Tell them what you do, [name].

What?

What do you do?

Interviewer: Run them over?

He does! You know better.

He's like, I'm first no matter what and if you're in my way, too bad.

Pedestrians always have the right away and people in wheelchairs always have the right away.

I'm disabled too. Now where's your manners?

Interviewer: Well I guess it's kind of like people in trucks. They don't understand what it's like to drive a truck, so, yeah you can't stop on a dime. I don't know.

Well, you know, the guys can slow down when they know they're coming to something at a point-

Interviewer: Just drive in the slow lane.

Right. Not speed up.

That helps to knock the people out of the way though.

Yeah... Well that's what they need. A video on how to slow down when you're in a wheelchair, slow down.

Interviewer: I don't know you're probably, I mean, you're pretty tall so do you have a problem with people not, just like looking over you at all?

Yeah.

Interviewer: You do still? 'Cause I know being as short as I am and sitting in a chair I definitely have that happen.

Couple years being in a chair you probably realized that you're almost considered like less of a citizen 'cause you're in a chair. You know, like you're next after me and-

Subject DS32 and DS33

Interviewer: And the first thing we've been looking at is traction control and slipping, so gravel, wet surfaces, snow, ice, things like that, we've been using a big sheet of Teflon, kind of like you probably saw on the ramp in there where they were doing that to simulate more of a slippery surface. And so one thing we're doing, at least on the programming side of it, is looking at—okay, so you're in this particular slipping situation, whatever it might be. How do you get out of it? What should be program in as to how to get out of it and stop the slipping? So whether that's slow down, whether that's—if one wheel's slipping, do you turn toward that wheel, do you turn away from it? You know, what do you do in these situations to try to get yourself out of it on your own, and what have you learned over the years in driving—how do you handle driving outside? Is there any techniques you've kind of developed that work for you?

P1: Basically going a suitable speed for the condition. Just like when you drive a car and it says it's 65 miles an hour, and if there's ice out there or snow, naturally you're not going to drive 65 miles an hour just because the sign says it does. I found that my chair, on occasion, will slip into high speed where you—speed range, this little control here. I had them tighten it up here, but it would go forward like that and when you hit your control to go forward, it would just jump. And next thing you know, you jumped right into a table. And it doesn't stop. It's not like you hit something and it automatically shuts off. It keeps right on turning, and I've banged up my knees that way, I got my hand stuck underneath the table, because—if you get under a table and a knob goes forward like that, and you're in, say, number four, for it to lift up, it lifts up, and it lifts the whole table and everything. So it can be very painful if you're not careful, and speed is the situation that causes that, so you need to constantly be aware of your speed control. Where you're at on the (torque?), or whether you're starting in first range, or second range, or third, or whatever. So I got my top speed set on my third range so it's, kind of, watches that. But again, the speed is what is the—and the surface of whatever you're traveling on, are the—what causes you to have accidents.

Interviewer: Mhmm. Okay. So are you saying that that speed control would actually like jiggle itself forward on it's own? Or you would bump—

P1: Either that or you actually bump it

Interviewer:

P2: You're bumping it—

Interviewer: You're bumping it with your finger.

P2: When you're using this one, or have a spasm. We actually had his changed out. That one happened a lot—

P1: And this should be a click. You know, click, click, click, as opposed to just, you know.

P2: Right. So we had to change so it's a lower profile and it doesn't get hit as often.

Interviewer: Oh, I see.

P2: Our occupational therapist says we had that same problem.

P3: And also with my right hand I—it shifts drives, and I don't know that.

P3: So you're clicking this one and it changes into a different drive and you don't know where they did it.

P3: Right, because I can't feel, so I really think that is an area that should be addressed.

Interviewer: So maybe, as far as like the control layout, either that control should not be there, it should be in a different—I mean, I think they probably did that so it's a big lever, it's easy to push, but it's almost too easy.

P2: Well in theory, this is just where you want it because you need everything accessible for where you're driving hand is. But it doesn't always take into account spasm, or something like he's talking about with the speed going too fast and then you're like—and when you move this, when you take your hand off of this it will stop. But if you're having a spasm and you can't get your hand—in fact you've got yours on right now. That's not a safe thing where it (touches?) the table, and then you don't realize what's—

P1: And to go along with what they're saying there, you should be very careful on what you are carrying. Whether you're carrying a bag or a tray or something like that, because what happens, you hit this, and then you're off flying with whatever you've got in your hand. And you may have something that catches on here and it's down and it's not going to stop until you run into something, unless you get whatever you've got off of this. And the other is if anyone comes to hug you, always turn off your equipment, because they'll lean down and next thing you know, you're taking them for a ride. And if you weigh 200 pounds like I do, my chair weighs 400, you run over their foot, it's going to break their foot.

P2: Right, and you even have that—we even have—like I help him get dressed, and I'll catch this if we—or I'll turn it on, I mean one way or the other, because you can hear it when it goes on. But, yeah. And all those effect when you're driving conditions with everything else.

P3: Something else that I have and I feel has not been addressed is the battery. I think like a lithium-type battery might be best.

Interviewer: Something like a higher density of power.

P3: That's correct. That's right, than this, because these wear—you run out of juice.

P2: You have to go quite a ways to run out because this is a powerful battery.

P3: No, I understand.

P2: But if you were stranded, or the electricity was off or something like that, you would...

P1: Well the main thing they got to do is have someone make sure your chair gets plugged in every night. That's what we do, and—whether you run one hour, or you run all day long. Because inadvertently, the next day you're going to be somewhere and before you know it, you're out of juice. And there's no reserve. This is doesn't give you an alarm saying, “You've got exactly one mile to go.”

P2: Right. You can see the bars but if you're not looking at that.

Interviewer: Okay, it's not that accurate. Okay.

P3: Also another area that I don't think was addressed at all is on the board—if it rains, there's no protection from the water.

Interviewer: Okay, and you've had trouble with that in the past?

P3: Oh, yeah.

P1: Oh yeah, I've knocked out my whole unit.

P3: Yeah, and I think that is the area that really should be addressed.

P2: Or making it waterproof, just so you know that it's waterproof and it's okay to be...

P1: I had a cup of liquid setting behind me—I normally set it back hear—and, unknown, it tilted over and the water went down into the system and shorted the—shorted this out. So these should be more—you should be able to go in the shower with these things.

Interviewer: [laughing] Well, I kind of agree with you. I know that there are like wheelchair durability standards that have been developed, however they're still voluntary. Wheelchair companies don't have to test their wheelchairs on this—

P1: Let's say you're in a situation that you're out in the park and all the sudden you get a thunderstorm, and you have to go a mile or something. You're going to get soaking wet. The controls are going to be soaking wet. Your whole chair is going to get wet from the water coming up, and next thing you know, you're stuck out in the middle of lightning and rain with no power. And you're not going to find too many people can push one of these chairs even if you unlock the wheels very far.

P2: Another thing that I wanted to address is that he has some trouble going down the ramp for our van because you're on a very narrow thing, and so he's turned around in the van and the wheels have to be turned to a forward motion, which if you start down the ramp before they're actually even, then you have the potential to go off—goofed up—

Interviewer: Right, cause when they swing around—yeah.

P2: And so—and even when you think that you're good, if you have a spasm—

P3: Which happens.

P2: Which happens. Or if the wheels decide they've got to twirl one more time—I don't know what it is—and our ramp doesn't have a very high lip, and so he's gone off with one wheel or another and it's a big predicament because you can't—

P3: We have an '09 Odyssey so it's very, very—

P2: It's not like it's a rinky-dink thing, but it's very hard and we have now have to have me standing by every time he's deploying and, even so, I can't change it because it will keep—

P3: She can't stop.

P2: It will keep going. It's got momentum from the little bit of a slant, and I think there should be something where you have a “I want to go really, really slow,” because if you have it on—

Interviewer: Like a three-speed or something.

P2: But if you have it on that, it won't make the little lip to get—I don't know how to describe it. It's a really weird thing.

P1: Yeah, I do—to avoid that, I put mine on one and a half speed and that way, it might do it, but you're not going to hit it that hard that it's going to send you over the top of it, or you take your hand right off of it and whatever. I think that to eliminate that, you should have a single wheel in the front in the middle.

Interviewer: Oh, okay.

P1: As opposed to outer wheels.

Interviewer: The two wheels on the outside—

P1: You still have your rear wheels and your drive wheels, but your guiding wheel should be in the front so it doesn't get hung up, like getting on the bus, as you probably have seen, you catch it there.

P3: And you have to have both wheels aligned just, you know, straight way.

P2: And in narrow things, like even our bathroom, the door in our hotel, the door is off and his chair barely fits. And if when you go backwards, the wheels—you can't go in far enough to

make it enough room to turn the wheels before you go back out again, so you have to do just the right maneuvering to get back out again. It's—

P3: Now understand, we're not complaining.

P2: No, we're talking about the wheel thing. Well I think you should have the outer wheels but also be—have an option to do what he's talking about, the guide wheel. I think that's a good idea. Or you could do another switch and say "I want the guiding wheel only," and then take these out of commission and—I don't know.

Interviewer: I never thought of like a three-wheeled wheelchair. They probably don't do it just because of the safety hazard—you know, it's like a three-wheeler.

P2: He leans forward and leans on those wheels, I—

P3: Like on a sports chair, you have three wheels.

Interviewer: Like a tennis chair or something.

P2: Yeah, but you have before leaned forward enough to put all of your weight on these wheels, and so if you only had one wheel that probably might not be a good thing. You could tip one side or the other.

P3: But it's worth checking out in your research.

P2: He's gotten stuck in the slush before, on the road, and just started—would not—

Interviewer: Just started sliding on—

P2: Yeah, total—just like you would with a car, only you're exposed to the elements in the wheelchair.

P3: If it's wet, my wheel's, my rear wheels just spin.

P2: And he was in some rock in our backyard and got absolutely totally—we could not get him out.

P3: Oh, man it was—

P2: Couldn't get his chair out, and got him out of the chair and then couldn't get him back into the chair because of the uneven rock and not—there's just—it was in an area he wasn't really supposed to be in

P2: But he had a mission. He thought he could just zip in there and do the mission and zip back out again and it did not work at all.

P3: It could get in there but it couldn't get out. [laughing]

P2: It was a bad situation. We ended up having to call our neighbor to help because I couldn't do it by myself either. I mean the two of us couldn't do it by ourselves.

Interviewer: Wow.

P2: But it was totally—the more we just dug more in, and there were rocks—that you know, flat rocks, and so that was hitting the bottom of the chair too, so also where our quick lock is. You know we have a quick lock underneath of there—

Interviewer: Oh, you have a quick lock as well? Yeah, so does [name].

P3: Yeah, I've got a question. If you come off the going down the ramp in the van, and you veer off halfway down to the left, and half of your chair is still on the ramp and the other half is not, what's underneath the chair that—

P2: That post that sticks out. That's the only—

Interviewer: That's rubbing on the ground?

P2: We're always—when that happen—

Interviewer: Yeah, because you've got that bolt that hangs down underneath, that quick lock bolt.

P1: That's the bad thing with the quick lock. You can't go across a loose piece of carpet without catching it, and the next thing you know, it binds up in the wheels if you're not careful.

P2: He's never had that experience but we've been leery about the ramp when it goes off. We've had him get off of the chair because he does have that capability to—but very difficult—and then try to lift the chair back on to the ramp because we don't want to have it go off the ramp, thinking we'll tear the quick lock—or the quick lock will ruin the ramp, one of the two.

P1: Now the most problems I've had with the easy lock, or whatever you want to call it, is trying to get hooked up in the car because you've got to get your wheels lined up, and then getting unhooked. Your tires are standing there and spin and it tears up your carpet, at least it's torn mine up.

P2: You mean when you push the button, you don't have enough time to push—to get yourself disengaged?

P1: No, I got enough time but like you said, sometimes if your wheels are not lined up, you got to get back—

P2: Oh, I see what you're saying.

Interviewer: So you got to like go forward and backwards and spin and, you know, kind of work yourself in there.

P1: But if you get on a—we had like a throw rug in the kitchen, and I'm back and forth, well it crunches up the rug once in awhile and once it catches under there, you're not getting off of that unless you've got someone else to help you change to another chair, and get out of your chair, and then undo the levers on the back and then they push and pull to get it off of their carpet.

P2: One thing that helped with the quick lock in our van is we don't have carpet—or I shouldn't say that. We did have carpet and they cut, you know like what you'd put under your desk, where you'd put your desk chair?

Interviewer: Yeah, the plastic stuff?

P2: Yeah, the people that do our mobility stuff cut that plastic all totally so it covered up the carpet, so you were on that hard plastic—

P1: That's a good idea. I...

P2: Yeah, and they did it so wonderfully that all the tracks—the plastic is under those tracks and everything. And then in our van that we have now, it was already made that way. They took out the whole—the lower stuff.

