SLD
SKYE LARO DESIGN

PARA-STOCK

RACING FOR THE PHYSICALLY CHALLENGED

How may we: facilitate competitive motor-sports racing for the physically challenged?

By

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REAR MOUNTED
ELECTRIC MOTOR
FRONT MOUNTED BATTERY SYSTEM


NATURAL COMPOSITE FIBERS

Abstract:

Motorsports have always existed to innovate forms of transportation and mobility for the user (the driver), and spectators, while providing competition and sport. By bringing the demographic of the physically challenged into the sport; innovation for people who need to be designed around can be increased, as well as motivation/inspiration given to those who need it most. This is important because in North America there are over 8 million licensed to drive physically challenged individuals. Veterans, retired emergency workers, and many more demographics are faced with mobility barriers in everyday life due to physical challenges, as well as young people, globally. Sports exist for the physically challenged; large events like the Paralympics are a dream for many physically challenged to compete, and something to be inspired from. A sport not included in the Paralympics is motorsport (of any form). Physically challenged individuals commonly drive with adaptive control systems. The problems within participation in motorsports for an individual with physical challenges are sourced in the control and safety of the user with the racing vehicle physically. Not only in a race but off track, the user needs to be comfortable driving and working on the product doing adjustments. Through observing the ways in which physically challenged individuals interact with common products/ carry out mobility tasks. Ergonomic studies around the arms, shoulders, chest, and torso- will be complete. The Product will be informed by physical tasks in, and around the user's control, safety, and maintenance needs of the product, to participate in motorsports racing.

Acknowledgments

Thank you to Gary Elliot for his knowledge, time and favors in sharing/teaching the knowledge of stock-car racing to be passed on to younger generations and thank you for the opportunity to participate in motorsports.

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Chapter 1- Introduction

1.1 **Problem Definition**

How may we: facilitate competitive motor-sports racing for the physically challenged?

Needs Statement:

The problem of race cars and motorsports for people with physical disabilities; is the lack of options for participation. The physically challenged don't have the option to participate or compete in real-life racing. Factors around safety and liability bring up various problems for the users, because of this, a series and a race car class have not been created to host a group of physically challenged drivers who compete. The problem that needs to be solved is an ergonomic task, including the harnessing and securement of one's body. maintenance, and transportation of the vehicle; a user experience task for the driver who would possibly own the car and need to make adjustments on different parts of the vehicle (ie; suspension, alignment). Different styles of controls and reliable useability for the driver will need to be critical for multiple different types of physical needs. Many physical disabilities, or injuries that alter someone's personal physical mobility, can differ in detail; therefore, people will need to have interior adjustment availability that still allows for safety standards to be met. (i.e.; seat height, distance from controls, throttle controls, and viewing needs)

1.2 Rationale and significance

Physically challenged individuals commonly drive with adaptive control systems. The problems within participation in motorsports for an individual with physical challenges are sourced in the control and safety of the user with the racing vehicle physically. Not only in a race but off track, the user needs to be comfortable driving and working on the product doing adjustments. Through observing the ways in which physically challenged individuals interact with common products/ carry out mobility tasks. Ergonomic studies around the arms, shoulders, chest, and torso- will be complete. The Product will be informed by physical tasks in, and around the user's control, safety, and maintenance needs of the product, to participate in motorsports racing.

1.2 Investigative Approach

Sports exist for the physically challenged; large events like the Paralympics are a dream for many physically challenged to compete, and something to be inspired from. A sport not included in the Paralympics is motorsport (of any form). Physically challenged individuals commonly drive with adaptive control systems. The problems within participation in motorsports for an individual with physical challenges are sourced in the control and safety of the user with the racing vehicle physically. Not only in a race but off track, the user needs to be comfortable driving and working on the product doing adjustments. Through observing the ways in which physically challenged individuals interact with common products/ carry out mobility tasks. Ergonomic studies around the arms, shoulders, chest, and torso- will be complete. The Product will be informed by physical tasks in, and around the user's control, safety, and maintenance needs of the product, to participate in motorsports racing.

1.3 Background/history/social context Topic: User-Product-Environment of Use (Triangulation)

Many countries including Europe, the United States, and Canada host millions of physically challenged, licensed-to-drive individuals. Vehicles: adapted to specific individual needs through technology allow the physically challenged to control a vehicle; special licensing courses exit; to be able to use adapted vehicles on public roadways, and even on the track, but a class/car for the demographic does not exist. Only 1 of 1 custom-built to individual race car(s) exist, for racers with physical challenges. Using radial controls, as well as Guido Simplex controls; users paralyzed from the waist down, or users who are leg amputees can operate the throttle and deceleration while steering in a vehicle, always providing full control for the user. Public roadways, private homes, and competitive track grounds; all contain similar challenges for the user; especially if alone. Problems like getting in and out of the vehicle, operating, and at the track competing isn't viable due to safety and user task challenges.

Motorsports are popular in many countries all around the world, one country, for example, would be the United States. Home to many tracks, but also home to over 8.1 million physically challenged licensed drivers. There is a missing spot for those drivers; they can see the sport, but not participate. This Is something the industry wants to change, by spreading inclusivity and allowing anyone to race, but the product has never existed to facilitate this. Motorsports are a product of the automotive industry; providing users a method to compete and race against each other on a closed course.

CHAPTER 2 – RESEARCH

2.1.1 User Profile

Primary-Paralyzed/ physically challenged (from the waist) down individuals who drive, and are interested in motorsports

User; Male or female aged 19-70 with a physical disability(s) limiting personal mobility. Particularly paralyzed athletes, or users interested in motorsports, with a physical disability. Individuals that drive with adaptive control devices in their personal vehicle.

Secondary-Individuals interested in motorsports

Retired emergency workers/veterans interested in motorsports, or users who aren't paralyzed, but struggle with some form of physical disability (spinal, or lower back for example)

Tertiary-Caregivers/Individuals interested in being involved with a team

Individuals who have loved ones and/or caregivers to a physically challenged user who participates in motorsports. Racing Pit crew members/volunteers who help on the car/race team during an event.

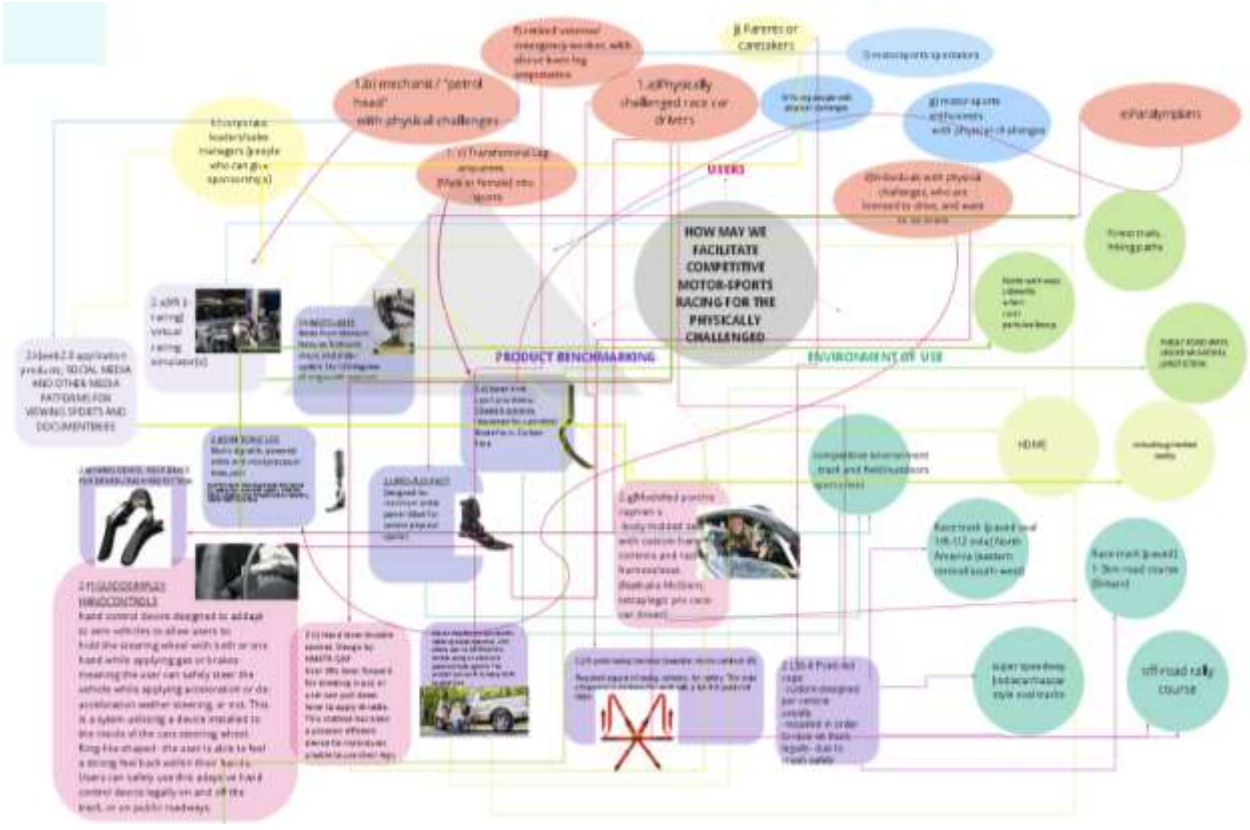


Figure 1

2.1.2 Current User Practice (Based on environment)

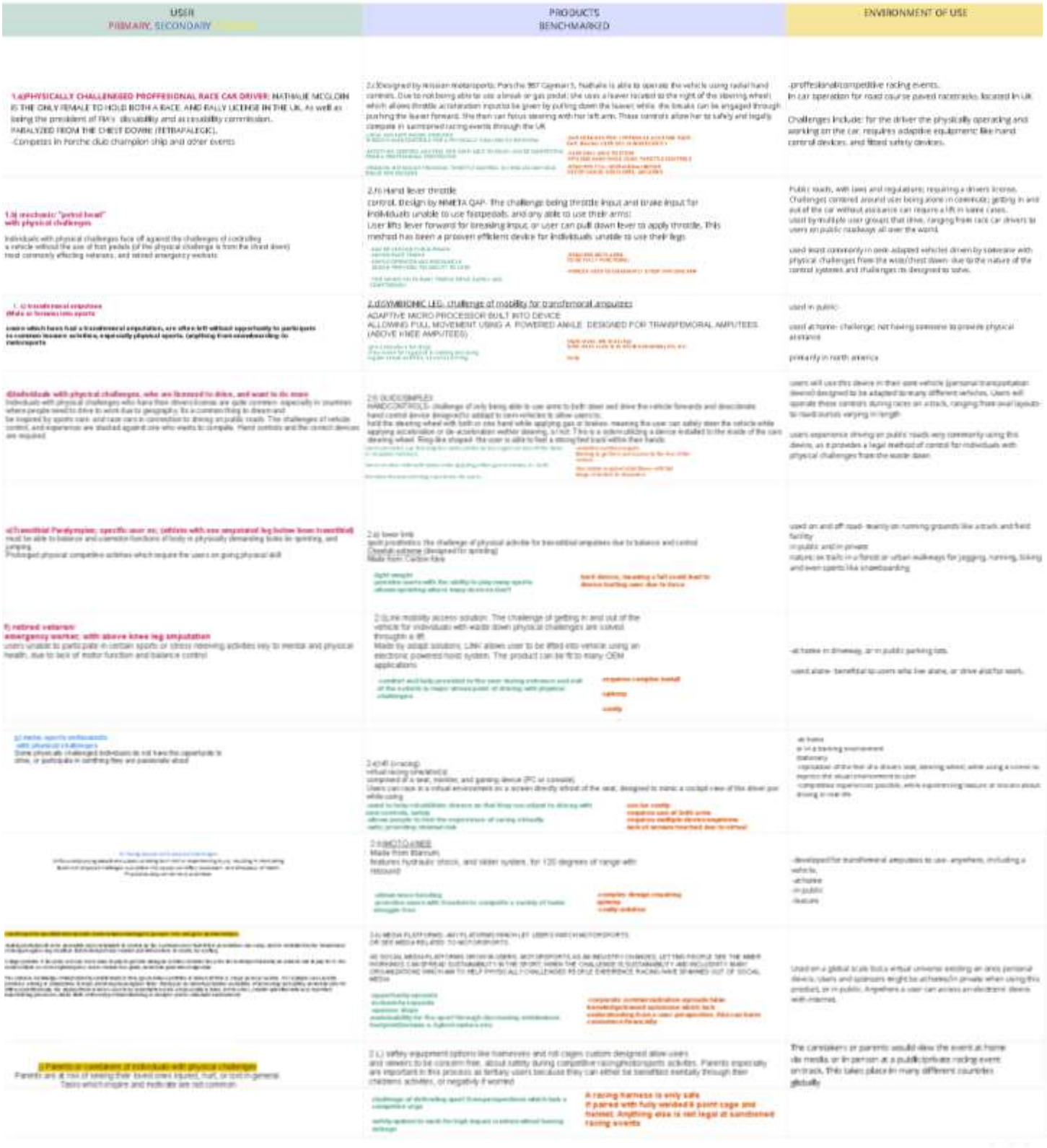


Figure 2

2.1.2 User-Interview Takeaways:

Interview 1: 32-year-old male. Experienced driver. transfemoral amputee with a prosthetic for the left leg. (Below the knee) Key takeaways: Manual vehicles do not work with the prosthetic but driving automatic vehicles with a foot petal works. Using handles for entrance and exit is essential. The user has experienced a lack of feasibility for competition considering physical challenges including operation of the race car, and logistics of racing the car, getting it to the track, maintaining the car, etc. The user's father raced stock cars while the user was growing up, for this reason, they have inside knowledge of the basics of motorsports, although not current, still relevant due to the logistical knowledge.

Interview 2: 68-Year-Old Male, Retired mechanic, automotive enthusiast. T4 and T5 Spinal injuries cause challenges with lower body mobility Key takeaways: User 2 enjoys driving and has a lot of experience. The problem faced by them when using a car is based around: physical movements required to get in and out of the vehicle, as well as micro-mobility tasks like shoulder checking, reaching for controls etc. When those problems occur, they can be a problem due to viewing blind spots, and hyperactivity. Although the user has no trouble doing these tasks- it can cause discomfort during the ride, which takes away from the overall driving experience.

2.1.3 User Observation – Activity Mapping

Figure 3

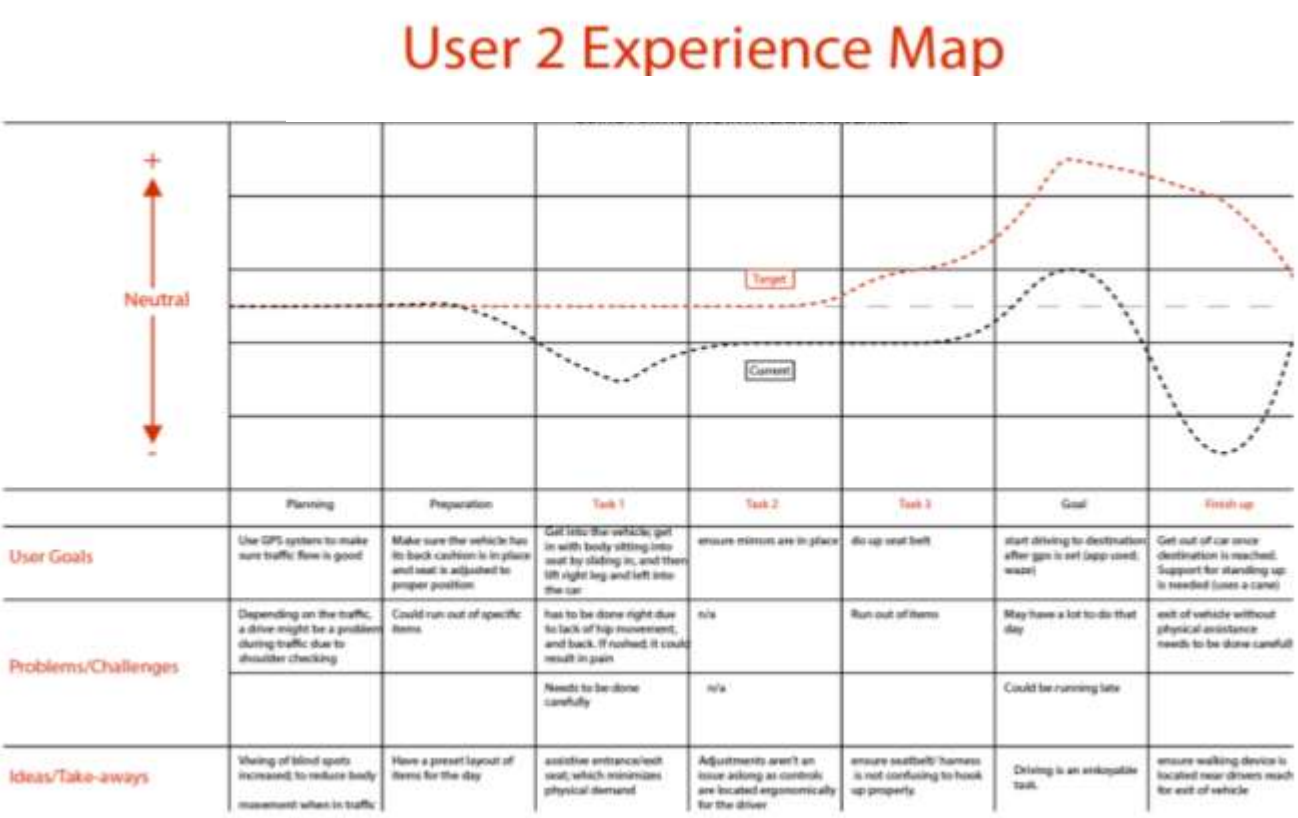


Figure 4

2.1.4 User Observation – Human Factors of Existing Products

User observational video 1
User journey map

Paraplegic Instructional Driving Video - Hand Controls
https://www.youtube.com/watch?v=cQraE9xrArw

	PLANNING	PREPARATION	TASK 1	TASK 2	TASK 3	GOAL	FINISH UP
USER GOALS	Get into car, and go for drive, without taking long	Insure space for entrance of vehicle					
USER ACTIONS	Place wheel chair and body perpendicular to car with ample space for:	Open car door	lift body from seat and scoot over to the right onto front drivers seat	lift legs into footwell underneath steering wheel	dismantle chair and place wheels below passenger seat	Tighten controls into place (travel adaptive controls, which tighten onto foot pedals via vice grip style clamps	Begin driving, after seatbelt is secured and car is turned on.
USER THOUGHTS	Takes time to get used to entering and exiting the vehicle.	Process is required in order to complete different people have different methods	Insure brakes on chair are engaged and hand grip is secure	Crossing the legs helps to avoid leg spasms.	Place wheels behind front seats to avoid them moving during the drive	Travel controls allow users to use multiple vehicles ad quickly reinstall hand controls on any vehicle	Driving is controlled via hand throttle (thumb) and brake lever (pushed in with hand grasp)
USER FEELINGS	Happy to go for a drive	focussed and steady	Amped up/ready to lift body, stressed	Concentrated/ concerned	Patient/in a hurry to dismantle chair at a steady pace	Concerned/stressed	Happy/ready to drive
STORYBOARD PHOTOS							

Figure 5

Analyzing User operations with driving a vehicle (Observation Video 1)

Physical challenge

In the video observed the user describes themselves as an Asia A - T4 Parapelegic. This means they are paralyzed due to spinal cord injury. Asia A is a scale used to define the level of impairment the injury causes to the user. Asia A means no sensory or motor function of the body from the injury and down. T4 means the user is unable to move/control their body from the waste down. The user is in a wheelchair due to this. The user has spasticity so this affects how they place their legs in the driver's seat

Mobility procedures

Procedures that require physical movement. In the video; the user does a range of tasks that required physical lifting, sliding and holding. The main stress point was sliding into the driver's seat from the wheelchair, while ensuring the wheel chair had its brake engaged on the right wheel. Another task that was timely; was disassembling the wheel chair; once in the driver's seat.

Using a product/device

The wheel chair is used for lifting body from car, during the entrance and exit out of car. The brakes hd to be engaged. Adaptive travel controls were used. This product is a hand control system which mounts onto the gas and brake pedal of an automatic-car. The device allows the user to steer with their left hand while using the breaks and gas with their right hand. The user has to push in a handle located below the steering wheel to the right, in order to engage the brakes of the car, and then use a button with their thumb to engage the gas/throttle of the car.

Ease of use/procedure

The user defined multiple task procedure which highlight preferred methods in order to save time, and physical stress. Like sliding one leg at a time, and sliding the body rather than trying to lift the body.

Defining and naming themes;

Physical challenge can be defined as Physical-Disability.

Mobility procedures can be defined as Physical-Tasks.

Using a product/device can be changed to User/Product-tasks.

Ease of use/procedure can be changed to; user-personal preference.

2.1.5 User Observation – Safety and Health of Existing Products

User Interaction- Racing Seat				
Needs	**Benefits and Underlying Needs**	**Level of importance**		
Basic Needs *Physiological*				
Harnessing (6 points)	Safety for drivers ensuring they will be secure			*High*
Back support, and leg support; allowing the driver to be positioned in a healthy and comfortable manner	**Driver:** back cushion provides soft but secure support for the back and tail bone, while allowing shoulders to move freely to move freely, and ensuring the full body can be harnessed safely		*Moderate*	*High*
Security *Safety, securing resources*				
Safety	Driver safety			
State, Group, Individual				
Securing resources *Optimization of limited resources (cost effectiveness)* • *Value* • *Accumulation of resources (wealth)*	Price is important to new drivers or team owners(limited wealth)			*High*
	Reliability, Adjustability		*Moderate*	
Control over the environment (tasks)	*Product (tool) that amplifies human abilities*			
Convenience *Ease of Use*	Ease of ingress-egress **MASTERY**			*High*
Speed (fast, less time)	Poor Design leads to slow exit under emergency			*High*
Control (precision, responsiveness, power)	Ergonomic support to allow full driver concentration **CONTROL and MASTERY**		*Moderate*	
Long-Term Security/Stability of Group *Health/care/activity* *Environmental sustainability* *Motorsport sustainability/inclusivity* *Insurance (car, house), pension, investments*	Caring for baby *Is my baby warm enough? Comfortable? Feeling safe?*			*High*
	Strollers are a form of security of the baby for parents	*Slight*		
Social Belonging *Effort / resources to belong to a 'tribe'*				
Fear of embarrassment	Might waste money/break the car			*High*
Fear of crashing	Could become injured or worse			*High*
Fear of missing out	Wanting to participate in sport or fulfill goals in a particular motorsport		*Moderate*	
Esteem ***Personal influence in 'tribe'***				
Social Status 'The elite have it…I want to be like them'	Highly Rated in the industry		*Moderate*	
Social Recognition	Well respected by most people due to brand		*Moderate*	
Sexual attractiveness	Not cheap (RECARO)	*Slight*		
Self-Actualization ***'Higher order' Functions/Needs*** ***Needs that are pre-dominantly 'outer cortex'***				
Intrinsic pleasure	Will it provide fulfillment and safety		*Moderate*	
Creative endeavors	Will it encourage participation and practice?		*Moderate*	
Experiential (extrinsic)	Will it promote comfort and support		*Moderate*	
Experiential (intrinsic)	Will it promote focus		*Moderate*	
Emotional	**Empathy:** *Is my body ergonomically positioned well enough to be sustainable for a long period pf time/ownership of the product*			*High*

2.2 Product Research

Hierarchy of design elements within the user interaction/experience of the product. The biggest challenges must be solved to make the product comfortable. Adjustability for different user control preferences, seating preferences, and positions. Innovating the harness points of the safety equipment with multiple options for different sizes. From survey results and user interviews, a common complaint with current personal vehicle experiences was- entrance and exit of the vehicle- because without having another person there for physical assistance; the user needs to have the appropriate product to hoist their own body out of the car, and onto their chair, or if they had walking assistive devices; a grabbing point to assist; had to be present. Upright seating positions were preferred due to these ease-of-use scenarios.

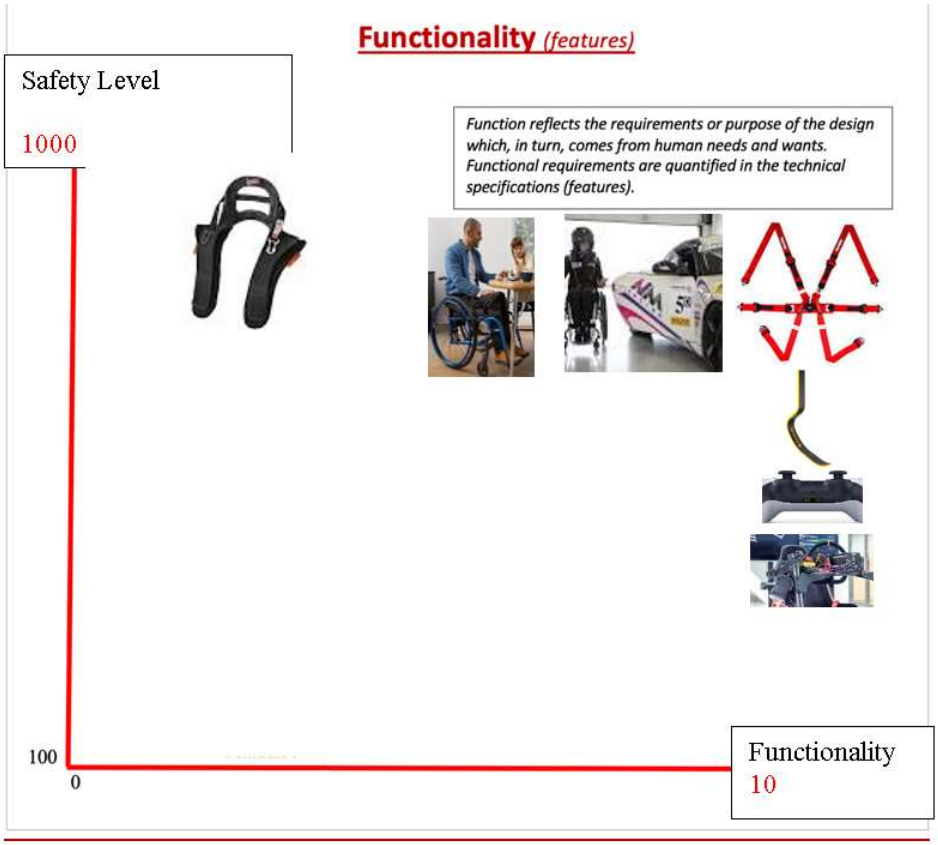
2.2.1 Benchmarking – Benefits and Features

Features

							
	1	2	3	4	5	6	7
	HELIO C2 FOLDING WHEEL CHAIR	Ossur Cheetah Extreme Nike Spike pad For sprinting/Extreme	Dual Shock Sony PlayStation 5 Controller	HANS DEVICE; NECK BRACE FOR DRIVER-CRASH PROTECTION	VR Racing Simulator **VARIO**	mission motorsports; Porsche 987 Cayman S,	6-point racing harness (example; Momo Camlock s6)
Power (Watts)	manual	Manual	Rechargeable battery	N/A	**Electric 12 v plug**	ICE-powered flat 6	N/A
Adjustable?	**Y**	n	Y	**Y**	Y	n	**Y**
Sound level	low	mid	Very low	n/a	**low**	high	**n/a**
Material	Carbon Fiber composite	Rubber and aero-space-carbon fiber composites	Injection Molded High impact polymer and rubber	Carbon Fiber and Kevlar	Plastic, aluminum	Carbon fiber Composite Steel Aluminum etc.	Polyester
Manufacturing	Bending	Laminated	Injection Molded	Laminated/molded	Injection Molded	Fabricated and bent steel Stamped body panels	Sewed
Dimensions (in.) (W) x (H) x (D)	(W)16.0(H)21.20(L)	**(w) 4, (H) 15, (L)10**	N/A	**Comes in multiple sizes**	**N/A**	**n/a**	**n/a**
Volume (in³)	5880	600	n/a	n/a	**n/a**	n/a	n/a

Figure 6

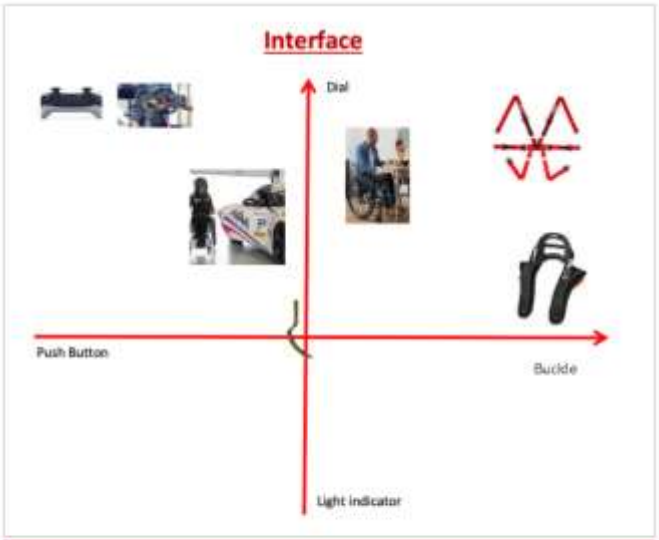
2.2.2 Benchmarking – Functionality of Existing Products



Take-Aways

Products designed for competitive activity are required to include safety specs, and functionality in order to help the user.

Figure 7



Design Take-Aways

Interface Types

a) Push button
b) Dial
c) Light indicators
d) Buckles

Figure 8

2.2.3 Benchmarking – Aesthetics and Semantic Profile of Existing Products

							
Shape *Geometric* Rectilinear, Ellipsoid, Cylindrical etc)	Cylindrical frame	Geometrical	Soft/rounded	Soft/round	Cylindrical/functional frame	Soft/smooth	Soft geometrical
Repetition - Arrays of holes - Arrays of lines	Tubing slots	Carbon pattern grid	Arrays of buttons	-patching/stitching	Arrays of buttons	Flowing body sections on the panels all the way around the exterior of the car. Tubing for roll cage on interior	Stitching
Pattern	Rim wires	Grid	Hand mapping	Stitching	Connection points	Fabrication and fasteners	Mesh

2.2.4 Benchmarking – Materials and Manufacturing

							
	1	2	3	4	5	6	7
	HELIO C2 FOLDING WHEEL CHAIR	Ossur Cheetah Extreme Nike Spike pad For sprinting/Extreme	Dual Shock Sony PlayStation 5 Controller	HANS DEVICE; NECK BRACE FOR DRIVER-CRASH PROTECTION	VR Racing Simulator **VARJO**	mission motorsports; Porsche 987 Cayman S,	6-point racing harness (example; Momo Camlock s6)
Material	Carbon Fiber composite	Rubber and aero-space carbon fiber composites	Injection Molded High impact polymer and rubber	Carbon Fiber and Kevlar	Plastic, aluminum	Carbon fiber Composite Steel Aluminum etc.	Polyester
Manufacturing	Bending	Laminated	Injection Molded	Laminated/molded	Injection Molded	Fabricated and bent steel. Stamped body panels	Sewed
Dimensions (in.) (W) x (H) x (D)	(W)14,(H)21,20(L)	**(w) 4, (H) 15, (L)10**	N/A	**Comes in multiple sizes**	**N/A**	**n/a**	**n/a**
Volume (in³)	5880	600	n/a	n/a	**n/a**	n/a	n/a

2.2.5 Benchmarking Sustainability

F1

Hybrid regenerative technology allows f1 cars to go one full race on a singlefill-upp of fuel. The fuel burned is green, and the hybrid power regeneration technology in the car; allows it to perform at maximum load for extended periods of time. This is a reason the equipment needs to be “bulletproof”, (very reliable).

Formula E

This is a high-class electric-powered racing class; while it looks similar to F1, it is much quieter, while being loud in an industry. F-E marks the beginning in a new generation of extremely fast, well-performing automobiles, powered completely by electric battery drive trains

Tesla:

Battery Skateboard vehicles. Manufacturing their own automotive parts, rather then out sourcing the manufacturing of specific components to the automobile; this is one of a kind for an automotive company. The company has indirectly assisted mobility for individuals with physical and/or mental challenges through ai technology, and user experience design. Quickly this has excelled Tesla to the top of the competition in the electric car market.

2.3 Summary of Chapter 2

Innovation through inclusion. Motorsports are a complex group of challenges implemented into a competition format. Unlike many sports, there are few ways to get involved, and it can be challenging to see the sport as viable when only a select few can do it. To improve the inclusion of people into the industry of motorsports; data is needed to figure out the demand of certain demographics. The focus of the project is to design for individuals paralyzed from the waist down. This is a demographic which has not been focused on in the motorsport realm. The issue is this leaves innovation out for adaptive vehicles from competitive testing because racing also helps the development of OEM cars. Racing tests the high limits of the products we have available for cars, the hardware those cars utilize, and how the user interacts with the vehicle to control it in a racing environment/scenario. With that innovation, the goal is to apply the same process for the physically challenged. Looking at events like the Paralympics; it is clear to see the high demand for inclusive sports, for the physically challenged athletes and fans, is very prominent and an industry. Sports like hockey have been modified with different equipment to allow for physically challenged individuals from the waist down (paralyzed) to play and compete. Sled hockey is the perfect example of a sport being modified to innovate and include a demographic; that otherwise; would not have been able to play hockey. Racing cars have an opportunity to be designed for a similar reason but have not yet been done. Current cars that have been made for paralyzed users- are simply one-off builds that provide the driver with the opportunity to race against able-bodied competitors- but no class or select car has ever been created for the physically challenged, to compete in racing against other non-able-bodied competitors.

Chapter 3 Analysis

Physically challenged user Ingress/egress with personal vehicle (no assistance)

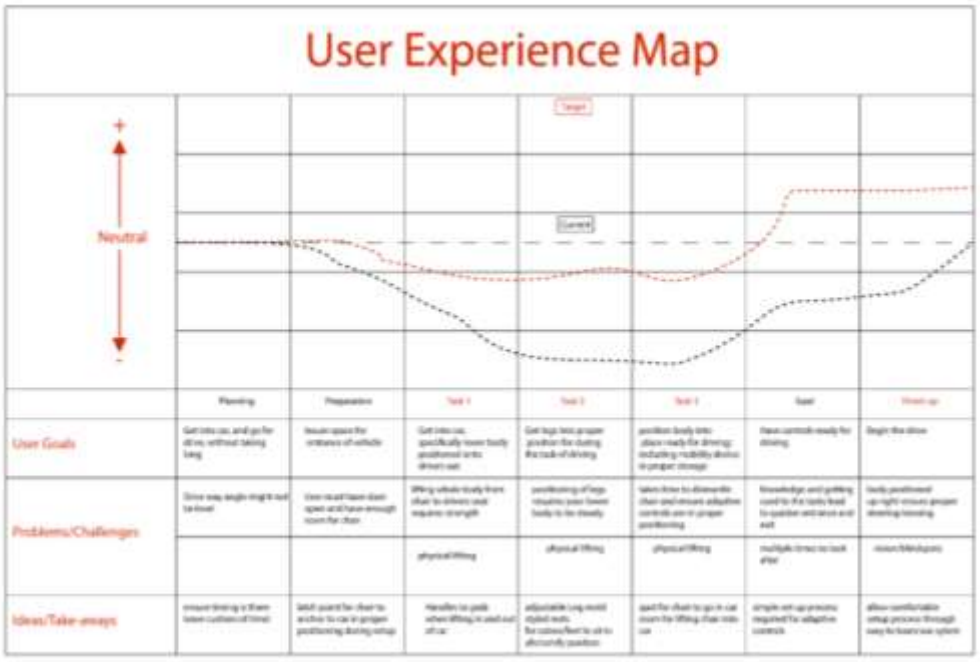


Figure 9

3.1.1 Needs/Benefits Not Met by Current Products Comparable

The physical challenges of the driver need to be focused on from the ground up. These problems range from user tasks of controlling the car to user tasks of maintaining/adjusting the car, and entrance/exit of the vehicle by the driver. Just like in reality; the design and innovation of racing- applies to the OEM world of manufacturing, which in turn, can also affect the global job marketplace by increasing job opportunities for the physically challenged because problems that need to be solved for motorsports driving, also apply to other forms of driving; within careers, and industries (like factory manufacturing/logistics/warehouse). On the market, there is the technology that provides physically challenged users safe, and legal hand controls for vehicles; like Guido Simplex hand throttle and breaking. The market lacks any product that provides the possibility for a physically challenged racing class. The technology and products on the market express a viable solution is yet to exist, but the materials and technology is there. Through efficient use of User research and product benchmarking; a

design that solves these problems will be created. Once this is complete, the car will exist to provide physically challenged users a car to race against similar opponents.

3.1.2 Latent Needs

- Gains: Adjustable vehicle control heights- for different-sized users
- Seat ergonomic support adjustments for users that need different seat angles
- Pains:
    - Headroom for users after being strapped in
    - Tight viewing angles due to body containment (cannot shoulder check)
    - Frustration at not being able to compete without the proper car/race class being built
    - Hidden: body can become more tired if the positions of the body (when controlling the car) strain the back, triceps, and lower and/or upper back.
- Usability & Ergonomics
    - Chronic strain on upper back and shoulders
    - Strain on the neck from g forces if supports aren't properly placed
    - Painful harness points if the harness cannot be adjusted properly per user with different seat positions requires equal adjustments available to the mount points to ensure proper harnessing angles
- Efficiency
    - Use of adjustment panels once inside the car; location of controls and analog method of use for controls for easy-to-understand and use features/needs. Many racing seats are not adjustable once installed, whereas this model requires adjustments after being installed. This requires added structural and moveable systems for the seat and seat rails regarding containment and securement to the racecar floor/chassis.
- Interaction
    - Handles for ingress/egress need to be placed ergonomically
    - Adjustment panels need to be accessible when seated in the car
    - Vehicle controls need to be adjustable for proper handling of the vehicle when the user is driving.
    - Hand controls allowing brakes to be applied via pressure sensitive trigger, as well as throttle/acceleration available via finger trigger (like the brake trigger)
    - Hand controls on both right or left in front of the user; allow for steering to be done via an analog stick controlled by one's thumb, or steering available via a steering wheel, (with an assistive hand knob for one-handed use.)
- Satisfaction
    - User can comfortably get in and out in an efficient time, with non-strenuous body movements
    - User can adjust controls and ergonomic supports easily once in the car to allow for comfy body positioning

3.1.3 Categorization of Needs

Wants, Latent Needs, and Immediate Needs that correlated to benefits.

Wishes

There was an easy way to get in and out of the car without help

There was a more comfy seating option when driving, due to awkward viewing angles, and posture.

Wants

A safe way to compete and race

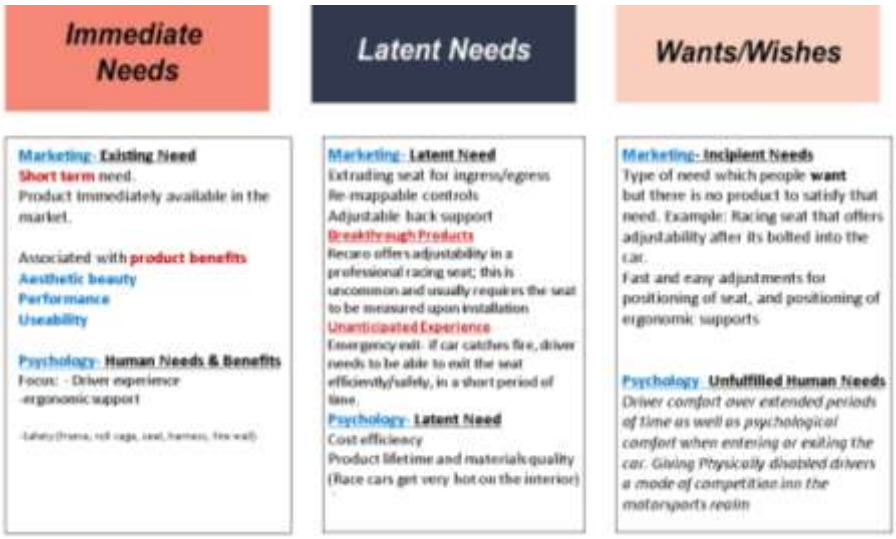
A less stressful process of operation due to adaptive controls

Latent Needs:

- Comfort once strapped into the vehicle
- Ease of use over long periods during high-intensity driving

Immediate Needs:

- Assistive handles for ingress and egress. Users need to be able to slide from their wheelchairs- into the racing bucket seat The user also needs to be able to leave the vehicle quickly if there is an emergency. This means the handles for lifting one's body, will need to be mapped logically and clearly for the user.
- Safety equipment like; 8 point harness- with proper mounting points. The harness angle required from the floor is dependent on the user's height
- Hand control steering, braking, and acceleration. Meaning foot pedals will not be used in this car. Certain users will prefer to use a steering wheel, and certain users will require analog stick steering via hand remote-style controls, due to physical mobility.
- Full body racing bucket seat, which adjusts in width, back angle, lumbar support, distance from steering controls, and height from floor



How the Design can accommodate for user needs:

User needs to be able to control the acceleration and braking of the vehicle through the use of hand controls, so that they don't need to use foot pedals. Users need the seat to be adaptive to their body size, stature/posture, and preferred method of ingress/egress. Users need to be able to get in and out quickly, and without assistance.

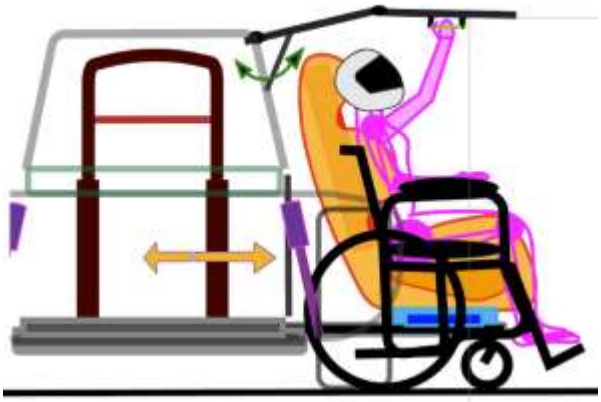
Control

Some users will require analog stick-hand control steering, rather than using a steering wheel due to the shoulder movement required by a steering wheel. Although a forklift-style hand knob will be available on the steering wheel if needed.

The control systems in the car will extrude out from the dash or be inactive and stored inside the dash and out of the way when not in use. This way the user has ample space ergonomically and a good/required viewing angle out of the front windshield.

Ergonomics and Ingress/egress

The seat will need to extrude out of the car by 24" to accommodate users getting into the car from a wheelchair. A trunk-style door will lift before the seat slides out; providing an upper support system for the user to grab onto; to lift their body. Handles will be mapped for the user to easily identify for efficient ingress/egress. User research/observations showed through measurements of the 50^{th} percentile male, and 50^{th} percentile female (Dreyfuss, H. The Measure of Man and Woman) and 1:1 tests that the users who slide into the seat, would prefer to have a handle above them, about 55-59" from the floor, to use their dominant side arm to slide in the seat, from a wheelchair. This requires the seat to rotate 45 degrees counter-clock wise, in order to allow left-handed individuals an above-head handle, and ergonomic space to transfer into the drivers seat from a wheel chair.



Safety

6+2-point harness, connected to a 10-point roll cage. This is a severe safety requirement for the securement and crashes safety of the user when in the car, in the case of an emergency. The harness design will add 2 new points to the (regularly used in racing) 6-point harness; by adding a strep for each thigh of the user. The 2 straps will come off the floor-mounted center point strap (that mounts in between the user's legs.)

3.2 Analysis – Usability

Task; entering using the race car hand controls /driver's seat	Ergonomics	Efficiency	Interaction	Satisfaction
Get into car	Bending of back and possibly knees, hoisting body.	The location of touch points is easy to sport and reach, lifting the body is strenuous on the user though	Hoisting body into a car by sliding off the wheelchair and onto the seat, or bending over and getting in manually onto the car seat from one's feat	Structural and easy-to-map touchpoints
Grab touch points	Hoist points (need to be strong/structural)	Analog lifting	Touching handles	Easy-to-reach hoist handles
Ensure proper seat adjustments/height	Back support Lower back support, Legroom	Adjustable seat positioning	Touching seat controls on the side of the seat	Easy-to-reach control panels
Ensure proper seat placement in relation to hand controls	Touch controls to adjust the seat.	Location of controls for seat	Touching seat controls on the side of the seat	Useful adjustments that provide needed support and comfort
Ensure proper control handle, and/or steering wheel heights	Easy to reach and use for extended periods of time. Ensuring proper arm angle per individual	Easy-to-use controls to provide proper adjustments anytime the user needs them	Using the control panel on the dash for vehicle control adjustments	Controls allow proper adjustments for the user's arms to be in a comfortable position during driving/use of vehicle hand controls

3.2.1 Journey Mapping -pain points/delight points

Pain Points:

Shoulder checking

Ingress/egress

Prolonged extension of arms

Prolonged uncomfortable seating posture due to seat

Viewing

Rapid movement of the steering wheel

Stress when driving due to other cars

Safety and ergonomics	Efficiency	interaction	satisfaction
Crash safety	Fast ingress/egress under emergency	Touchpoints for body hoisting and door controls/escape panel on the roof	Secure body and mind at ease when thinking of worst-case scenarios
body positioning	Proper movement available once in seat	Movement of the body when driving, and under g forces	Control of the vehicle is comfortable and encourages focus on vehicle handling
Harnessing positions/angles	Safe securement and harnessing under g forces, or a sudden halt due to a crash	Impact of g forces on the driver with harness and seat; shoulder straps, leg thigh straps, and center belt with leg securement straps	Proper strap/belt mount points adjust with seat placement to ensure safe angles of; harness straps.

3.2.2 User Experience/Usability

This User Observation was focused on specific key activities.

These specific key activities were: Using analog controls in the interior of the car; using a mock-up model

These specific key activities were determined by …. User interviews and user observation research

The main points studied were:

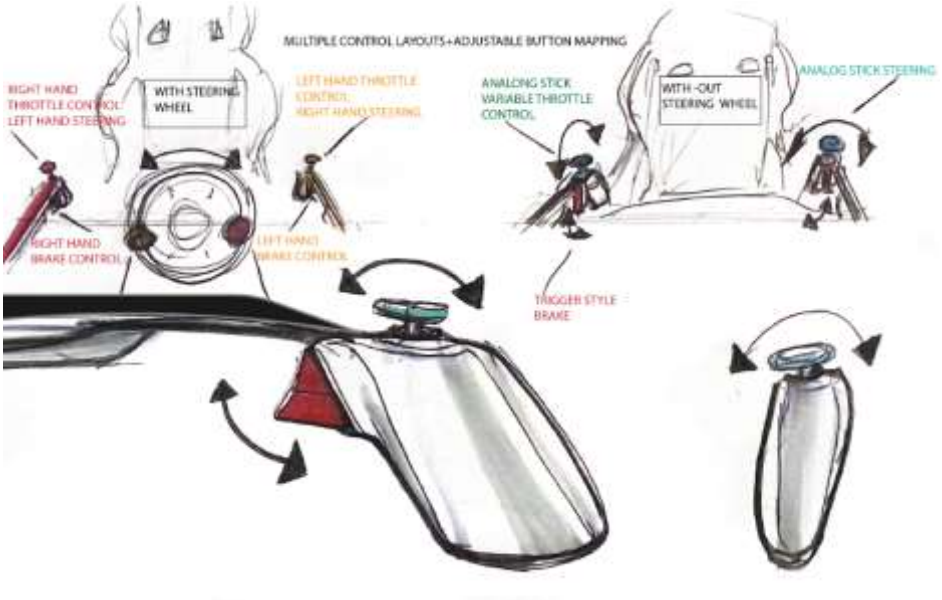
Driver positioning; ergonomically and safely

Controls and control positioning for the driver

The adjustability of seat/supports.

Ingress/Egress testing extruding the driver's seat; to help users get in and out of the car from a wheelchair.

Figure 10



Design Intent/concept exploration

Create a class of “Race-Car” for the physically challenged. Utilize electric drivetrains of the future, as well as innovate the driver and maintenance experience of the vehicle. Increase inclusivity within a sport that requires investment, and dedication. Motivate athletes of all different types of demographics. Create a safe vehicle for athletes paralyzed from the waist down- to compete in (drive/operate on track legally)

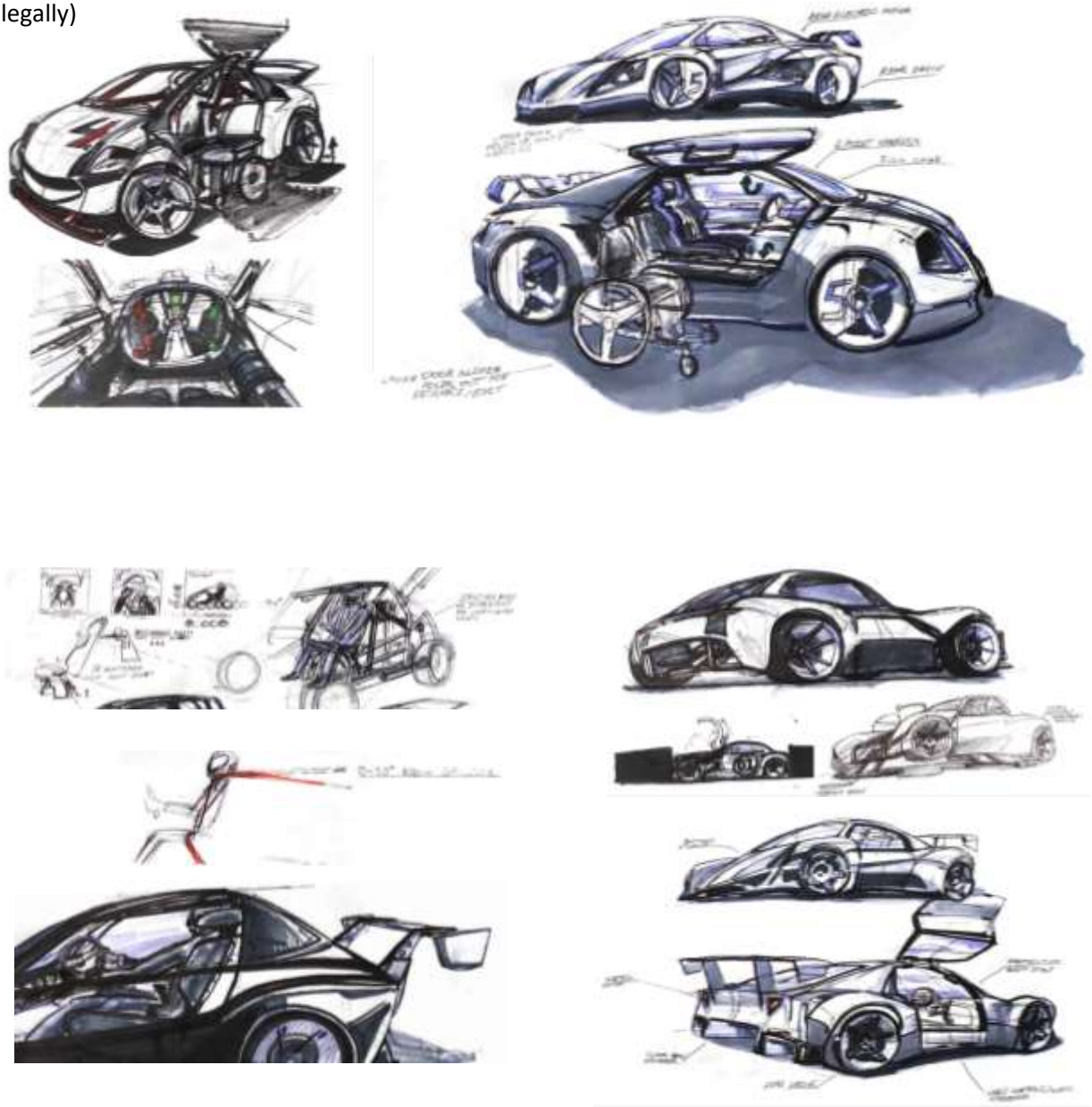


Figure 11

3.3 Analysis – Human Factors 1:1 scale study

Concept Goals/Semantic profiles

Create a user experience that allows fast and safe entrance/exit of the vehicle.

Create a vehicle that allows physically challenged users to be comfortable and competitive when driving

Lightweight body; with a hydraulic system that self-jacks the car up; before the user exits the vehicle in the pit section.

Improve movement process through hand control systems.

3.3.1 Human Factors

The semantic diagrams below were designed based off of research and then updated after the 1:1 study was finished. The final measurements are designed to fit male and female 50th percentile-sized individuals. Percentile sizing was selected based off of the physically disabled male and female body types.

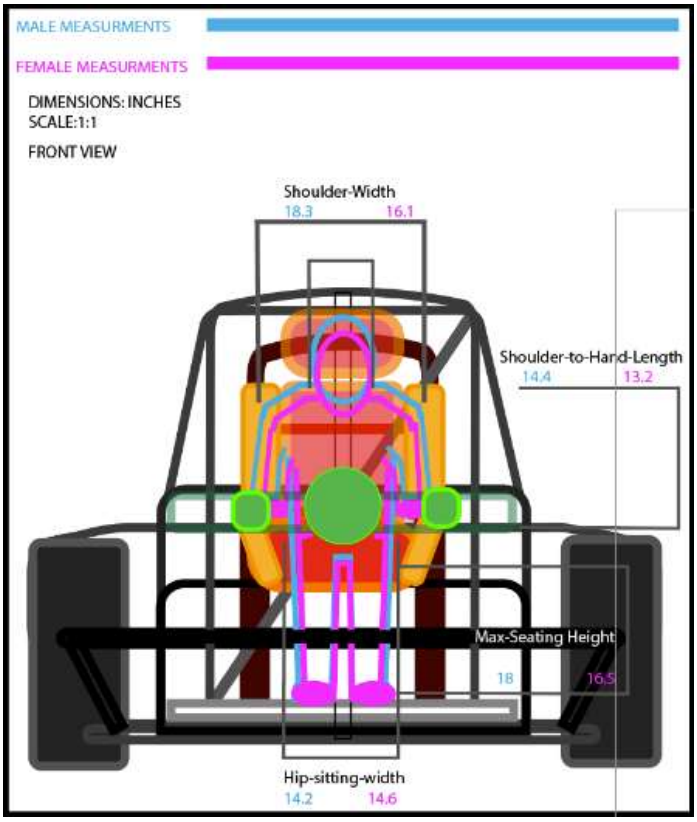
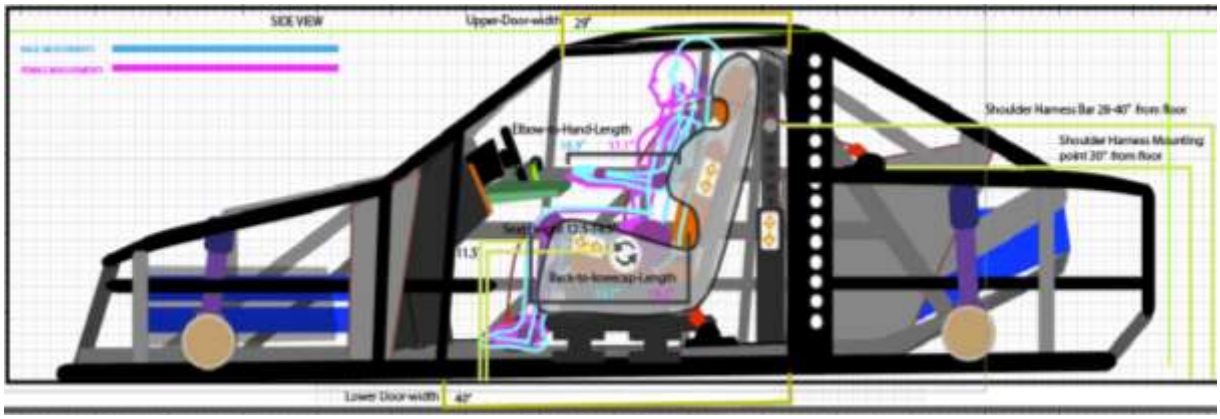
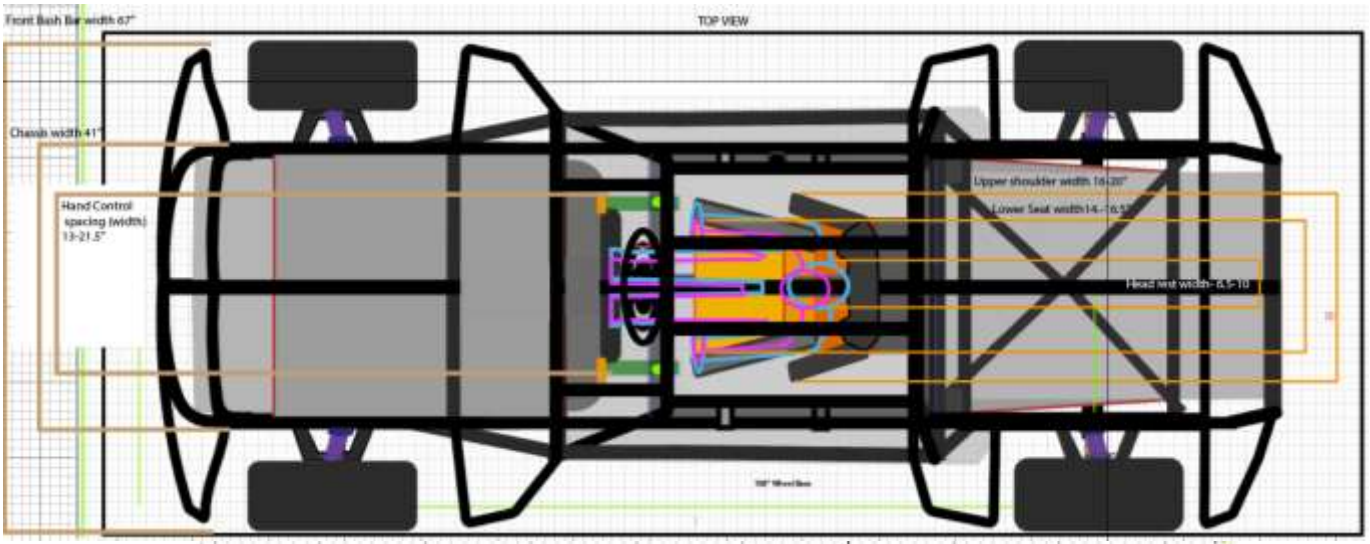


Figure 13


SIDE VIEW
Upper-Door-width 29"
Elbow-to-Hand-Length
Shoulder Harness Bar 28-40" from floor
Shoulder Harness Mounting point 20" from floor
Back-to-kneecap-Length
Lower Door-width 42"


Front Bush Bar-width 67"
TOP VIEW
Chassis width 41"
Hand Control spacing (width) 13-21.5"
Upper shoulder width 16-20"
Lower Seat width 14 - 16.5"
Head rest width- 6.5-10

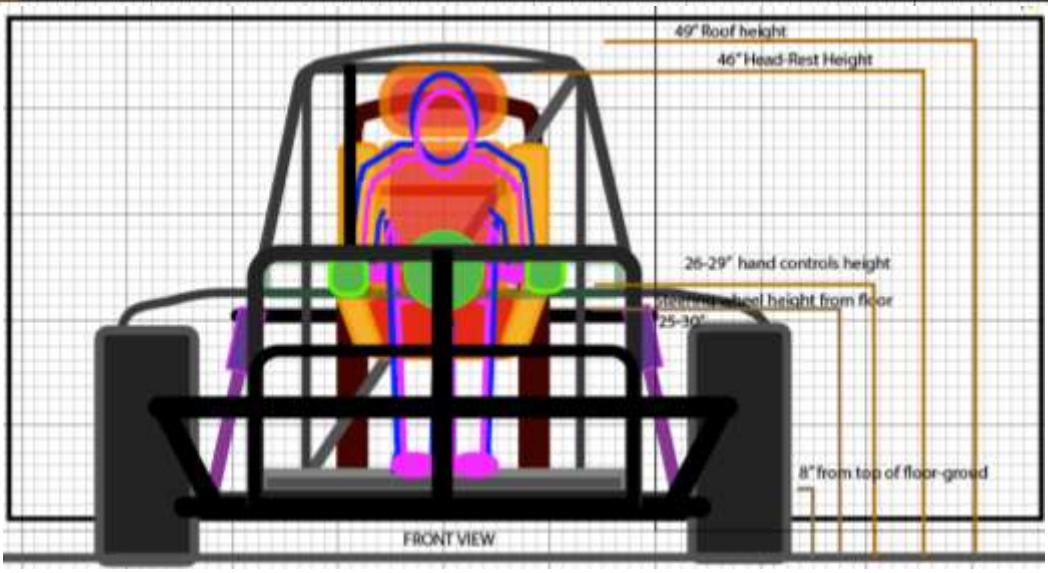

49" Roof height
46" Head-Rest Height
26-29" hand controls height
25-30"
8" from top of floor-grood
FRONT VIEW

Figure 14

3.3.2 Ergonomic – 1:1 Human Scale Study

Description of Users targeted by product.

Individuals with physical challenges aged 19-70 who are interested in driving a race car- or who enjoy motorsports. Male or female individuals in the 50th percentile are the focus of the model; and the design, in order to account for individuals in wheelchairs, but also individuals who walk with assistive devices or have spinal issues that affect their physical mobility, but still allow them to walk.

Evaluation Process:

The observation process consisted of watching a 50th-percentile male and female going through the steps of operating a car. The actions of controlling the car were done using mock-up controls, while photos were shot; to capture needed movements of the user's hands, forearms, biceps, and shoulders. The mock-up also includes the seat to understand the user's ergonomic supports needed for the lower back, spine, upper back, and shoulders, also insuring comfortable body containment.

-Observing the user get in and out of the vehicle-Ingress/Egress

-Observing the user position themselves in the vehicle/seat comfortably

-observing the user touch control panel locations

-observing the user showing their preferred height for entrance handles (if needed)

-observing the user steer and operate the throttle/braking system of the car using analog sticks and trigger-style buttons.

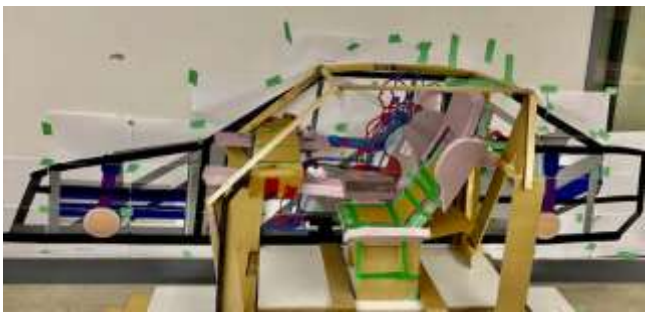
Objective

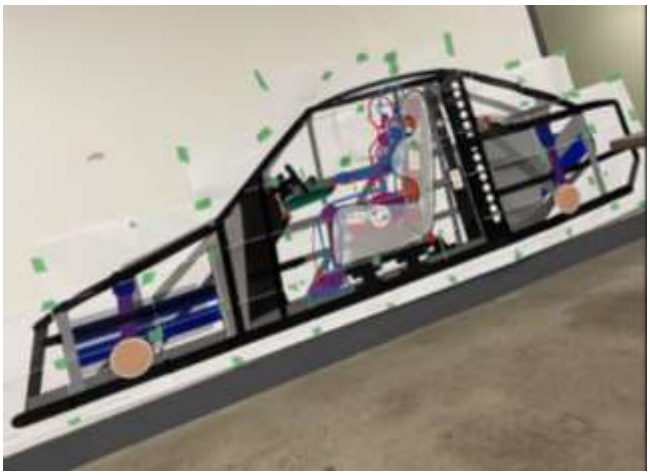
The Key Objective of the study is to develop the proper range of size specifications for; control instrument panel height/steering wheel and controller height. Seat angle from the floor, seat height, and seat distance from the steering controls. Grab points for the user to hoist themselves in and out of the car will also be configured based on measurements observed.

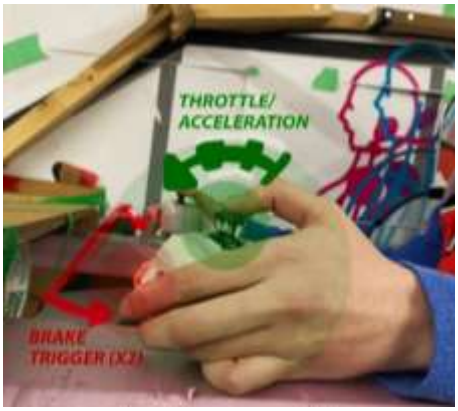
From the observations, the roof height, seat adjustment options, and control settings will be configured. Using observation 1 measurements and new measurements from both male and female 50th percentile participants.

Certain measurements will be adjusted as well as confirmed through observations 1 and 2.


HANDLE NEEDED
CURRENT SEAT EXTRUSION: 19"
NEEDS INCREASE BY 4"







3.4 Aesthetics and Semantic selection

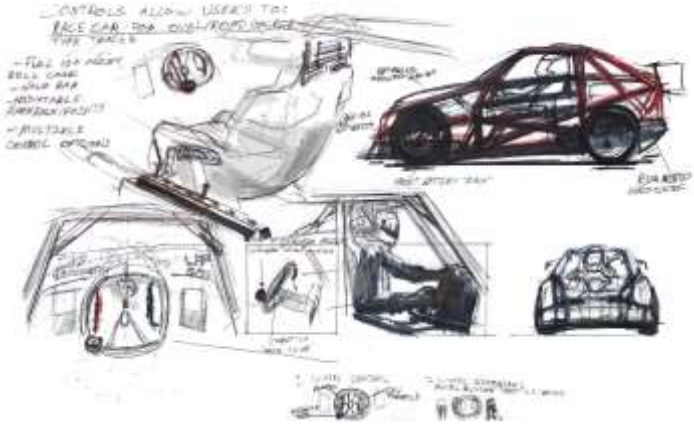
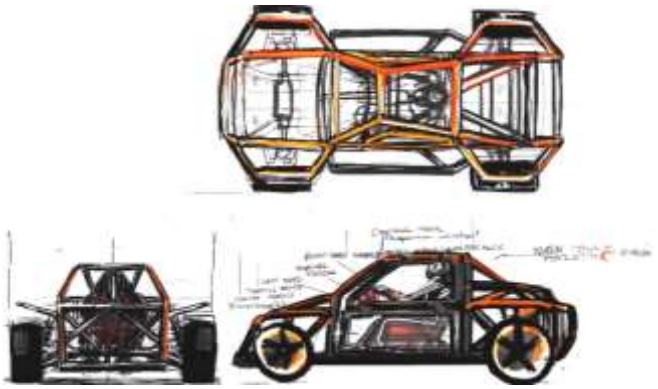
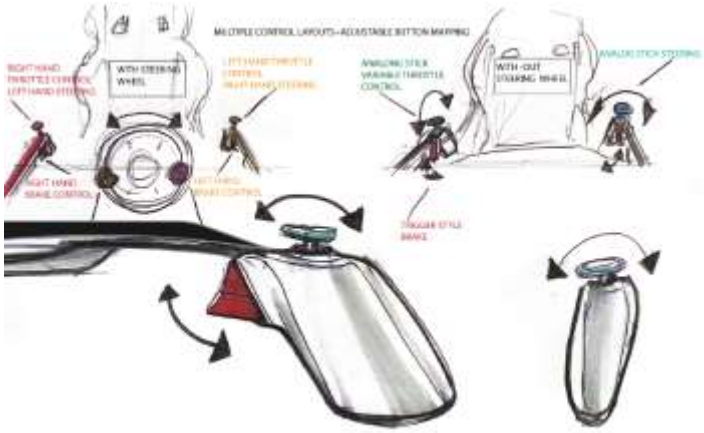
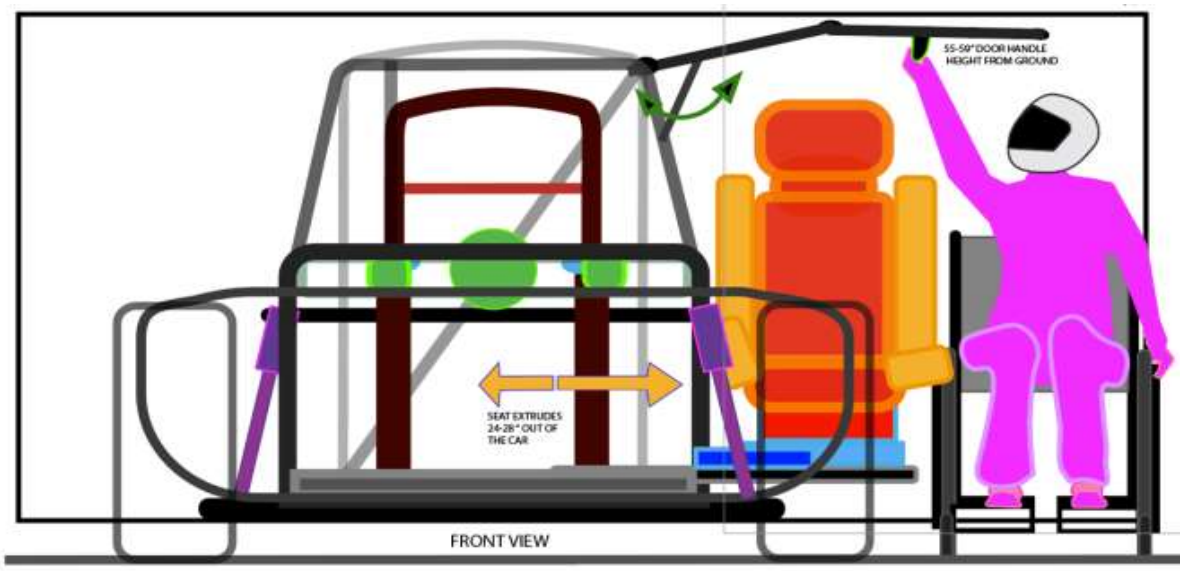


Figure 15

The design of this car is inspired from NASCAR-modified stock cars. The modifieds of North America have been an oval track racing series for 74 years. The National Association for Stock Car Auto-Racing series began in February 1948. The car is designed around user safety and usability. The controls are meant to bring a new sense of control for users who have limited mobility. Technology allows for the controls to have haptic feed back, allowing the user to feel more of the car and what actions they are doing when driving. The control system allows for multiple methods of steering control; selected by user preference or upper body physical need. The cage of the car is to protect the user at all costs, while the outside bash bars are meant to protect the car from collision damage. Aspects of the car body will cave in on impact; to protect the user from the residual impact of an accident.