P1: So the little pinpoints are sticking up?

P2: No, down.

P1: Oh, okay. They're still down.

Interviewer: Into the carpet.

P1: But I wonder if they work better if you actually had them sticking up?

P2: I'm not sure because I want to be able to—

P2: —walk in there or lay stuff down and I don't know.

P1: Well you can, it's just a little plastic thing. You don't want to walk on there with your bare feet. [laughing]

P2: But that part works really well, and the other thing we did with this vehicle is that when they put the quick lock spot, they moved it over as far as they possibly could to the left toward the

inner part, and then that wheel thing that you're talking about on the side doesn't happen, and he's had way better drive-in and click and you're in place because you've got like maybe that much more room. It's not that much of a different but it's a huge amount for your forward motion.

P1: I'm constantly opening the side door and...

P2: Yeah, I know what you mean. I know what you mean. But they moved it over as far as they possible could. We—where the new position was going to be for the quick lock.

P1: Well I used to—I changed my arms out because I broke these off so many times, hitting the walls or something like that, and they were sticking out longer—the other chair—this chair when they were newer. And so I said, the third time that I'm about to have them replaced, I said "I'll just go get me some chair-rail molding and fix them." I haven't had a problem since.

Interviewer: Does—do these not have horns, this particular controller?

P3: They do not.

Interviewer: I did not know that.

P3: Well now you do.

P1: And you can order one.

Interviewer: Can you?

P1: Yeah, you get a little horn device and it hooks up to your power supply and you push the button. But I agree with you. It should have a horn because you've got—when I go to Virginia Beach on the boardwalk, you got people with their head up in the air, and you don't want to run over anyone because if you do, they'll be suing you for breaking their foot.

P2: Well we actually had an experience where our daughter, who is used to being around wheelchairs all the time because of her dad, a number of years ago she was in that kind of—it was like a fair kind of a situation at the beach—and a lady in a power chair rammed into the back of her heel. And she wasn't there and my daughter didn't stop. She was walking but the lady did not control her wheelchair and it cut her heel and she ended up having to have physical therapy and the whole bit, and the lady—my daughter was so shocked that it had happened—and immediately felt pain, but didn't even realize it was this big old cut—she had to have stitches and everything—the lady said, "Oh, sorry!" And she went on. We don't even know who the person was.

P3: Yeah I would have liked to have caught her.

P2: But her—she had a plate like yours.

P1: It's like the skiing. A young man racing down the hill with another guy, and I'm waiting for the rest of the group to come down, and he hits me dead center in my back and knocks me 10 feet out of my skis. Now I'm weighing 210 pounds and I literally thought I broke my back. I was—all I could do was suck in snow in my mouth, and fortunately the only thing I broke was my hand, but he kept right on going. He caused the accident and fortunately for Wild Turkey and water, I was able to make it through the rest of the day. [laughing]

Interviewer: Okay.

P2: But I guess awareness of your surroundings is—that's I guess why I brought up the thing with our daughter because that lady had no clue what she was doing, or she could have had a

spasm or whatever. It was maybe not even really something that was—and she didn't know how serious it was.

P1: I think lights and the horn for any wheelchair that you're going to take outside, you should have, because most people, they like to go for a walk and there's not sidewalks so you've got to go down a street in a neighborhood or something like that, and at dusk if you don't have something flashing or something like that, people are going to run right up on top of you.

P2: I was thinking about getting just like—regular bikes.

P3: What bicycles have.

P2: Yeah, I was thinking about that when we—not that long ago we were out when it was getting kind of dusky, and you said “I'm getting kind of uncomfortable that we're out here too late.”

P3: Because if you really think about it, the public doesn't care.

P1: I don't think it's they don't care, it's just that they're only looking for cars and they're not looking for wheelchairs. Because I used to ride a motorcycle, and the reason I quit was because people would cut in front of you, slam on their breaks, not even realizing you're in a different situation than they are, or not even realizing you're there.

P3: I know, I know. I just—it pisses me off. My wife doesn't quite agree with me on that but I—like I was a chaplain in the Air Force, and I just get pissed off at the public because they are either—they're always in a hurry and they don't have time to slow down.

P2: Yeah, I agree.

P3: They don't care. Okay, I don't care either. Just stay out of my way. Leave me alone. I'm being honest here.

P1: Well again that's just like the survey says, you try to avoid the situations.

P3: Well that's true.

P1: If you know there's going to be—going to a football game and everyone in the world is coming out of the same entrance and everything, you either go early or go late or don't go at all, because you're going to get in that crowd, and someone's going to be pouring beer on you, walk into you with a cigarette lit, or anything like that, because you are not at their level.

Interviewer: Yeah, and they're probably just going to look right past you or over you or something like that.

P3: You know basically these are good chairs. We're satisfied with them. I am. You can tweak them by perhaps improving some things, but the things is whatever—when you're done with the study and you compile all of your information, it's going to take at least three or four or five years for something like that to be put on a wheelchair. You know?

Interviewer: Oh, I agree.

P3: It'll take time.

P1: But these companies should do—like Invacare—they should come to the VA or a veteran's, you know, and like we're doing a study here. Hire people to do a survey per year, or six months, on testing their product and the problems that they have and use that data to build a better wheelchair. Because we can set here all day—

P1: the worst thing this thing is, it doesn't have any hydraulic springs in it or anything. Not that that would help you—it's got these springs in the back, but that doesn't help you [talking over each other], and you hit a bump, it jars the hell out of you, or it's going to flip. If you hit something hard or it just lurches you forward or something like that.

Interviewer: Your main wheels don't have any suspension probably.

P1: Right.

P3: But I have to say, it gets the best gas mileage of any vehicle that I've I'm driven. I'm going tomorrow to 21st Century Scientific, where they manufacture the bouncer, and they're going to loan me a chair for the event for Saturday for the outside park—in the river...

Interviewer: The power something?

P2: The Power Rally.

P3: Power Rally. But it's got springs on it. It's got the lights. It's capable of—if you get the right one it can lift you up, stand you up straight. You can move the chair standing.

Interviewer: Is one of those. Okay.

P1: Yeah, definitely, because I can't take this flat ride where you—like the old sports cars, they don't give. And this is a ton height wise that if you did spin around, you don't stay on the ground, it's going to flip.

Interviewer: What do you as far as driving—like with the hills—I mean, where do you find problems with either feeling like you're going to tip over, what kind of situations are those, or will the losing traction? What situations do you find that happens?

P1: I went up a very steep hill once, and I thought that I would run out of power before I got to the top. I shouldn't have even done it, but I finally got all the way up to the top, so my neighbor says, "I'm scared to death you're going to go down the hill." I said, "[name]. Would you mind walking in front of me?" [laughing] Because [name]'s a big lady. [laughing] I said "Just in case, you just fall down and stop me." And fortunately going down was not as bad as going up because I just put it in low range and just went down as slow as I possibly could without having to lose that situation. But I would have to be doing it on gravel or on rocks because this chair does not do well on gravel unless you've got a hard foundation underneath it. And the same thing with sand or wet. You're going to be stuck out there until someone comes and pushes you.

P2: We did a service project once for someone in our Sunday School class, and her driveway was like this, and so we had a person in the back helping push up so he could have access to the house to help, up their driveway. And it was quite steep, and then on the way down, had somebody holding on the back to just kind of give another—even though he was in a slow speed. And then when you get anything that's like that down to the bottom, you've got to--

Interviewer: Transition.

Yeah, and the chair doesn't do very well with that either. A chair—any chair.

P1: It's just like coming across the (bump?), coming into the back of this building over here. You know, I mean on the other building. You come through the garage there, and you got a ramp you got to go up, and you hit that hard—forget it. You're going to—you just hope you hit it even and--

Interviewer: Instead of with one wheel, it would knock you off kilter.

P1: Yeah, and my driveway is probably about 30 degrees at home, and I don't want to put it in a high speed range because this thing starts lurching on you because you're going too fast. And if you know you're doing that, stop, put it in a lower speed so that you're not lurching because you're going to lose control on that.

P2: I think it would be really good for a new power wheelchair user to have something to peruse through, a book of some sort, not just how to run your wheelchair, but what you guys are doing I

think is a really good idea to come up with some teaching for them, and then also to—like scenarios of this is what works, these are danger things, this is another way approach it. Because some of the things we learn by trial and error, you can get injured in the trial and error period.

P1: Yeah, unfortunately the VA does not have a long enough training program for wheelchairs. They've got good quality technicians, but they don't have the time to build in to make sure you understand the problems that you're going to have on the outside. I had one pick me up because I wanted to see what the quickie chair, with the powered assist wheels, would do in the gravel and on the grass, and it really worked very well. But again, any of the chairs, you get real wet grass or something like that, you're going to start slipping and sliding. But you need, like you said, a course that you have to be certified. If the VA's going to buy it for you, you've got to know how to use it before you take it out of the building there, just like they give you a driving test to get your driver's license.

Interviewer: Yeah, that's kind of what we were thinking of.

P1: But they don't have someone certifying if you're capable of driving the wheelchair that you're going to be using.

P3: You know it's just like I look at this as my legs because I can't walk or anything. I'm paralyzed from the waist down. But just like an automobile, every year since—(about 16 years?)—there's always something, an improvement on it. And I think maybe that might be a goal for this, is adding an improvement like that, you know, to make it consumer-friendly.

Interviewer: But—

P3: I mean, I'm thankful and I'm sure my brother is. We're thankful that we have this, absolutely, but we're just sharing, like you said, this is a survey, a research survey, so we're just sharing ideas.

Interviewer: Yeah, no. That's exactly what I was after. And yeah, I think obviously the most short-term outcome of this would be some kind of training material, a video, pamphlet, whatever something—training course. I know—and then a longer term goal would obviously be adding some of these more advanced features to a wheelchair, but that's a lot harder to do because that's, unfortunately, people don't pay for their own wheelchair, and that's when the big problem comes in is—wheelchairs are designed for the insurance company, no—they're designed so the insurance company will pay for it is what I mean.

P3: Exactly.

P1: The VA needs to put a—this is what needs to, the basics that have to put on a wheelchair before we will buy it.

Interviewer: They can, they can and that's kind of the avenue that's being taken in some cases.

P1: One is a video, or a CD, or a DVD on use with the book that comes out with it, if you have any questions on your particular model chair because a lot of things that the chair will do, and if you don't know that, you never use that feature on it.

P3: And you always have a certain percentage that are idiots and you—

Interviewer: Of course, of course.

P2: Well another thing in a booklet or something is to say that you need to adapt it to your own personal condition, too. Because if you have spasms, or if you have fatigue—fatigue is another thing, because if you don't—if he's getting really tired, his driving skills go down, and that's another issue that if you just have it—you blanket this works and this doesn't work—but you

have to take into account, like you were saying, the road conditions and all of that—it's also your own personal condition. Or if you're distracted, or if you're depressed, I mean it all affects your driving ability.

P1: Well all wheelchairs, do not fit all people, you know. It has to be designed around that particular person based on his degree of capability of—because some of these people who don't really have the physical controls over, or they have limited controls, they can be very dangerous—especially if they hit the wrong button or something like that. So they should definitely be geared so they won't go [unintelligible] a certain speed, or there should be a kill switch. It's just like a boat. If you fall out the boat, you got the—

Interviewer: Wristband, yeah.

P1: Wristband, and you pull it out, your boat doesn't run off and leave you.

P3: Now also an area which wasn't addressed in this, and maybe there's nothing that needs to be addressed or can happen, is when we like go to the (next?) games in Denver, we fly. That means our wheelchairs have to be packed up and loaded, and then when we get to Denver they'll be unloaded and then the same thing when you turn around. The point I'm trying to make is, my chair has taken a—has been broken because of that. Now is there anything—and maybe there isn't and that's fine—that can make the chair, perhaps, more sturdier where it won't break?

P2: Well also that could be a whole other thing that you guys could do research and then put out something to the airlines in how to handle a chair. When we flew back from the games last year, they—okay, we were on a plane. We were supposed to be on a different plane, but we ended up being on a plane that the door height was too short to have this go in upright, so they turned it on it's side. Guess which side they turned it on? The control side. Now why would you do that? This whole thing got mashed up.

P3: Plus they put weight on top of it.

P2: Yeah, it was—number one, why were we—

P1: I guess that's the reason they say they're not responsible for—

P2: But they need some knowledge on how to handle a situation like that, and also when such a big group of us was traveling, why did they switch planes?

P3: But how do you teach an idiot not to do that?

P2: No, no. It's a knowledge lack. It's a lack of knowledge. Not really how sensitive—

Interviewer: Well it's one of those things that, I mean yeah, if you're going to take your cello on the airplane, you get a hard case for it—an aluminum hard case, and you pack it in foam because you know it's going to get abused. And there's no hard case for a wheelchair unfortunately.