3.4 Trends/Inspiration

Symbolism:

Paralympics first event: 1960; Rome, Italy. The Paralympics have grown since then And mark a staple in physically challenged athletics/sports.

In February 1948 NASCAR was formed. This started the Modified Racing series. The Modified class allowed drivers to run old and new vehicles

Made in the United States. Each vehicle was vastly different in appearance as the class

Had very loose body rules; and nobody template.

Technology:

Formula 1: Hybrid/power regeneration technology (recharging battery from brake force, and exhaust pressure)

Formula E: electronic battery-driven racing vehicles

Inspiration: Body styling, and color scheme.

Richie Evans (1941-1985) Stock-Car Hall of fame, and 9x NASCAR Modified Champion. (#61 Racing)

In 1978 Richie Evans designed all his race cars, which ended up being very successful. The body design he used; utilized

Sheet metal body components created a hollow shape in the top half of the car. This gave the car a large amount.

Of downforce, and speed in comparison to other cars. The modified stock car of today has a similar

style to the design created by Richie Evans

Famously, the body color of Richie's car was always orange. This is because it was the only paint that Richie could get for

free due to his friend working for a city construction business.

This coined the term; “Evans-Orange” and is an inspiration for the projects first concepts color pallet

Trends:

Sheet metal body for stock car

Open wheel body style (NASCAR MODIFIEDS)

3.4

3.5 Analysis – Sustainability: Safety, Health, and Environment

The project aims for increasing the inclusivity/participation of physically challenged people in the sport that is auto racing. With the global initiatives to design motorsports that don't emit a large carbon footprint. Therefore, the project's power plant will be electric, and the batteries will be sourced based on ethical materials sourcing. Other rules and guidelines have inspired the safety technology within the car's roll-cage design, and harness angles.

Paralympics

NASCAR Rules and regulations for stock-car racing

North American Stock car racing and touring car racing rules and regulations.

Racing cars is very expensive and requires energy. The term energy is used to describe; what the individuals who race- require to drive. Motivation, knowledge and of course driving skill. When out on track- the sport requires respect, maturity, professionalism, and wit. This is because drivers operate their cars while being very close together. Drivers leave space for each other when someone is on the inside of them going into a corner. If not; an accident is likely to occur. The sport is a give and take type of event; with how drivers treat each other on and off the track. If the sport of racing could be broken down into attributes; the skills required would be; Business and professional practice (to afford racing in the first place), Driving skill (in high stress environments close to other cars , and mechanical/engineering skill. These 3 skills are all unique. The business skills require individuals to be able to communicate clearly and respectfully. Driver skill is a mental and physical task that requires experience and patience, while mechanical/engineering skill requires knowledge, interest, and academic- skill. The sport of racing brings out many needed skills that are all unique. While these skills might keep others from racing; reducing the amount needed skills; is a way to draw more individuals to the sport.

Safety

12-point roll cage is designed to have as little seams as possible, to prevent bending or breaking under high stress events like; crashing into a wall, getting t-boned, front end and rear end collision, as well as flipping. For the safety of the driver, harnessing points will contact the users shoulders, thighs, and legs. This will be a custom 8-point harness with 2 straps added to the middle leg strap; keeping the drivers legs harnessed in position to the seat when sitting and driving. The user will have their neck harnessed using a Hans device, as per rules and regulations in modern day racing.

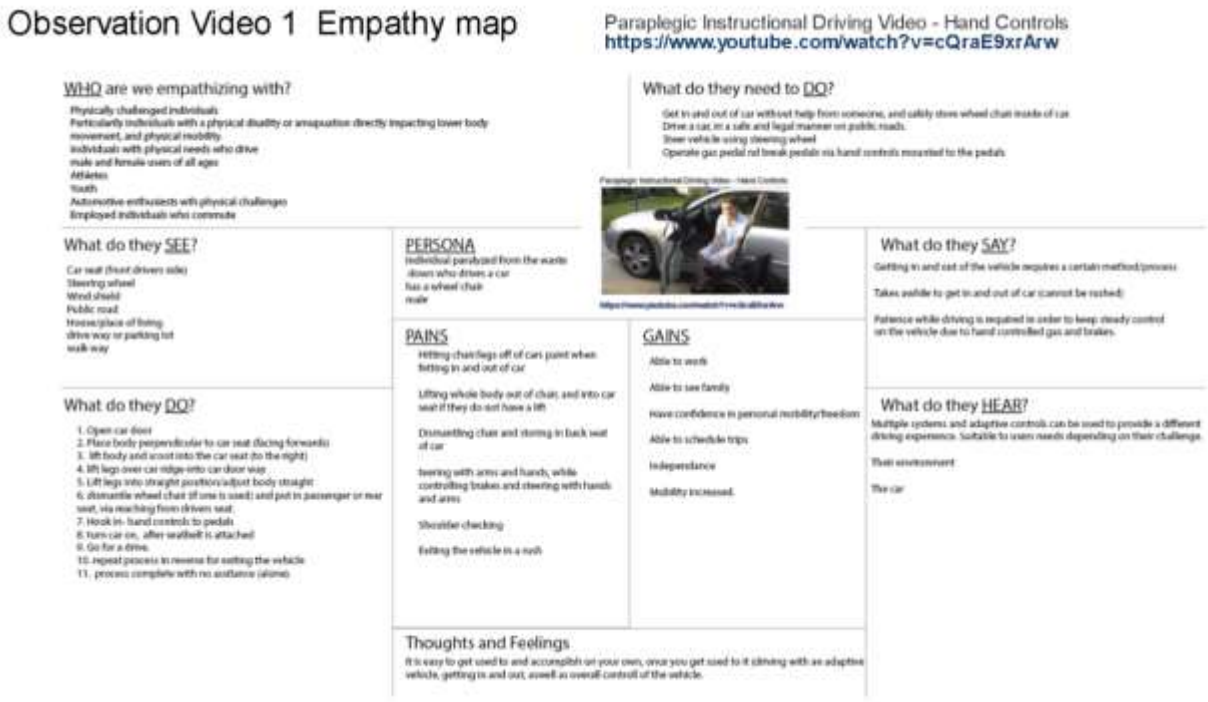
Health

The driver will be harness to the seat using an 8-point harness. The straps will be made of polyester webbing material, with a 2” width; to fit the users pelvic bone better. Other harnesses may offer 3” widths on the straps- but 2” straps have been proven to fit better; offering more harnessing safety.

3.6 Analysis – Innovation Opportunity

A new class of racing for a new demographic of individuals, who have never been the focus of a motorsport series. The feasibility is based around providing safe and efficient control, physical securement, and overall user experience of a racing vehicle. Ingress/egress is a challenge that needs to be solved for users in a wheelchair, which will change the layout of the car. The function of the car is to allow users to race it on; Oval-track dirt or paved, and road-course-style tracks will be the function of the race-car design. This is to increase the options for drivers located in different geographic locations with participation, and logistics.

3.6.1 Needs Analysis Diagram

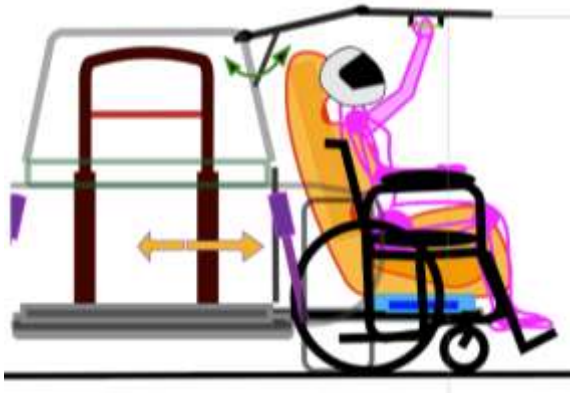


3.6.2 Desirability, Feasibility & Viability

Desirability:

The car allows users to freely enjoy the product that is, a race car. The options of control remove the need for a gas pedal/brake pedal. The ingress and egress is a priority for the user experience; to ensure smooth task flow/experience when users have lower body physical challenges.

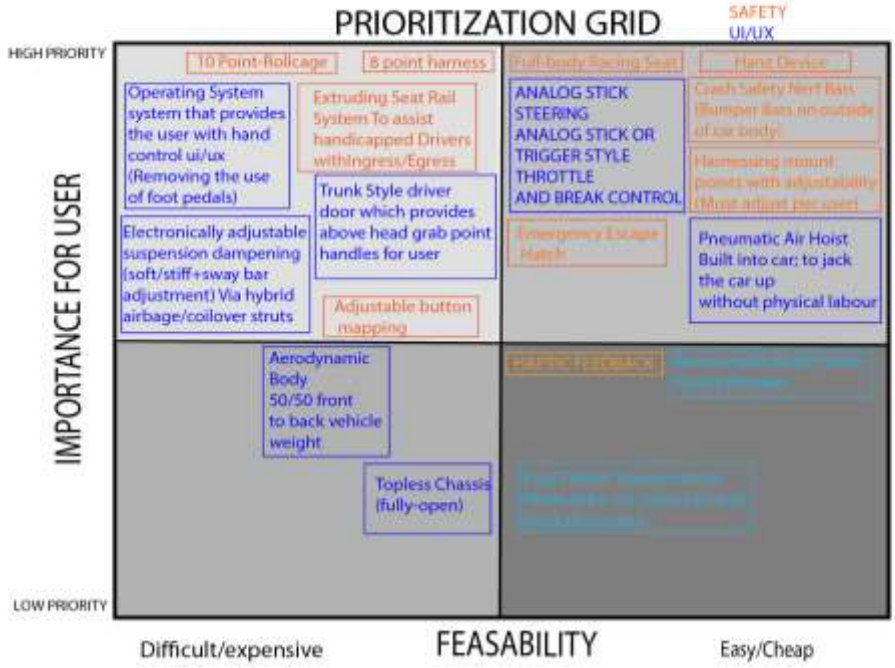
The seat will provide multiple options for ingress and egress methods by mapping handles on the trunk-style door. The seat can be extruded from the car and rotated using a key fob controller. This will allow users in wheelchairs to enter the seat from the left or the right.



Viability:

The design creates a new market for users with physical challenges; where the market has lacked a product or experience for individuals who want to race in a competitive and safe environment. The design is meant to create a new series of racing that centers around drivers with physical challenges. The FIA has created a new sanction; led by Nathalie McGloin to increase inclusivity in motorsports. This is a global initiative to increase the opportunity of participation in motorsports for the physically challenged. Users will be able to be licensed to race; by doing a special training course that teaches them the controls; and ensures their ability to drive in a racing environment. For racing the users will need to acquire sponsorships that commercialize their team- and associated companies. In reference to events like NASCAR, F1, or even smaller series at local short track ovals in north America operate based on the model of sponsor ship. This is how teams/drivers can afford the costs of operation.

FEASIBILITY



3.6.3 Materials/Manufacturing

Using materials popular in the industry like; carbon fiber, CRS (Steels), and safety equipment like; 10 point roll-cage and a specially designed harness/racing seat; the design can safely provide physically challenged users the user experience they have not been able to partake in. Sustainable materials will be thought about after the user's needs, and the product's functions are capable of achieving high performance in order to race safely. Clean/ethical manufacturing will be weighted heavily in the process of selecting materials while ensuring the user is able to afford the product. In other words, the car is meant to increase motorsports sustainability by increasing the market size and adding a new demographic into the industry. The power plant and use of the car is aiming towards clean use. This means the car will need to be powered by lithium-ion batteries.

Steel tube Frame: Fabrication, Metal bending.

Roll-cage: Steel bending and fabrication

3.7 Design Brief

The primary objective is to provide physically challenged users with a race car that they can fully operate in a competitive motorsports environment. The race car does not have foot pedals and instead has hand controls. The operating system and interior ergonomics are designed for individuals with lower body mobility challenge to easily operate, adjust and control on and off of a racetrack.

Goals:

Increase participation of the physically challenged in motorsports by designing a vehicle/car-class around the demographic.
Mitigate the risk of pain/injury that occurs when entering or exiting a vehicle
Mitigate the risk of other injuries caused by traditional racing harness and seat
Integrate Hand Control throttle and braking
Integrate Hand control analog stick steering/or knob and steering wheel
Streamline the adjustment process of suspension setups at the racetrack
Eliminate the need for physical labor when adjusting suspension setup by integrating hybrid electronically controlled airbag/coil overs
Mitigate distractions when driving through the use of haptic feedback and AR.
Ensure the product is comfortable and contains body during G-forces onto the physical body of driver
Improve the aesthetic appeal of the equipment for the user

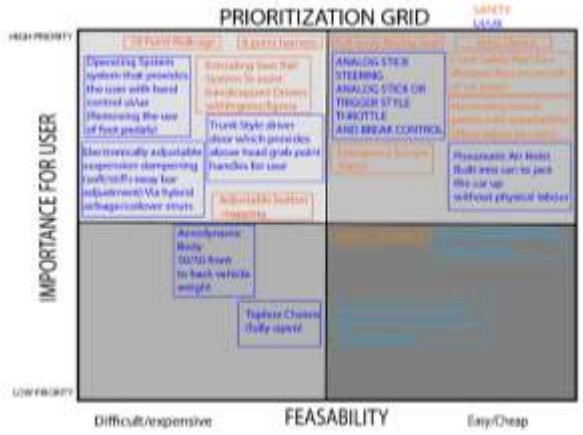
Chapter 4 Design Development

4.1 Initial Idea generation

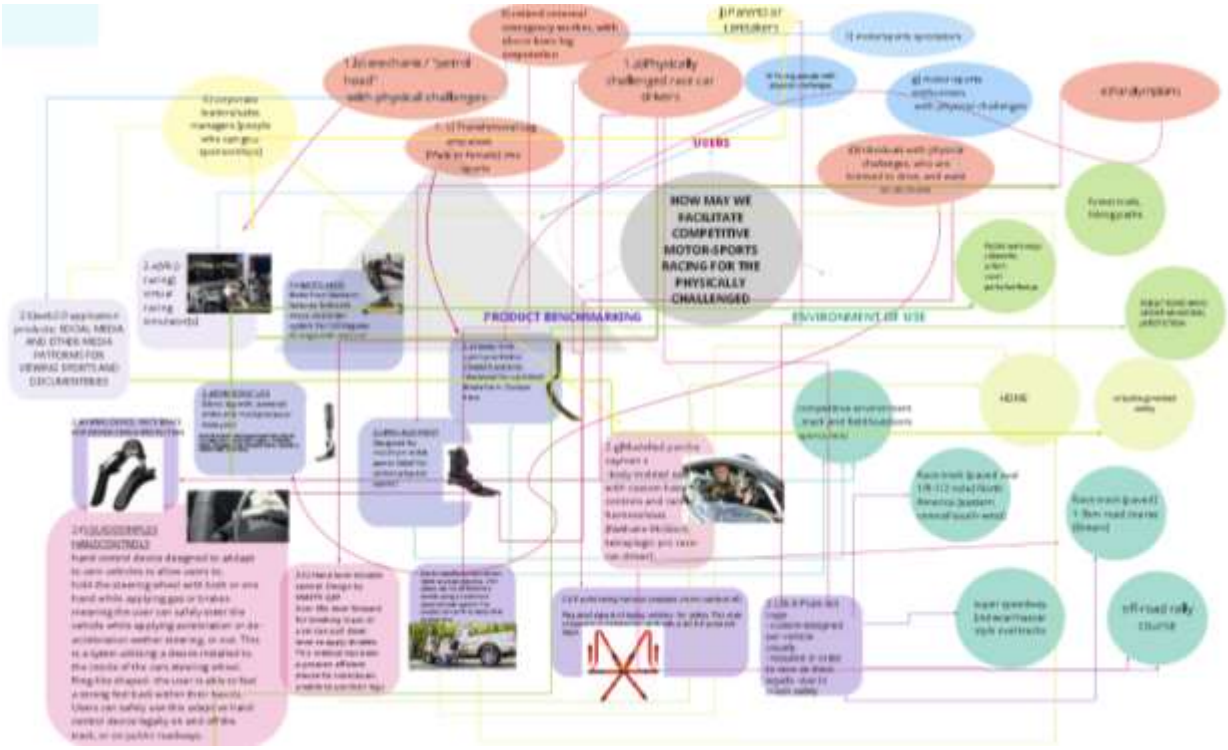
- Create a class of “Race-Car” for the physically challenged
- Utilize electric drivetrains of the future, as well as innovate the driver and maintenance experience of the vehicle
- Increase inclusivity within a sport that requires investment, and dedication
- Motivate athletes of all different types of demographics
- Create a safe vehicle for athletes paralyzed from the waist down- to compete in (drive/operate on track legally)

4.1.1 Aesthetics Approach & Semantic Profile

The approach to the shape and size of the car is based on the user experience being aimed for. The car needs to be “light on its feet” and easy to control. Steering methods on this vehicle could be controlled via analog sticks. requiring the car to be predictable and planted.

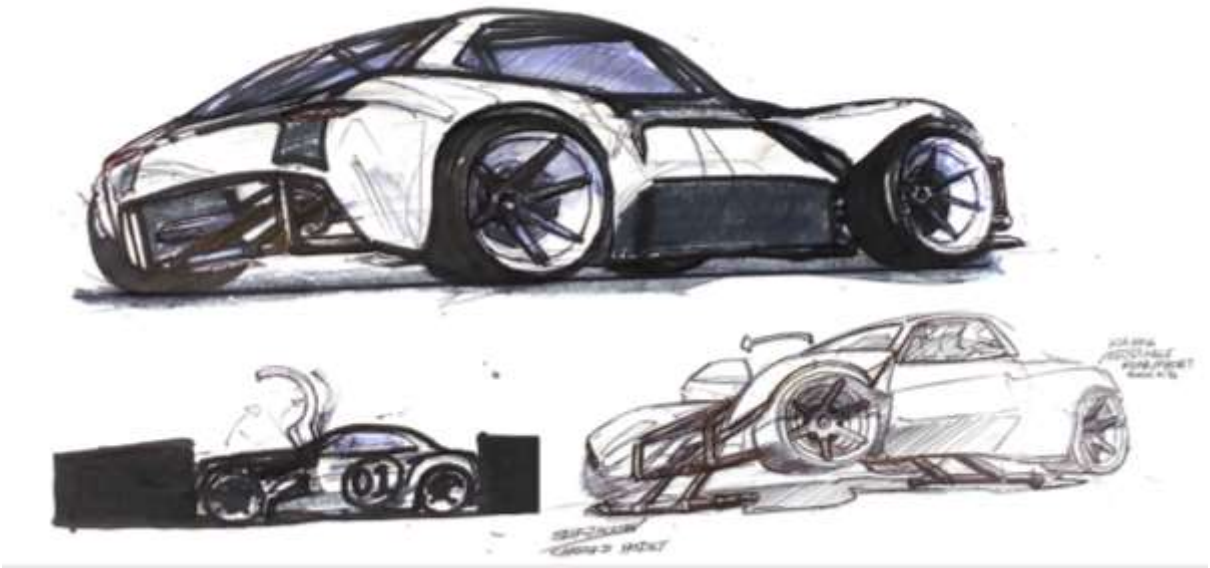


4.1.2 Mind Mapping



4.1.3 Ideation Sketches

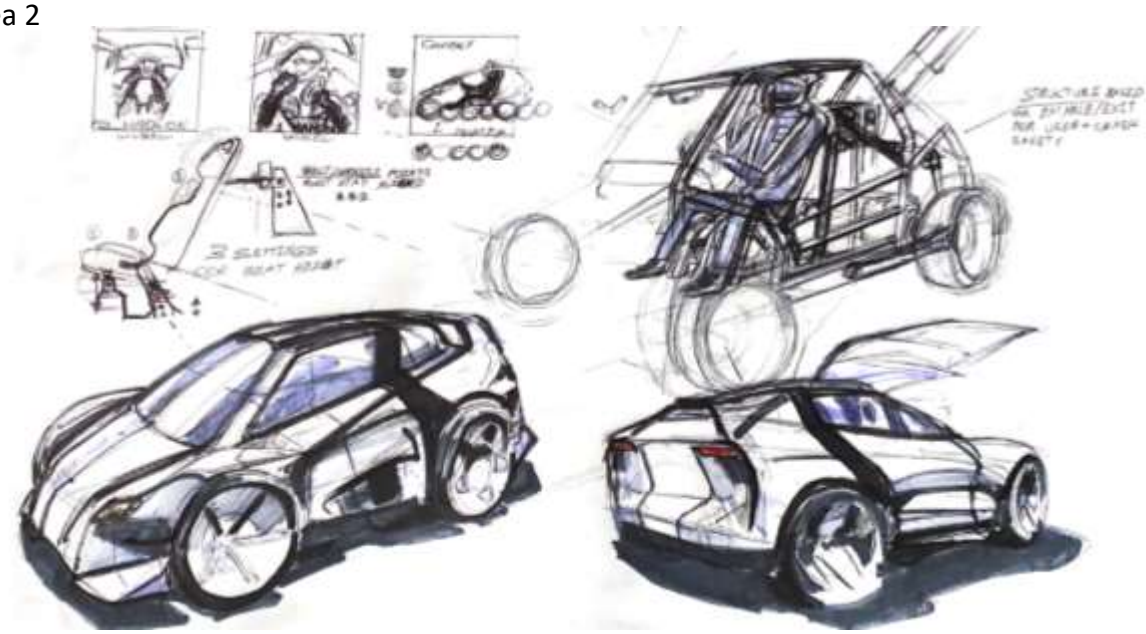
Idea 1



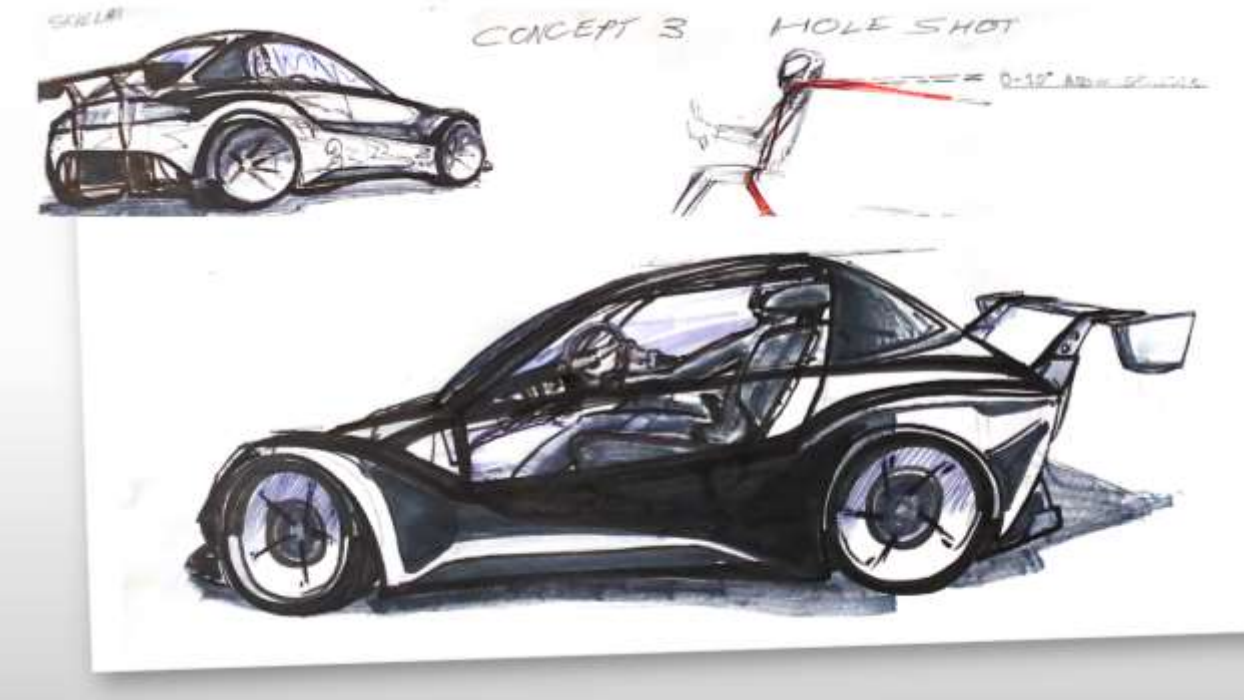
Small-mid sized race car. Features include UI/UX which eliminates the eed for physical labour when adjusting suspension and power train system(s) on the car.

-Self Jack (hydraulic jack, powered by pneumatic air) -Full tube frame roll cage/bumper bars

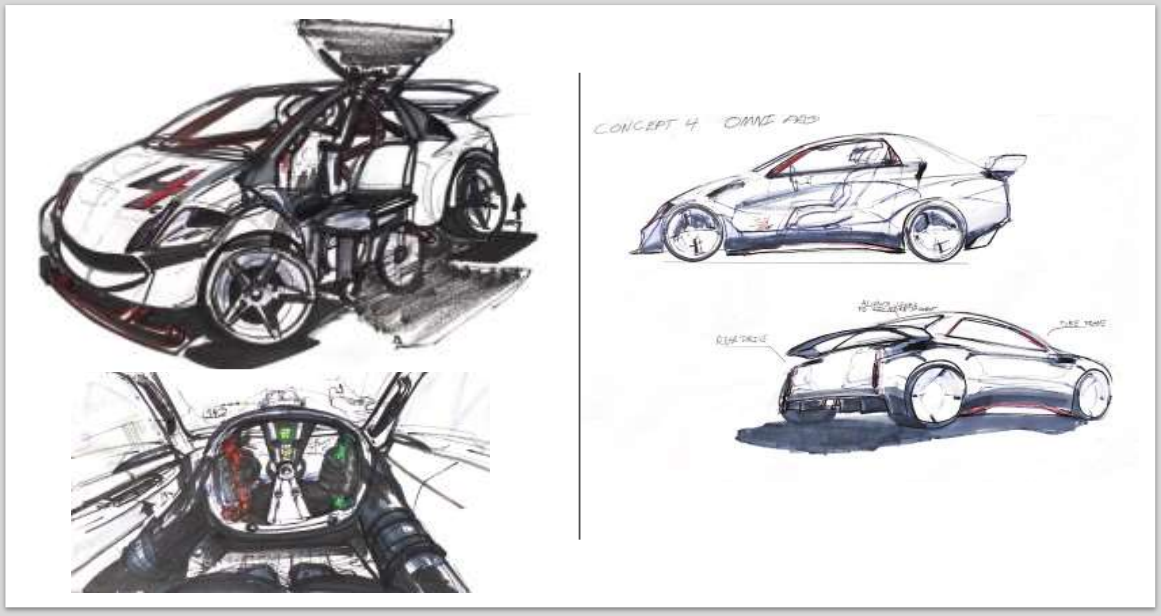
Idea 2



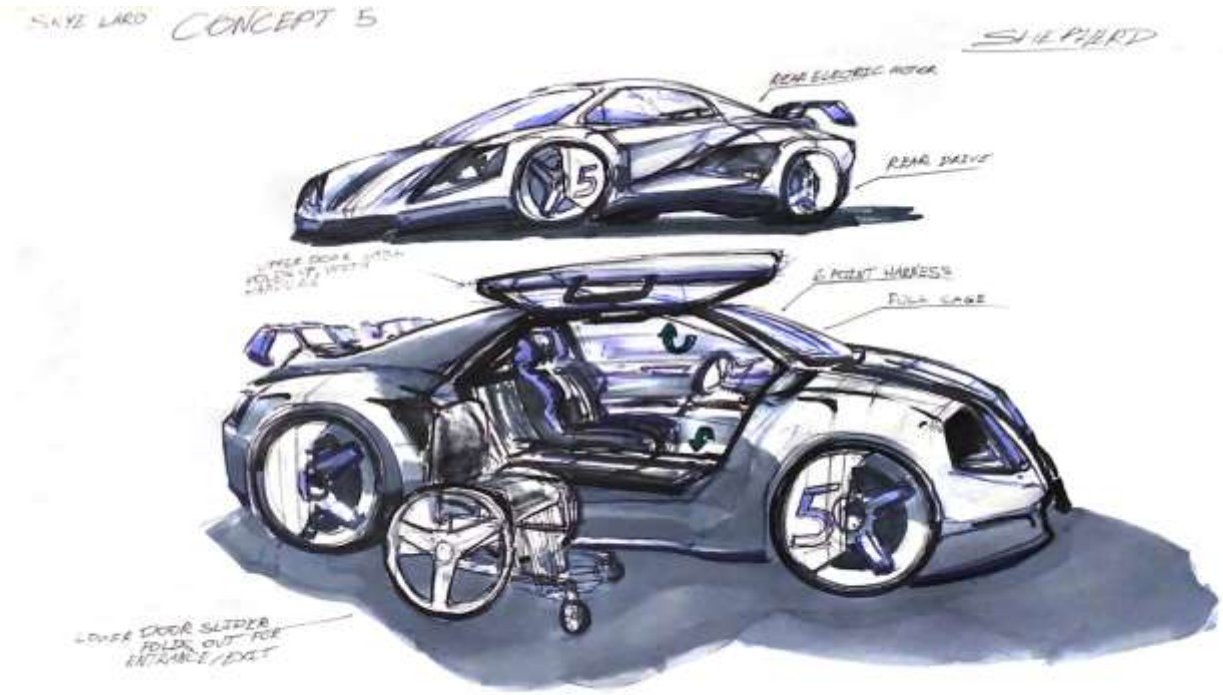
Idea 3



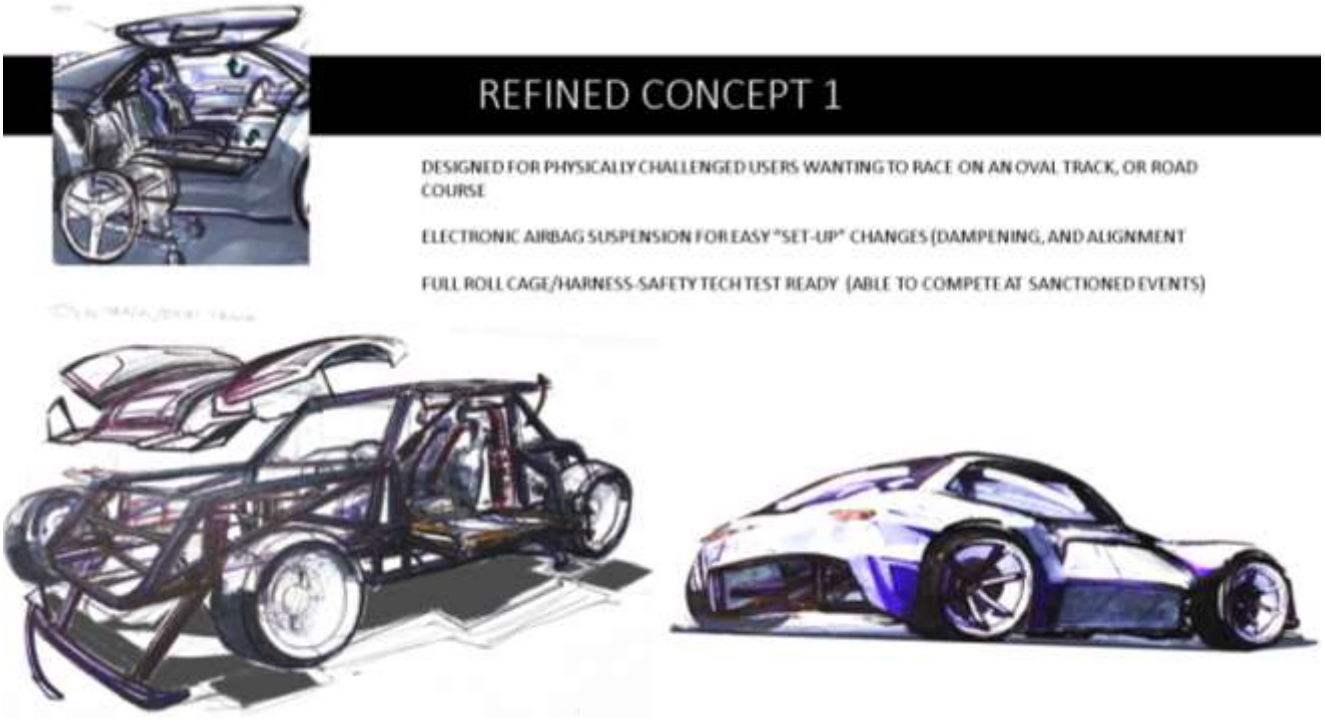
Idea 4



Idea 5



4.2 Concept Exploration

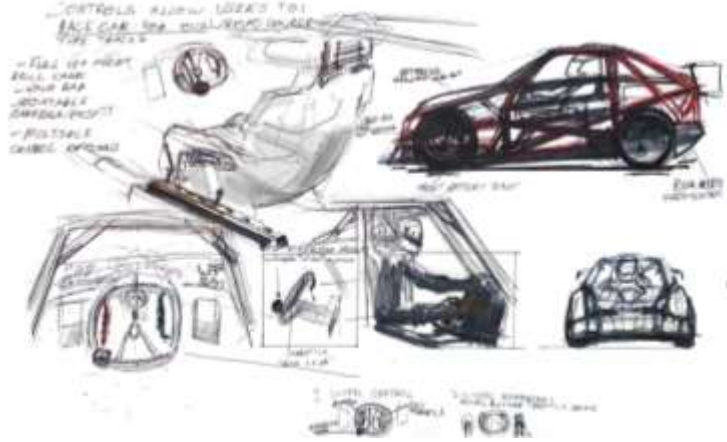


REFINED CONCEPT 2

ROAD COURSE/TIME ATTACK BODY SIZING

FULL ROLL CAGE/HARNESS-SAFETY TECH TEST READY (ABLE TO COMPETE AT SANCTIONED EVENTS)

MULTIPLE CONTROL SETTINGS FOR A WIDE VARIETY OF PREFERENCES



REFINED CONCEPT 3

USER CONTROLS FOCUSED ON 3 POINTS OF CONTROL;
STEERING /BRAKING
E-BRAKE
SHIFTING

FULL ROLL CAGE/HARNESS-SAFETY TECH TEST READY (ABLE TO COMPETE AT SANCTIONED EVENTS)

DESIGNED FOR ENVIRONMENTS HOSTING DRIFT EVENTS (COMPETITIVE OR RECREATIONAL)

4.3 Concept Strategy/Concept Requirements

- Create a class of “Race-Car” for the physically challenged
- Utilize electric drivetrains of the future, as well as innovate the driver and maintenance experience of the vehicle
- Increase inclusivity within a sport that requires investment, and dedication
- Motivate athletes of all different types of demographics
- Create a safe vehicle for athletes paralyzed from the waist down- to compete in (drive/operate on track legally)
- Create a user experience that allows fast and safe entrance/exit of the vehicle
- Create a vehicle that allows physically challenged users to be comfortable and competitive when driving
- Lightweight body; with a hydraulic system that self-jacks the car up; before the user exits the vehicle in the pit section.
- Improve movement process through hand control systems.

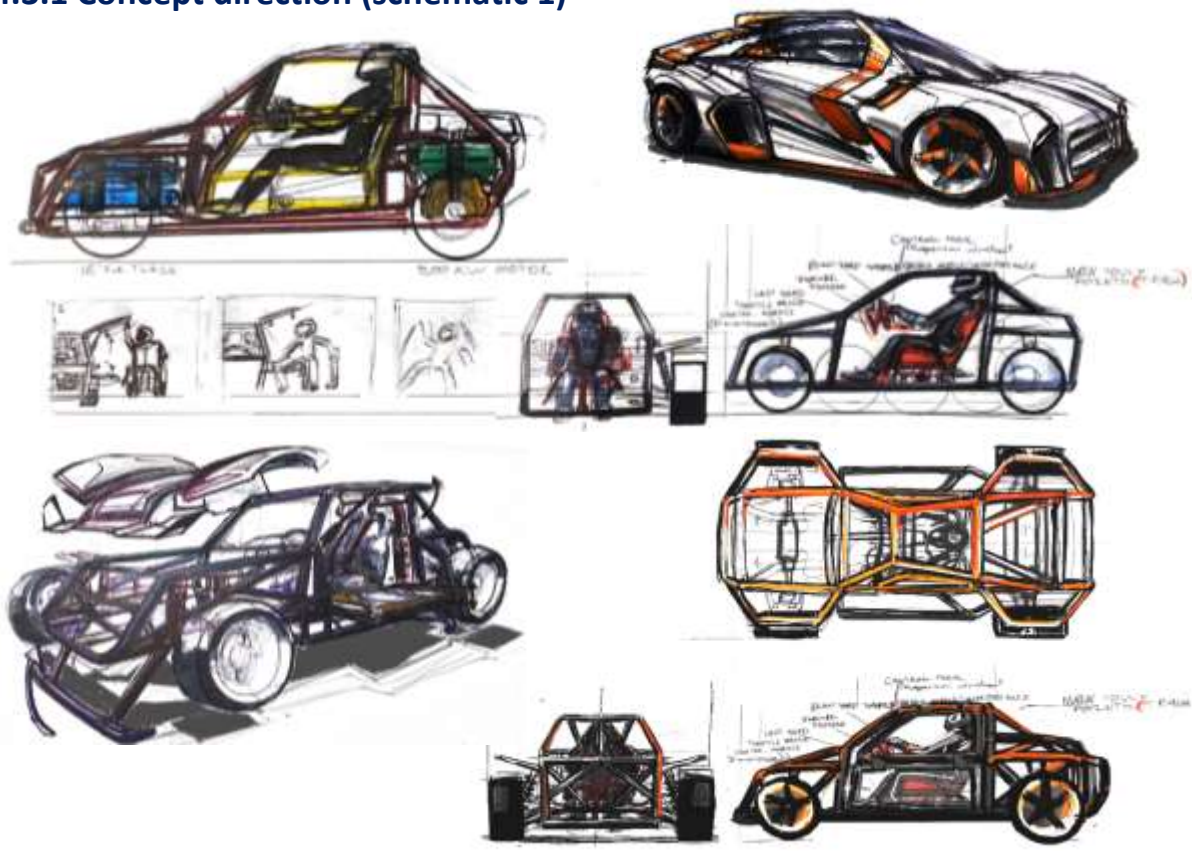
Ingress and egress are important aspects of observation because of the problems it entails for physically challenged users. The solution is to have an extruding seat. The user tests made it clear that the seat needs to extrude by 4” more than the 18” it currently extrudes. This will provide more room, which is especially required for users who need to rotate their seat to slide in. The door needs to be a trunk-style system with piston rod supports that operate via the hydraulic pump, due to their needed weight for safety. The seat will slide out on rails, powered by the hydraulic piston located at the bottom center of the seat, to the right of the driver.

Problems: Users experience struggle with entrance and exit of the vehicle, without physical assistance.

Viewing and seating is often an issue with either comfort or viewing.

Steering and acceleration over prolonged periods of time.

4.3.1 Concept direction (schematic 1)

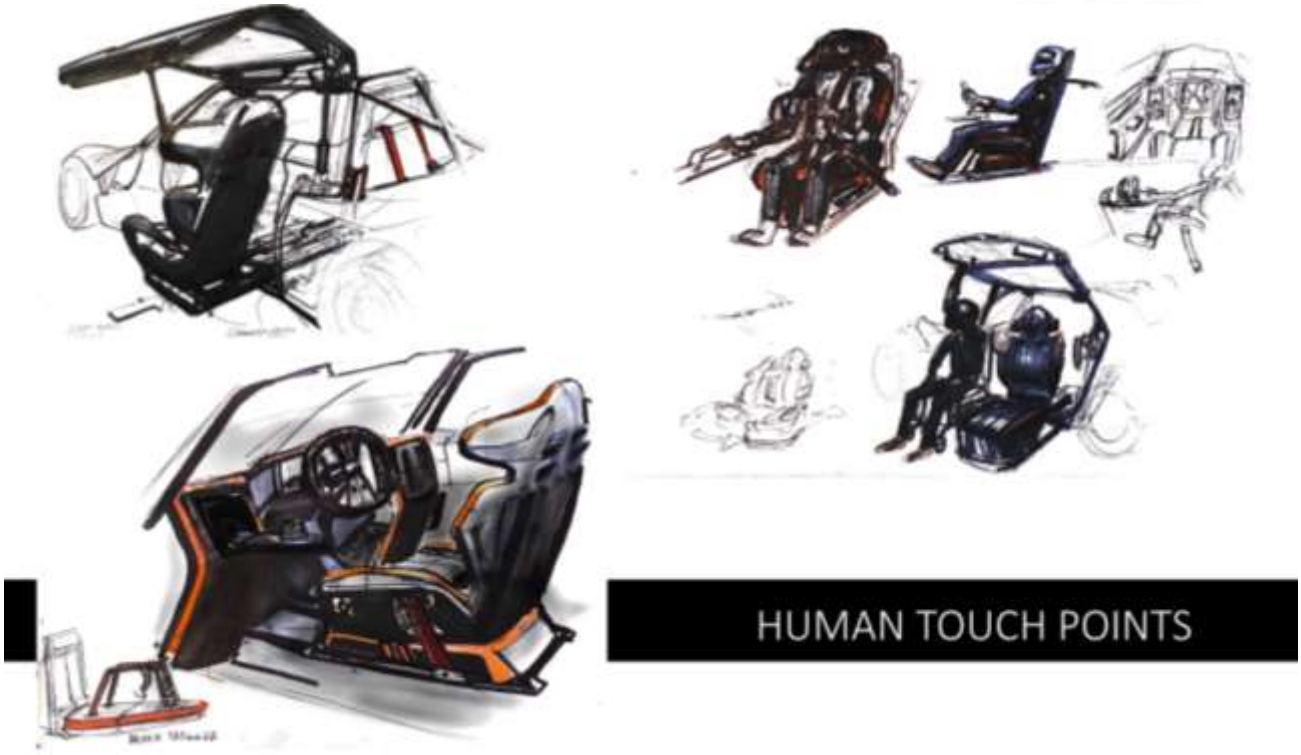


4.3.2 Concept direction (schematic 2)

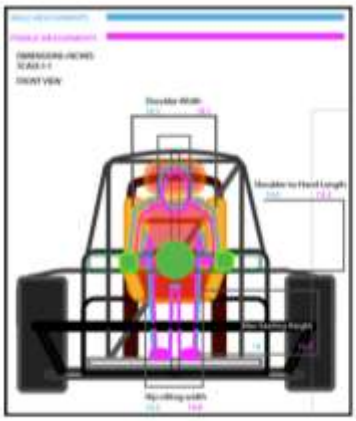
4.4 Concept Refinement & Validation

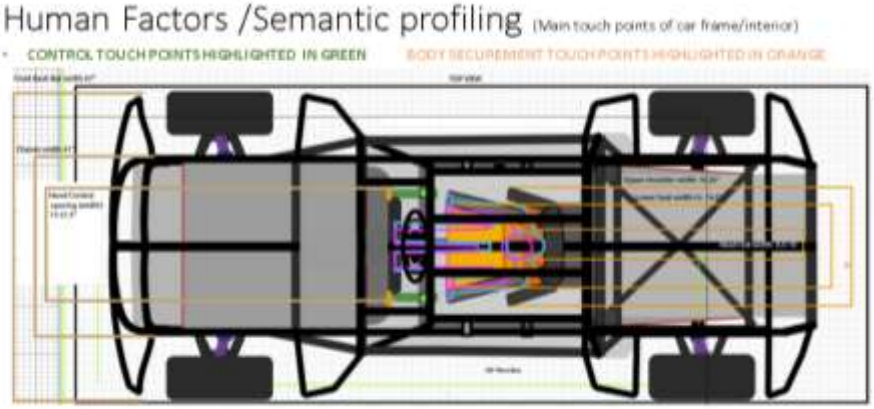
4.4.1 Design Refinement

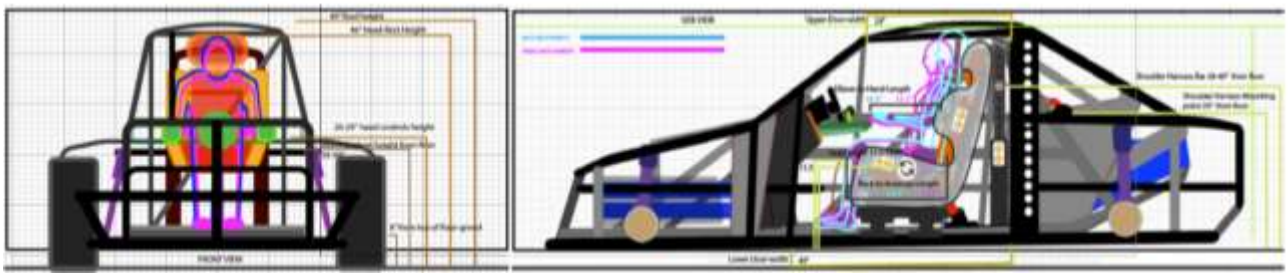
4.4.2 Detail Development

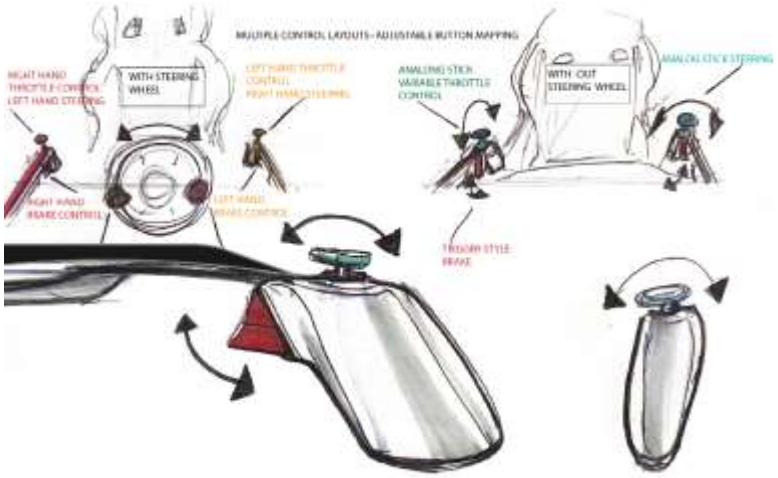


4.4.3 Refined Product Schematic & Key Ergonomic







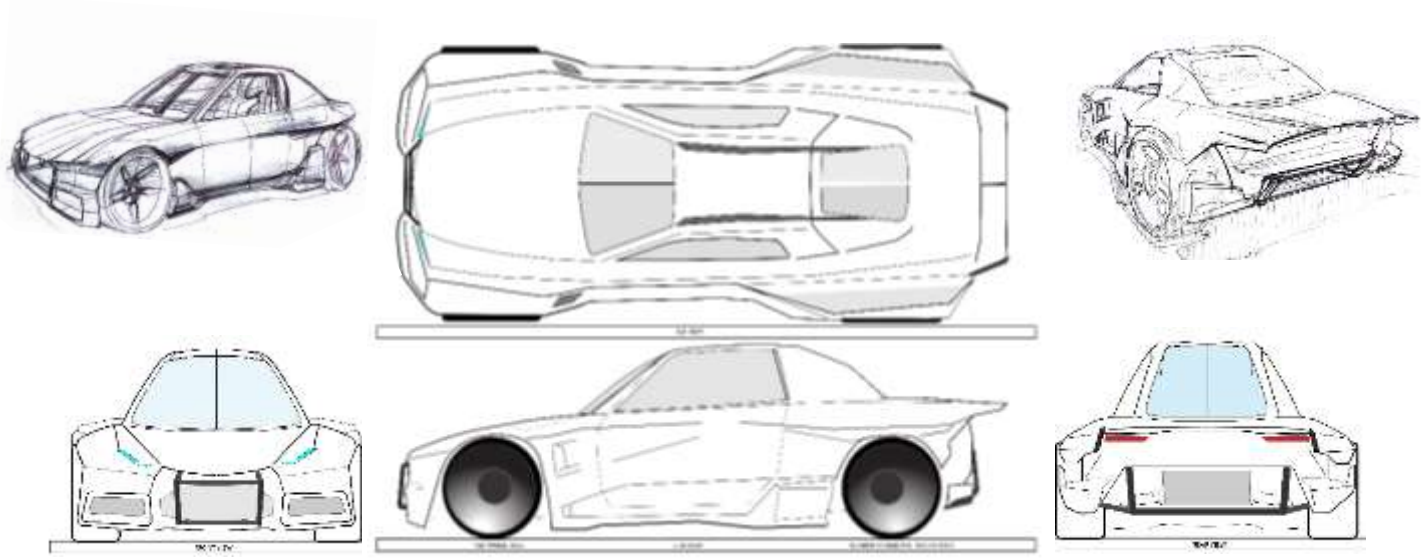


4.5 Concept Realization

Para-Stock

How May we Facilitate motorsports for the physically challenged.

4.5.1 Design Finalization

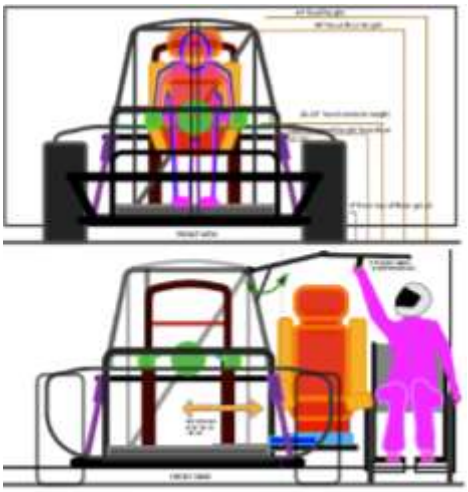


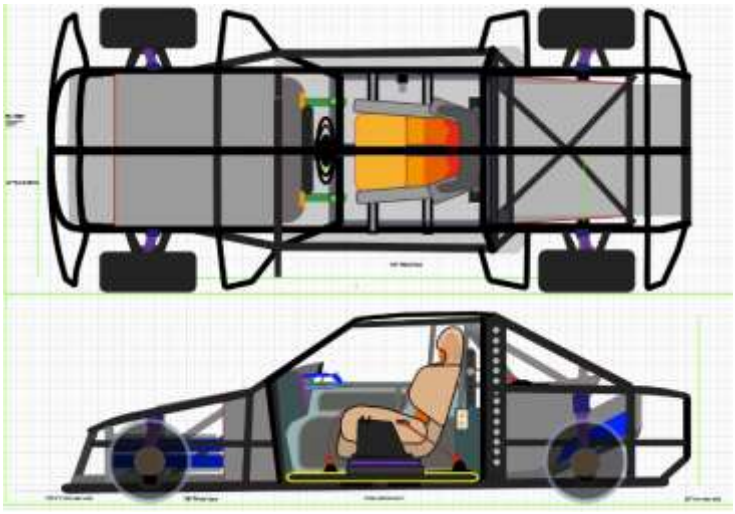
REAR WHEEL DRIVE

FRONT BATTERY STORAGE

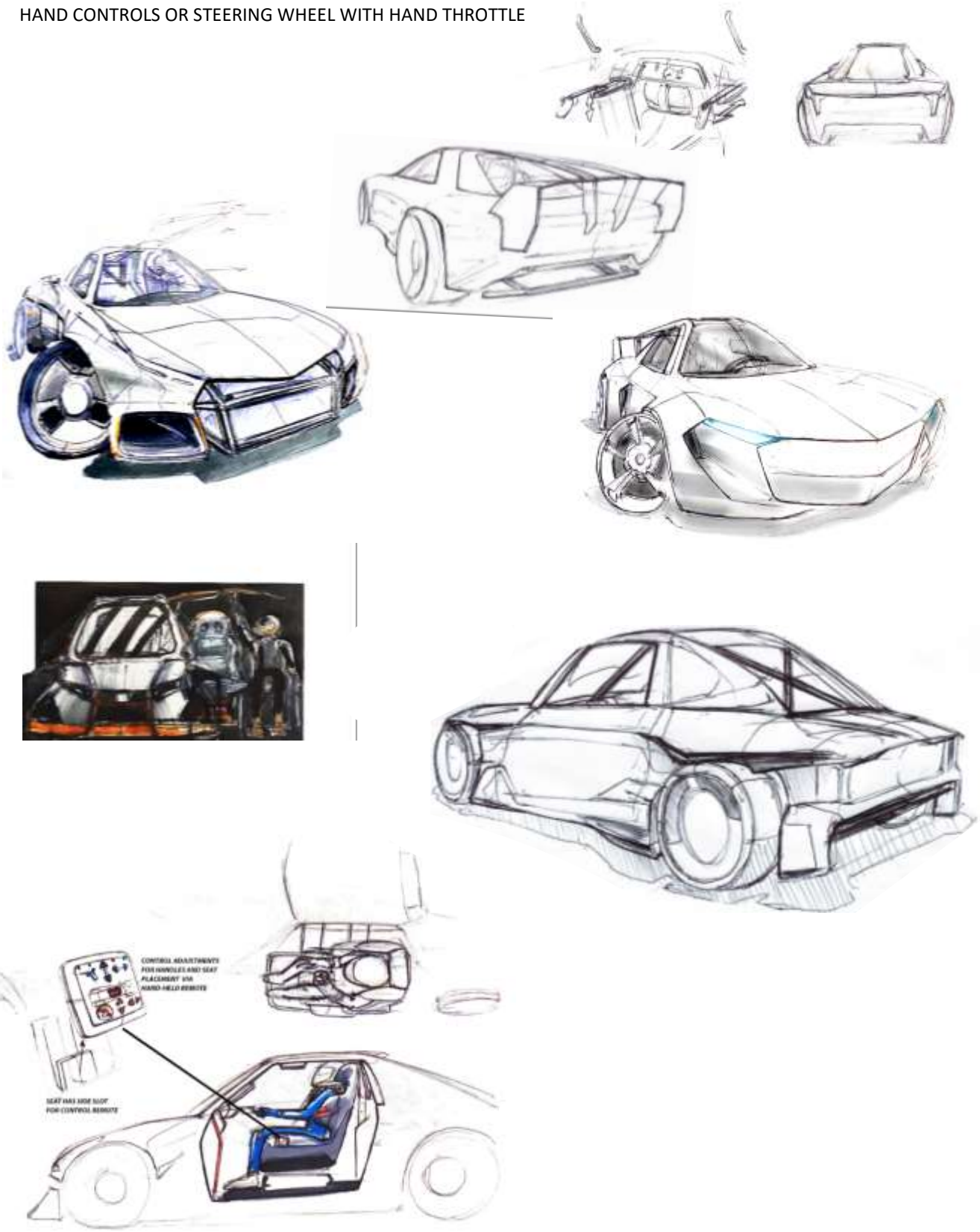
MID/REAR ENGINE PLACEMENT

SMALL/MID SIZED CAR





HAND CONTROLS OR STEERING WHEEL WITH HAND THROTTLE



4.5.2 Physical Study Model

Usability Ergonomic 1:1 Study

User Demographic:

Individuals with physical challenges aged 19-70 who are interested in driving a race car- or who enjoy motorsports. Male or female individuals in the 50th percentile are the focus of the model; and the design, in order to account for individuals in wheelchairs, but also individuals who walk with assistive devices or have spinal issues that affect their physical mobility, but still allow them to walk.

User objectives:

- The Key Objective of the study is to develop the proper range of size specifications for; control instrument panel height/steering wheel and controller height. Seat angle from the floor, seat height, and seat distance from the steering controls.
- User Focus: Male and Female 50th Percentile Ergonomic requirements.

Human Factors

Ergonomic 1:1 Study

Evaluation Process:

The observation process consisted of watching a 50th-percentile male and female going through the steps of operating a car. The actions of controlling the car were done using mock-up controls, while photos were shot; to capture needed movements of the user's hands, forearms, biceps, and shoulders. The mock-up also includes the seat to understand the user's ergonomic supports needed for the lower back, spine, upper back, and shoulders; also insuring comfortable body containment.

-Observing the user get in and out of the vehicle-Ingress/Egress

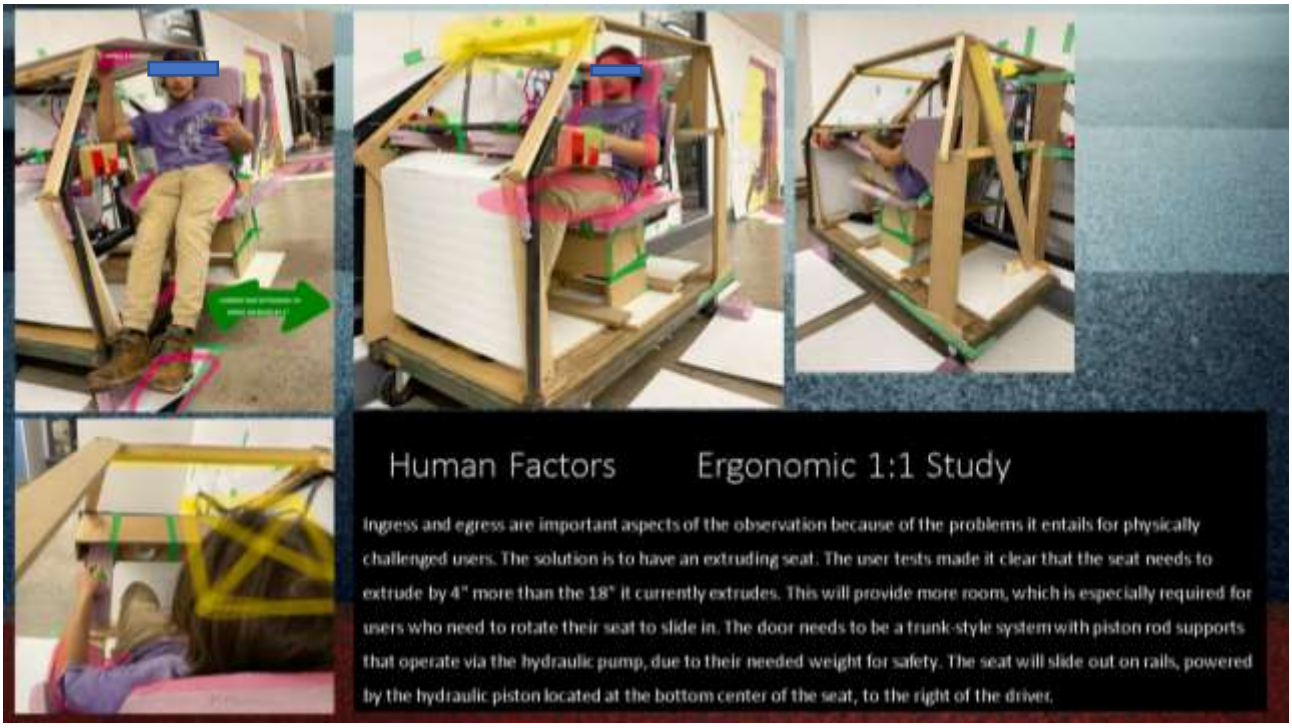
-Observing the user position themselves in the vehicle/seat comfortably

-observing the user touch control panel locations

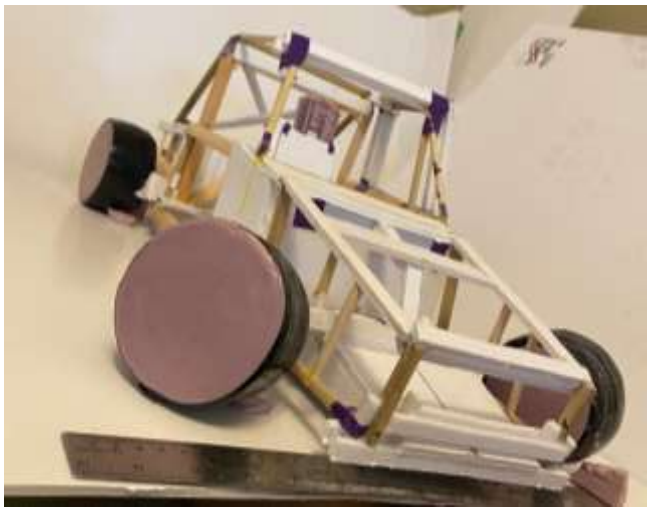
-observing the user showing their preferred height for entrance handles (if needed)

-observing the user steer and operate the throttle/braking system of the car using analog sticks and trigger-style buttons.

- The seat is very important for the feel of the car. The user's shoulder blades, lower back, and spine will be in constant interaction during g forces from racing. Therefore, the seat has 3-5" of depth, created with the side-mounted portions of the seat (on the bum rest) which rotate up or down. The headrest also needs to be thicker and have side walls like the backrest and bum rest, to ensure the user's head does not move around when driving. This will make the user unable to shoulder check; either mirrors or special cameras need to be interfaced in the driver's HUD, for blind spot detection.



1:6 SCALE MODEL



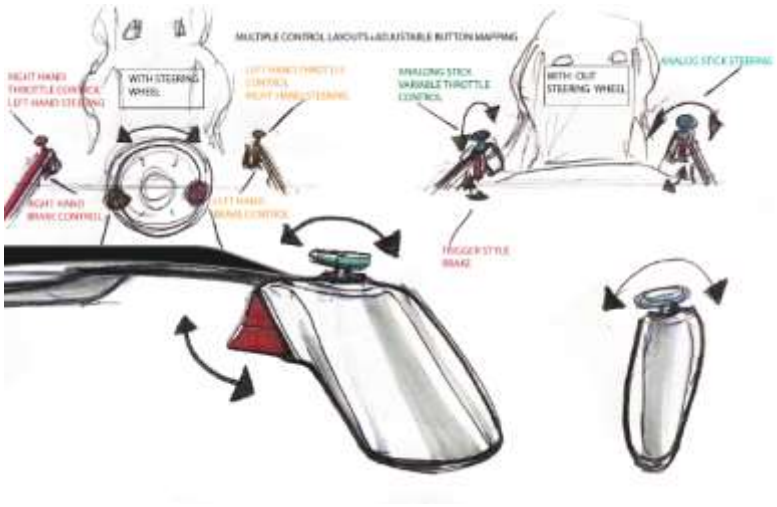
4.6 Design Resolution

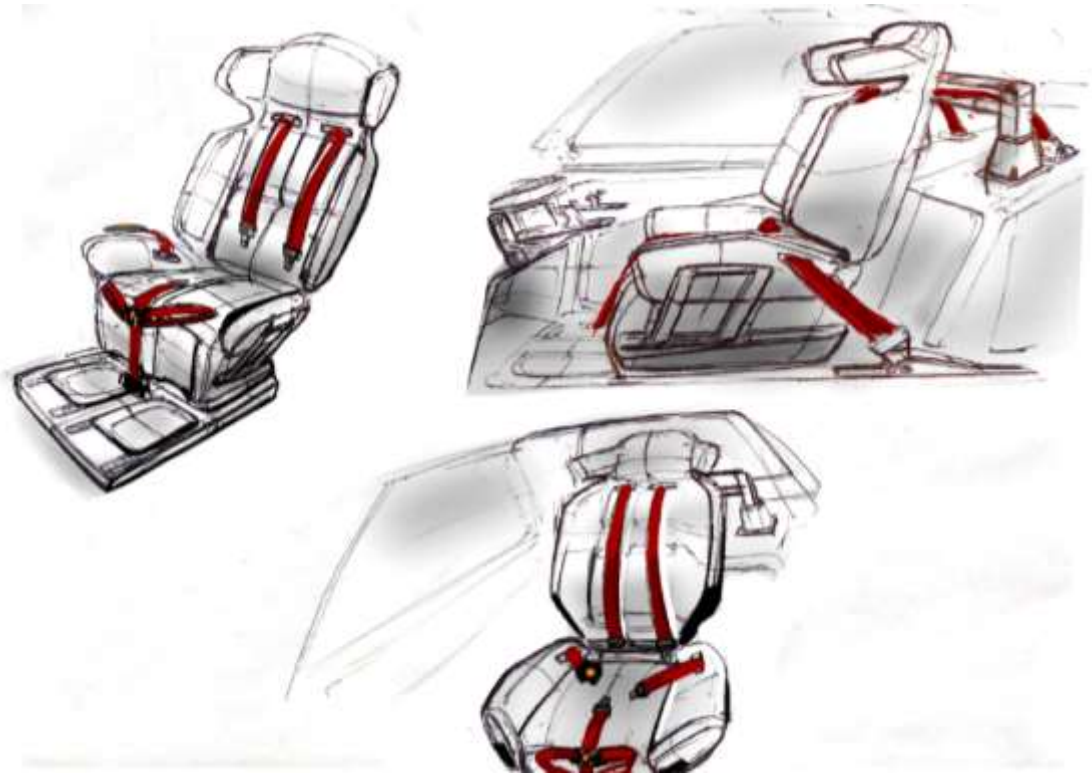
- Efficiency
    - Use of adjustment panels once inside the car; location of controls and analog method of use for controls for easy-to-understand and use features/needs. Many racing seats are not adjustable once installed, whereas this model requires adjustments after being installed.
- Interaction
    - Handles for ingress/egress need to be placed ergonomically
    - Adjustment panels need to be accessible when seated in the car
    - Vehicle controls need to be adjustable for proper handling of the

      vehicle when the user is driving.
    - Hand controls allowing brakes to be applied via pressure sensitive trigger, as well as throttle/acceleration available via finger trigger (like the brake trigger)
    - Hand controls on both right or left in front of the user; allow for steering to be done via analog sticks controlled by the user's thumb, or steering available via a steering wheel, (with an assistive hand knob for one-handed use.)
- Safety/satisfaction
    - User can comfortably get in and out in an efficient time, with non-strenuous body movements
    - User can adjust controls and ergonomic supports easily once in the car to allow for comfy body positioning.
    - 12-point roll cage is designed to have as little seams as possible, to prevent bending or breaking under high stress events like, crashing into a wall, getting t-boned, front end and rear end collision, as well as flipping. For the safety of the driver, harnessing points will contact the users shoulders, thighs, and chest. This will be a custom 7-point harness with 2 straps added to the middle leg strap; keeping the drivers legs harnessed in position to the seat (when harnessed in for operation). The user will have their neck harnessed using a Hans device, as per rules and regulations in modern day racing.
    - The drivers seat will be made with a formed steal seat pan, made to have

      strength resembling the roll cage. This is because the seat needs to protect the

      driver, and not bend under immense pressure.

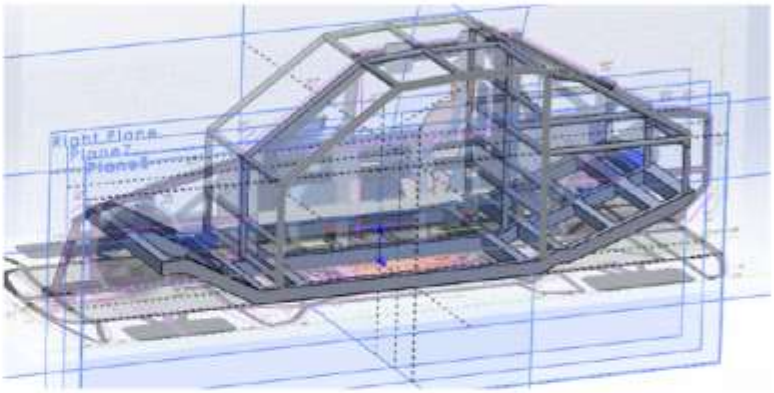

MULTIPLE CONTROL LAYOUTS + ADJUSTABLE BUTTON MAPPING
WITH STEERING WHEEL
WITH OUT STEERING WHEEL
ANALOG STICK STEERING
ANALOG STICK VARIABLE THROTTLE CONTROL
TRIGGER STYLE BRAKE



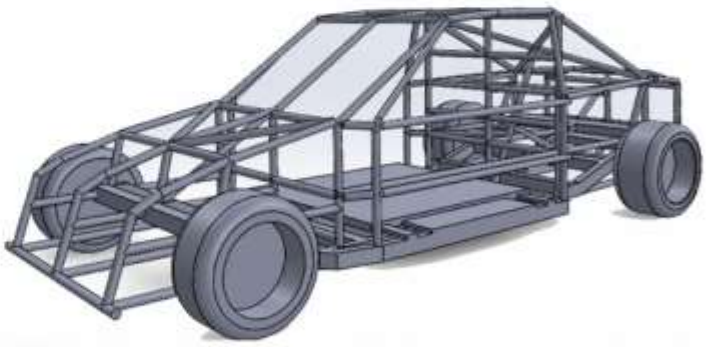
4.7 CAD Development

PARA-STOCK

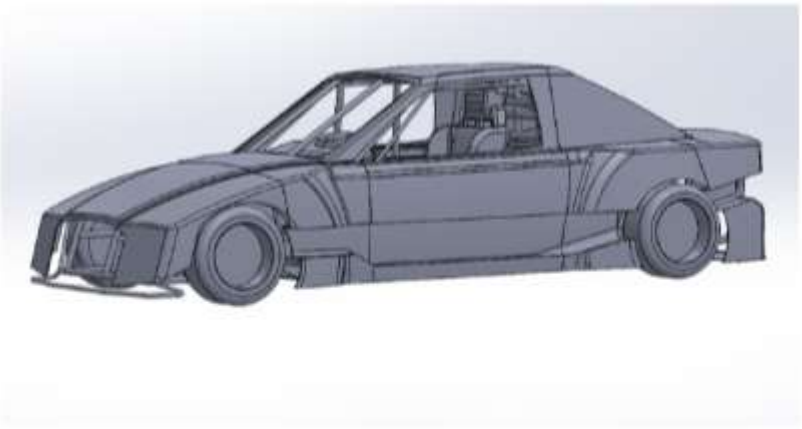
Using the final technical drawings;
The roll-cage and chassis were created first.