P1: The problem you have is the people they hire at the airport, they're paying them 10 and 12 dollars an hour and they're not trained to handle or use this, so that's the reason before I even get out of my chair, I say “Look, you've got these releases here,” because they could leave your wheelchair on. You could be in the air for 12 hours, in time you get there you don't have any battery left.

P3: Well who did we meet here that had that roll?

P2: Saran wrap around the whole thing. Those rolls of Saran wrap all over the controls and everything because they've gotten so much of their electrical stuff messed up.

P1: It's a very good idea because my wires were hanging out. It's like they pull them out, but apparently something else stuck in there, or another piece of—and I said “Jesus, I hope they don't snap the wires,” because then you're out altogether.

P2: Right. There's some sort of battery that they have to—

P2: Well, no. There's some sort of batteries that they have to unplug, but these batteries they don't.

P1: Because they think they're (dry?).

P2: Yeah, so they have something in their brain that says like [unintelligible]—

P1: But they don't know the difference between a dry-cell and a wet-cell.

Interviewer: I used to use a power chair for quite a few years and, yeah, I don't think—like whatever they learn in ground-handling school is you know what--

P1: Not much because my daughter teaches them. [laughing]

Interviewer: But it seems to like they still think all wheelchairs have wet-cell batteries and I've never met anybody that still had a wheelchair with a wet-cell battery in it, and so I am definitely not sure—I mean yes, somebody needs to tell them. And you tell them they don't need to be taken apart but they don't listen to you.

P1: They don't—when you get the wheelchair, that's part of the training because the VA will tell you, “These are basic questions if you're ever asked,” and everyone gets a little carrying bag. You got a printed card right there in a different area that you need to—if someone wants to know your type of battery or whatever, it's right there. Or the weight or something like that, because a lot of people don't know how much it weight until they go in and have the chair weighed and then they say, “Wow, your chair weighs 400 pounds.”

Interviewer: I definitely—I had the same gripe and it's definitely that, you know, a power chair is not made like a suitcase. It's not made to be packaged up and put on an airplane. It would be nice if—I mean, most of the time, backrests can be dismantled—armrests and things like that—but there's no quick way to do it. There's no like airplane mode where you like fold your armrest down, fold the backrest down, take off the controller, stick it in the special spot under the seat, and—you know, it's all in this nice package with handles on it so they can just pick it up and put it in the airplane type of thing. That would be wonderful, but it doesn't exist.

P3: It would be awesome if you could develop and put on every one of these power chairs an ejection button.

P2: I was thinking a transformer. Make it like a transformer.

Interviewer: A transformer. I wish, I wish.

P1: You can take the heavy foam that doesn't break and wrap the middle on, and duct tape it on, or put it around the control here and secure it so—but that's something on top of this. It's going to break this thing off here, and without it, you're not going to go anywhere.

Interviewer: This controller, does it have a plug in the back of it or not?

P1: Yeah, it's got—well it doesn't plug in there, it's got—right here.

Interviewer: Oh, it plugs—

P1: I mean you could, but they're all sealed right here.

Interviewer: Because I know that's what I had done with my controller was I would take this—this was more of a quick release right here, and I would just unplug it and take this whole section with me as carry-on on the airplane.

P2: We've taken the legs, and the headrest and the seat cushion as carry-on.

Interviewer: As carry-on.

P2: Well he sits on the seat cushion on the airplane.

Interviewer: But I mean other than that, yeah, I mean the controller is obviously the worst thing.

P1: I found—I had my tires since I changed after three years, and the first week I was using the new wheels, and I was trying to get out of the van. It was spinning the wheel, and all the sudden the wheel fell off.

Interviewer: The whole wheel?

P1: The whole wheel fell off. All the screws came right out, and the screws were only about this long, so you might check that when you get home—see how long your screws are because they just barely catch the threads on the inside. You may want to go to a little bit longer threaded and put a lock-washer on it, because all of them were loose. All five of them came out one time over here. And these were loose on the other side, so I doubled the size. And you got to make sure you don't get a long enough one that will screw into the motor. [laughing]

P3: I remember a couple years ago, we had tube tires. And we were at the games and somebody said "You should really get non-tube tires." I said, "Oh, I've never had any problem with these at all." Well it wasn't too long at all that I did.

P2: They like almost made me swear that we were going to go immediately and get this type because they have people—

P1: This was like a donut. It just set inside the tire and the tire just goes right inside there and the hubcap holds it on. So it's not a separate hubcap that the wheel's mounted to. The hubcap is the part of the wheel that it (rides?) on.

P3: I'll have to check. I can't tell if his looks low. It shouldn't be low. It's not full of air.

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Interviewer: Yeah, OK. So the duty cycle isn't 100 percent. Right.

Interviewer: It's maybe more like 50 percent or something.

Right, and see for a standard wheelchair, this would be fine.

Interviewer: OK.

This wheelchair demands a lot of power, is what it does.

Interviewer: Yeah. [indecipherable]

It has onboard computers in the back of it that control and rationalize the power, depending on what you need.

And when you hit an uneven surface unexpectedly, it gives power to the wheels that need it, based on what it needs and at the same time, its stability. It's controlling the stability.

Interviewer: Right. Does it have a tilt sensor in it?

Yes, yes it does.

Interviewer: OK. So it will actually feel the environment and compensate for it. So if you're tilting too much, what does it do?

It compensates, or it tries to.

Interviewer: By like somehow adding more power like [indecipherable] you, so you're not tilting.

Right. Right.

Interviewer: OK.

And it will do it. It will go to a point where if something's in the way, it will ram it -.

Interviewer: So like if you were, let's say, going on a side slope, like this, normally a wheelchair would tend to like you know turn, it keeps it going straight.

Yeah, it don't do that. Yeah.

Interviewer: OK.

Now it does have a tendency when it goes fast to start dragging to the left.

Interviewer: OK.

And we're still trying to figure out what's causing that, because usually that would be wear and tear on the wheels. But it's not; the wheels are balanced.

Interviewer: Right.

That shouldn't be the issue why it keeps trying to stay (on the left?) versus the right.

Interviewer: Yeah.

Unless the drive is anchored on the left, and it's just naturally pulling to the left because of that.

Interviewer: And you have four motors or two?

It's four motors, one on each wheel inside the chassis, and one of them is a hydraulic motor.

Interviewer: OK. OK.

And that's for the lift [indecipherable].

Interviewer: OK. You do have a small hydraulic circuit in this.

It's very small. About like that, it comes with [indecipherable]

Interviewer: I mean we do have like a pump and a reservoir and all that.

Yeah. Oh, yeah.

Interviewer: OK.

And even what he has in it now, he only makes it heavy for stability purposes. It's not too heavy. The seat only weighs 30 pounds.

Interviewer: OK.

Most of the weight is on the bottom, which is another reason why you've got good traction for stability on uneven surfaces.

Interviewer: Right, OK. So what other, do you have any other sensors besides like a tilt sensor and stuff?

I know he has a sensor that deals with battery – it's a battery conservation sensor. What it does is it allows you to step up the power, without drawing that, that power from the battery. So there are step ups that will--for the demands when you are going on uneven surfaces that will give you the power you need without taking that equivalent power out of the battery. It simply just magnifies the power to what it needs to, or amplifies it.

Interviewer: Right. But how do you get more power without taking power from somewhere else? Because you don't get something for nothing.

Well, it's like – no, but you can learn to, with the passengers, store power in the first and then you'll have say 20 percent more power on this side of the fence than you started out with.

Interviewer: Yeah. OK. Does this use – well, does this use regenerative braking at all? Like you're coming down a hill, will it actually put power back into the battery?

Yes. Yes, it charges the battery.

Interviewer: OK. That's good to hear.

I told them that. I said you might as well. I actually told them we really need to consider putting an alternator in here, so that we can use the kinetic energy for our movement as a battery storage.

Interviewer: Right. OK. So you've got the capacitor bank for giving you an extra boost. OK, that makes sense.

Yeah.

Interviewer: And then the balance wheels you need to either have two-wheel or the four-wheel drive.

Right. But you know like I said when you start to get on that weird angles, it starts to give me more power. And the wheels that aren't being used at the moment, prepare, you know compensation.

Interviewer: Oh, so when it knows you're tilted because you're on a hill or something...

Or you're getting ready to tilt – it actually starts sensing the tilt before you actually get into it.

Interviewer: Right, OK.

So it starts to compensate. And by the time you're there, you're already moved. It's a smooth transition instead of a herky jerky or stop.

Interviewer: OK. Yeah.

I mean he did a really good job of that. I gave him the numbers, and he converted it into clinical manifestation. He did a really good job.

It has two batteries. It has power-compensating circuitries for terrain. It has – what was that thing called? – he told me about that before – it was his idea that particular idea. It acts like anti-brakes when you're on an incline coming down. That's when it uses – you'll hear it when it switches. You'll hear switch to that mode whenever you go downhill. You know it's charging your battery.

Interviewer: OK. OK. It will sound different.

Yeah, it sounds different and then it feels different, too, if that makes any sense to you. You can actually feel the difference.

I mean because the difference when I'm on a platform – a stable platform, horizontal – or going up a hill. It's a different type of feel than when you're going to downhill. It's like it switches to another mode to start the regeneration mode.

And if you have enough distance, When I went up to Mine Mountain, I went up to Pea Mine Mountain. It was an 8,000 foot summit.

But it was a graduated incline about like this.

And it was an – you know it was an animal trail. So it was an underground trail. And we got all the way up to the top platform where – because the salmon use that mountain. They have like steps in it.

Interviewer: Yeah, OK.

So what happened was we got all the way up to the top. I only lost like two lights. Then he said, "Let's go on back down the mountain." So we went back down the mountain. He started his compensation mode, and you could actually hear it starting the compensation where it switched into regeneration. And by the time I got to the bottom, I got my lights back. So I had full, you know full charge by the time I got back down.

Interviewer: And I mean at this point we're focusing on traction control and tipping, stability. We haven't gotten – we're still working on the traction control part. But we're trying it out like on different surfaces and you know seeing, trying out like different programs you know that we write and see which one keeps the slipping to a minimum.

Yeah. This is something that I learned when I was going up Mine Mountain. I'm going to show you. It's kind of hard to believe that there's no incline, but... Let me – when I was going – turn you on, first off.

When I was going up it, and I'm going to simulate going uphill. The seat, even though the chair would be in this position, the seat would be lateral with the...

Interviewer: Flat with the hill...

Flat, right. So – well, not flat with the hill, not angled. It's actually pretty level.

Interviewer: But I mean flat – level, yeah.

Right. So you compensate with the seat. You see what I'm saying?

Interviewer: You like tilt the core?

Right, yeah.

Interviewer: Yeah, yeah, OK.

And then if you're going downhill, you tilt it up, and you'd be straight, even though the wheelchair itself isn't.

Interviewer: Right.

So if you could come up with a system that can automatically do that.

Interviewer: So like an auto-leveling system.

Because there are people who are just never going to be used to the fact of dealing with those types of obstacles.

Interviewer: Yeah.

They're going to overcompensate, which you were talking about and panic.

And then they're going to hurt themselves doing it, because of the kneejerk reaction and fear of oh, I'm going to fall out of my chair of it.

Interviewer: Yeah.

You got to – you know there are very few people who are steady-headed when they're in a position of – you know they don't think first. They react.

Interviewer: Yeah, yeah.

And that's where the trouble comes. So if you could come up with some kind of a – and they would probably have to be some kind of gyroscopic you know sensor that would keep the seat level. That means you would have to have some – the wheelchair would have to have some measure of rocking formation where the seat is.

But safety-wise, it would eliminate people who can't handle those environments.

Interviewer: Yeah, because it would help keep the center of gravity more like right over where it should be.

And keep – see if you would have – if you're in a position where you're stable all the time, you don't panic. You think.

Interviewer: Yeah.

So when you're on a situation where you're on an uneven surface like that, it's not scaring you, because you're staying in the right position. You can actually operate your wheelchair more efficiently. And the thing is the same with a wheelchair. If you can get it so that the wheelchair eliminates the fear factor, then the person will control the wheelchair more efficiently.

And that's – I mean that's, that's the best thing I can think of that you can do to compensate.

Because there's always going to be bad terrain. And there's always going to be those unexpected terrains that you hit. Like for instance if it's wet, and the ground starts to sink, and the wheelchair starts to lurch forward, the seat compensates and the wheelchair, you know. You're not panicking and overdriving it and digging a hole in the ground. You see what I'm saying? And you got – you know you rock back, rock forward, and get out of the hole. You're

not panicking. Why? Because you're not – it's not a threat to you, because you're always in that lateral position.

It's a mental thing more than anything else, actually, that it would help a person to be more confident.