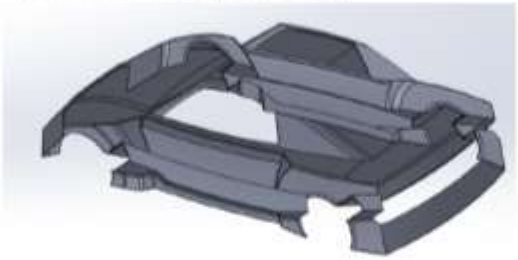


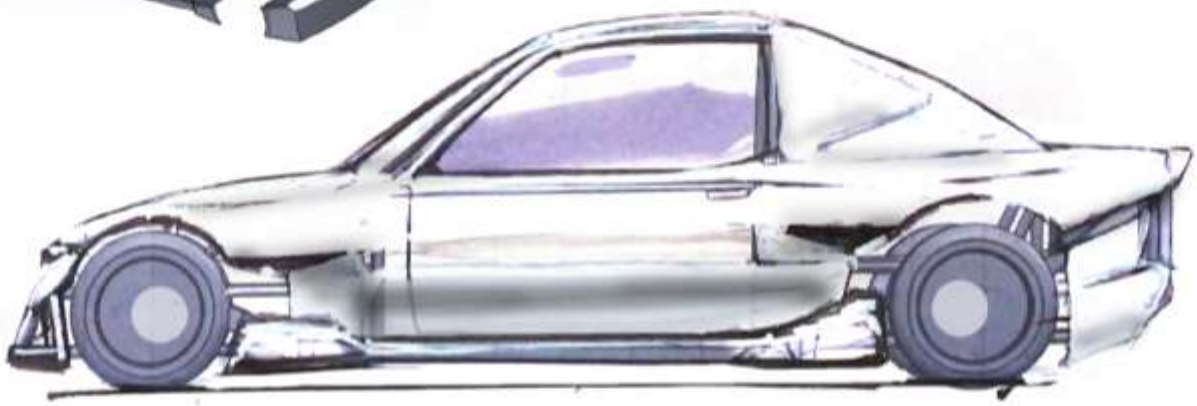
After the main components of the cars structure underneath the skin was complete; The final concept sketches were complete- to insure the body design would fit over the roll-cage



A surface was created for the model to make up the body, but certain surfaces could not be extruded. Meaning the 3D print version of the body required changes. This is the 3D print body-



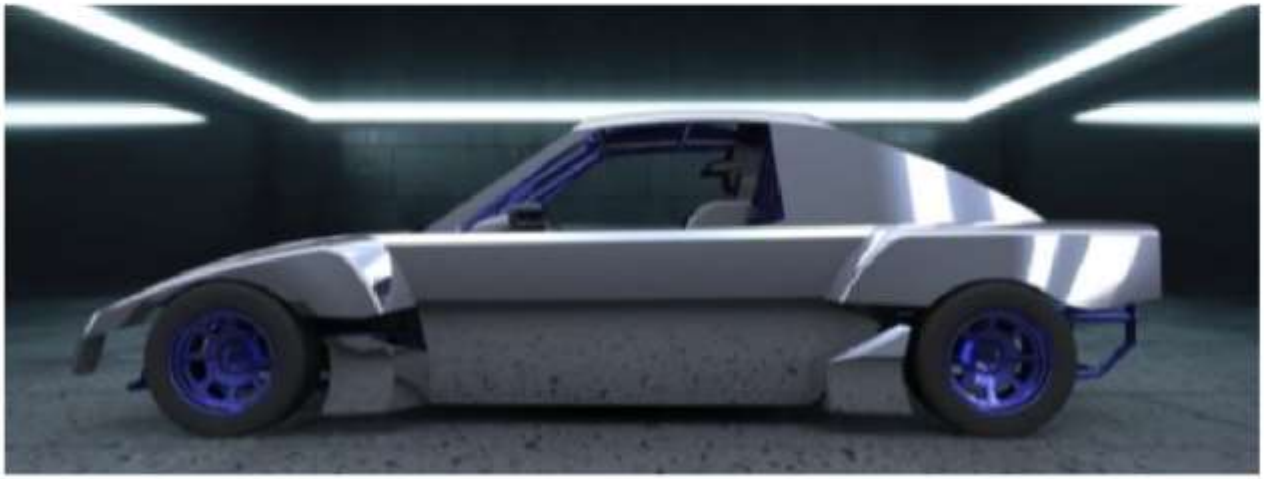




With the main structure being complete, and built to spec- the seat system with extruding floor could be created. The floor that extrudes hosts the floor mounts for the lower parts of the safety harness.

Details like; electronic drive-train, suspension, and steering components were created after the body design was refined enough to work with the rollcage, chassis, and other features.

Final Renders:



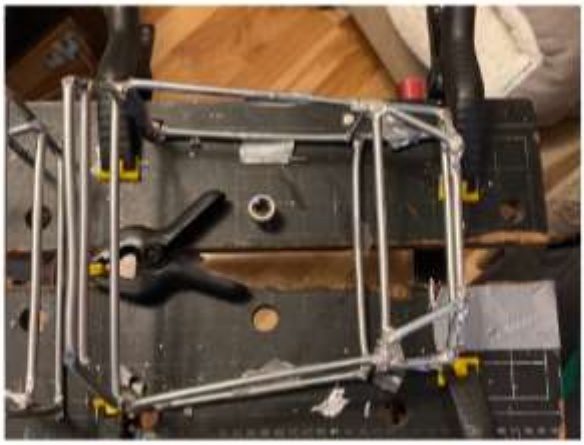
4.8 Model Fabrication

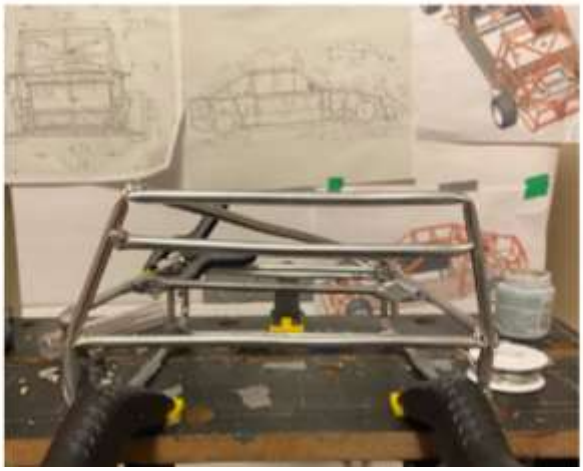
SKYE LARO DESIGN

1/6 SCALE
FINAL MODEL

BUILD, AND PROCESS

Pre-Fab: Cutting, Bending, 3D Printing





Fabrication/Test Fitting

Assembly/Finishing: Sanding, Grinding and Painting Roll-Cage

Assembly/Finishing:
Sanding and Priming Body

Assembly/Finishing: Painting Interior 3D Printed Parts
Painting Exterior 3D Printed and Prepped Body


Assembled Model
Finished:
(Without body)

Assembled Model-Finished

Chapter 5- Final Design

5.1 Design Summary

PARASTOCK is a one seated racing vehicle- designed to be driven on a flat track oval, or road coarse. Oval track was selected first due to its availability to users.

The physically challenged are the demographic of focus, due to not being able to use foot pedals; they need the same amount of control accessible through their hands. This has driven the project towards being hand controlled and removing gas and brake pedal(s) all together.

To make this vehicle accessible to as many users as possible- it is designed to be affordable, using materials that will not be out of reach financially due to high costs.

The vehicle utilizes an electronic drive train, and electronic controls to give the user more control over the vehicle, on and off the track.

RWD

370-400HP / 300KW

Water cooled, equipped with emergency electrical fire water system to prevent.

battery combustion.

Benefit Statement:

Users will be able to race other individuals similar-to themselves in physical manner. Meaning PARASTOCK will be made a competitive series; like other classes of racing where the cars are either all the same or restricted by a tight rule book making them the same performance wise.

Users will be able to enter and exit this vehicle with ease, regardless of their personal mobility. Parastock's floor and seat extrusion system will allow user to remotely control the driver's door-to open upwards, and have the floor slide out with the seat. The Door will act as an overhead guide with handles for the user to grab and slide themselves onto the driver's seat.

The car is equipped with ample safety measures to protect the driver at all costs and ensure ease of mind when driving the car under intense circumstances-Racing.

5.2 Design Criteria Met

5.2.1 Full Bodied Interaction Design

Wishes: There was an easy way to get in and out of the car without help

There was a more comfy seating option when driving, due to awkward viewing angles, and posture.

Wants: A safe way to compete and race

A less stressful process of operation due to adaptive controls

Latent Needs:

• Comfort once strapped into the vehicle

• Ease of use over long periods during high-intensity driving

Immediate Needs:

• Assistive handles for ingress and egress. Users need to be able to slide from their wheelchairs- into the

racing bucket seat The user also needs to be able to leave the vehicle quickly if there is an emergency.

This means the handles for lifting one's body, will need to be mapped logically and clearly for the user.

• Safety equipment like; 8 point harness- with proper mounting points. The harness angle required from the

floor is dependent on the user's height

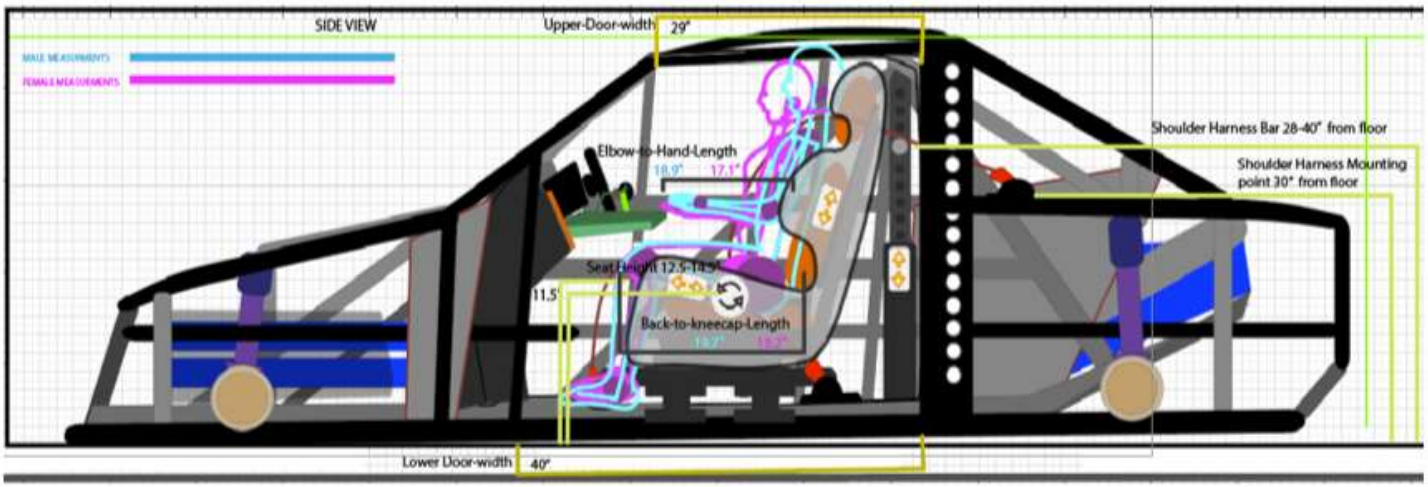
• Hand control steering, braking, and acceleration. Meaning foot pedals will not be used in this car. Certain

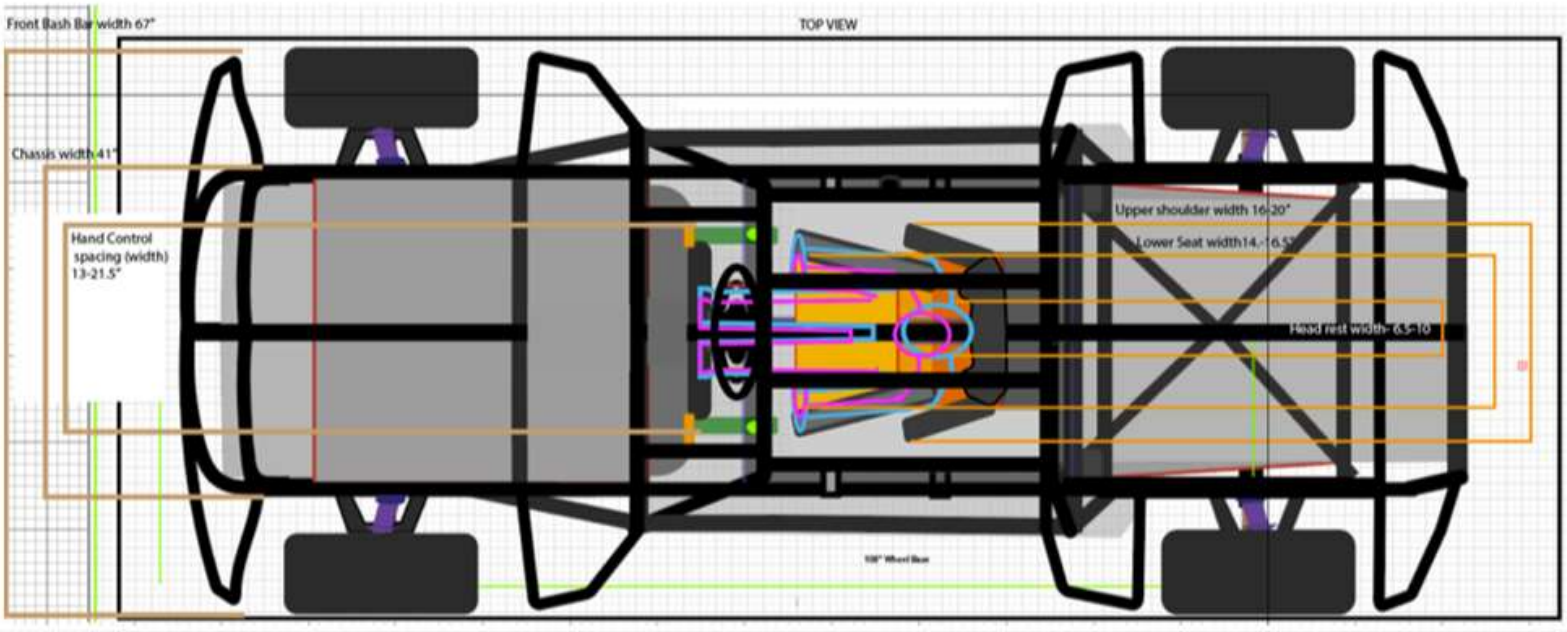
users will prefer to use a steering wheel, and certain users will require analog stick steering via hand

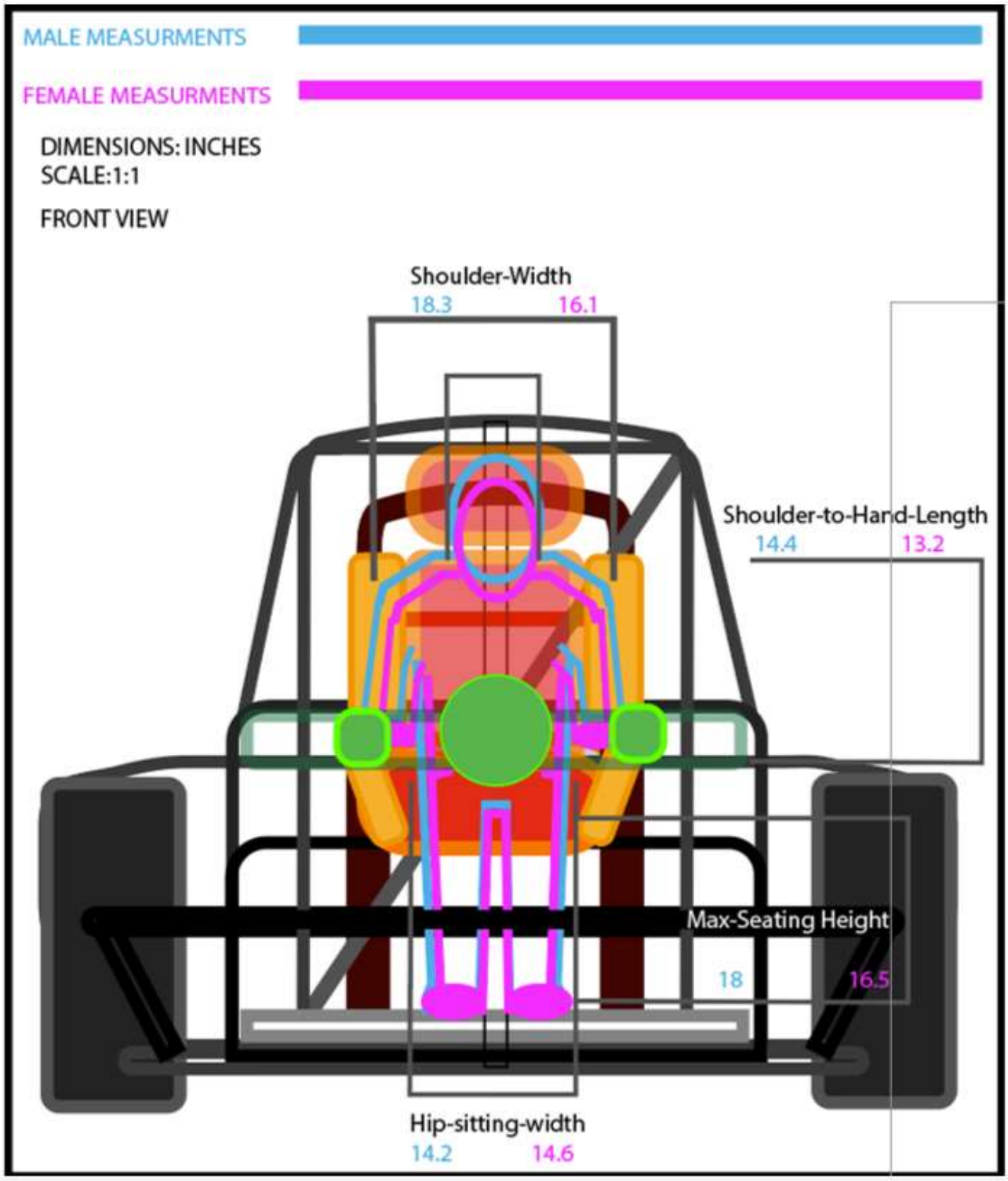
remote-style controls, due to physical mobility.

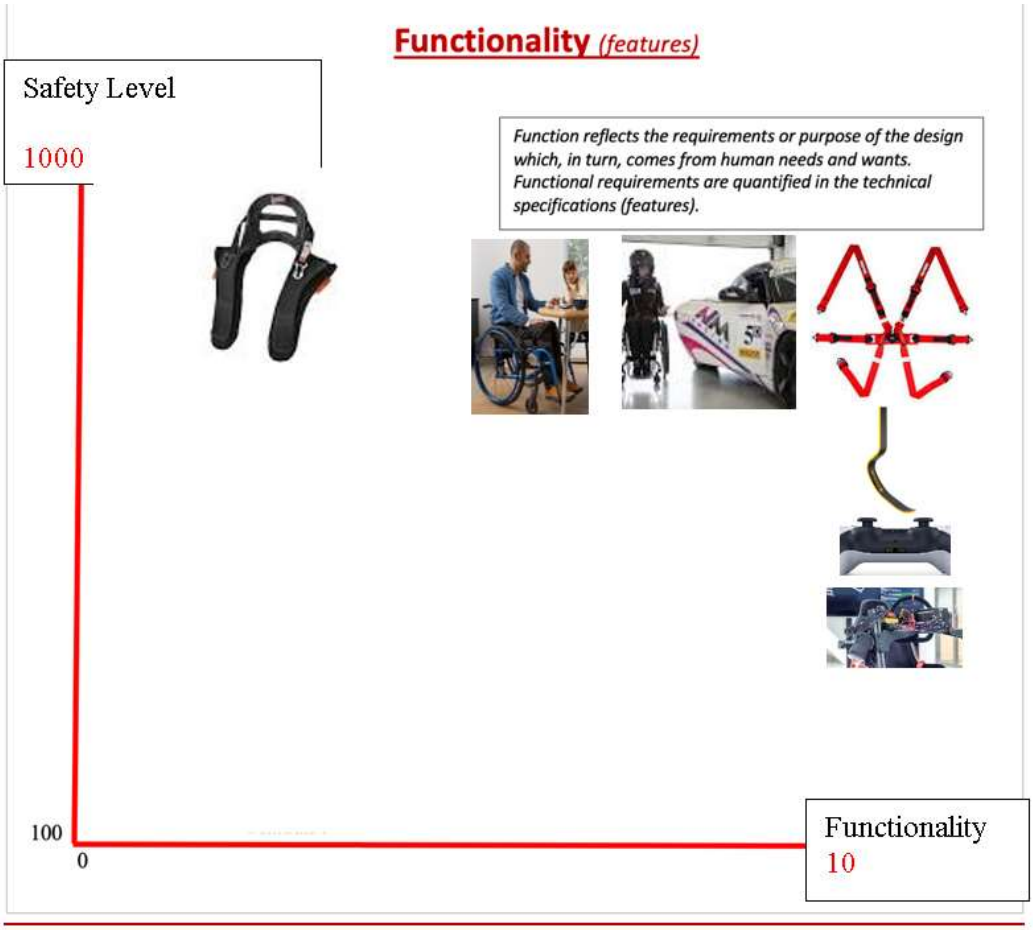
• Full body racing bucket seat, which adjusts in width, back angle, lumbar support, distance from steering

controls, and height from floor


SIDE VIEW
Upper-Door-width 29"
Shoulder Harness Bar 28-40" from floor
Shoulder Harness Mounting point 30" from floor
Elbow-to-Hand-Length
18.9" 17.1"
Seat Height 12.5-14.5"
11.5"
Back-to-kneecap-Length
Lower Door-width 40"

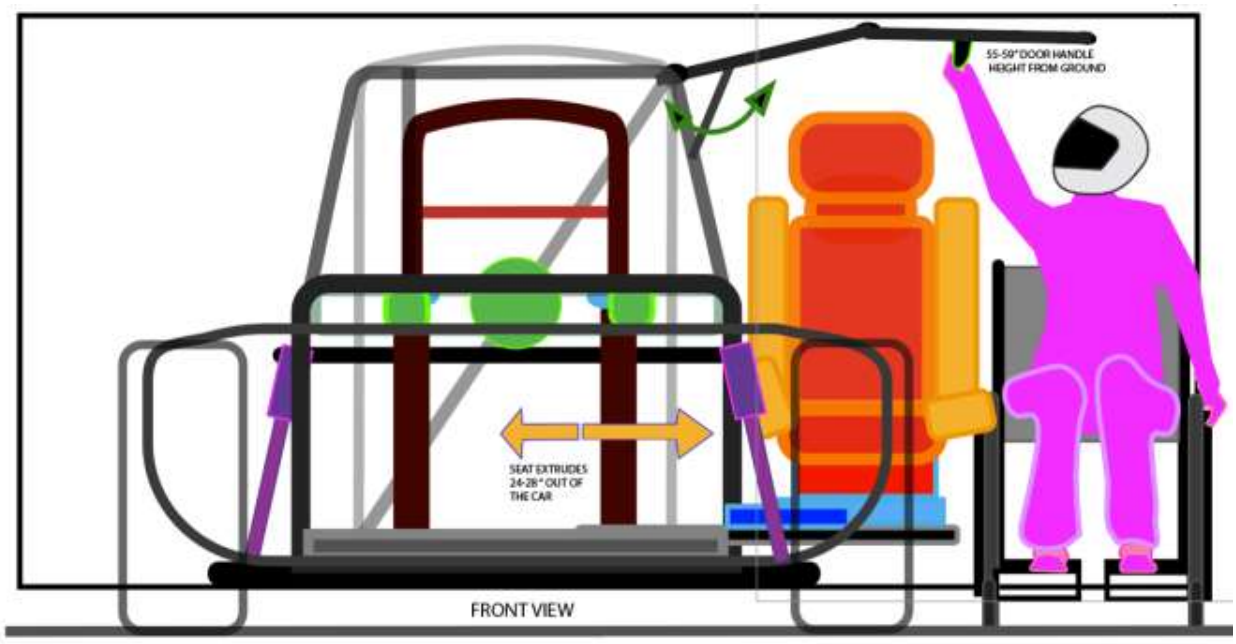

Front Bash Bar width 67"
TOP VIEW
Chassis width 41"
Hand Control spacing (width) 13-21.5"
Upper shoulder width 16-20"
Lower Seat width14.-16.5"
Head rest width- 6.5-10

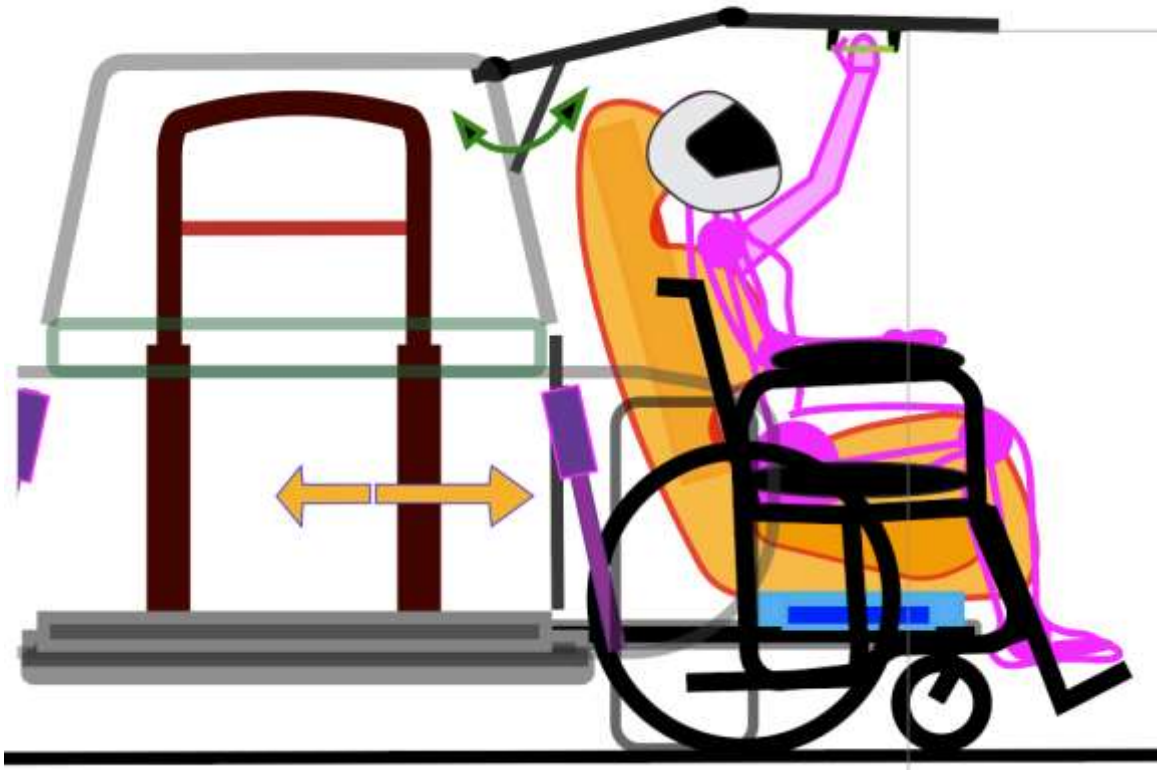

MALE MEASURMENTS
FEMALE MEASURMENTS
DIMENSIONS: INCHES
SCALE:1:1
FRONT VIEW
Shoulder-Width
18.3
16.1
Shoulder-to-Hand-Length
14.4
13.2
Max-Seating Height
18
16.5
Hip-sitting-width
14.2
14.6

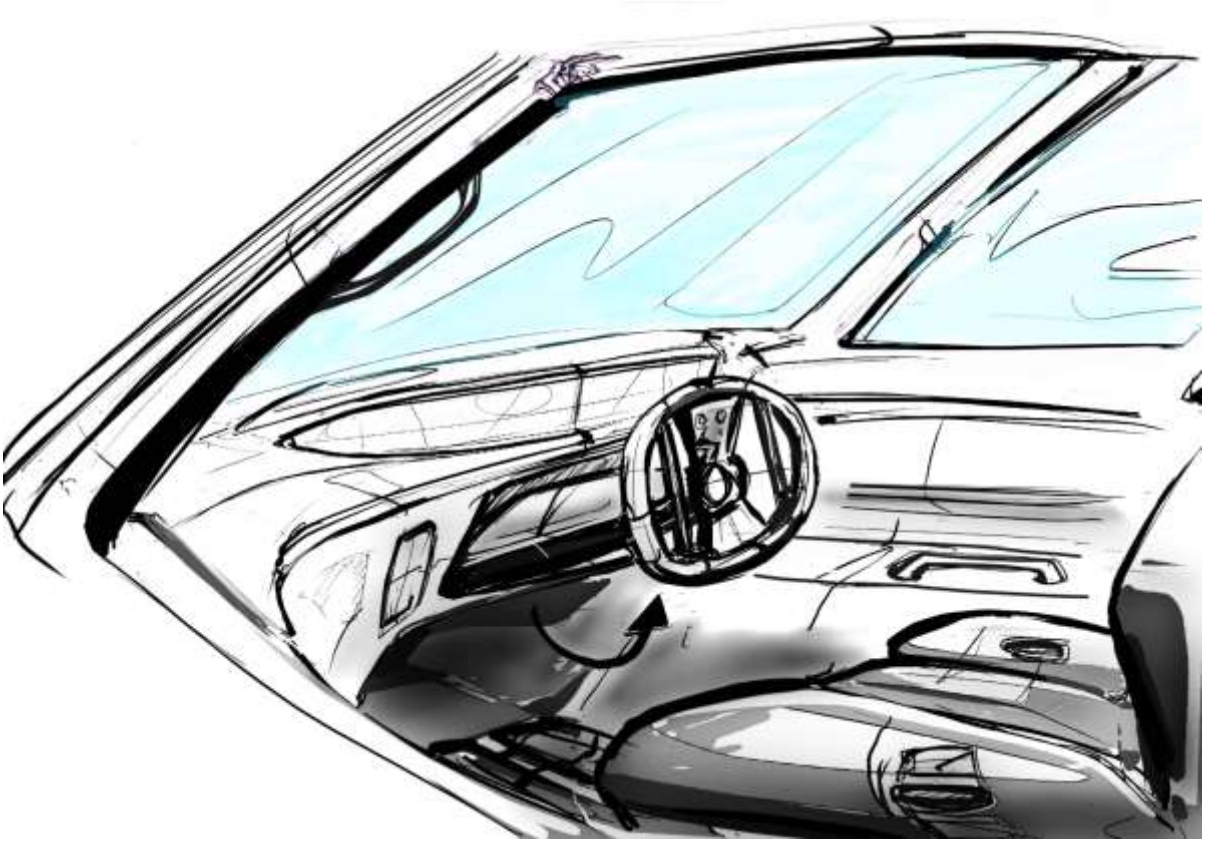


Take-Aways

Products designed for competitive activity are required to include safety specs, and functionality in order to help the user.







5.2.2 Materials Processes and Technology

The project tackles many issues relating to; safety of the driver, new technology in racing engines (electric driveline vs ice driveline) and new technology in mobility. There are many requirements and needs for the individuals being targeted for this product. Harnessing, seating and control methods are the initial problem to overcome, followed by cost and materials; for the car to be affordable to people, and feasible to race. This brings the next problem which is car maintenance and track day procedures (car adjustments, and mechanical work). An aspect of sustainability that inspired this project is; longevity of the sport that is- Car racing, as well as increasing the inclusivity of the sport that is- car racing. The car will initially be made to order, and work with customers to provide the most feasible experience possible, from user experience to manufacturing. The electric drivetrain will be only the tip of the iceberg when it comes to the carbon footprint of this car. The main body components will utilize materials providing sustainability factors that reduce the carbon footprint of every aspect of the car, from production and manufacturing, to user experience, and longevity of the product.

Literature review:

1.1 Materials:

Structural Materials

CRS Steel tubing 1.5”

CRS Steel Rectangular tubing 2x3”

High grade steel fasteners for Nuts, Bolts, and studs (M12)

Body Panel/aero materials

Recycled polyethylene terephthalate (rPET) honeycomb material.

Bcomp Flax fibers (Natural fiber composite), Amplitex flax fabric wit power Ribs reinforcement grid.

Drive Train

Electric motor, powered by cooled batteries.

Interior Materials

Webbed Polyester Harness straps

rPET hand controls

Tencel Fabric to provide padding around the roll bars closest to the driver, as well as for the padding material on the driver's seat, and steering wheel.

1.2 Manufacturing

The car will be produced by order since the roll cage requires fabrication and hand-built marriage of the chassis to the body of the car. The drivetrain will utilize electric motors to provide little to no carbon footprint from operation. The batteries will be sourced from environmentally responsible materials and companies.

The electric drivetrain and battery placement offers a simple assembly process while keeping adjustability in mind for users.

CHASSIS/FRAME RAILS; CRS rectangular steal (2x3")

Roll cage; Bent CRS steel (1.5" in diameter) 12-point seamless. This will be made using metal machine. Welded to car chassis. The chassis and roll cage will be designed using Solid works CAD, and programmed to a tube bending machine for bending, and cutting.

The body panels will be made from CNC milled molds, and then filled and cured to create the natural fiber body panels.

Interior control devices will be 3D printed using rPET, as well as aero pieces. Utilizing CAD to streamline the manufacturing process of as many components as possible.