Interviewer: Right. Right. Yeah. Well, that's kind of – I mean that's what we were shooting for, and just to help new – I mean the idea being if you could institute all this stuff on a wheelchair, it would be safer from the get go. So as a new user, driving one without the years of experience, they're going to be safer right off the bat.

And if you build a wheelchair, but you can't do that, then some kind of a safety feature that says, "This wheelchair is not designed for [indecipherable] at steep angles of inclination."

So we – you can't do that.

Interviewer: Well, the thing is, though, those rules are on wheelchairs, now. They say you know don't go up a hill more than this steep. Don't go do – nobody does it.

But it's no good. Let me tell you why. There's no way to know whether or not the angle of inclination is bad for you or not until you get out there and do it.

There's no way to know until you're out there. Because you're not even going to know what the angle of inclination is until you're actually on the surface.

So there's no way to avoid it, until you get to it.

Yeah. So you're sitting in a car like this. OK. Oh, that's too much angle there. I mean the average Joe is not doing that. You know what I'm saying? So they need a wheelchair that compensate, or at least warn them, when they reach an angle of inclination.

And like I said before, they're not training anybody how to use these chairs. They give it to them, and they say "good luck." You see a lot of these wheelchairs with war scars on them. It's because these people were never trained. They're banging into walls and everything else they find. But driving a wheelchair should be like driving a car. They should have instructions on how to safely traverse point A to point B. I had to teach myself. I went out to the parking lot. First time in my wheelchair, I taught myself how to turn, how to you know, but I did that on my own. And I used driver's lessons. I didn't use wheelchair. I use the driver's standard for driving a wheelchair. That's how I drive my wheelchair. [laughs] And I needed it, because I was going to the post office every day.

Subject DS35

Interviewer: About... well, okay. Let's start with, have you ever had any situations with, like, where you lost traction? Like sliding and stuff like that? How did you – how do you compensate for that? How do you get things back under control?

Usually I point the chair downhill.

Interviewer: Downhill, okay.

And when I try to put my weight--uh, it's hard to in the middle of [unintelligible] put my weight on it.

Interviewer: Right.

But I'll try to find where the momentum is. And then I use that. I'll shift my weight towards the side where the weight is that. Unless it's going like off a hill or something.

Interviewer: Right. To give more traction to that side.

To get some momentum.

Interviewer: To get momentum, okay.

And gradually maybe use momentum like in a power sliding car, 'cause like, you can – if you were coming downhill and you were going across that way and you started to slide this way, if instead of trying to go back in there which makes you fall down, if you can point downhill and get some momentum and then gradually aim yourself, you can swing yourself back into it. So instead of--

Interviewer: Right.

That way you can get the momentum and then [unintelligible].

Interviewer: Because if you didn't have enough, you would just slide down the hill sideways. Sideways, yeah.

Interviewer: And then that would give possible tip over. Especially if you hit something.

Interviewer: Right.

So downhill, at least you can gain some control.

Interviewer: Yeah, exactly.

If you can't regain it at least you know where you're going to.

Interviewer: Right, right.

The worst thing is going backwards in one of these things and not knowing where you're going.

Interviewer: Oh yeah, I'm sure. Yeah, not being able to look back and see what's going on. What about, um...

The (first?) thing I've ever had to do was turn around completely and tuck my body and my head into the chair, to try to tilt it over. And that way I'll fall and when I hit, I'll hit on padding.

Interviewer: Oh, like you knew you were tipping over, and so you protected yourself by – Switching around and using the seat as padding.

Interviewer: Really? Okay. 'Cause which way were you tipping? Sideways or backwards? I was going backwards sideways, so I switched around –

Interviewer: Okay.

I [unintelligible] to protect my head and neck.

Interviewer: Right. And did that work?

Yes.

Interviewer: It did?

Tilted over and it--it's heavy enough so it didn't roll over me and I just rolled off of it.

Interviewer: Okay. Good deal. So, you know –

But then again, I don't know, I'm average athletic, but someone with a little less capability, I suppose, would have a hard time doing that.

Interviewer: Right, right, less functioning or something. Yeah. Falling out of a chair can be pretty disastrous for some people.

That's why I wish they would put springs in there. And then you could spring out.

Interviewer: [Laughing] like an ejection seat.

Yes, yes. Like a riding brake.

Interviewer: Okay. So, yeah.

Interviewer: That's true, that's true. Um, so like with the hills, you mentioned the sliding in conjunction with hills. Um, do you – how are hills for you? Do you pretty much stay away from them?

I try to stay away from them.

Interviewer: Okay.

And I think a lot of it is pre-planning. If you know where you're going, you can – you might take a bus. But you can't avoid it. I try to realize that if I might – some congestion I might come across, that if I can avoid it, it's awesome, there's not a whole lot of people out.

Interviewer: Right, right. Less crowded, okay. So –

I have a bad habit, I'll jaywalk.

Interviewer: Okay.

I don't get out during traffic hours.

Interviewer: Right. You don't want to wait for that light to turn.

Well sometimes, you go a little bit farther than your charge allows, and you have to be a little conservative and say, "Well, you know, I can save a little juice if I can cut across here."

[Laughing]

Interviewer: Oh, okay. So that's where the jaywalking happens.

Yeah.

Interviewer: Gotta conserve power.

I suppose you probably don't want to stick that in the manual [laughing].

Interviewer: Yeah. "If your battery is dying, jaywalk is necessary."

[Laughing] you probably don't want to put that in.

Interviewer: Yeah. Huh.

The worst place and the place that I love to [unintelligible] is the buses. When that ramp starts, ding, ding, ding, ding, ding, you automatically see the jaws get tight, like, "Oh, here we gotta wait for this guy now."

Interviewer: Oh yeah.

'Cause they're in a hurry. Of course, LA is the only place you'll find people that will race to a stop sign.

Interviewer: Oh my, yeah, the whole big-city-in-a-wheelchair thing, that's definitely – I have a friend that, you know, he drives a chair around all the time, and uses it almost like a car. I mean, he takes the bus a lot of places too, but you know, if it's a nicer day, he'll just drive his chair and he goes all over town. I'm sure he's had lots of close calls.

Yes [unintelligible]. There's different ways to react about it. I mean, you can get bitter –

Interviewer: Right.

But you know, you just gotta keep your head about you. Given the opportunity, I mean, how many people that you know – there's always, you can find nice people. You gotta look for them.

Interviewer: Right, oh yeah. And I agree. It's just wrong to have that view of people, that they're, you know, always be skeptical of people. You know, assume the best unless you have a really good reason not to –

Or they're [unintelligible].

Interviewer: 'Cause a lot of people are genuinely nice, you know?

Given the opportunity, I'd like to think people are nice.

Interviewer: Yeah, exactly. Exactly. Yep. For sure. Um, so stay away from hills, what about like, you know, if you're outdoors and you got gravel, or kind of dirt, you know, dirt, stuff like that – Under no means should one get on gravel.

Interviewer: No gravel.

No.

Interviewer: Because you just, the wheels are too little and they dig in?

They dig in. If you don't have any help to help push out you're stuck.

Interviewer: Okay. No gravel. So probably only, like, if you're going to go out, you know, stay on like, a packed dirt road or something like that?

Stick to sidewalks.

Interviewer: Yeah.

Unless you have one of those come-alongs.

Interviewer: So no –

You know, that wouldn't be such a bad idea, to have a –

Interviewer: A come-along?

Or, what do you call it?

Interviewer: Like a winch?

Like a winch, a little winch would help.

Interviewer: Right.

You find a person and you stick with it. They'll drag you out. [laughing].

Interviewer: Exactly. And you know, so far in the responses we've gotten, it seems like getting stuck, tipping over, and I know there's a third one –

Running out of power.

Interviewer: Slipping, like slipping, getting stuck, and tilting over are like, the biggest things people are worried about, as far as what could really go wrong, you know? Obviously, tipping over and getting stuck are the two biggest ones, but I have had people mention power before, it's just –

If there was some way to recharge while you're going –

Interviewer: While you're going? Okay.

Because the momentum of the wheels themselves would act almost like a dynamo or something like that.

Interviewer: Mm hm.

That would – whoever comes up that is going to be okay –

Interviewer: Well that--it exists, however, I don't think anybody's done it on wheelchairs. Yeah, well, actually –

Cha-ching [laughing].

Interviewer: soft, you just stay away from completely, which is a good idea in a chair like that. Um, so the cross-slips are probably out as well, you don't do any of that.

No.

Interviewer: Um, let's see. What about... um, what do you do, you actually said you like being around a crowd. When you're in a crowd, how do you, you know, make sure – do you just try to

stay back from people and give yourself enough room so if they stop all of a sudden, you have time to stop?

I make a lot of noise.

Interviewer: Make a lot of noise. So people just hear you and move out of the way.

And they see that – and people, you know, like people--even if [unintelligible]. They can tell the speed and they – I get going--but I can stop quickly. I don't purposely, I don't drive--

Interviewer: Right, yeah, sure. [Unintelligible] You're around.

I'm around.

Interviewer: Please stay out of my way, okay.

And I drive close to things like [unintelligible] and things like that, because you can move around those. People give those –

Interviewer: They'll stay away from those as well. So you'll be in the less busy areas, basically. Okay.

Interviewer: Have you ever – so you did say before, you had the problem with – you tipped over sideways when you fell off the edge of the curb.

Yes.

Interviewer: So that's happened. Have you ever tipped over forward or backwards, and what was the condition there?

Um, like I said I was fooling around trying to get on a ramp.

Interviewer: Must have been a pretty steep ramp.

Well, yeah. [Laughing] I didn't make it to the top.

Interviewer: Okay. What about, like, coming down a ramp? If you're not too careful when you hit the bottom where it flattens out, do you ever have a tendency of like, your wheelchair wants to roll forward?

Yes, all the time.

Interviewer: All the time?

Yeah.

Interviewer: Okay. So do you just have to –

I stand up.

Interviewer: You stand up.

I stand up and lean backwards.

Interviewer: Lean back?

Mm hm.

Interviewer: Put the weight back in your chair? Okay. Do you slow down at all, or do you just sort of power through it?

I slow down enough so that I don't jar. It hits because that will propel me forward.

Interviewer: Right. Okay. 'Cause that was one thing we were thinking, that the more – and this is almost at the wheels toward the front, so once you're coming down the hill and you catch, yeah, it's going to not be run over, so. Okay. So you kind of try to shift your weight to the back.

Interviewer: Um, do you – have you ever gotten in a situation where you kind of got stuck, um, but you didn't want to like, dig yourself into a hole, 'cause that would make you more stuck, so you know, maybe you like, rocked yourself to try to get more traction on one side? Or like leaned over one side to give that wheel?

I try backing up.

Interviewer: You try backing up?

And if I can't back up, I try to get up and then try to go forward with less weight.

Interviewer: Right. Stand next to the chair and drive it out, okay. That works. Alright. Any – let's see. Any other examples of – there's no real winter weather issues, obviously.

Yeah, I don't – winter at worst it's wet.

Interviewer: Got it. Okay. What about the night driving? How do you handle that?

I've got some lights I hook up.

Interviewer: Like um...

They're motorcycle – not motorcycle –

Interviewer: Motorcycle, or some –

Bicycle.

Interviewer: Bicycle lights? Okay.

One here, one here, and then in the back--the engine.

Interviewer: The two red ones. Okay. Hmm, bicycle, huh? So how are they powered?

Battery.

Interviewer: Battery, okay.

That's why a dynamo would be nice.

Interviewer: Wait. Are they the ones that, like, go on a headband kind of thing?

The kind you can put them –

Interviewer: On a headband, yeah.

Which, but instead of my head, I put them on the--

Interviewer: You just strap them down, like, on your controller. Okay.

Interviewer: so what about water and stuff? Rain and puddles and things like that? You have problems with that?

I just stay out of the rain.

Interviewer: Okay.

If I get caught in the rain, well.

Interviewer: Yeah, it happens.

I thought it would be nice if I had a canopy.

Interviewer: I think a lot of people wish that. Okay. [unintelligible] pushing out water. But when you've been out, like, after it has rained, so the ground's wet, do you ever have any trouble with, you know, sliding a little bit on the wet ground?

I don't go out when it's wet.

Interviewer: When it's wet? Okay. So you're pretty cautious of that.

Uh huh.

Interviewer: Not pushing the envelope too far, not pushing your luck, I should say.

I'll push but when I have as much control of the situation as I can.

Interviewer: Okay.

And then I push hard.

Interviewer: What was the deal with curb cuts? Why do you avoid that?

Curb cuts?

Interviewer: Yeah. The dish down on a curb, so you can get down? It's usually, like, at a stoplight? Where you go down to the road, across, and then up again?

Those are people's driveways.

Interviewer: That's true, yeah. People's driveways have similar things.

So that's why I go – I stay on the street.