5.2.3 Design Implementation

A CLASS PARTS	B CLASS PARTS	C CLASS PARTS
IP PANAL	HUD DISPLAY (DASH) STAMPED PANEL	ELECTRONIC LCD TOUCH SCREEN GREEN BOARD(S)
HAND CONTROLS	HAND CONTROL RAILS X4 HAND CONTROL MOUNTS X4 ANALOG STICKS X2 TRIGGER BUTTONS UPPER X2 TRIGGER BUTTONS LOWER X2 CONTROLLER HOUSEING X2	ELECTRONIC RELAY ELECTRONIC DISTRIBUTOR FUSE BOX (FRONT-NON INTERIOR) FUSE PANAL (A) INTERIOR CONTROLLER BARRING ANALOG STICK MOUNT ANOLOG STICK 360 SLIDER PLASTIC CLIP ALUMINUM SCREW
INTERIOR FLOOR	GREEN-BOARD BRUSHLESS MOTOR (VIBRATION) RUBBER PAD	CARBON ALLOY (GRADE 10.9) BOLT GR10.9 NUT (M1x1.25) ALL HIGH GRADE FASTENERS= M1X1.25
PASSENGER SIDE INTERIOR PANAL	HYDRAULIC PISTON (FLOOR) FLOOR EXTRUSION PISTON RAIL SYSTEM-SEAT FLOOR STAMPED PANAL (SIDE) HANDLE RAIL AND MOUNTS HANDLE	MOLDED STEEL HINGES HINGE BARRING DOOR LOWER INTERIOR STAMPED PANAL DOOR UPPER INTERIOR STAMPED PANAL BOLTS FOR HYDRAULIC PUMP PUMP MOUNTS SEAT RAIL OIL TUNNELS OIL PUMP FOR SEAT AND FLOOR RAIL LUBRICATION WATER RESEVOIR OIL RESEVOIR
SIDE DOOR	DOOR HINGE UPPER X2 DOOR HINGE LOWER X2 DOOR MOUNT PISTON DOOR PISTON MOUNT INNER RAIL/SLIDER FOR DOOR PISTON	HEAT SENSORS 1-6 SEAT ELECTRONIC GREEN BOARD SEAT ELECTRONIC RELAY lp PANEL BRACKET IP PANEL MOUNT IP PANAL BOLTS NUTS ALL SUSPENSION COMPONENTS MIRRORED= (2x qnt #) X2 = RIGHT AND LEFT SIDE
SEAT ASSEMBLY	SEAT FLOOR LOWER SEAT FLOOR UPPER (ROTATES) SEAT POSITIONING MOUNT	FRONT LOWER CONTROL ARM X2 FRONT UPPER CONTROL ARM X2 FRONT STRUT FRONT SHOCK FRONT SHOCK TOP HAT FRONT SHOCK AIR BAG SHIM
REAR INTERIOR PANAL	SHOULDER HARNESS BAR MOUNT HARNESS BAR RAIL STAMPED PANEL	REAR SHOCK TOP HAT REAR SHOCK STRUT REAR SHOCK REAR SHOCK AIRBAG SHIM FRONT INNER TIE ROD FRONT OUTER TIE ROD FRONT SWAY BAR SWAY BAR LINKS
CRS ROLL CAGE TUBE CHASSIS	2X3"TUBE FRAME 1.5" COLD DRAWN STEEL BENT AND FABRICATED 12 POINT CAGE	SUSPENSIONS BOLTS GRADE 10.9 SUSPENSION NUTS REAR CONTROL ARM MAIN REAR PUSH ROD/ARM REAR TRAILING ARM REAR WHEEL BARRINGS FRONT WHEEL BARRINGS
HUB ASSEMBLY FRONT	SUSPENSION COMPONENTS X 8 STEERING COMPONENTS X7 WHEEL MOUNTING COMPONENTS X4	REAR BRAKE ROTORS FRONT BRAKE ROTORS FRONT BRAKE CALLIPERS REAR BRAKE CALLIPERS BRAKE BOOSTER BRAKE LINE ROUTING
HUB ASSEMBLY REAR	CV SHAFT (AXLES) X2 WHEEL MOUNT X4 SUSPENSION X8	COOLING SYTEM WATER LINES OIL LINES ELECTRONIC POWER DISTRIBUTOR FOR SLIDING FLOOR ND SEAT SYSTEM POWER RELAY TO SHOCK TOWERS FRONT POWER RELAY TO SHOCK TOWERS REAR
DRIVE TRAIN	ELECTRIC MOTOR 300KW (400 HP) ELECTRIC POWER CONVERTOR BATTERY PACK ELECTRIC COOLING SYSTEM INTERIOR COOLING SYSTEM	MOTOR MOUNTS BATTERY MOUNTS BATTERY HARNESS BATTERY COOLING TUB RAIL SYSTEM FOR ENGINE REMOVAL RAIL SYSTEM FOR BATTERY REMOVAL
HARNESS	7 POINT HARNESS HARNESS FLOOR MOUNTS CLASPE WITH QUICK RELEASE	
EXTERIOR BODY PANELS	Recycled polyethylene terephthalate (rPET) Natural Fibre Composites (Molded)	

COMPLETE CAR-PARASTOCK BILL OF MATERIALS

TOTAL COST FOR 1 FULL ASSEMBLED CAR WITHOUT TOOLING $(CAD): 35,539.00	COSTS ARE APPROXIMATE	TOTAL NUMBER OF MAIN ASSEMBLY PARTS: 187	SKYE LARO

CHASSIS/ROLLCAGE FRAME
BOM 1 28 PARTS

TOTAL COST FOR PARTS $(CAD): 8390.00

ROLL CAGE

FINISHING: Powder Coated

- SHOULDER HARNESS BAR
- FRONT CRUMPLE ZONE
- REAR CRUMPLE ZONE
- BASH BARS FRONT
- BASH BARS REAR
- BASH BARS FRONT SIDE
- BASH BARS REAR SIDE
- BODY MOUNTS REAR UPPER
- BODY MOUNTS REAR LOWER
- DRIVER "HALO" UPPER MIDDLE SECTION OF ROLL CAGE
- REAR CAGE BRACING

FRAME

FINISHING: Powder Coated

- FRAME FRONT HALF
- FRAME REAR HALF
- INNER SHOCK TOWERS FRONT
- INNER SHOCK TOWERS REAR
- BATTERY MOUNTS
- ENGINE MOUNTS
- BODY MOUNTS REAR UPPER
- BODY MOUNTS FRONT UPPER

INTERIOR
BOM 2 46 PARTS

TOTAL COST FOR PARTS $(CAD): 3014.00

IP PANEL/ CONTROLS

FINISHING: Powder Coated Metal, Anodized Aluminum, Painted Plastics

- HUD DISPLAY (DASH)
- STAMPED PANEL
- HAND CONTROL RAILS X4
- HAND CONTROL MOUNTS X4
- TRIGGER BUTTONS UPPER X2
- TRIGGER BUTTONS LOWER X2
- CONTROLLER HOUSEING X2
- GREEN-BOARD
- BRUSHLESS MOTOR (VIBRATION)
- RUBBER PAD

SEAT/ FLOOR

FINISHING: Powder Coated

- HYDRAULIC PISTON (FLOOR)
- FLOOR EXTRUSION PISTON
- RAIL SYSTEM-SEAT FLOOR
- PISTON
- SEAT FLOOR LOWER
- SEAT FLOOR UPPER (ROTATES)
- SEAT POSITIONING MOUNT
- MOUNT

DOOR/ INTERIOR PANELS

FINISHING: Powder Coated Steel and Anodized Aluminum

- STAMPED PANAL (SIDE)
- HANDLE RAIL AND MOUNTS
- HANDLE
- DOOR HINGE UPPER X2
- DOOR HINGE LOWER X2
- DOOR MOUNT
- DOOR PISTON MOUNT
- INNER RAIL/SLIDER FOR DOOR
- EXTERIOR DOOR HANDLE
- INTERIOR DOOR HANDLE

BODY
BOM 3 24 PARTS

TOTAL COST FOR PARTS $(CAD): 4090.00

WIND SCREENS

FINISHING: n/a

- FRONT WINSHIELD
- REAR WINDHSIELD
- DRIVERS SIDE WINDOW NET
- WINDOW NET LATCHES

BODY PANELS

FINISHING: Sprayed

- FRONT SECTION
- QUARTER PANELS FRONT
- SECTION 3 UPPER
- SECTION 3 LOWER
- GREEN HOUSE / ROOF (A,B, AND C PILLARS OF EXTERIOR PANELS)
- SECTION 4 UPPER
- SECTION 4 LOWER
- SECTION 5 TRUNK
- REAR QUARTER PANELS

MECHANICAL
BOM 4 89 PARTS

TOTAL COST FOR PARTS $(CAD): 20 045.00

DRIVETRAIN

FINISHING: Powder Coated

- ELECTRONIC POWER DISTRIBUTOR FOR SLIDING FLOOR AND SEAT SYSTEM
- POWER RELAY TO SHOCK TOWERS FRONT
- POWER RELAY TO SHOCK TOWERS REAR
- MOTOR MOUNTS
- BATTERY MOUNTS
- BATTERY HARNESS
- BATTERY COOLING TUB
- RAIL SYSTEM FOR ENGINE REMOVAL
- RAIL SYSTEM FOR BATTERY REMOVAL
- 300 KW ELECTRIC MOTOR (370-400 HP)
- SEMI-AUTO Electronic Transmission POWER CONVERTOR
- 35 KILLOWAT HOUR BATTERY (240 LITRES)

HYDRAULICS AND WHEELS

FINISHING: Powder Coated Steel Anodized Aluminum

- RAIL SYSTEM FOR ENGINE REMOVAL
- RAIL SYSTEM FOR BATTERY REMOVAL
- FRONT BRAKE CALLIPERS
- REAR BRAKE CALLIPERS
- BRAKE BOOSTER
- BRAKE LINE ROUTING
- COOLING SYTEM WATER LINES
- OIL LINES
- RMS
- TIRES

SUSPENSION AND STEERING/ WHEEL MOUNTING

FINISHING: Powder Coated

- FRONT LOWER CONTROL ARM X2
- FRONT UPPER CONTROL ARM X2
- FRONT STRUT
- FRONT SHOCK
- FRONT SHOCK TOP HAT
- FRONT SHOCK AIR BAG SHIM
- REAR SHOCK TOP HAT
- REAR SHOCK STRUT
- REAR SHOCK
- REAR SHOCK AIRBAG SHIM
- FRONT INNER TIE ROD
- FRONT OUTER TIE ROD
- FRONT SWAY BAR
- SWAY BAR LINKS
- SUSPENSIONS BOLTS GRADE 10.9
- SUSPENSION NUTS
- REAR CONTROL ARM MAIN
- REAR PUSH ROD/ARM
- REAR TRAILING ARM
- REAR WHEEL BARRINGS
- FRONT WHEEL BARRINGS
- REAR BRAKE ROTORS
- FRONT BRAKE ROTORS

- SHOULDER HARNESS BAR
- FRONT CRUMPLE ZONE
- REAR CRUMPLE ZONE
- BASH BARS FRONT
- BASH BARS REAR
- BASH BARS FRONT SIDE
- BASH BARS REAR SIDE
- BODY MOUNTS REAR UPPER
- BODY MOUNTS REAR LOWER
- DRIVER "HALO" UPPER MIDDLE SECTION OF ROLL CAGE
- REAR CAGE BRACING

- FRAME FRONT HALF
- FRAME REAR HALF
- INNER SHOCK TOWERS FRONT
- INNER SHOCK TOWERS REAR
- BATTERY MOUNTS
- ENGINE MOUNTS
- BODY MOUNTS REAR UPPER
- BODY MOUNTS FRONT UPPER

- HUD DISPLAY (DASH)
- STAMPED PANEL
- HAND CONTROL RAILS X4
- HAND CONTROL MOUNTS X4
- TRIGGER BUTTONS UPPER X2
- TRIGGER BUTTONS LOWER X2
- CONTROLLER HOUSEING X2
- GREEN-BOARD
- BRUSHLESS MOTOR (VIBRATION)
- RUBBER PAD

- HYDRAULIC PISTON (FLOOR)
- FLOOR EXTRUSION PISTON
- RAIL SYSTEM-SEAT FLOOR
- PISTON
- SEAT FLOOR LOWER
- SEAT FLOOR UPPER (ROTATES)
- SEAT POSITIONING MOUNT
- MOUNT

- STAMPED PANAL (SIDE)
- HANDLE RAIL AND MOUNTS
- HANDLE
- DOOR HINGE UPPER X2
- DOOR HINGE LOWER X2
- DOOR MOUNT
- DOOR PISTON MOUNT
- INNER RAIL/SLIDER FOR DOOR
- EXTERIOR DOOR HANDLE
- INTERIOR DOOR HANDLE

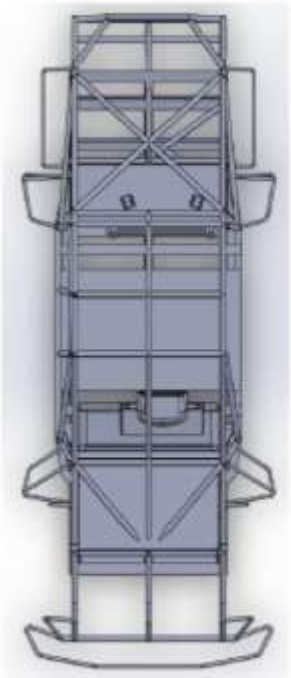
- FRONT WINSHIELD
- REAR WINDHSIELD
- DRIVERS SIDE WINDOW NET
- WINDOW NET LATCHES

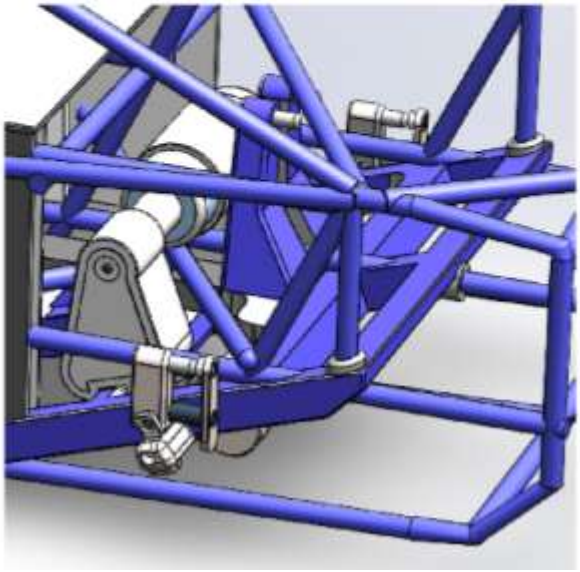
- FRONT SECTION
- QUARTER PANELS FRONT
- SECTION 3 UPPER
- SECTION 3 LOWER
- GREEN HOUSE / ROOF (A,B, AND C PILLARS OF EXTERIOR PANELS)
- SECTION 4 UPPER
- SECTION 4 LOWER
- SECTION 5 TRUNK
- REAR QUARTER PANELS

- ELECTRONIC POWER DISTRIBUTOR FOR SLIDING FLOOR AND SEAT SYSTEM
- POWER RELAY TO SHOCK TOWERS FRONT
- POWER RELAY TO SHOCK TOWERS REAR
- MOTOR MOUNTS
- BATTERY MOUNTS
- BATTERY HARNESS
- BATTERY COOLING TUB
- RAIL SYSTEM FOR ENGINE REMOVAL
- RAIL SYSTEM FOR BATTERY REMOVAL
- 300 KW ELECTRIC MOTOR (370-400 HP)
- SEMI-AUTO Electronic Transmission POWER CONVERTOR
- 35 KILLOWAT HOUR BATTERY (240 LITRES)

- RAIL SYSTEM FOR ENGINE REMOVAL
- RAIL SYSTEM FOR BATTERY REMOVAL
- FRONT BRAKE CALLIPERS
- REAR BRAKE CALLIPERS
- BRAKE BOOSTER
- BRAKE LINE ROUTING
- COOLING SYTEM WATER LINES
- OIL LINES
- RMS
- TIRES

- FRONT LOWER CONTROL ARM X2
- FRONT UPPER CONTROL ARM X2
- FRONT STRUT
- FRONT SHOCK
- FRONT SHOCK TOP HAT
- FRONT SHOCK AIR BAG SHIM
- REAR SHOCK TOP HAT
- REAR SHOCK STRUT
- REAR SHOCK
- REAR SHOCK AIRBAG SHIM
- FRONT INNER TIE ROD
- FRONT OUTER TIE ROD
- FRONT SWAY BAR
- SWAY BAR LINKS
- SUSPENSIONS BOLTS GRADE 10.9
- SUSPENSION NUTS
- REAR CONTROL ARM MAIN
- REAR PUSH ROD/ARM
- REAR TRAILING ARM
- REAR WHEEL BARRINGS
- FRONT WHEEL BARRINGS
- REAR BRAKE ROTORS
- FRONT BRAKE ROTORS



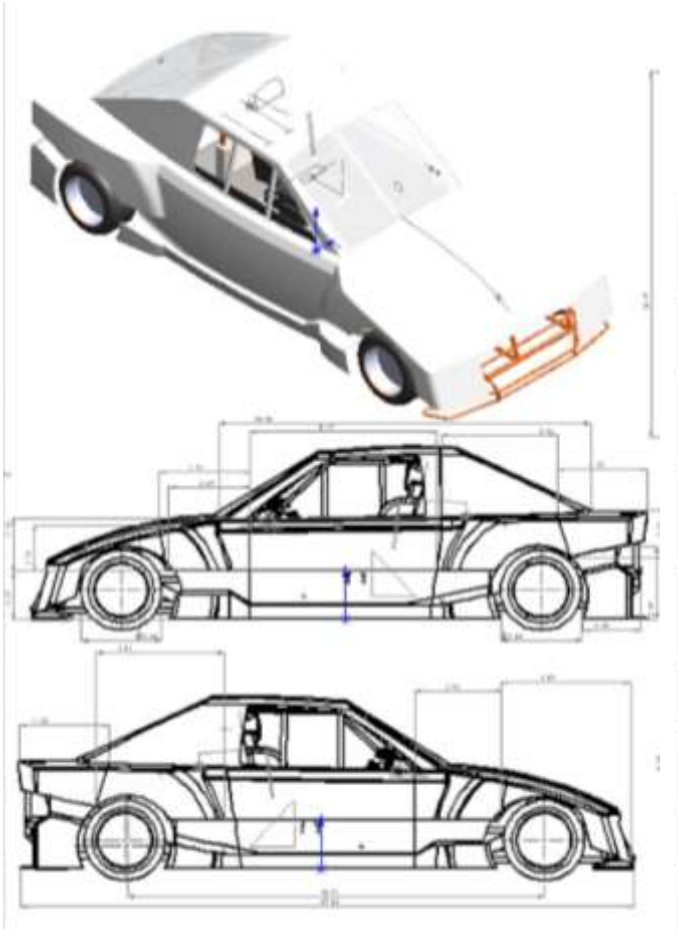


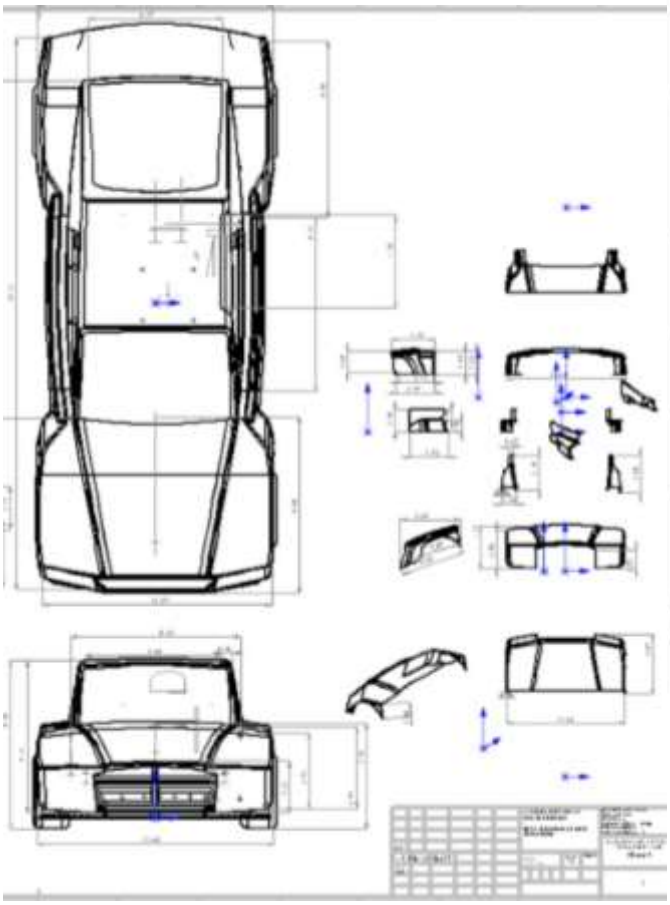
BOM 1 ROLL CAGE AND CHASSIS

PART	Quantity/ # of part(s)	MATERIAL	MANUFACTURING PROCESS	COST $ Dollars(CAD)
SHOULDER HARNESS BAR	1	COLD DRAWN STEEL (CDS) 1.5"TUBED	STEEL TUBING FABRICATION	100.00
FRONT CRUMPLE ZONE	1	CRS 1.25"TUBED	STEEL TUBING FABRICATION	1300.00
REAR CRUMPLE ZONE	1	CRS 1.25"TUBED	STEEL TUBING FABRICATION	1200.00
BASH BARS FRONT	1	CRS 1.00"TUBED	STEEL TUBING FABRICATION	100.00
BASH BARS REAR	1	CRS 1.00"TUBED	STEEL TUBING FABRICATION	100.00
BASH BARS FRONT SIDE BASH BARS REAR SIDE	1 1	CRS 1.00"TUBED	STEEL TUBING FABRICATION	80.00 80.00
BODY MOUNTS REAR UPPER	2	CRS 1.00"TUBED	SHEET STEEL FABRICATION	40.00
BODY MOUNTS REAR LOWER	2	20 Gauge Cold -rolled Steel	SHEET STEEL FABRICATION	30.00
DRIVER "HALO" UPPER MIDDLE SECTION OF ROLL CAGE	1	CRS 1.50"TUBED	STEEL TUBING FABRICATION	1500.00
REAR CAGE BRACING	1	CRS 1.50"TUBED	STEEL TUBING FABRICATION	300.00
FRAME FRONT HALF	1	CRS 3x2"	STEEL TUBING FABRICATION	1100.00
FRAME REAR HALF	1	CRS 3x2"	STEEL TUBING FABRICATION	1200.00
INNER SHOCK TOWERS FRONT	1	CRS 3x2"	STEEL TUBING FABRICATION	350.00
INNER SHOCK TOWERS REAR	2	CRS 3x2"	STEEL TUBING FABRICATION	250.00
BATTERY MOUNTS	4	CRS 2x1"	STEEL TUBING FABRICATION	550.00
ENGINE MOUNTS	2	CRS 2x1 with rubber	STEEL TUBING FABRICATION	250.00
BODY MOUNTS REAR UPPER	2		STEEL TUBING FABRICATION	50.00
BODY MOUNTS FRONT UPPER	2	CRS 1" TUBED	SHEET STEEL FABRICATION	60.00
TOTAL	28	n/a	n/a	8390.00

BOM 2 INTERIOR/CONTROLS

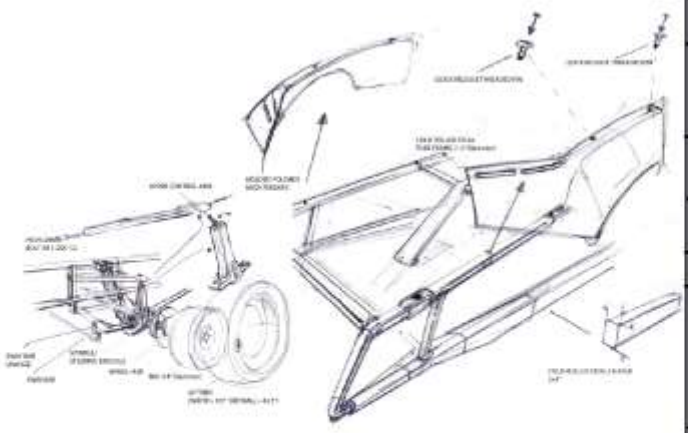
PART	Quantity/ # of part(s)	MATERIAL	MANUFACTURING PROCESS	COST $ Dollars(CAD)
HUD DISPLAY (DASH)	1	R-PLA	3D Printed	150.00
STAMPED PANEL	1	R-PLA	3D Printed	80.00
HAND CONTROL RAILS X4	4	Aluminum	CAST	25.00
HAND CONTROL MOUNTS X4	4	Aluminum	CAST	350.00
TRIGGER BUTTONS UPPER X2	2	Polystyrene	INJECTION MOLDED	5.00
TRIGGER BUTTONS LOWER X2	2	Polystyrene	INJECTION MOLDED	5.00
CONTROLLER HOUSEING X2	2	PCR Resin	INJECTION MOLDED	30.00
GREEN-BOARD	1	PCB and Copper Solder	PRESSED	12.00
BRUSHLESS MOTOR	2	Copper and Aluminum	AUTOMATED BLDC (woven)	20.00
(VIBRATION) RUBBER PAD	2	Synthetic rubber	INJECTION MOLDED	350.00
HYDRAULIC PISTON (FLOOR)	1	CRS STEEL	CNC MILLING	250.00
FLOOR EXTRUSION PISTON	1	CRS STEEL	CNC MILLING	250.00
RAIL SYSTEM-SEAT	2	CRS STEEL	CNC MILLING	50.00
FLOOR PISTON	1	CRS STEEL	CNC MILLING	250.00
SEAT FLOOR LOWER	1	CRS STEEL PLATING		120.00
SEAT FLOOR UPPER (ROTATES)	1	CRS STEEL PLATING	CNC MILLING	80.00
SEAT POSITIONING MOUNT	1	CRS STEEL PLATING	CNC MILLING	80.00
STAMPED PANAL (SIDE)	1	CRS STEEL PLATING	STAMPED	60.00
HANDLE RAIL AND MOUNTS	2	Aluminum	CAST	30.00
HANDLE	2	CRS STEEL	STAMPED	20.00
DOOR HINGE UPPER X2	2	CRS STEEL	STAMPED	75.00
DOOR HINGE	2	CRS STEEL	STAMPED	75.00
LOWER X2 DOOR MOUNT	2	CRS STEEL	STAMPED	75.00
DOOR PISTON MOUNT	1	CRS STEEL	STAMPED	230.00
INNER RAIL/SLID-ER FOR DOOR	1	Aluminum	CAST	65.00
EXTERIOR DOOR HANDLE	1	Aluminum	CAST	12.00
INTERIOR DOOR HANDLE	1	Aluminum	CAST	15.00
TOTAL:	46	n/a	n/a	3014.00





BOM 3 BODY/WINDSCREENS (CNC MILLED MOLDS)

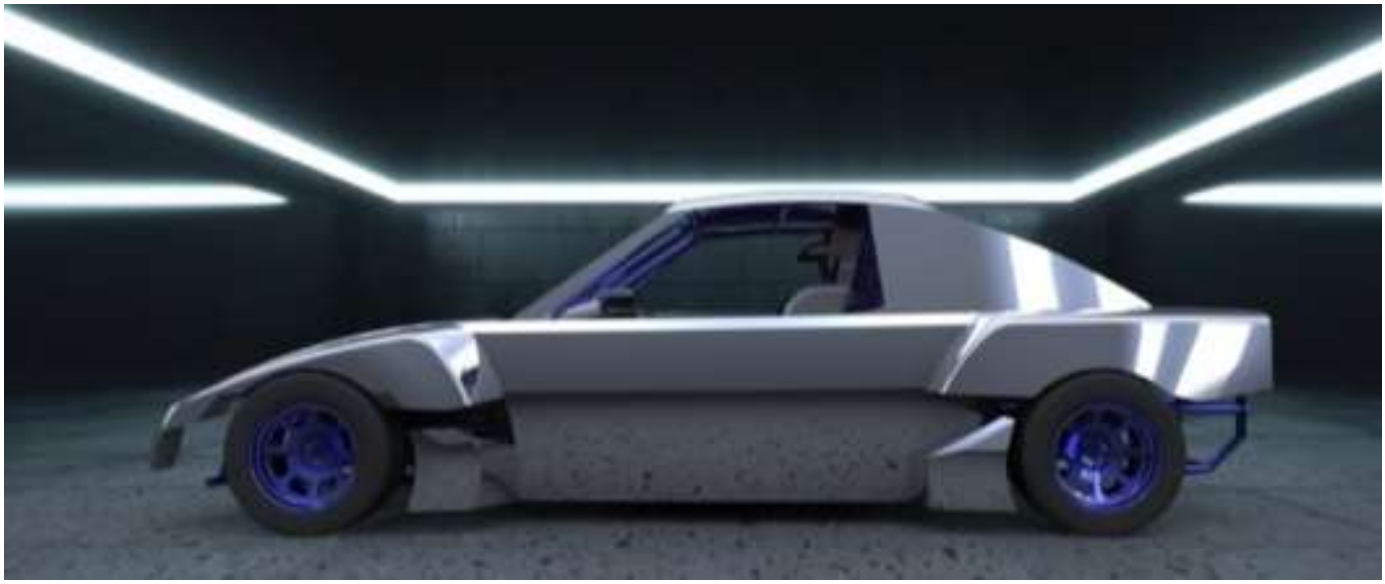
PART	Quantity/ # of part(s)	MATERIAL	MANUFACTURING PROCESS	COST
FRONT WINSHIELD	1	Polycarbonate-Synthetic Resin	Cut-and Fabbed	140.00
REAR WINDHSIELD	1	Polycarbonate-Synthetic Resin	Cut-and Fabbed	120.00
DRIVERS SIDE WINDOW NET	1	Nylon	Outsourced	100.00
WINDOW NET LATCHES	2	CRS STEEL	STAMPED	40.00
FRONT SECTION	1	Natural Fiber Composite	INJECTION STAMPED/MOLDED	450.00
QUARTER PANELS FRONT ((LEFT AND RIGHT)	2	Natural Fiber Composite	INJECTION STAMPED/MOLDED	230.00
SECTION 3 UPPER (LEFT AND RIGHT)	2	Natural Fiber Composite	INJECTION STAMPED/MOLDED	250.00
SECTION 3 LOWER (LEFT AND RIGHT	2	Natural Fiber Composite	INJECTION STAMPED/MOLDED	140.00
GREEN HOUSE / ROOF (A,B, AND C PILLARS OF EXTERIOR PANELS)	1	Natural Fiber Composite	INJECTION STAMPED/MOLDED	450.00
SECTION 4 UPPER (LEFT AND RIGHT)	2	Natural Fiber Composite	INJECTION STAMPED/MOLDED	280.00
SECTION 4 LOWER (LEFT AND RIGHT)	2	Natural Fiber Composite	INJECTION STAMPED/MOLDED	160.00
SECTION 5 TRUNK	1	Natural Fiber Composite	INJECTION STAMPED/MOLDED	180.00
REAR QUARTER PANELS (LEFT AND RIGHT)	2	Natural Fiber Composite	INJECTION STAMPED/MOLDED	350.00
RIMS AND TIRES	4	STEEL RIMS WITH SLICK RUBBER TIRES	Out Sourced	1200.00
TOTAL	20	n/a	n/a	4090.00



BOM 4 MECHANICAL/SUSPENSION AND WHEELCOMPONENTS

PART	Quantity/ # of part(s)	MATERIAL	MANUFACTURING PROCESS	COST
ELECTRONIC POWER DISTRIBUTOR FOR SLIDING FLOOR AND SEAT SYSTEM	1	n/a	Out Sourced	150.00
POWER RELAY TO SHOCK TOWERS FRONT	1	n/a	Out Sourced	200.00
POWER RELAY TO SHOCK TOWERS REAR	1	n/a	INJECTION MOLDED	80.00
MOTOR MOUNTS	2	CRS STEEL	MILLED	
BATTERY MOUNTS BATTERY HARNESS BATTERY COOLING TUB RAIL SYSTEM FOR ENGINE REMOVAL	2 1 1 1	n/a n/a n/a Aluminum	Outsourced Outsourced Out Sourced CAST	350.00 700.00 300.00 400.00
RAIL SYSTEM FOR BATTERY REMOVAL	1	CRS STEEL and Aluminum	STAMPED/ CAST	500.00
300 KW ELECTRIC MOTOR (370-400 HP)	1	n/a	Out Sourced (AM RACING)	8200.00
SEMI-AUTO Electronic Transmission	1	n/a	Out Sourced	2000.00
POWER CONVERTOR	1	n/a	Out Sourced	1500.00
35 KILLOWAT HOUR BATTERY (240 LITRES)	1	n/a	Out Sourced	4500.00
FRONT LOWER CONTROL ARM FRONT UPPER CONTROL ARM	2 2	STEEL	STAMPED	230.00
FRONT STRUT FRONT SHOCK	2 2	CRS STEEL	MILLED	200.00
FRONT SHOCK TOP HAT	2	CRS STEEL	MILLED	40.00
FRONT SHOCK AIR BAG SHIM	2	RUBBER	INJECTION MOLDED	200.00
REAR SHOCK TOP HAT	2	CRS STEEL	MILLED	40.00
REAR SHOCK STRUT	2	CRS STEEL	MILLED	200.00
REAR SHOCK	2	CRS STEEL	MILLED	230.00
REAR SHOCK AIRBAG SHIM	2	RUBBER	MILLED	200.00
FRONT INNER TIE ROD	2	STEEL	STAMPED	40.00
FRONT OUTER TIE ROD	2	STEEL	STAMPED	40.00
FRONT SWAY BAR	2	STEEL	STAMPED	80.00
SWAY BAR LINKS	2	STEEL	STAMPED	25.00
SUSPENSIONS BOLTS GRADE 10.9	18	Carbon Alloy	MILLED	90.00
SUSPENSION NUTS	16	Carbon Alloy	MILLED	40.00
REAR CONTROL ARM MAIN	2	CRS STEEL	STAMPED	280.00
REAR PUSH ROD/ARM	2	STEEL	STAMPED	220.00
REAR TRAILING ARM	2	STEEL	STAMPED	140.00
REAR WHEEL BARRINGS	2		Out Sourced	200.00
FRONT WHEEL BARRINGS	2		Out Sourced	160.00
FRONT/REAR BRAKE ROTORS	2	Carbon Ceramic	Out Sourced	180.00
TOTAL	89	n/a	n/a	20 045.00

5.3 FINAL CAD RNDERINGS




NASCAR HOME TRACKS
23
SLD

SLD
SKYE LARO DESIGN

Agile | manufacturing inc.
ISO 9001:2015

PARA-STOCK

5.4 FINAL MODEL IMAGES

1/6 Scale Model Created By:
Skye Laro

Thankyou to Agile Manufacturing for the 3D Printing Services During This Model Build.