Interviewer: Okay. So you don't – so you prefer –

I don't use the sidewalk.

Interviewer: Not to use sidewalks at all. Okay.

I mean, you live in the city, the traffic it's [laughing]

Interviewer: Yeah.

And I go against traffic.

Interviewer: Right, right. So you can do that, like in town? In LA – because the sidewalks just aren't – the curb cuts, the get downs they have, are they just pretty rough and not very good quality?

They are steep.

Interviewer: They're steep?

They're steep and...

Interviewer: Yeah, that could get kind of just dangerous.

Interviewer: Okay. They walk you around.

The only trouble I have to worry about is buses and trucks.

Interviewer: Okay.

'Cause I make sure that they see me.

Interviewer: Uh huh. But the cars see you but the buses and trucks don't.

Well, I try to stay--I try to get near the middle line if possible. So I'm right up there where the cars are.

Interviewer: The middle what? Like you drive down the middle of the – Street.

Interviewer: Wow. Like between one – if there's two lanes going one way and two lanes going the other way, you would be like on the double yellow –

As near to where it starts to level off as possible.

Interviewer: Wow, okay.

So all streets curve–

Interviewer: Crown, yeah, they have a crown. So you stay right in the middle.

I try to stay as close to the top peak of the crown if possible.

Interviewer: Wow, okay. And –

It works.

Interviewer: It works?

Because they see you.

Interviewer: Yeah, they see you...

Or sometimes, if you're over – they [unintelligible] I bet if you did a study you find out that most people get killed closer to the curb than they do to the –

Interviewer: In the middle. That would be an interesting study to do. Wow, okay. And you're doing all that while you've got your little lights, like you say.

At night I do, but during the day, I just –

Interviewer: Just cruise. Right. Okay.

And people beep and yell and scream and I get flipped off a lot [laughing] but the thing about it is if they're yelling at you, they're screaming and flipping you off, you know they saw you. [Laughing]

Interviewer: Right. And they're probably going to be like, "Well, if I accidentally hit him with my amazing car, then my car would be ruined," and they probably don't even care that you'll be hurt or dead or whatever, they're just like –

They're just afraid that their insurance –

Interviewer: Yeah, "I don't want my insurance to go up, I'll ding up my car, so I'd better stay away from him," you know, "shouldn't hit him." Okay.

I do appeal to their human particles.

Interviewer: Yeah, you kind of provide a need there. That's funny.

I know it's odd, but it's worth it –

Interviewer: So. But, you know, like you said, you have a good reason for driving down the middle of the road 'cause the curb cuts don't work and yeah. If it works, you feel like you're safer there and you get where you're going, then why not?

I mean, it's always a quick downhill, zoom! To safety. And I look far enough ahead to where if see--I used to drive motorcycles [unintelligible] So if there's a car, I'll [unintelligible] up and get between the cars and let them pass.

Subject DS36 and DS37

Interviewer: So what about winter driving? You guys have any – you know how you handle like snow or ice and that kind of thing?

I'm OK in slush or hard-packed ice.

Interviewer: OK, hard-packed ice, OK.

It's the soft, fluffy snow or unpacked snow.

Interviewer: Where you slide around...

Yeah.

Yes, that's true.

Interviewer: OK.

You slow it down. That's what I do.

Interviewer: OK. Because I've heard – I've also heard the exact opposite for people, that the hard-packed stuff has more ice in it, and so they slide around more. If they go in fluffy stuff, that they actually get more traction in kind of new fallen snow, because it hasn't been packed down, yet.

If it's more than an inch, inch and a half...

Interviewer: Yeah, then you have problems. Oh, OK.

The inch then gives you traction. If it's more than an inch, then it takes away from the traction.

Interviewer: OK. It just makes things really slippery, OK.

This is pretty heavy. The thing is pretty heavy.

I find that I just go slow.

Interviewer: OK.

And inclines, I tend to stay away from them. I really do, you know people will zoom up, and I'll just stay the heck away from them. I'll find a way to get around it.

Interviewer: So the snow – how do you deal with like the slipperier stuff, like the ice and things? You know if there's a sidewalk; they haven't – you know maybe they scraped it off, but there's still little spots where it's kind of icy and stuff like that. You just make sure you go really slow so you don't spin around too much.

Yeah.

Interviewer: OK.

Because this is, like I said, it's very heavy. And the wheels, I mean the tires, you got some grip.

Interviewer: Yeah.

So I always slow it down.

Interviewer: OK.

Slow it down and make sure you're going straight...

Yeah. Right.

Don't turn on the ice.

Interviewer: Right.

Slide – yeah.

As long as you've got enough inertia, it will carry you over the ice.

Interviewer: OK, so similar to driving – you know driving a car.

Driving a car, yeah.

Interviewer: Yeah. Don't make any sudden moves.

Right.

Interviewer: Don't speed up on slow down too fast, that kind of thing.

Interviewer: what about with the water, you know after it's rained and you know there's big puddles? Or even if you get caught in the rain, is there any a – do you ever have any trouble with your chair, with you know water getting into it and causing problems or...?

I've never driven in the rain, except one, just one big downpour. I'll wait.

Interviewer: Yeah, OK. All right. You've never gotten caught out in the rain or anything like that?

Not big time.

I live in Seattle, so it's a daily thing.

I avoid the puddles, just because I'm afraid of getting water up underneath. But for the most part, if it's coming down overhead, I don't really care about it. I get wet all over. Where it splashes up underneath, I worry about groundwater.

Interviewer: Right. Is the – how kind of closed off is the Omegatrac on the bottom?

I think it's kind of plastic. Most of the access is through the top.

Interviewer: Yeah, OK. But you still don't want to take the chance.

Yeah, I don't want to get stuck.

Interviewer: Right, right.

When I was here, I went down to the Waterfront. I got doused down there. No problem.

Interviewer: Oh, the one that pours in from above?

Yeah.

Interviewer: Yeah. [laughs] OK.

So, I'm not too shy around water.

Interviewer: Well I guess living in Seattle, you can't be. You know have some like automatic umbrella that unfolds above you when it starts to rain or something... You'd think something like – somebody living in Seattle would invent something like that.

I've had it, gone through puddles like two, three inches deep when and it was OK.

Interviewer: OK. All right. What about – let me look down the list here – stuff like gravel and dirt and mud and kind of the softer surfaces like that where in some cases – and I've had somebody, some people tell me if you can, if you keep your momentum up, you can, you can go across them and not sink in too much.

Yes.

Interviewer: And you know you don't dare stop kind of thing... And you know other people are like oh, I just sink right in, so I avoid that completely.

What I do is, like with gravel – the first time I encountered gravel was over here at the track.

Interviewer: Oh, really?

Yeah.

Interviewer: OK.

Yeah, first time. And I keep it level, keep it straight, and move on. And there weren't any dips, so I felt good. And then the grass really surprised me, because I thought I would, I would sink, because this thing is really heavy. It weighs 400 pounds.

Interviewer: OK. Yeah.

I kept it straight and change the speed and just kept it steady.

Interviewer: Right. OK.

So it was all right.

Interviewer: It didn't – it worked out all right.

Yeah. It didn't grind down. It didn't do anything.

There's two different kinds of gravel. Some gravels sink down more than others.

Interviewer: OK.

So it depends on the kind and how deep it is.

Interviewer: OK.

On a dirt road up at track and field today, the dirt road was fine. I didn't see the track.

Interviewer: Yeah.

It was like up at a – what's that restaurant where the barbeque was on Monday or Tuesday?

Interviewer: Shenanigan's.

Yeah, there's like a little gazebo right next door with a gravel trail, and I could – that's the good kind of gravel for me.

Interviewer: Yeah. Yeah. OK.

Because it doesn't matter how deep it is.

Interviewer: It's hard, hard-packed down, OK.

Yeah. And some driveways, like down in the industrial area, down by the stadium in Seattle, there's a lot of parking lots that are gravel, and you have to watch out and make sure. You can usually see which areas are hard and which are soft. So you stay in the hard spots.

Interviewer: OK. Yeah, OK. You can just like make ruts and just kind of sink, sink down in if you're not careful.

The same with sand... Wet sand is all right, but you don't want to stop. You just want to keep going, same speed, or you'll sink in and start digging holes.

Interviewer: Yeah. OK. Right, right.

You was mentioning grass. It depends on the time of year, I guess, how much they water it.

Yeah.

In Seattle, I can't go on grass until May, June, maybe July, because there's so much moisture in the ground. I just wind up digging holes.

You definitely check it out before you get on it.

Yeah.

Which will cross – [unintelligible] cross. Because I thought I was going to get trapped over there.

Interviewer: OK. So you're saying in some cases the grass, the ground, is so soft. You can't really tell, because the grass is covering it up. But it's really soft, and you'll just kind of sink into the ground if you're not careful.

Yeah.

Right.

Interviewer: Yeah, OK. So it needs to be dry – a little drier, definitely. OK. All right. Do you ever have any problem with it's you know wet grass after a rain or something? You know slipping at all on grass?

Yeah. It's much more slippery when it's wet. Or if it's dry grass right after it's cut, that can be slippery, too.

Interviewer: OK. OK. Because does it – does the grass like give off some kind of – when you cut it?

If it's dry like brown dry, it turns to like straw.

Interviewer: Oh, OK. And then you just kind of slide on it.

Right.

Interviewer: Yeah, OK.

Usually if it's that dry, then you'll get down in the dirt and it's hard enough.

Interviewer: Yeah, OK. All right.

I just think you're right, because today I couldn't tell if that grass had been watered. I saw other people go across it on foot. So I just said well, I'll cross and I took my time. It was all right. I don't generally go on grass.

Interviewer: Yeah. OK, really? OK.

Uneven sidewalks, things like that – that's a challenge for me. I worry about it, because I don't think that this – initially I don't think that the chair will support.

Interviewer: Rocking motion and kind of twisting motion...? Yeah.

It does.

Interviewer: It does. OK. That's good.

I tend to go this way when the chair's going that way.

Interviewer: Right, kind of lean to help balance it out for the...

Interviewer: All right, what about driving on like hills and stuff, driving up and down and along the side, the side of the hill, so you're kind of leaning like this?

Yeah.

Interviewer: Do you have any problems?

That worries me.

Yeah. You don't know when – I slow it down. I really do, but then the – I lose control sometimes, because of the motion.

Interviewer: Yeah. Because your wheelchair wants to kind of like turn to point down the hill.

Yeah, so you got – you know.

Interviewer: With the front wheel drive, well you wouldn't have that problem nearly as much I would say.

It still wants to spin around backwards.

Interviewer: It does.

I don't like, whether it's going across the hill or turning around, I – I'd rather go down all the way the hill, go down the hill all the way.

Turn around and come all the way back up.

It just freaks me out. I'm worried about tipping over all the time.

Interviewer: OK. You, with the, with your power chair, do you ever tilt back when you're coming down a hill to keep yourself level?

Always.

Interviewer: You always do that? OK.

Otherwise, if I play too hard, I can feel the back wheels coming up.

Interviewer: OK.

I'll feel like I'll tip over forward.

Interviewer: Right, right. OK. How about going like up and down a hill? Not sideways, but...

Up and down, you mean smooth pavement?

Interviewer: No. I – well... Just more like steeper hills. They're probably going to be like covered with grass, like in a park or something like that.

I don't do that.

Interviewer: You don't do that at all?

[laughs] I don't do that.

Interviewer: Or even – I mean it could be even like on a sidewalk or something, too.

A sidewalk...

Interviewer: Like if you know you had a road that went up a hill you know that's pretty steep. And down, you're coming down the sidewalk, do you...?

It's easier going up for me than going down, because I find it easier.

Interviewer: All right.

I used to take these off.

Interviewer: The foot rests?

Yeah, take them off before I...

Interviewer: OK.

When I was going to the gym and stuff like that, I'd encounter terrain like you were talking about.

Interviewer: OK.

And I just – I feel safe going down – going up.

Interviewer: Going up, yeah.

Coming down...

Interviewer: You feel like you'll maybe go out, fall out forward, or something if you slow down too fast.

Yes.

Interviewer: Yeah, OK.

As far as me, going uphill, again I'm much more comfortable in that. This thing has so much torque, it will go up. It will go up anything, but it's hard to go down. So if I have any question about the steepness, I'll go down backwards.

Interviewer: Yeah. Oh, really?

See I never thought about that. I've got to remember that.

Interviewer: All right.

Often if it's a question, especially on grass I'll turn around and go backwards, just so I don't have to turn around on a hill.

Interviewer: OK. What do you do about looking behind you? Do you have somebody else looking out for you?

I can see most of what's behind me, so.

Interviewer: I guess there's not a lot of – yeah.

Yeah. If there's a crowd, then I'll even say, "Watch your toes."

People watch out for you.

Interviewer: Yeah. OK. Now when you're going up a hill, and you're – if you had to stop for some reason. When you start out again, do you ever like pop a little wheelie, when you start out?

Yes, yes, yes. [laughs]

Interviewer: OK.

This thing has five different speeds, and I...

Interviewer: Right. If you've got it turned up too high, it will just – yeah.

It will [beep].

Interviewer: Yeah, a little wheelie.

Yeah. But at they say you won't fall over, because...

Interviewer: Well you've got the little, the wheelies, the anti-tip wheelies in back.

I don't believe in them. [laughs]

Interviewer: You don't believe in them, OK. You don't trust them, huh?

I say "whoa" every time.

Interviewer: OK. Well, that's definitely one feature we want to include in ours, because we'll have a tilt sensor in the wheelchair.

Yeah.

Interviewer: Do you ever have any problems, like if you're coming down a steep ramp or something, and you hit the transition of the flat at the bottom? Do you ever have any problem with getting you know, lifting it up a little? You know lifting the back up at all, or...?

Yes. The same going uphill, I have to adjust, watch my footrest because it's such a long (base?).

Interviewer: OK. Right.

It'll scrape, It'll scrape, It'll scrape.

So I tilt back a ways.

Interviewer: Right.

Because they say like the things – the paperwork says only a five percent grade.

Interviewer: Yeah, well...

This thing does 45 percent grades.

I think they're just doing it cover the liability area.

Interviewer: Oh, yeah. Right, right. Yeah, OK. I had that conversation earlier. Kind of like, well one guy was suggesting that you actually, in your controller, you could like have some kind

of warning light or an alarm that would say you know you need to get off this hill, because it's too steep for you kind of thing, you know?

Interviewer: Have you always driven a front wheel drive chair?

I started out with a rear wheel.

Interviewer: Started out with rear wheel, OK. What are the good and bad points as far as driving do you see between front and rear wheel?

Front wheel seems to have more torque getting up the hills.

Interviewer: OK. All right.

I don't know; I'm strictly Omegatrak. Rear wheel, like you said you pop wheelies sometimes when you're starting.

Going up inclines on the bus.

Just getting on the bus, I have to be very careful. I do, because I could fall. It just scares me.

Mid-wheel drive, they get ice on it real easy going up a – if there's more than an inch lip – a [indecipherable] lip.

Going up driveways, you can get ice on it very easily if you don't have enough inertia.

I just like the chair I'm in, because of all the power.

Everything else [indecipherable] speed.

Interviewer: Did the, did the rear wheel drive ones, do you think, go – have the higher speeds?

Higher speed, definitely.

Interviewer: OK. You can move, huh?

Yeah. I can't – to be in the race, this is on five. I put it on five, the highest one.

And as I go along, I got to, I turn that up slowly. Because if I turn – if I try to start off--It'll--ah man, it'll throw me fast.

Interviewer: [laughs] OK. So when you started to race out, so started driving and then you turned it up all the way. OK.

Yeah. I turned it--it's already on five [indecipherable] chair.

Interviewer: OK. All right. Let me – we talked about sand a little bit. All right. I guess we've – unless – we've covered pretty much everything that was on this list, unless you guys had any other you know notable situations that you think would be good, you know that you wish you had known when you first started driving power chairs.

Going over grass, it hides...

Interviewer: It hides the potholes, right.

The thing I found in Memphis – across the street from the hospital there, the sidewalk is uneven.

The trees have grown up, and roots have pushed it, pushed through the concrete.

Interviewer: Yeah.

Sometimes it's safe to drive on the street.

Interviewer: Street, OK, because the sidewalk's so bumpy and torn up.

Yeah, right. And that's something I had to learn. It took me some time. Because it's really unsafe, very unsafe.

Interviewer: To drive in the street...?

I mean unsafe – no.

Interviewer: On the side...?

On the sidewalk, yeah, very, very unsafe sometimes...

Interviewer: So you feel safer driving on the side of the street.

Right, facing the traffic coming.

Interviewer: Facing the traffic, OK, and you feel like the drivers can, can see you, and when...?

Yeah, they can. Yeah, right.

Interviewer: And they can get, you know you haven't had too many close calls or anything.

No close calls at all.

Interviewer: OK. Wow. That's nice.

One other thing I wish I had learned is to watch you know, like they teach you when you drive, to watch 20 feet ahead of you or whatever.

Yeah, yeah.

Interviewer: OK.

So if there's ten potholes, you can figure out which way to go around the potholes, or straddle the pothole so you go over it.

Interviewer: Right, yeah.

Not the wheels over it, but goes underneath you, instead of jostling you around.

Interviewer: Yeah, OK. Just to pay attention to what's coming up, look out ahead.

Yeah, to look ahead and learn to straddle obstacles, or instead of going over.

Interviewer: OK. Yes, you'd have to get a sense of how wide your wheelchair was, so you know OK, I can straddle that one, but I got to go around that pothole or stuff like that.

Right.

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Interviewer: Or you know if you're going up the hill, it could be level. So he felt like, at least, that when you're in that tilted situation, if you're sitting level at least, he said you're not going to be as worried, and you can make more a level-headed decision on a "What should I do now" kind of thing, instead of instead of—if you're all titled up funny and then things start to go bad, you kind of panic, so...

P2: Well just like him—he comes down those—the ramps from the [unintelligible], and when it's on the curb, it's up pretty level—it gets pretty level. But when it's just going all the way down to—

Interviewer: To the street

P2: To the street, to the drive area, he's actually putting his arm behind his chair to—

Interviewer: To like hold yourself back.

P2: —hold himself back.

P3: To hold myself back, yeah.

P2: So if that could just level it out a little.

Interviewer: Right. Well I think the other part is that, kind of the center of gravity—the center of weight, and in a power chair, at least a rear wheel drive one, it tends to be in front of the back wheels. And so if you're coming down a hill, your weight ends up being over the castor wheels instead, and so you've got more of a chance of tipping like that, coming down a ramp.

P2: That's right.

P3: And your feet lay off the pedals, could always hang up too.

P2: Right, they get caught up.

Interviewer: Right, so...

P1: I have that problem with the—

P3: And then you come to a dead stop and you go “Oh.”

P1: I have a problem with the cuts in the street in Chicago, because they’re—

Interviewer: Oh, the curb cuts.

P1: Yeah, the two—curves are so high and then they’re too steep. And then they got them bumps on it, the raise—

Interviewer: So that makes it worse.

P1: Right, so then I get caught up on the—

Interviewer: Footrest. Okay.

P1: And there’s no—I don’t...

P3: If I find out if there’s too steep like that, everything, then turning around and going down in backwards makes you feel more steady.

P1: I don’t know.

P2: Well you’re pretty heavy—don’t catch then.

P1: Yeah, but then my anti-tippers catch.

Interviewer: Oh, right. Okay.

P1: So I wind up having to go the alley and come out on the street.

Interviewer: From the alley?

P1: From the alley.

P3: You’re out there running around with cars.

P1: Yeah, but there’s no other way to do it because you can’t get off the curb cut.

Interviewer: So like at a crosswalk, you can’t—it’s too steep.

P1: No, I got to go back to the alley and then up the street.

Interviewer: Wow.

P3: And the curb cut isn’t ADA specified.

P1: No. It’s bad.

Interviewer: It’s not made properly. Yeah.

P1: But they’re not going to change it and it’s there. That’s the problem.

Interviewer: Yeah. Well if anybody complains, they’re like “Oh, look. We do have curb cuts.”

P1: Exactly.

Interviewer: “They even have bumpy strips.”

P1: So how do you get past something like that?

Interviewer: The transition is so steep. It’s just so steep where it meets the street that you can’t go through it.

P1: Correct. Because the curb is at least 8 inches.

Interviewer: Wow. And you definitely want your—

P1: Anti-tippers.

Interviewer: Okay. Do you end up needing them very often, the ones in the back or not?

P1: Well they’re kind of stuffed up so I don’t think I do, but I guess I do.

Interviewer: Right, you’re probably coming off of something, you would hit them. Yeah, so the backing up thing, plus it’s probably—

P1: I’d be afraid. It’s just so—and then those bumps. They got like grazed—the whole thing.

Interviewer: Any issues with other like hill—steep situations, whether it’s driving on the side of it, or going up or down hills? Do you find it easier to go up or down?

P3: Well it’s always easier to go up because your—the back [unintelligible] a little better.

Interviewer: Yeah, in rear wheel drive chair.

P3: You’re more like in a recliner. You’re reclining—

Interviewer: It’s more comfortable to go up.

P3: Yeah, at least I find it that way.

Interviewer: And you probably—well in a rear wheel drive chair, you have more traction going up to because your weight is kind of shifted to the back on your drive wheels.

P2: Well another issue with the trunk control—he has the trunk control, so that—

P3: In a mid wheel drive with castors in front and castors in back, they’ll hang up to where your drive wheels are up in the air and you’re not going anywhere.

Interviewer: Okay. Have you had a mid wheel drive chair before?

P3: I’ve talked to guys that have mid wheel drive chairs and that’s the reason I will not have one.

Interviewer: Okay.

P1: With me, I think just because I’ve only had the chair—it’s going on three years now—when I’m going up, like right over here, too, I always tend to lean forward going up, because I’m afraid I’m going to go back.

Interviewer: Tip over. You feel like you’re going to tip over backwards.

P1: I really do, I just—especially on a steep hill I always feel like I’m going to go. So I always tend to go this way, so for me, going down is better.

Interviewer: Okay. Do you try to like, when you’re going down, do you kind of lean back a little bit like this when you’re going down the hill?

P1: I do. I lean back a lot.

P2: And she has trunk control.

P1: Right, that’s true. It’s a little different.

P2: It’s a little different.

Interviewer: Okay. What about driving across the side of a hill where you kind of have to always be fighting it to stay going straight? Or something—

P1: I haven’t really done that.

Interviewer: You haven’t really done that?

P1: No.

P3: I’ve done that. I mean—

Interviewer: Where your wheelchair is always wanting to like swing down the hill kind of thing, and you keep fighting it to hold it straight?

P3: Yeah, you start up here and you’re going around the hill and pretty soon you’re down there.

Interviewer: Sliding. [laughing]

P1: Oh, hell. I’d be in the alley. I’ll go around. [laughing]

Interviewer: Well you know, if you’re out in a park or something like that and you’ve got to go across some corner of a grassy hill or something like that.

P1: No, we’re pretty flat in Chicago.

Interviewer: Pretty flat—okay, you’ve got a good point there.

Interviewer: Well being from Chicago, what about driving in the winter time?

P1: Ice is what's really—because you just don't have any traction at all. There's just no traction. So I could be going, and I'm going slow—just like when you're driving a car, you want to go slow—but the thing is is that it's pretty much going to do what it wants to do. As heavy as the chair is, it'll just...

Interviewer: Okay, so you hit that patch of ice and you're sliding a little bit—what do you do at that point?

P1: What I usually do is I stop whenever I'm going to stop, and then I try to start again.

Interviewer: Just really slowly.

P1: Right. Really slowly, and it can take some time. And then usually somebody comes around and helps push the chair where I need it to go, because I can't get out of it.

Interviewer: So even if you stop so you're still on the ice, and you try to go slowly, sometimes you just still—you're skidding. It doesn't—you just need somebody to push you basically.

P1: That's correct. Right. Because I'll start (sliding?) and they'll push me.

Interviewer: Yeah, alright.

P1: And then the other thing again is to go more towards the street, because the streets are clearer. They snowplow the streets. The sidewalks they don't.

Interviewer: Like if you're on the sidewalk—oh, so you would drive like on the edge of the street, not on the sidewalk.

P1: —because a lot of the sidewalks are not.

P3: Well they got to have a place to put the snow. They put it on the sidewalk. [laughing]
[all laugh]

P3: Some of these cities are like that really.

P1: Yeah, it's really different. So more traction is what you really need.

Interviewer: Right. Wow, okay.

P3: I mean you can't put winter snow tires on your chair because then you still got to take it into the house and you don't want to rip all the junk in the house.

P1: That's right.

P3: If there was something quick you could put on like a—

P2: A chain.

P3: Chains or something.

P1: Or spikes.

Interviewer: Chains for a wheelchair.

P3: Then you got a clearance problem too and everything, but—then you got to be able to snap them on, snap them off really quickly because you don't want to take them in the house. I could just see somebody, if I come in with chains across the linoleum—

P1: We have wood floors.

P3: You'd probably have more trouble than me.

P1: Yeah, we have wood floors. But something—something to easily put on and take off for winter conditions.

Interviewer: Yeah, just add to the traction, yeah. What about—yeah, so you're saying sidewalk's just unusable a lot of times for you in the winter time.

P1: Right, because it's up to the residents to shovel the snow.

Interviewer: Oh, okay. So where do they usually walk? Just on top of the snow on the sidewalk?