Materials:
Aluminum/Copper .25" Brake line (25 feet)
Solder
PLA and SLA Plastic
Rubber
Suade
Sheet Metal (Steel)

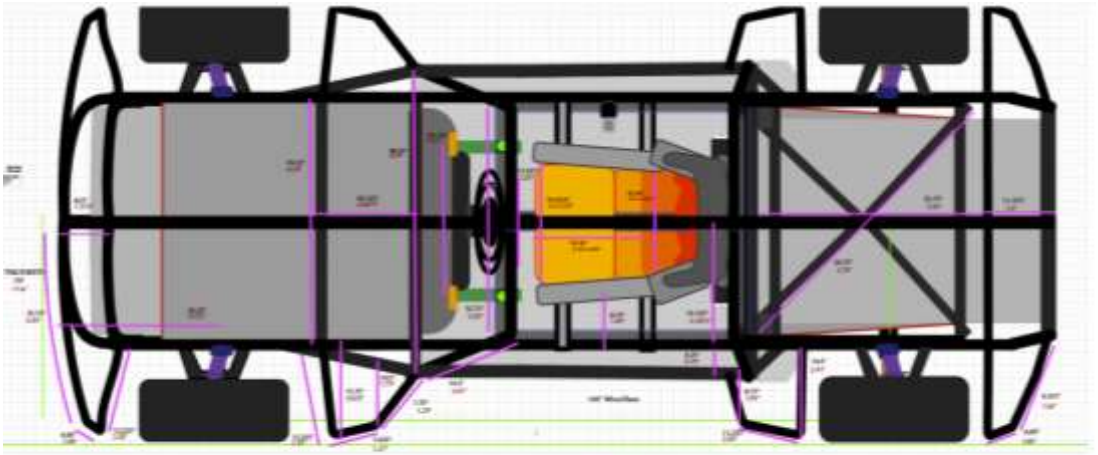
Length of Physical Building Period:
5 Weeks

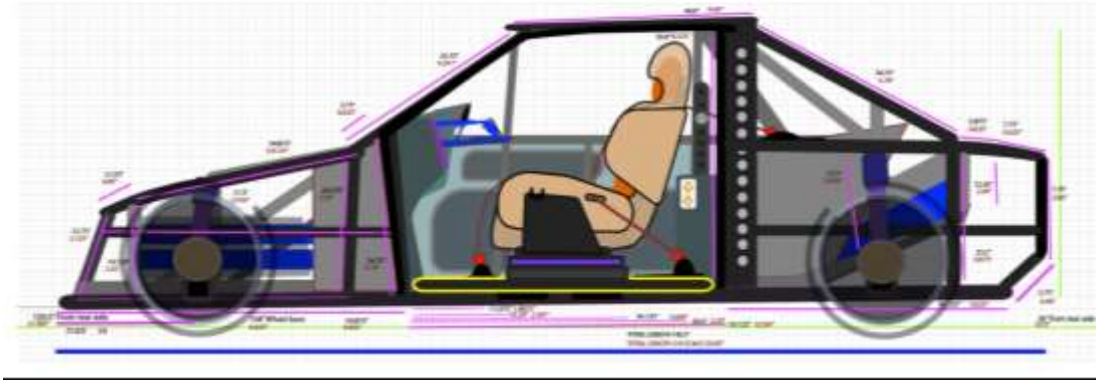
Assembled Interior, Cage/Chassis and Body - Finished

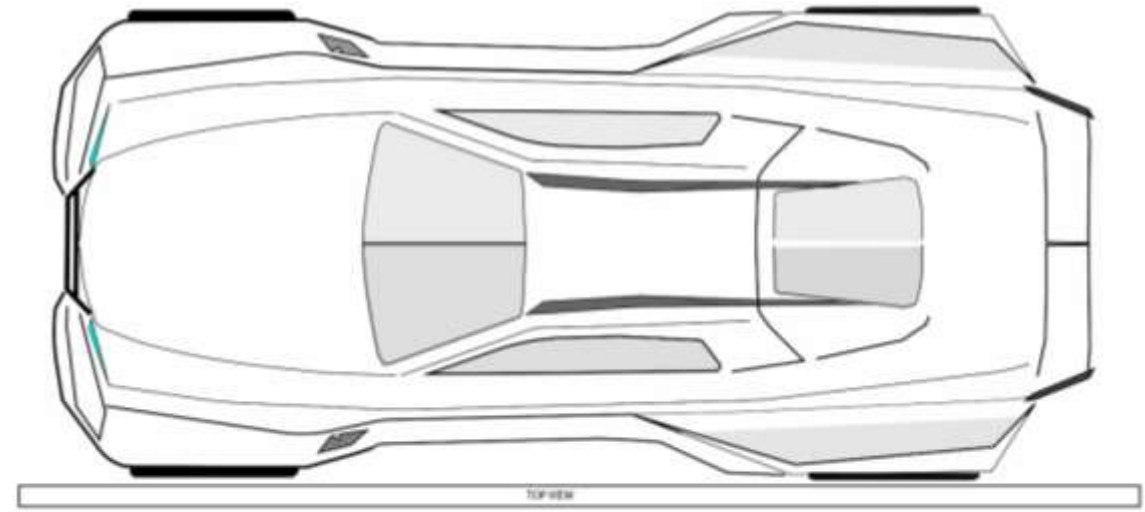
PARA-STOCK

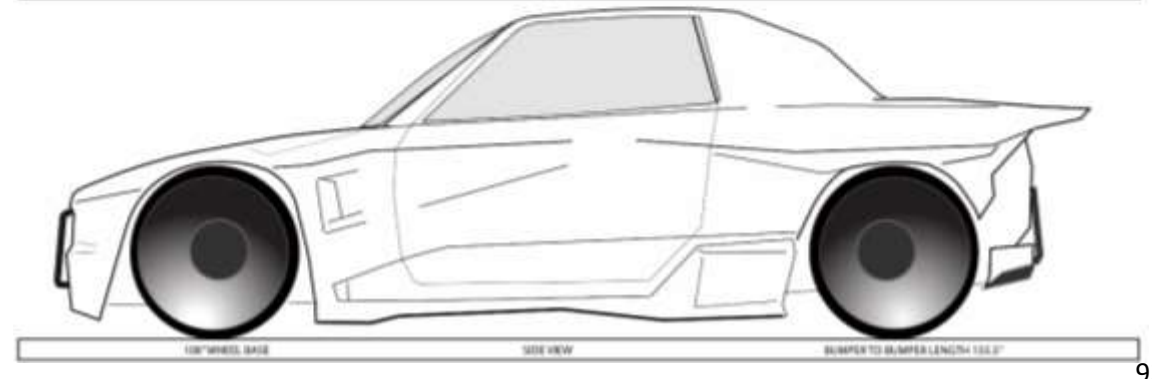
SLD
SKYE LARO DESIGN

5.4 FINAL TECHNICAL DRAWINGS:

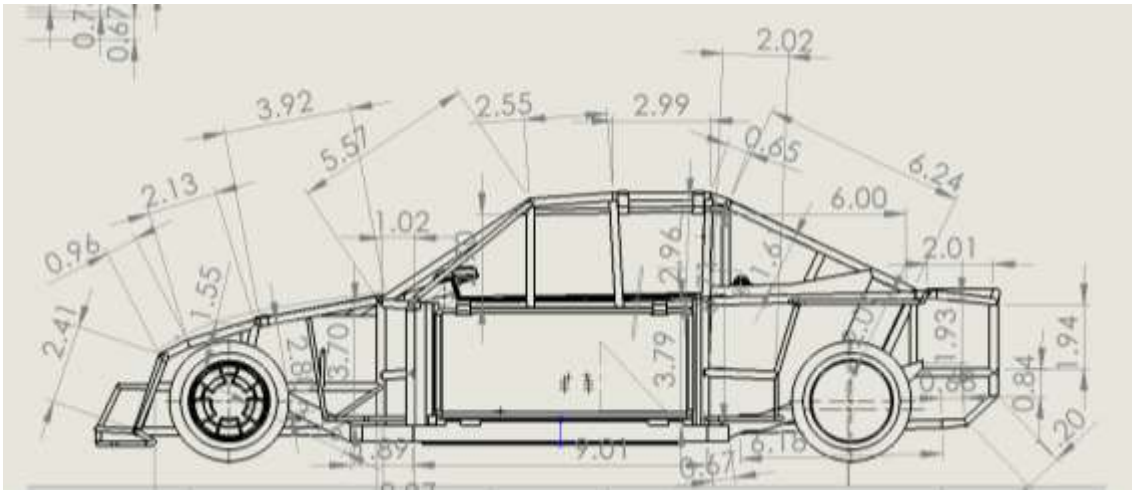


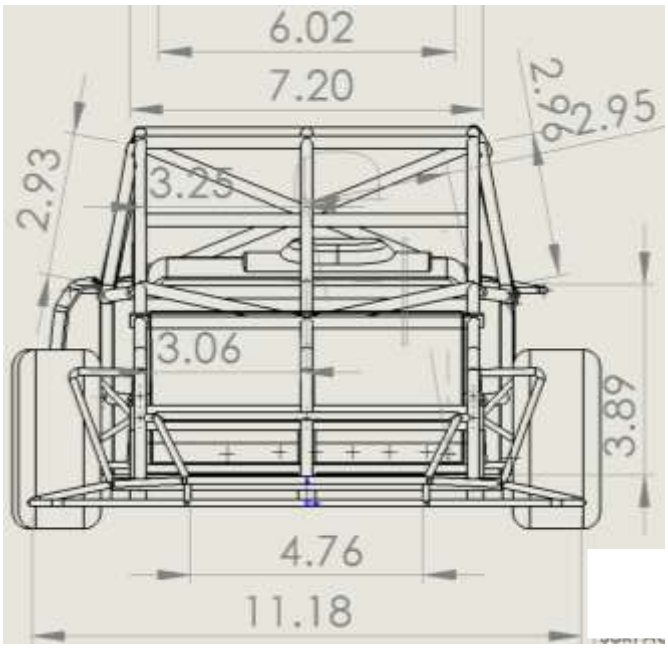


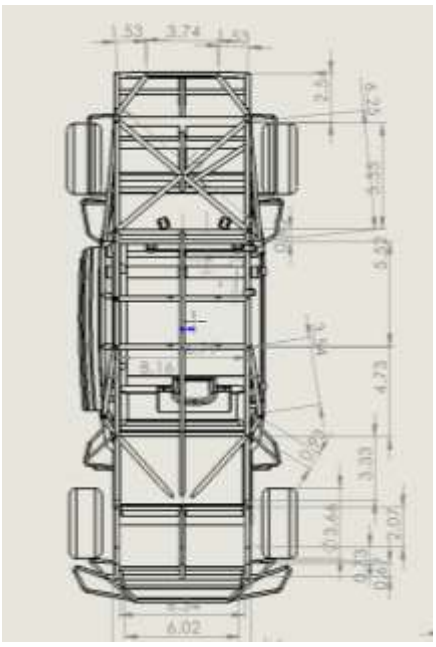


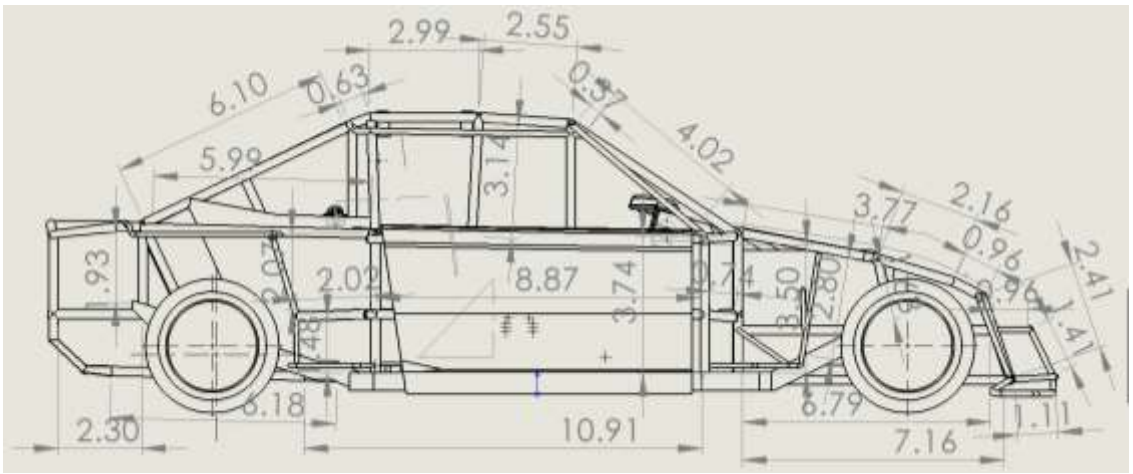


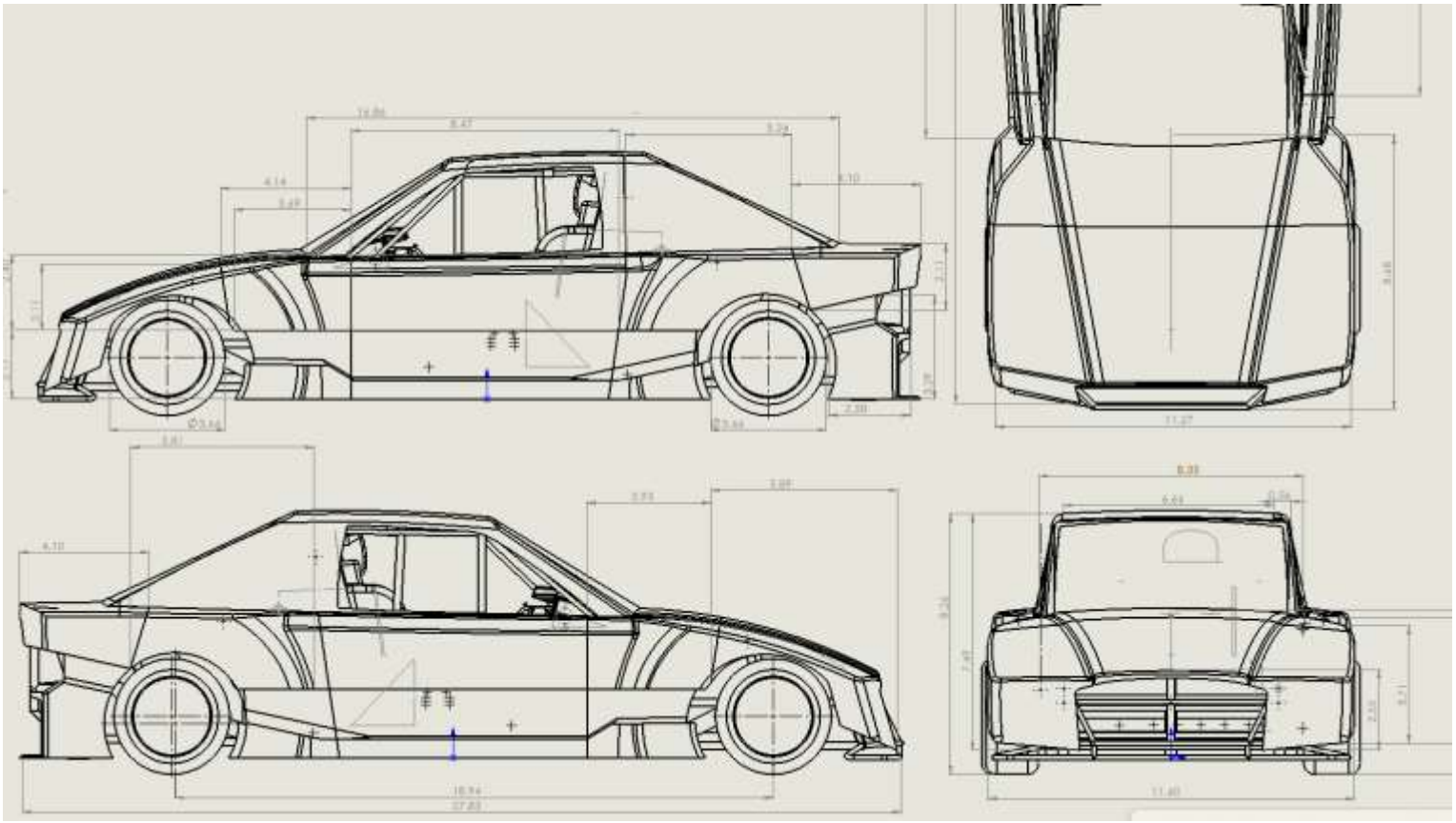
1:6 SCALE TEHCNICAL DRAWINGS:

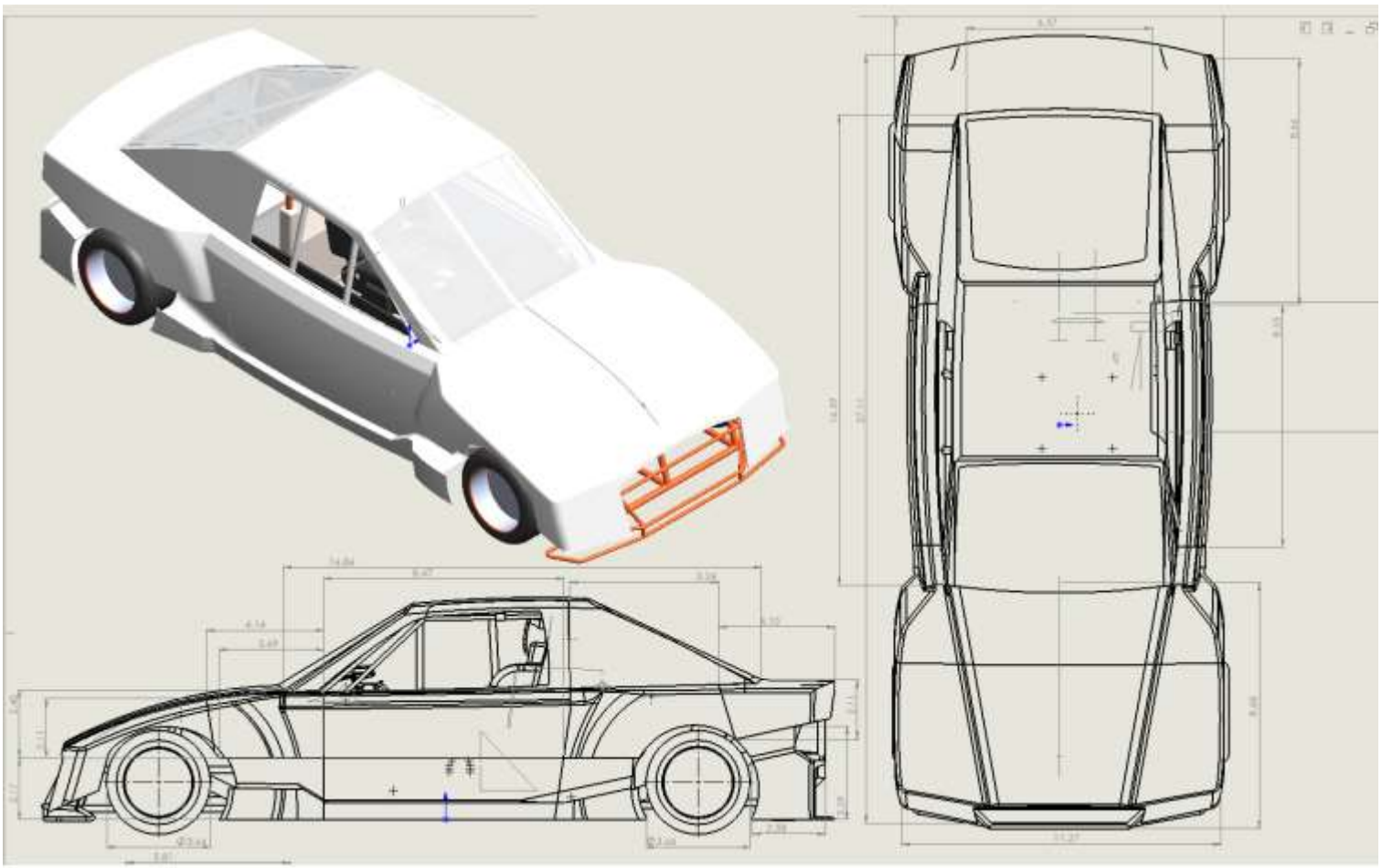


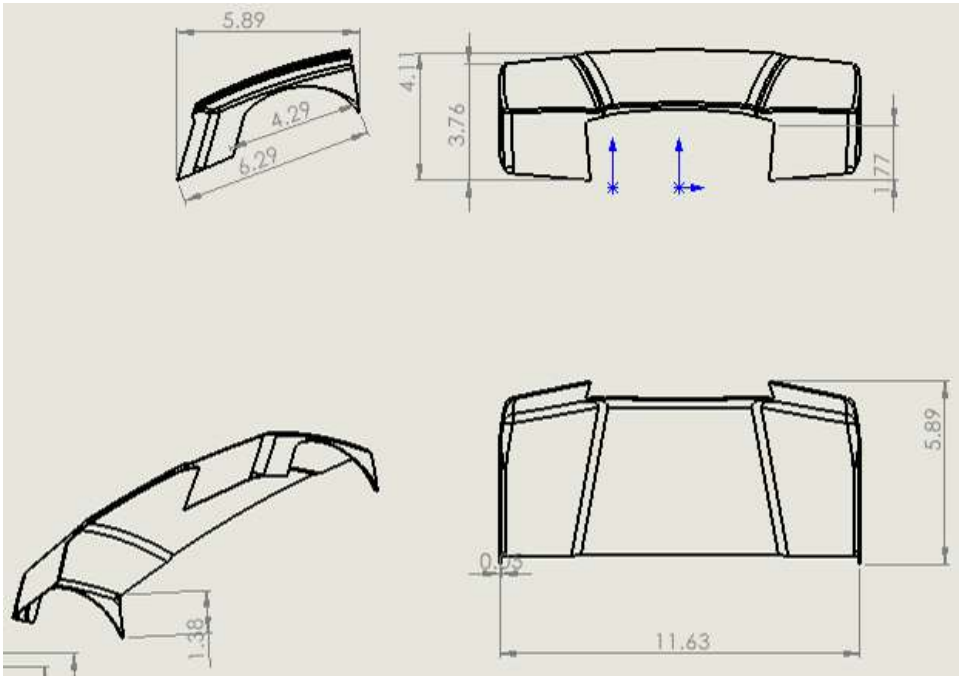


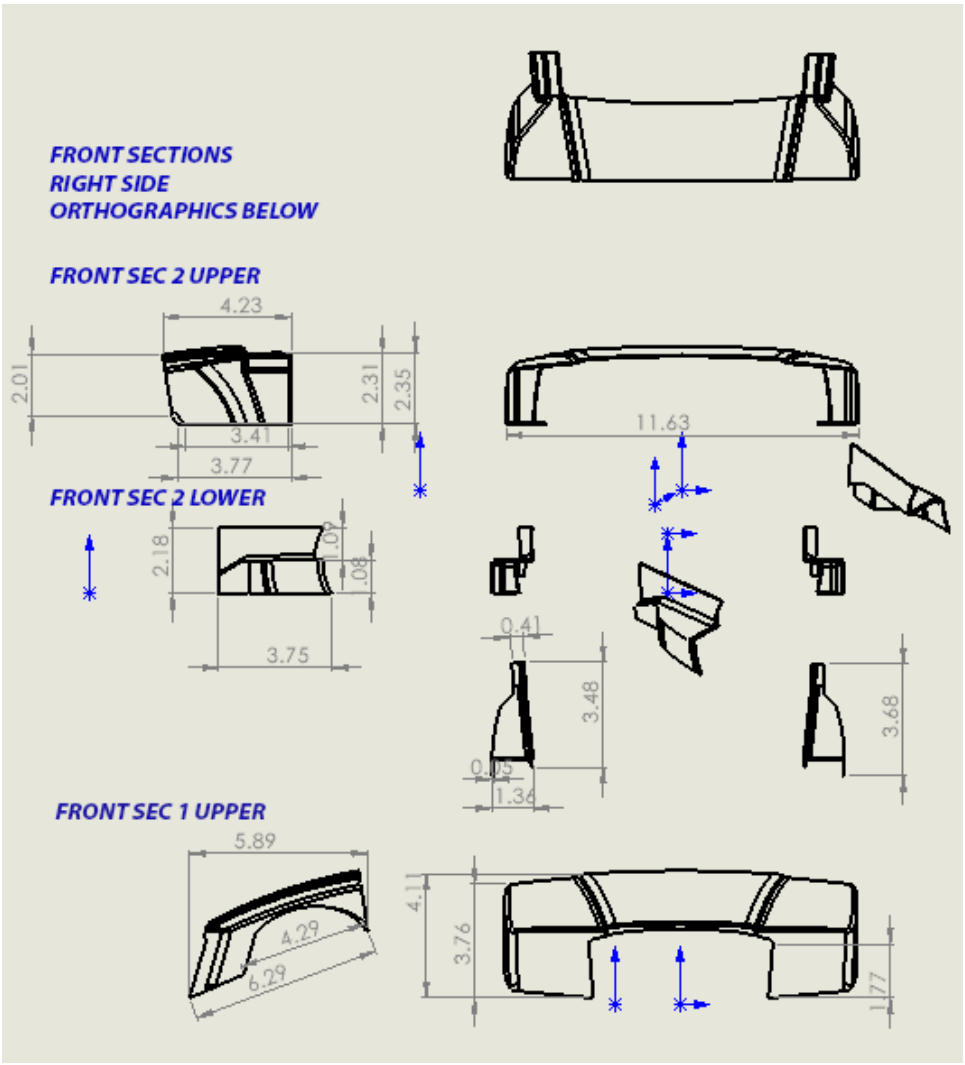









5.89
4.29
6.29
4.11
3.76
1.77
1.38
5.89
11.63


FRONT SECTIONS
RIGHT SIDE
ORTHOGRAPHICS BELOW
FRONT SEC 2 UPPER
4.23
2.01
2.31
2.35
3.41
3.77
FRONT SEC 2 LOWER
2.18
1.09
1.08
3.75
11.63
0.41
3.48
3.68
1.36
FRONT SEC 1 UPPER
5.89
4.29
6.29
4.11
3.76
1.77

5.6 Sustainability

The aero panels of the race car will utilize rPET; a material developed by EconCore. This is a material that is made up of non-food post industrial and consumer waste. EconCore is based in Leuven, Belgium. The material has been developed to offer a cheap/cost effective solution for production of honeycomb cores. The material is 100% recycled and provides a new technology/material that is sustainable for the environment, and the user.

rPET is a Light weight and durable material; capable of withstanding forces equal to 1000 times its weight. Hight temperature resistance. High bending resistance under high forces. Cost effective solution for items like; spoilers, front splitters, diffusers, and other aerodynamic items that will be utilized for the race car. The product/ material is a cost effective, high performing, and sustainable for the environment.

Bcomp natural fiber composite body panels create 10% of the Carbon foot print that other materials like carbon fiber create; meaning it is a material that can replace carbon fiber, while being more strong, light weight. They have already been proven in racing series like Formula 1, Formula E, and GT 4 touring car racing. This body material is a sustainable solution for body work and will be used instead of carbon fiber.

Inclusivity:

Utilizing the decades of evolution and ingenuity in stock car, and touring car motorsports, the chassis and frame will be safe, structural, and legal for users to race on licensed oval tracks, and road course tracks across North America, and Europe. Aiming to tick all the boxes on safety regulations, while sourcing sustainable and cutting-edge materials for the aero of the car, and control methods that users will experience when in control of this machine. The scope of the project is vast in the sense that it offers a new sport; inspired by the Paralympics and aiming to inspire others. The project is complex and needs to have no detail missed; but is aloud to step out of the box with materials, manufacturing, and user experience. This car will represent the old, and the future of motorsports racing. An age of racing that includes anyone who has the spirit to pursue driving a racecar. Where motorsports are not looked at as an unsustainable sport on the environment.

Chapter 6- Conclusion

PARASTOCK is a rear-wheel-drive electric racecar- the first of its type. What's its type? The physically challenged.

This product is more than a car; what comes with it is a; proposal for a new motorsport; with a new form of competitor. Increasing the overall opportunities for people to race. The goal of this car is to create a new era in motorsports where; it isn't just one type of person who drives a race car. The sport needs to appear accessible as to attract more of an audience. It is no secret that racing can make you a small fortune; but you need a large fortune before you start racing in the first place. That's why series holders and event holders that sanction events; would need to be created for PARASTOCK. Inspired by the Paralympics; this is a huge undertaking; but one that has been put off for too long. Racing is a sport that relies on more than just the driver; that's why PARASOCK is made to assist the user with maintenance, adjustments, and overall getting comfortable with racing.

This project has been heavy on the research aspects, but through that, has constructed a plan- and the materials needed to solve the problems; that stop physically challenged drivers from competing in auto-racing. PARASTOCK is estimated to be a car that could be sold for under $40,000.00 (CAD). It is the future that Motorsports need- Bringing electronic drive train stock cars to the market, while offering a new demographic the chance to race.


10 LAPS TO GO

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Appendix:

A DISCOVERY

Problem Definition

How may we: facilitate competitive motor-sports racing for the physically challenged?

Needs Statement:

The problem of race cars and motorsports for people with physical disabilities; is the lack of options for participation. The physically challenged don't have the option to participate or compete in real-life racing. Factors around safety and liability bring up various problems for the users, because of this, a series and a race car class have not been created to host a group of physically challenged drivers who compete. The problem that needs to be solved is an ergonomic task, including the harnessing and securement of one's body. maintenance, and transportation of the vehicle; a user experience task for the driver who would possibly own the car and need to make adjustments on different parts of the vehicle (ie; suspension, alignment). Different styles of controls and reliable useability for the driver will need to be critical for multiple different types of physical needs. Many physical disabilities, or injuries that alter someone's personal physical mobility, can differ in detail; therefore, people will need to have interior adjustment availability that still allows for safety standards to be met. (i.e.; seat height, distance from controls, throttle controls, and viewing needs)

User observational video 1
User journey map

Paraplegic Instructional Driving Video - Hand Controls
https://www.youtube.com/watch?v=cQraE9xrArw

	PLANNING	PREPARATION	TASK 1	TASK 2	TASK 3	GOAL	FINISH UP
USER GOALS	Get into car, and go for drive, without taking long	Insure space for entrance of vehicle	Get into car, specifically lower body positioned in the drivers seat	Get legs into proper position for during the task of driving	position body into place ready for driving, including mobility device in proper storage	Have controls ready for steering	Begin the drive
USER ACTIONS	Place wheel chair and body perpendicular to car with ample space for:	Open car door	lift body from seat and scoot over to the right onto front drivers seat	lift legs into footwell underneath steering wheel	dismantle chair and place wheels below passenger seat	Tighten controls into place (travel adaptive controls; which tighten onto foot pedals via vice grip style clamps	Begin driving, after seatbelt is secured and car is turned on.
USER THOUGHTS	Takes time to get used to entering and exiting the vehicle.	Process is required in order to complete different people have different methods	Insure brakes on chair are engaged and hand grip is secure	Crossing the legs helps to avoid leg spasms.	Place wheels behind front seats to avoid them moving during the drive	Travel controls allow users to use multiple vehicles ad quickly reinstall hand controls on any vehicle	Driving is controlled via hand throttle (thumb) and brake lever (pushed in with hand grasp)
USER FEELINGS	Happy to go for a drive	focussed and steady	Amped up/ready to lift body, stressed	Concentrated/ concerned	Patient/in a hurry to dismantle chair at a steady pace	Concerned/stressed	Happy/ready to drive
STORYBOARD PHOTOS							

Physical challenge

In the video observed the user describes themselves as an Asia A - T4 Parapelegic. This means they are paralyzed due to spinal cord injury. Asia A is a scale used to define the level of impairment the injury causes to the user. Asia A means no sensory or motor function of the body from the injury and down. T4 means the user is unable to move/control their body from the waste down. The user is in a wheelchair due to this. The user has spasticity so this affects how they place their legs in the driver's seat

Mobility procedures

Procedures that require physical movement. In the video; the user does a range of tasks that required physical lifting, sliding and holding. The main stress point was sliding into the driver's seat from the wheelchair, while ensuring the wheel chair had its brake engaged on the right wheel. Another task that was timely; was disassembling the wheel chair; once in the driver's seat.

Using a product/device

The wheel chair is used for lifting body from car, during the entrance and exit out of car. The brakes hd to be engaged. Adaptive travel controls were used. This product is a hand control system which mounts onto the gas and brake pedal of an automatic-car. The device allows the user to steer with their left hand while using the breaks and gas with their right hand. The user has to push in a handle located below the steering wheel to the right, in order to engage the brakes of the car, and then use a button with their thumb to engage the gas/throttle of the car.

Ease of use/procedure

The user defined multiple task procedure which highlight preferred methods in order to save time, and physical stress. Like sliding one leg at a time, and sliding the body rather than trying to lift the body.

Defining and naming themes;

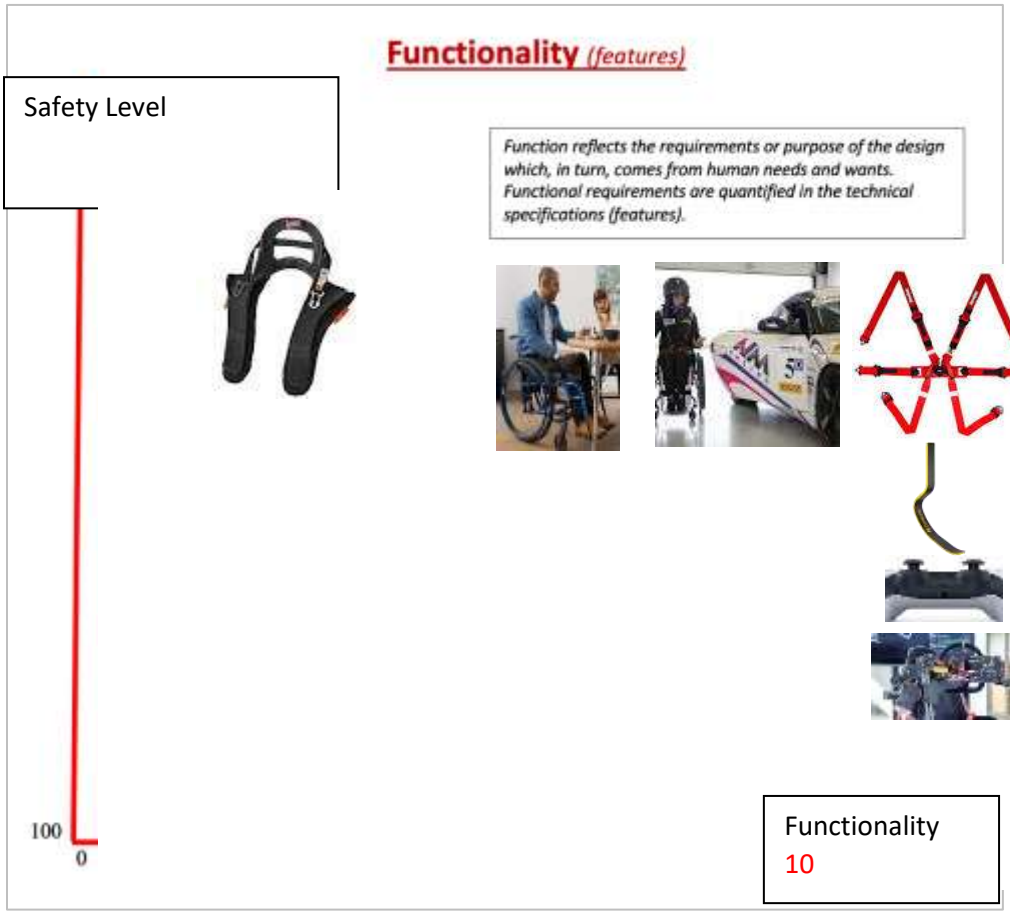
Physical challenge can be defined as Physical-Disability.

Mobility procedures can be defined as Physical-Tasks.

Using a product/device can be changed to User/Product-tasks.

Ease of use/procedure can be changed to; user-personal preference.