P1: Yes. Right, and then what happens is if they don't shovel is, as soon as the temperature drops at night and then it freezes, and then you get ice on top of the snow. Because if someone has walked on ice on snow, then immediately it will—well, later it will become ice because it's compacted. The cold weather makes it ice. So you got to shovel as soon as it falls.

Interviewer: Right, okay. Yeah, I had a few people tell me they definitely preferred driving—you know, if it's snowed and then haven't plowed the sidewalk yet, riding on the new snow is a lot better than—

P1: That's right because you have more traction than ice.

Interviewer: —than driving through packed-down snow because you got the ice problem and you can't always see—it's usually bumpier, and then you can't always see where it's icy and where it's not and stuff like that.

P3: It could be frozen ruts to where all of the sudden you're hung up, and everything else like that.

P1: That is correct.

Interviewer: Frozen ruts, okay. So everybody needs a four wheel drive chair that lives where it snows.

P1: Or like you said, if they could pick up something that—

P2: Four wheel drive won't go on ice either.

P1: Like you said, if they could develop something—if something could be developed easily, that would be a great solution.

Interviewer: Kind of like an add-on for the...hmmm. Chains for a wheelchair or spikes.

P2: But even vehicles driving on ice are very—

P1: But if you're going slow, you can pretty much—if you have something you could, just to grab on, you could negotiate—you could get out of it and then be able to snap them off.

Interviewer: Right, okay. So more—actually just drive. Alright. Driving alone the edge. Now would that be—that would be more of a neighborhood thing is what you're talking about, when you have to drive in the street. I mean I'm hoping downtown or something, they clear everything off.

P1: No, downtown is good. They do, they do. But one doesn't live downtown.

Interviewer: Right. So in the neighborhoods and stuff, it's up to the residents and so there you end up driving in the street.

P1: Right, that's correct.

Interviewer: Okay. What about you [name]? You got any observations? You from up north or where are you coming from?

P3: Yeah, Ohio.

Interviewer: Oh, Ohio. Okay.

P1: So you have the same kind of thing I do.

P3: Yeah, Lake Erie. The snow--the lake effect.

P1: Yeah, you have the same thing I do.

P3: So I mean a lot of times you'll go downtown, and I've been downtown and sidewalks are not shoveled. Forget it, you're not going anywhere. I'm just going back home. So you don't even try.

P3: And why is it they always plow—when they plow a parking lot, they always pile the snow in the handicap parking spots?

P1: That is correct.

Interviewer: I've had a lot of people mention that actually, yeah.

P2: They don't expect you to be out.

P1: That is correct. You are absolutely correct.

P3: They got 10,000 other parking spots but they always stick it in the handicap.

Interviewer: That's the big spot. Or they'll pile it in that area where there's the curb curb—you've got like two handicap spots and then like a ramp up to the sidewalk, and they'll pile it right on the ramp or something.

P1: That's right. Or all the shopping carts will be in the handicap spot right where you have to open your door to get into your car.

Interviewer: Yeah. I don't know that designing a better wheelchair could solve that.

P3: No, I don't think it would.

Interviewer: Yeah, that is a public education problem.

P3: The only way that you can solve it is design a wheelchair with full traction and a plow blade on it for us up north.

P1: What about something that will help identify what's behind us? Because you can never see what's behind you.

P2: A mirror?

P3: Something that can—

Interviewer: We had that discussion earlier this week—I had with a few people. So the mirror was brought up, like I guess there's—I don't know if they go on the glasses or the helmet, like what bicycle riders use. I think those actually mount off the helmet, don't they? It's kind of like a little rear-view mirror that mounts off the helmet and it's about that big. I guess you could also have some sort of a mirror off the armrest. Somebody else suggested getting like a really tiny, almost like a web-camera and mount it on the back, and then have a little screen the size of what's in a digital camera or something. Just a little tiny thing you could—

P1: Or something right here on the joystick. Because if you have the joystick here, that's where you pretty much—you look forward when you go—if you could figure out somehow to add on it, you know what's behind you. And then the camera or whatever's projecting it would be protected because you got the same distance—you got more distance from the wheels back here. That would be a good way to go.

P3: Some people don't know when you're going to back up so back up beepers would be good. But you got to be able to shut them off at times.

Interviewer: What do you do know? Just be like, "Excuse me back there, I'm going to back up"?

P1: Exactly, you're like you're constantly you know mm hmm.

P3: Or "Look out, here I come."

Interviewer: Right, right.

P1: It's really difficult, backing up.

Interviewer: Well probably most people don't—when they're walking along in the same crowd as a wheelchair, they don't think about—they'll step in front of you and expect that you stop on a dime, or stuff like that.

P1: Right. And you can't, right.

P2: Well, I think it's people that aren't around wheelchairs.

P1: Yeah, well you know—like me, I'm usually around people that aren't around wheelchairs. I'm not—the only time I'm in a setting where I'm around people with other chairs is when I go over to the VA hospital. Other than that, I'm the solely in a community that is able-bodied.

Interviewer: So, do you feel like you have to educate people all the time, because you're in that—

P1: No, I just feel like I have to be more aware.

Interviewer: Just more aware.

P1: So if we had the technology on the chair to help further that awareness, then I feel that it would—or like you said, I feel you'd be able to get out. He said in the winter he doesn't even try it, because he knows because of the snow, or because he's not going to be able to do that. If we had the way to do it, then I'm sure we'd all be out there doing it.

P3: It would give us more independence.

P1: Absolutely. It was the same way before I got my power chair. I couldn't go anywhere or do anything unless I had somebody with me to push me, to go the distance. Once I got my power chair—so it's all about having the right equipment to continually—to be active and out there. You know, so it could be simple little things. I'm grateful I have the chair period, but just the other little things that could help keep us safe and have us out there.

P3: Well what some of them need is, they don't realize, when to cut the chair off with something like that. Like a beam or something like that; some users that got too close to something, it would cut the chair off.

Interviewer: It would slow down or stop them. Yeah, right. Kind of like a proximity sensor type of deal. Yeah, we're definitely working on that kind of thing to. Keep you from running into stuff and—that'd probably be more in an enclosed environment, but keeping you away from—

P3: Oh, I could use one in the back right now. I back into stuff all the time. I can do it, you know.

Interviewer: Exactly.

P1: Exactly, and you can't—

P3: "I can get out of here no problem." Oops.

P2: Right.

P3: "Yeah dear, I didn't put that hole in that wall. You sure you didn't?"

P1: Yeah. [laughing]

Interviewer: Yeah, the whole hole in the wall thing, that's—I've heard a lot about that.

P3: And some people just don't have a sense of humor about it.

Interviewer: What about like you're out in the park or something and you got like the gravel trails or something out through a park, or—

P1: I get stuck all the time.

Interviewer: You get stuck.

P1: I don't do them anymore. I just try to avoid them.

Interviewer: Just stay away.

P1: Because I just...

Interviewer: You just dig in and you get stuck.

P1: Right

P3: And if you get an easy lock pin for driving with your chair and everything hanging down, you get stuck that much quicker because you got less clearance on the bottom.

Interviewer: Right. I've looked at a few of those on some guy's chairs and you got what, maybe an inch that it's off the ground? Maybe even a little less.

P3: Maybe.

Interviewer: Yeah, it's nothing. Okay.

P3: Of course Permobil did come up with an answer for that.

Interviewer: Oh, I heard that, yeah. The pin that pulls up.

P3: They have a retractable—yeah.

Interviewer: That's nice. But it's like their own—it's not an add-on thing. You have to have a Permobil to be able to use it.

P3: You have to have a Permobil. You can't add it to other chairs.

Interviewer: Yeah, unfortunately. So gravel is kind of a no-no.

P3: Gravel you avoid.

P1: Sometimes you can't though. When I go out to the archery range at the Forest Preserve, yeah they adapted it, but once you get up there you have to go through gravel in order to get to where you fire. So we're trying to work with them now to take all that gravel out.

Interviewer: So what did they adapt then?

P1: They actually—where it was curbed, there's no curb cuts, so they put ramps so you could actually get up there and you can shoot archery. But it's gravel before you get—

Interviewer: Up to that point. Right, right. So in your experience when you had to drive through gravel, have you found—well some other people told me that if you—you can't stop driving through gravel. You for sure will get stuck. But if you keep going and you kind of like go as fast as you can and go through it, usually—you'll kind of hopefully bump along the top and actually get through it. But if you slow down too much, or you stop and then try to get going, you'll just dig yourself in. Is that—

P1: It depends—

P3: I found, when I had then other chair, it had bigger wheels in the back. It had 20 inch wheels compared to this one. So I'm going in backwards, my front wheels may have dug in, but they're not dug in where they're deep. I'm dragging them along and the back wheels are the ones eating up the—would go through.

Interviewer: Would go through, yeah.

P1: It depends how deep the gravel is.

Interviewer: Right. Right, because if it's not very—and probably the size of it, too, makes a difference as well.

P1: I just avoid it.

P3: We do a lot of avoiding.

P1: Well, I get stuck.

Interviewer: Well the goal is to keep that to a minimum

P1: Well I get stuck.

Interviewer: What about the wet, like wet grass and stuff like that? If you have to—you're on a sidewalk and you got to go off in the grass or something, and it's wet, do you have problems with sliding a little bit on that or slipping around, or not usually?

P3: If it's flat, no. If it's a little slopy, it might get a little greasy or something like that.

Interviewer: Okay.

P3: Other than that, really that isn't a big issue.

P1: Not with me either.

Interviewer: And the ramps, what about—something somebody said was like going up and down hills, especially in a rear wheel drive chair if you're going up the hill, and you have to stop for some reason, then you start again, if you start too quickly it wants to do a wheelie on you?

P1: Yes, it wants to pop up.

P3: You're center of gravity's totally off.

Interviewer: Right. So in your case you probably lean way forward and—

P1: I always—I don't stop.

Interviewer: You don't stop, you just power up to the top.

P1: Yeah, and then I'll wait for—if someone's with me, they'll catch up with me when—I'll wait for them up there, but I'm not stopping. I'm just not real confident with that, you know?

P3: I've had a lot more experience [unintelligible]. It doesn't bother me. I mean, I have one guy on each side of me in a push chair that they're grabbed onto my chair and I'm towing them up the hill and stuff like that.

Interviewer: Okay. But you've had that same thing where you pop a wheelie like that?

P3: Oh, I've had—I've had it—you know, when I'm even pulling people up a hill that, you know, my front wheels will pick up and I'll just go back on my wheelie bars and everything, but you just keep going and just—like her, I lean a little forward and—or else just power down a little bit, then it will settle back down.

Interviewer: Okay.

P1: Going up a hill and going down a hill, I'm going slow.

Interviewer: Yup.

P1: Everything else, I'm going as fast as I can.

Interviewer: That's the other thing—a wheelchair that goes faster. Everyone wants to go faster outside.

P1: Well the thing is, I play tennis out of this. So this is as fast as it can—

Interviewer: —You play tennis in a power chair?

P1: I do. This is as fast as it goes. But my problem is going back, it just—if I'm going full speed ahead, then to go back, it just kind of cuts it more than half.

Interviewer: Right, because it doesn't ever let you go back at the same speed you can go forward.

P1: Yeah, so you can't go back to get the ball. You got to just keep going forward, like turning around and stuff. But you can't take your eye off the ball. It's interesting, playing tennis.

Interviewer: I bet. Tennis in a power chair, okay. I did not know—

P1: —on a regular court.

Interviewer: —people played tennis in a power chair.

P1: On a regular court.

Interviewer: Hmm. Okay.

P1: It's one of the events in the Paralympics.

Interviewer: Really?

P1: Absolutely

P1: To adapt it. Right, like when I play tennis—because this is on my right side here—I play tennis cross-handed because I have to control the chair this way.

Interviewer: So you drive it with your left and hit—wow, okay.

P1: Right, because to switch it over, then I wouldn't be able to do archery, because when I do archery, I push it back and I need this side off. So you'd just have to figure it a different way.

Interviewer: Right, right. Okay. Yeah, so kind of a more modular power chair that you could add this to, to make it—yeah.

P1: Right. Just like the traction for the winter—I like your idea.

Interviewer: Chains.

P1: You can still have the same chair, but be able to get out there and negotiate the weather.

Interviewer: Do you need a tire that has like—you hit the button and spikes pop out of the tire.

P1: Yeah, there you go. [laughing]

Interviewer: Like a porcupine or something.

P3: You've been watching too much Speed Racer. [laughing]

Interviewer: Oh, my. I tell—like the power chair that does everything. What would that tell you?

P3: That's not going to exist. Nothing is going to do everything.

P1: No.

Interviewer: That's true. That's true. It's just—

P1: All I want is a rear view mirror...

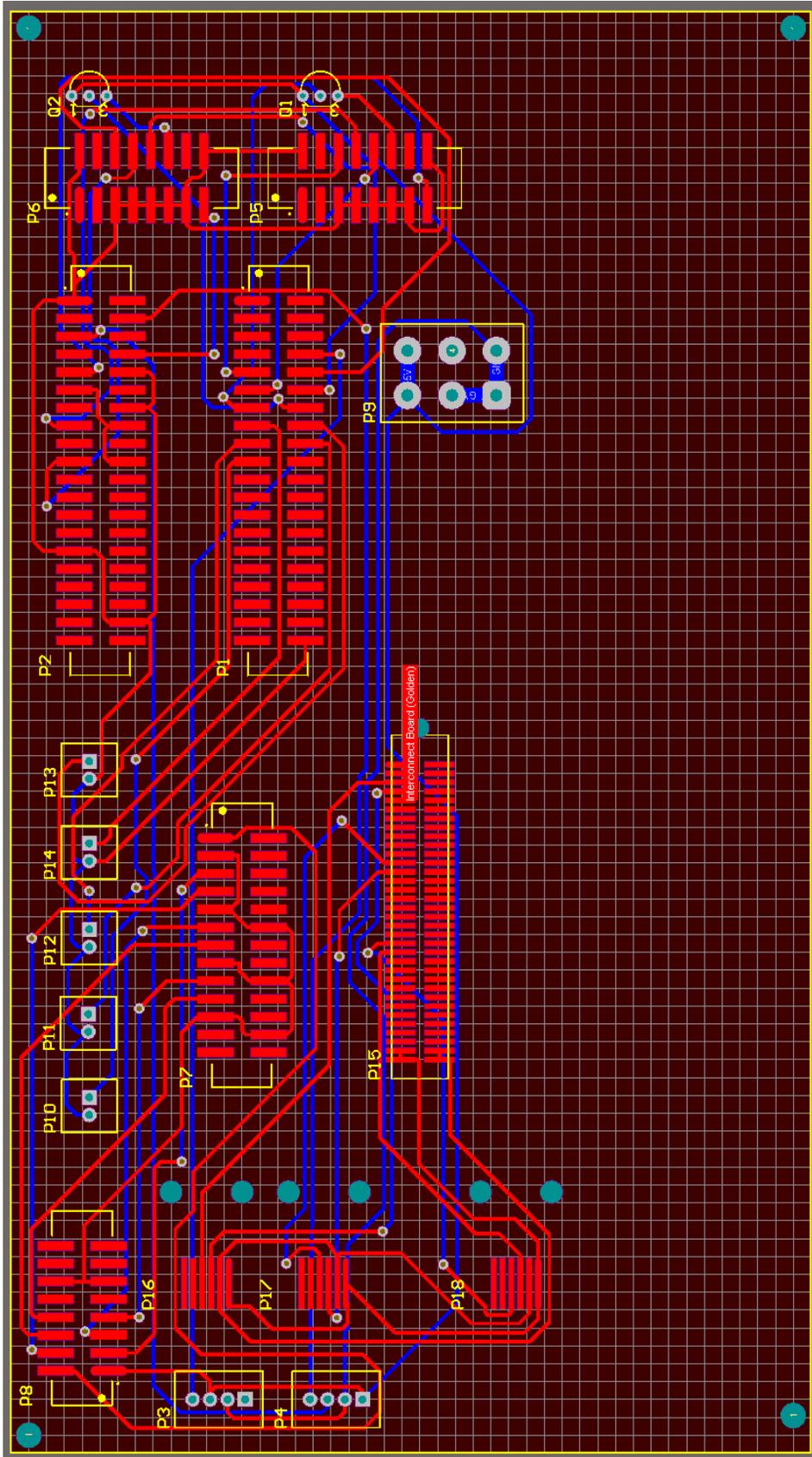
Interviewer: And spikes.

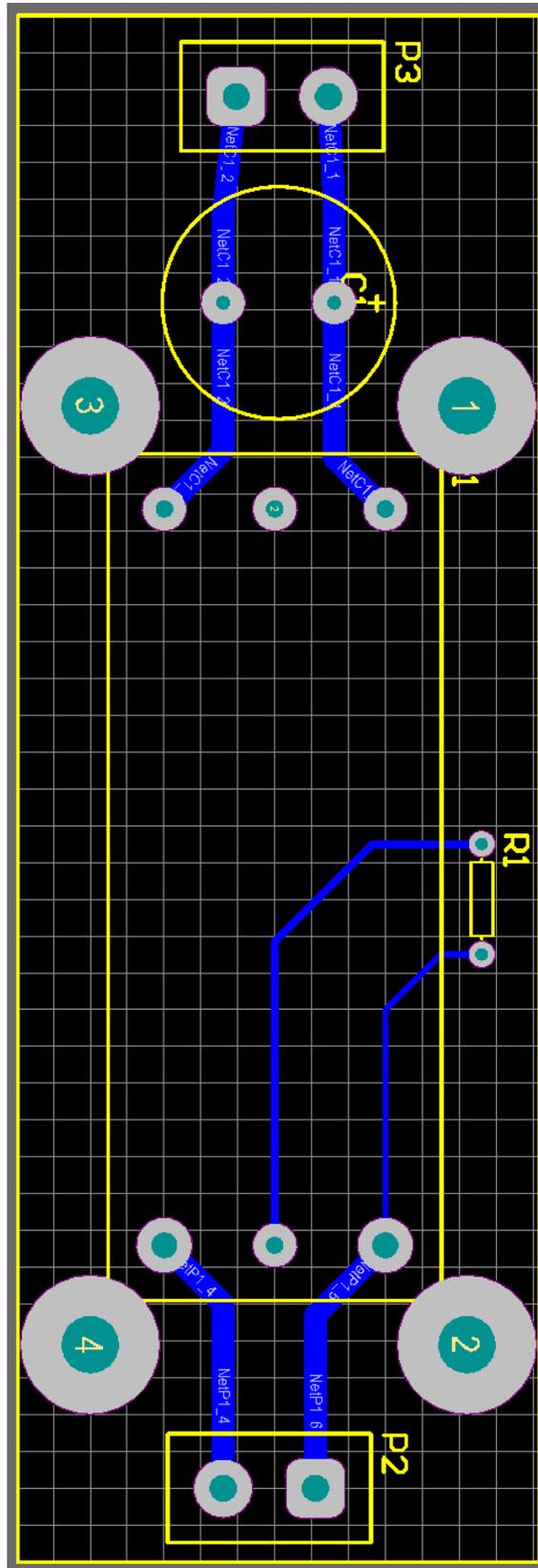
P1: And something for the—and traction.

APPENDIX C

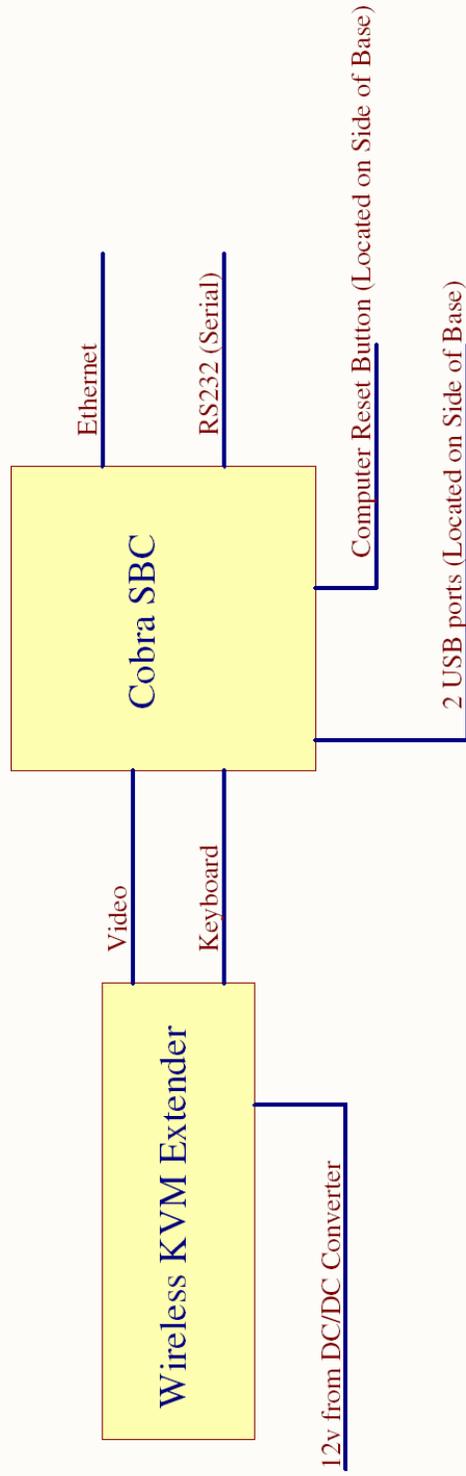
ELECTRICAL DRAWINGS

The following electrical schematics show the details of the advanced EPW controller design.

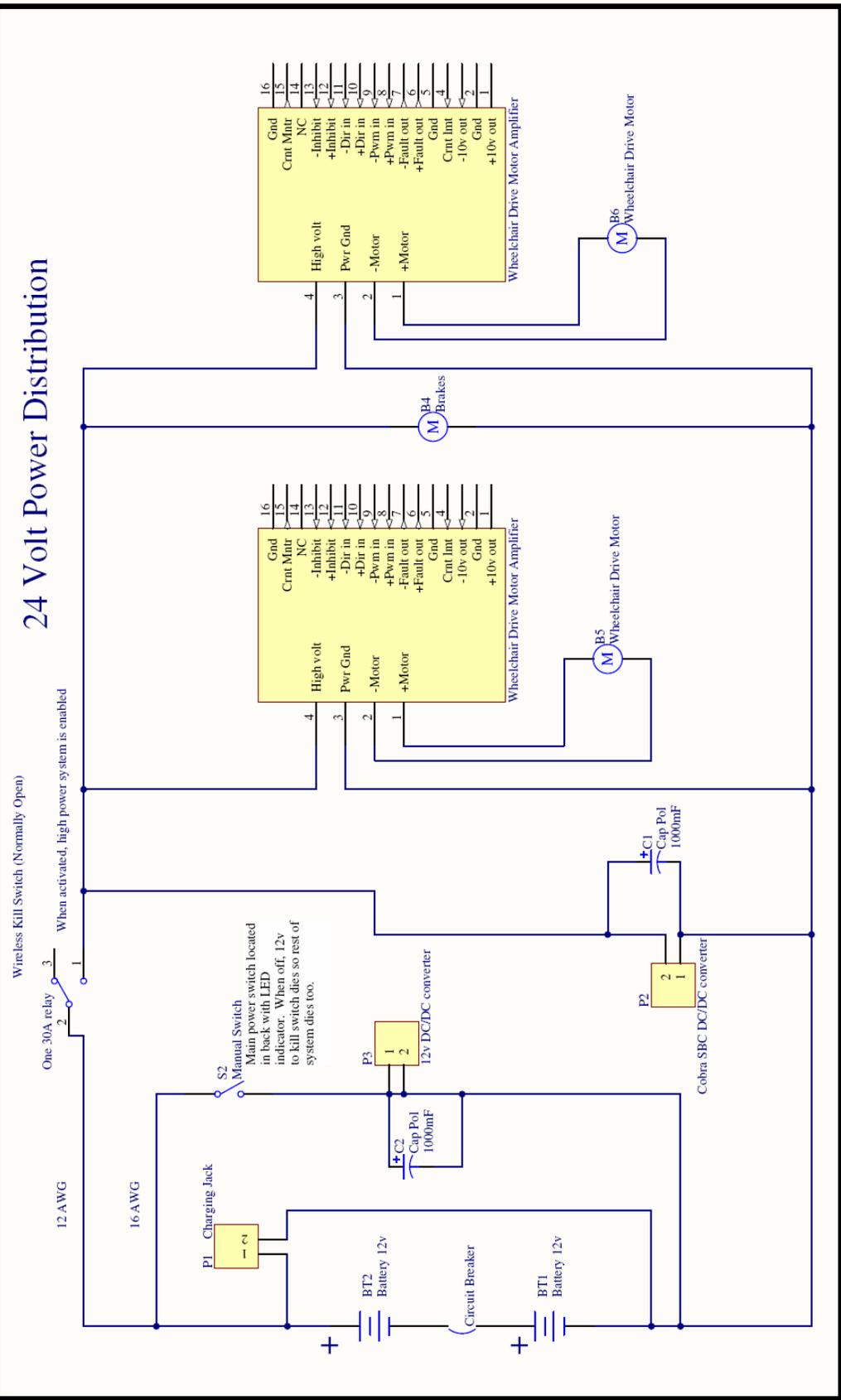




Cobra Single Board Computer Interfaces



24 Volt Power Distribution



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