C FIELD RESEARCH (PRODUCT)



Takeaways

TABLE 2.2.1 Top Benefits of Benchmarked Products	
1	Wheelchair accessible
2	Increases mobility
3	Allows users to race a vehicle and be in control
4	Allows physically challenged users to drive
5	Increases safety during motorsports driving

Take aways

							
	1	2	3	4	5	6	7
	HELIO C2 FOLDING WHEEL CHAIR	Ossur Cheetah Extreme Nike Spike pad For sprinting/Extreme	Dual Shock Sony PlayStation 5 Controller	HANS DEVICE; NECK BRACE FOR DRIVER-CRASH PROTECTION	VR Racing Simulator **VARJO**	mission motorsports; Porsche 987 Cayman S,	6-point racing harness (example; Momo Camlock s6)
Power (Watts)	manual	Manual	Rechargeable battery	N/A	**Electric 12 v plug**	ICE-powered flat 6	N/A
Adjustable?	**y**	n	y	**y**	y	n	**y**
Sound level	low	mid	Very low	n/a	**low**	high	**n/a**
Material	Carbon Fiber composite	Rubber and aero-space-carbon fiber composites	Injection Molded High impact polymer and rubber	Carbon Fiber and Kevlar	Plastic, aluminum	Carbon fiber Composite Steel Aluminum etc	Polyester
Manufacturing	Bending	Laminated	Injection Molded	Laminated/molded	Injection Molded	Fabricated and bent steal. Stamped body panals	Sewed
Dimensions (in.) (W) x (H) x (D)	(W)14,(H)21,20(L)	**(w) 4, (H) 15, (L)10**	N/A	**Comes in multiple sizes**	**N/A**	**n/a**	**n/a**
Volume (in^3)	5880	600	n/a	n/a	**n/a**	n/a	n/a

TABLE 2.2.2 Top Features of Benchmarked Products

1	High grade light weight material for mobility
2	Extreme tolerances for certain activity
3	Weight in materials
4	Safety
5	Sizing adjustable?
6	Function informs the shape

2.2.2 Functionality

Functionality benchmarking was carried out to determine common functionality amongst the product grouping as well as market differentiation.

Characterizing the functionality was carried out using the data set collected for the features, selecting most common features, and comparing two features in an x-y graph.

User Interaction- Racing Seat				
Needs	Benefits and Underlying Needs	Level of importance		
Basic Needs *Physiological*				
Harnessing (6 points)	Safety for drivers ensuring they will be secure			*High*
Back support, and leg support; allowing the driver to be positioned in a healthy and comfortable manner	**Driver:** back cushion provides soft but secure support for the back and tail bone, while allowing shoulders to move freely to move freely, and ensuring the full body can be harnessed safely		*Moderate*	*High*
Security *Safety, securing resources*				
Safety	Driver safety			
State, Group, Individual				
Securing resources *Optimization of limited resources (cost effectiveness)* • *Value* • *Accumulation of resources (wealth)*	Price is important to new drivers or team owners(limited wealth)			*High*
	Reliability, Adjustability		*Moderate*	
Control over the environment (tasks)	*Product (tool) that amplifies human abilities*			
Convenience *Ease of Use*	Ease of ingress-egress **MASTERY**			*High*
Speed (fast, less time)	Poor Design leads to slow exit under emergency			*High*
Control (precision, responsiveness, power)	Ergonomic support to allow full driver concentration **CONTROL and MASTERY**		*Moderate*	
Long-Term Security/Stability of Group *Health/care/activity*	Caring for baby *Is my baby warm enough? Comfortable? Feeling safe?*			*High*
Environmental sustainability *Motorsport sustainability/inclusivity*				
Insurance (car, house), pension, investments	Strollers are a form of security of the baby for parents	*Slight*		
Social Belonging *Effort / resources to belong to a 'tribe'*				
Fear of embarrassment	Might waste money/break the car			*High*
Fear of crashing	Could become injured or worse			*High*
Fear of missing out	Wanting to participate in sport or fulfill goals in a particular motorsport		*Moderate*	
Esteem *Personal influence in 'tribe'*				
Social Status 'The elite have it…I want to be like them'	Highly Rated in the industry		*Moderate*	
Social Recognition	Well respected by most people due to brand		*Moderate*	
Sexual attractiveness	Not cheap (RECARO)	*Slight*		
Self-Actualization ***'Higher order' Functions/Needs*** ***Needs that are pre-dominantly 'outer cortex'***				
Intrinsic pleasure	Will it provide fulfillment and safety		*Moderate*	
Creative endeavors	Will it encourage participation and practice?		*Moderate*	
Experiential (extrinsic)	Will it promote comfort and support		*Moderate*	
Experiential (intrinsic)	Will it promote focus		*Moderate*	
Emotional	**Empathy:** *Is my body ergonomically positioned well enough to be sustainable for a long period pf time/ownership of the product*			*High*

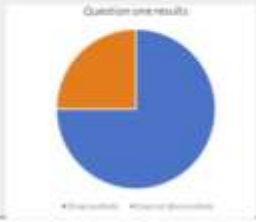
User Survey Results

Group surveyed: Individuals with any sort of physical challenge/challenges;who drive. M/F- aged 16-75

In person hand out survey and online survey completed October 2-8

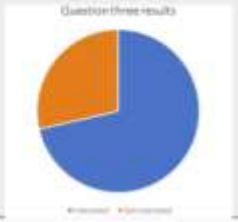
Number of respondents: N=8

Q1: Do you operate/drive a personal vehicle?
Yes__ No__

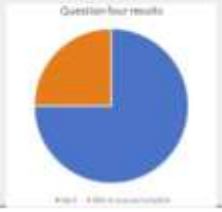


Q2: Do you find it challenging getting in and out of your personal vehicle without assistance?
Yes__ No__

Q3: Do you find yourself interested in the idea of participating in car-racing?
Yes__ No__



Q4: Is it hard to find an opportunity to safely/legally test your driving limits with adaptive controls in place competitively or for fun?
Yes__ No__

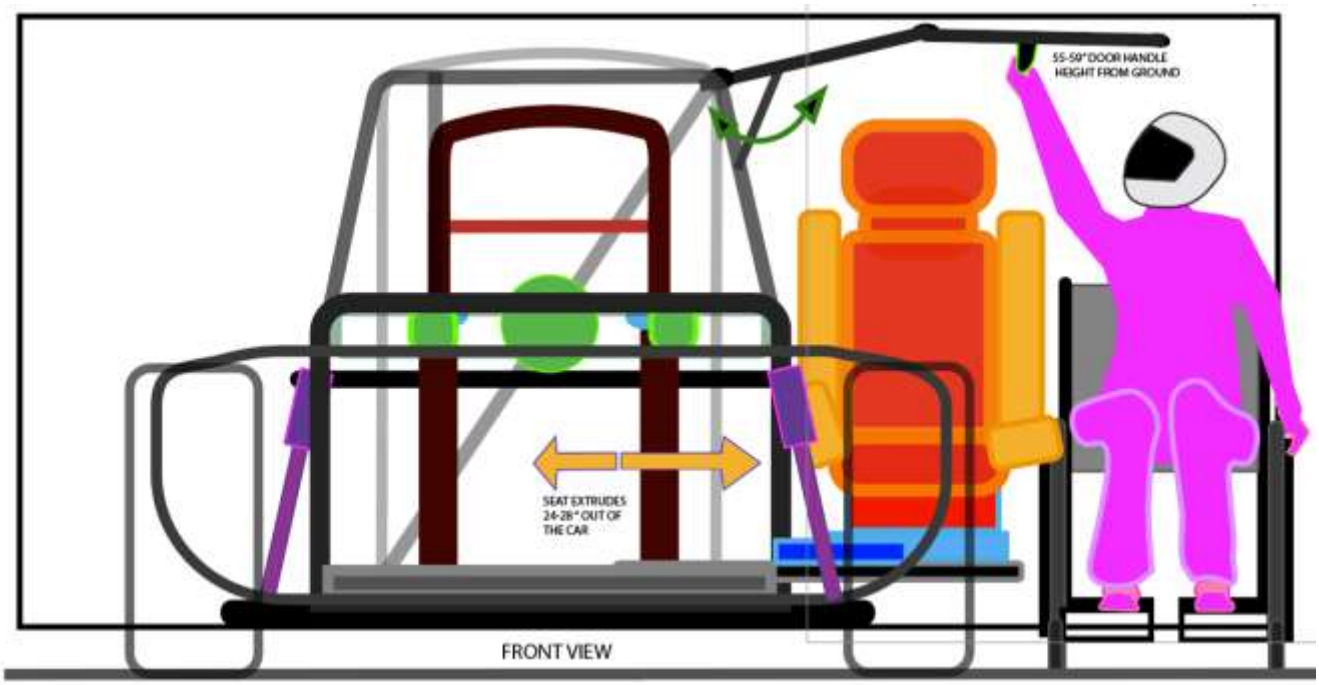


Q5: When problem needs occur while operating a vehicle; please rank the following tasks from 1-5. (1-meaning the most challenging and 5-meaning the least challenging)

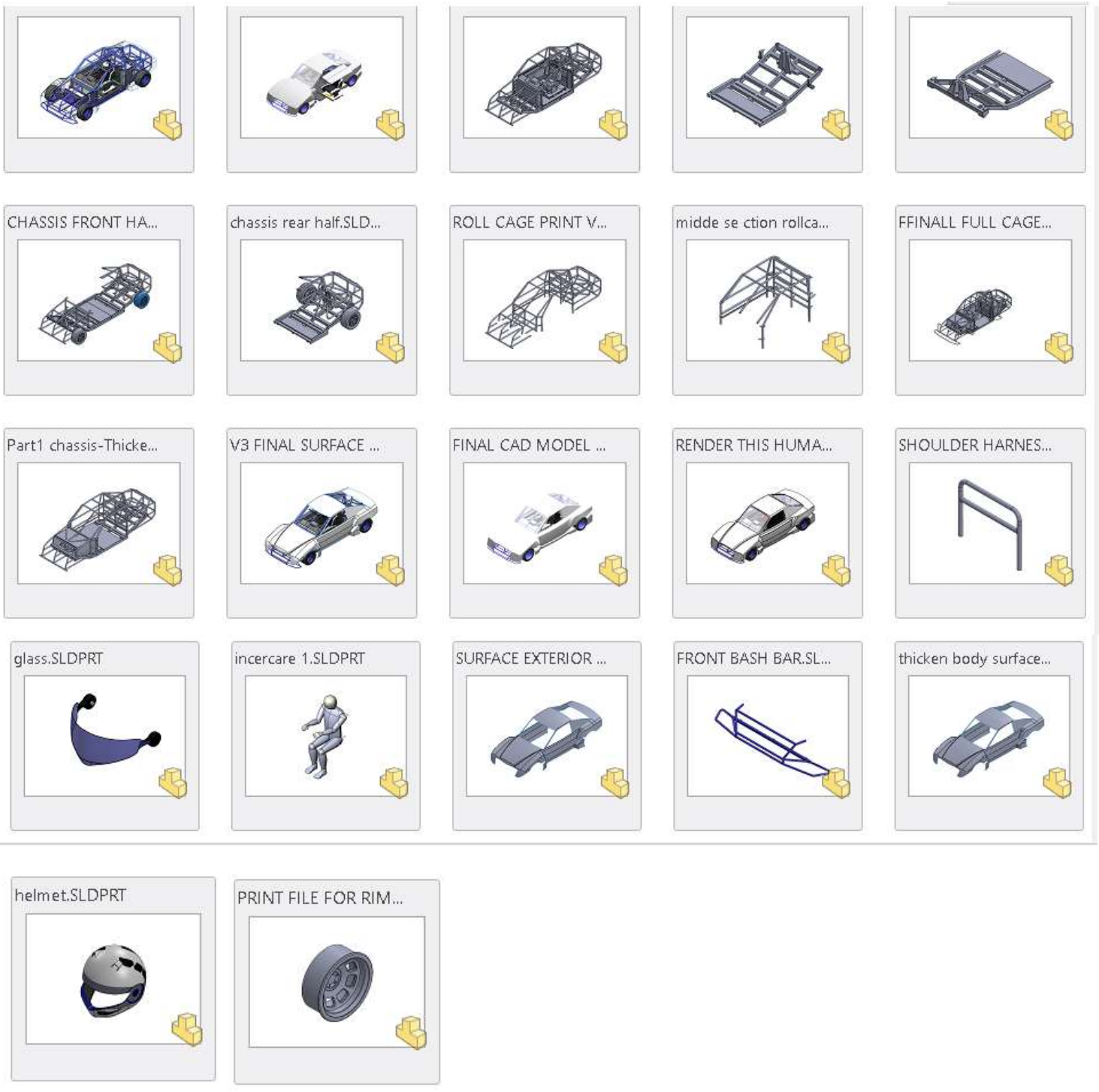
A)Steering 1 B)acceleration/deceleration 2 C)entry/exit of vehicle 3 D)Lane-changing 4 E) viewing/seating position 5

Results from respondents:

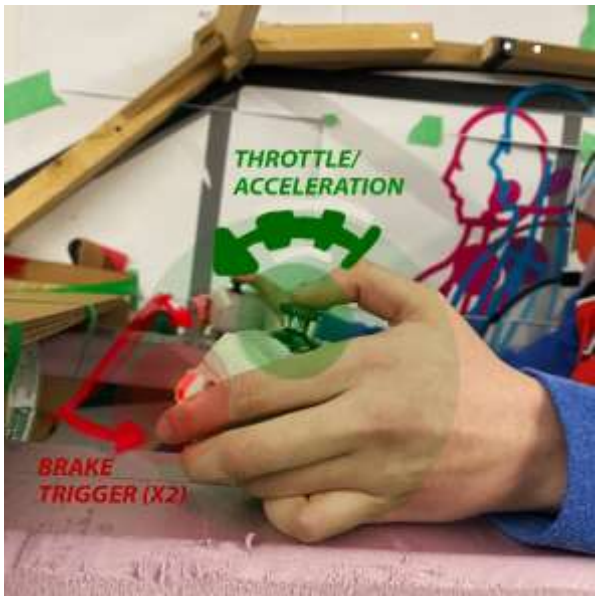
r1:1 C)	2 E)	3 D)	4 B)	5A)
r2:1 E)	2 D)	3 A)	4 C)	5B)
r3:1 A)	2 C)	3 D)	4 B)	5E)
r4:1 C)	2 E)	3 B)	4 D)	5A)
r5:1 B)	2 C)	3 A)	4 D)	5E)
r6:1 C)	2 D)	3 A)	4 E)	5B)
r7:1 D)	2 A)	3 E)	4 B)	5C)
r8:1 C)	2 E)	3 D)	4 A)	5 B)



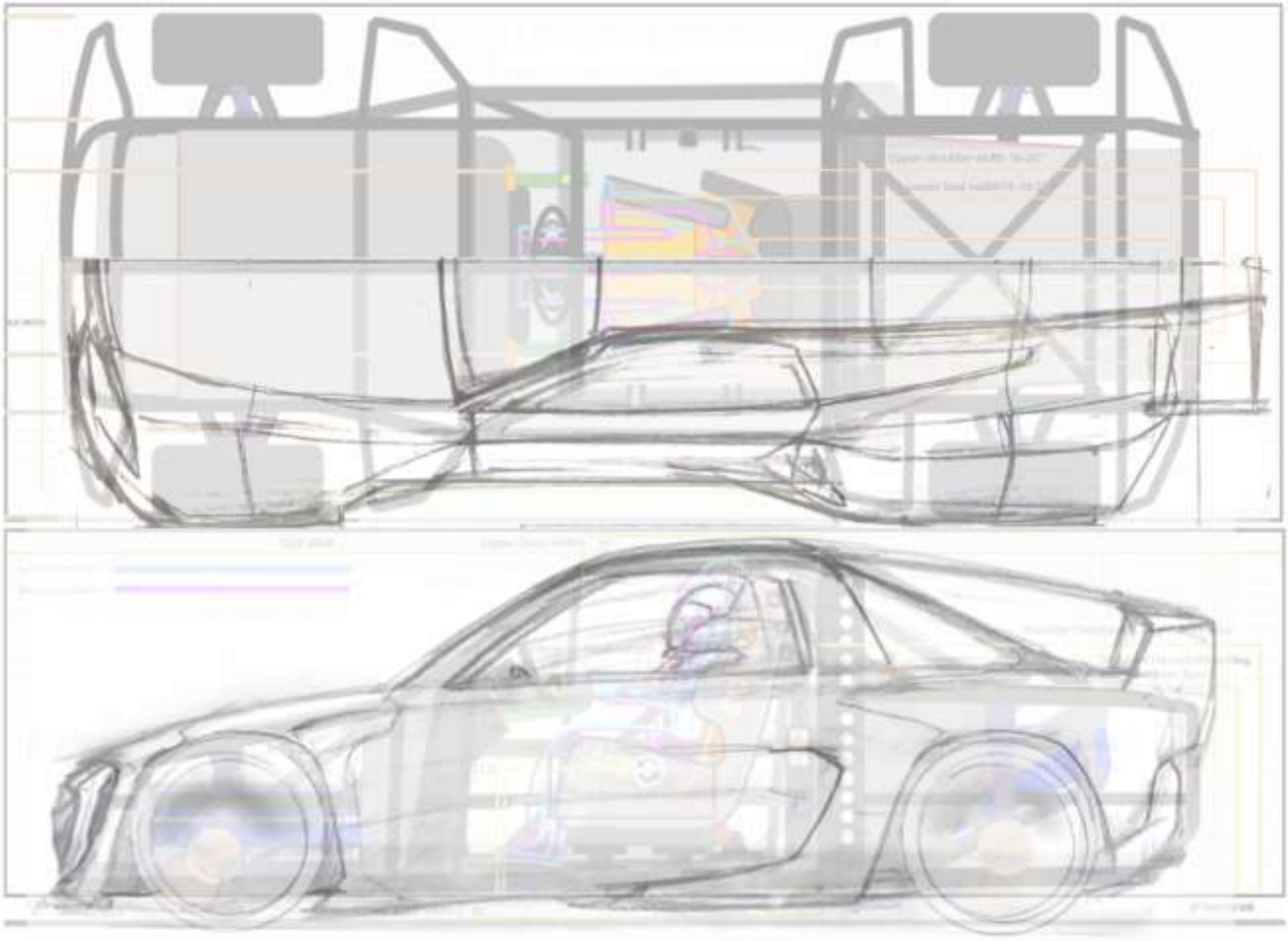
E CAD DEVELOPMENT

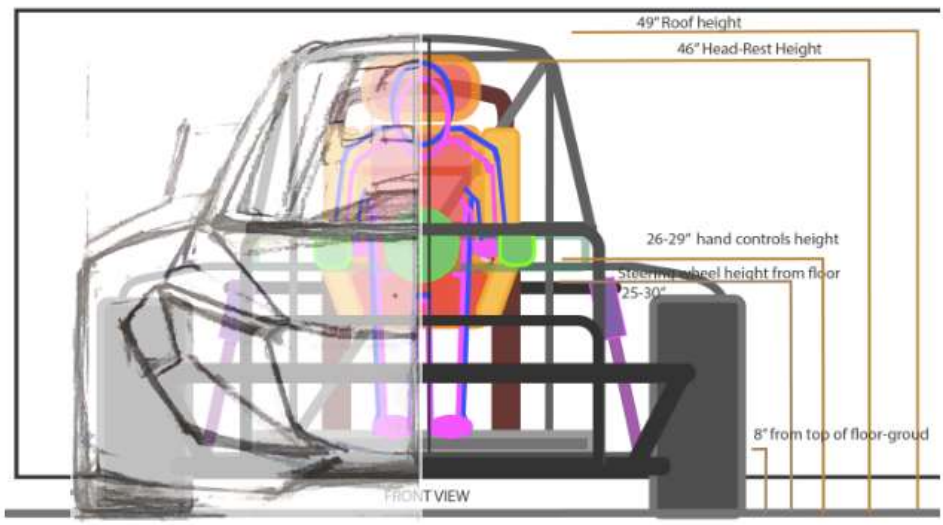


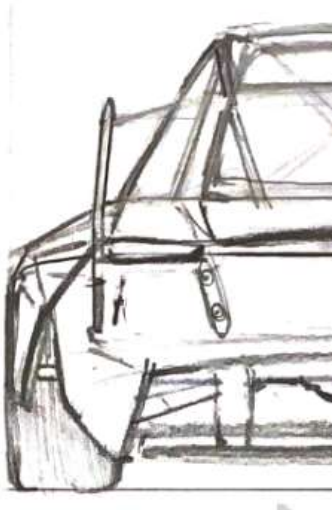
F PHYSICAL MODEL PHOTOGRAPHS

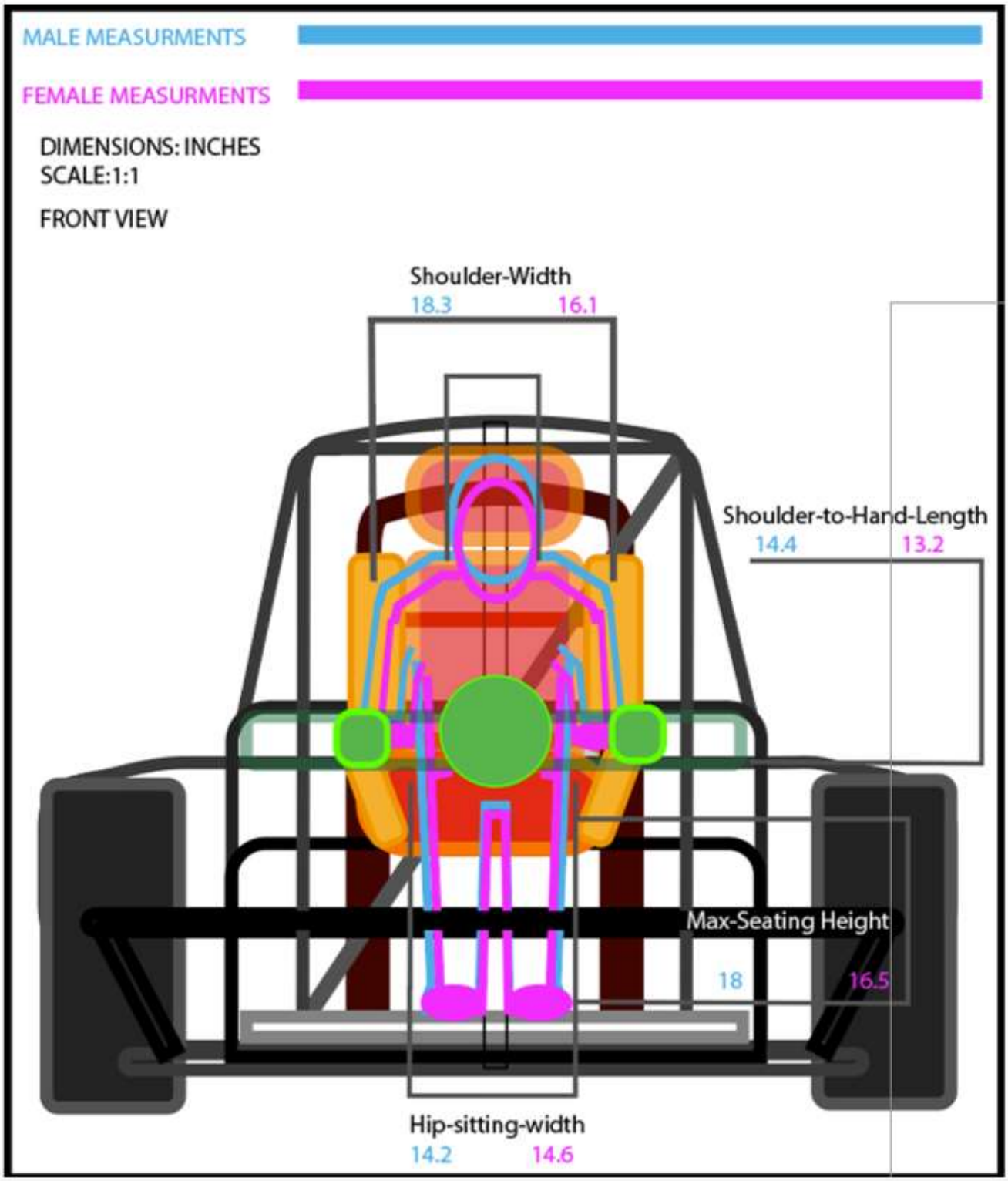


G TECHNICAL DRAWINGS








MALE MEASURMENTS
FEMALE MEASURMENTS
DIMENSIONS: INCHES
SCALE:1:1
FRONT VIEW
Shoulder-Width
18.3
16.1
Shoulder-to-Hand-Length
14.4
13.2
Max-Seating Height
18
16.5
Hip-sitting-width
14.2
14.6

H BILL OF MATERIALS

A CLASS PARTS	B CLASS PARTS	C CLASS PARTS
IP PANAL	HUD DISPLAY (DASH) STAMPED PANEL	ELECTRONIC LCD TOUCH SCREEN GREEN BOARD(S)
HAND CONTROLS	HAND CONTROL RAILS X4 HAND CONTROL MOUNTS X4 ANALOG STICKS X2 TRIGGER BUTTONS UPPER X2 TRIGGER BUTTONS LOWER X2 CONTROLLER HOUSEING X2	ELECTRONIC RELAY ELECTRONIC DISTRIBUTOR FUSE BOX (FRONT-NON INTERIOR FUSE PANAL (A) INTERIOR CONTROLLER BARRING ANALOG STICK MOUNT ANOLOG STICK 360 SLIDER PLASTIC CLIP ALUMINUM SCREW CARBON ALLOY (GRADE 10.9)
INTERIOR FLOOR	GREEN-BOARD BRUSHLESS MOTOR (VIBRATION) RUBBER PAD	BOLT GR10.9 NUT (M10x1.25) ALL HIGH GRADE FASTENERS= M10X1.25
PASSENGER SIDE INTERIOR PANAL	HYDRAULIC PISTON (FLOOR) FLOOR EXTRUSION PISTON RAIL SYSTEM-SEAT FLOOR STAMPED PANAL (SIDE) HANDLE RAIL AND MOUNTS HANDLE	MOLDED STEEL HINGES HINGE BARRING DOOR LOWER INTERIOR STAMPED PANAL DOOR UPPER INTERIOR STAMPED PANAL BOLTS FOR HYDRAULIC PUMP PUMP MOUNTS SEAT RAIL OIL TUNNELS OIL PUMP FOR SEAT AND FLOOR RAIL LUBRICATION WATER RESEVOIR OIL RESEVOIR
SIDE DOOR	DOOR HINGE UPPER X2 DOOR HINGE LOWER X2 DOOR MOUNT PISTON DOOR PISTON MOUNT INNER RAIL/SLIDER FOR DOOR PISTON	HEAT SENSORS 1-6 SEAT ELECTRONIC GREEN BOARD SEAT ELECTRONIC RELAY Ip PANEL BRACKET IP PANEL MOUNT IP PANAL BOLTS NUTS ALL SUSPENSION COMPONENTS MIRRORED= (2x qnt 4) X2 = RIGHT AND LEFT SIDE
SEAT ASSEMBLY	SEAT FLOOR LOWER SEAT FLOOR UPPER (ROTATES) SEAT POSITIONING MOUNT	FRONT LOWER CONTROL ARM X2 FRONT UPPER CONTROL ARM X2 FRONT STRUT FRONT SHOCK
REAR INTERIOR PANAL	SHOULDER HARNESS BAR MOUNT HARNESS BAR RAIL STAMPED PANEL	FRONT SHOCK TOP HAT FRONT SHOCK AIR BAG SHIM REAR SHOCK TOP HAT REAR SHOCK STRUT REAR SHOCK REAR SHOCK AIRBAG SHIM
CRS ROLL CAGE TUBE CHASSIS	2X3" TUBE FRAME 1.5" COLD DRAWN STEEL BENT AND FABRICATED 12 POINT CAGE	FRONT INNER TIE ROD FRONT OUTER TIE ROD FRONT SWAY BAR SWAY BAR LINKS SUSPENSIONS BOLTS GRADE 10.9 SUSPENSION NUTS
HUB ASSEMBLY FRONT	SUSPENSION COMPONENTS X 8 STEERING COMPONENTS X7 WHEEL MOUNTING COMPONENTS X4	REAR CONTROL ARM MAIN REAR PUSH ROD/ARM REAR TRAILING ARM REAR WHEEL BARRINGS FRONT WHEEL BARRINGS REAR BRAKE ROTORS
HUB ASSEMBLY REAR	CV SHAFT (AXLES) X2 WHEEL MOUNT X4 SUSPENSION X8	FRONT BRAKE ROTORS FRONT BRAKE CALLIPERS REAR BRAKE CALLIPERS BRAKE BOOSTER BRAKE LINE ROUTING COOLING SYTEM WATER LINES OIL LINES
DRIVE TRAIN	ELECTRIC MOTOR 300KW (400 HP) ELECTRIC POWER CONVERTOR BATTERY PACK ELECTRIC COOLING SYSTEM INTERIOR COOLING SYSTEM	ELECTRONIC POWER DISTRIBUTOR FOR SLIDING FLOOR NO SEAT SYSTEM POWER RELAY TO SHOCK TOWERS FRONT POWER RELAY TO SHOCK TOWERS REAR MOTOR MOUNTS BATTERY MOUNTS BATTERY HARNESS BATTERY COOLING TUB
HARNESS	7 POINT HARNESS HARNESS FLOOR MOUNTS CLASPE WITH QUICK RELEASE	RAIL SYSTEM FOR ENGINE REMOVAL RAIL SYSTEM FOR BATTERY REMOVAL
EXTERIOR BODY PANELS	Recycled polyethylene terephthalate (rPET) Natural Fibre Composites (Molded)	

COMPLETE CAR-PARASTOCK BILL OF MATERIALS

TOTAL COST FOR 1 FULL ASSEMBLED CAR WITHOUT TOOLING $(CAD): 35,539.00	COSTS ARE APPROXIMATE	TOTAL NUMBER OF MAIN ASSEMBLY PARTS: 187	SKYE LARO

CHASSIS/ROLLCAGE FRAME BOM 1 28 PARTS TOTAL COST FOR PARTS $(CAD): 8390.00		INTERIOR BOM 2 46 PARTS TOTAL COST FOR PARTS $(CAD): 3014.00			BODY BOM 3 24 PARTS TOTAL COST FOR PARTS $(CAD): 4090.00		MECHANICAL BOM 4 89 PARTS TOTAL COST FOR PARTS $(CAD): 20045.00		
ROLL CAGE FINISHING: Powder Coated	FRAME FINISHING: Powder Coated	IP PANEL/ CONTROLS FINISHING: Powder Coated Metal Annodized Aluminum Painted Plastics	SEAT/ FLOOR FINISHING: Powder Coated	DOOR/ INTERIOR PANELS FINISHING: Powder Coated Steel and Annodized Aluminum	WIND SCREENS FINISHING: n/a	BODY PANELS FINISHING: Sprayed	DRIVETRAIN FINISHING: Powder Coated	HYDRAULICS AND WHEELS FINISHING: Powder Coated Steel Annodized Aluminum	SUSPENSION AND STEERING/ WHEEL MOUNTING FINISHING: Powder Coated

The aero panels of the race car will utilize rPET; a material developed by EconCore. This is a material that is made up of non-food post industrial and consumer waste. EconCore is based in Leuven, Belgium. The material has been developed to offer a cheap/cost effective solution for production of honeycomb cores. The material is 100% recycled and provides a new technology/material that is sustainable for the environment, and the user.

rPET is a Light weight and durable material; capable of withstanding forces equal to 1000 times its weight. Hight temperature resistance. High bending resistance under high forces. Cost effective solution for items like; spoilers, front splitters, diffusers, and other aerodynamic items that will be utilized for the race car. The product/ material is a cost effective, high performing, and sustainable for the environment.

Bcomp natural fiber composite body panels create 10% of the Carbon foot print that other materials like carbon fiber create; meaning it is a material that can replace carbon fiber, while being more strong, light weight. They have already been proven in racing series like Formula 1, Formula E, and GT 4 touring car racing. This body material is a sustainable solution for body work and will be used instead of carbon fiber.

J APPROVAL FORMS

Student Name:	Skye Laro
Approved Thesis Title:	Competitive Motor Sports for the Physically Challenged

THESIS PROJECT – DESIGN APPROVAL FORM

Design is reviewed and approved to proceed for the following:	X	**CAD Design and Development Phase**
Comment: Continue design refinement in CAD development, need to iron out detailing and product's features, pay attention to surfacing, components, and assembly methods for design feasibility. Viable holistic design thinking in conjunction with considerations into sustainability aspects. CAD development must be at least 75% complete for review before approval for fabrication.		

Design is reviewed and approved to proceed for the following:	X	**Model Fabrication Including Rapid Prototyping / 3D Printing and Model Building Phase**
Comment: Waiting for CAD development review (as of Feb-21). CAD progress well, design generally completed, interior refined, continue detail refinement, once refined, fabrication of model can begin.		

Instructor Signature(s):

Catherine Chong F.K. Matovu

Date:	07 March 2023

PANEL ON RESEARCH ETHICS

TCPS 2: CORE 2022

Certificate of Completion

This document certifies that

Skye Laro

successfully completed the Course on Research Ethics based on the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS 2: CORE 2022)

Certificate # 0000839595

29 September, 2022

Timeline

<u>Phase 1:</u> Research and Development of the Concept Plan

Analysis on the interest in racing/driving from the perspective of the target user group.

Analysis on the systems and devices currently used to allow physically challenged drivers to- accelerate and decelerate their personal vehicle. This will help to develop a physical study which is designed around users in a wheelchair- and how they would prefer to safely exit and enter a vehicle, as well as drive a vehicle in an intense setting.

Analysis of The Physically challenged drivers, and their common practices.

Gathering of Physically challenged users who approve and consent to; being a part of the ergonomic research. A cost analysis on the development of a full tube framed racing vehicle, and the restrictions/safety requirements to be a legal race car for North American Sanctioned Racetracks, and/or FIA global requirements.

Materials research: finding the proper materials which could be utilized and developing a cost-friendly car for the target users.

Experts in the field; Research and communication will be done with experienced drivers/mechanics to ensure the viability of the blueprint and concept plan. Team Quaker State #36 Racing-Team will be coming on board to oversee the project as it goes through the phases with Veteran Racecar driver: Gary Elliott

PHASE 2: Development of Blueprint, and Ergonomic Study of user

Blueprints and user diagrams presenting human touch points and areas of harnessing, as well as adjustment measurements.

Consenting users will be documented in a study where they enact entering a car and lifting themselves out of the wheelchair and into the driver's seat. Measurements will be taken which will solidify the blueprint dimensions and needed features of the vehicle.

Concept features will be tested with the users using a 1:1 mockup model of the interior and roll-cage design.

Phase 3: Finalizing the Following: Roll-cage, Chassis, Interior, and Seat-System

Blue-prints and Human touch point diagrams will be finalized with changes made to the overall dimensions where issues were discovered with user physical testing.

The Materials needed for the prototype model will be presented and finalized for CAD to begin.

The CAD model will be made using solid works upon approval.

The final dimensions and scale will be decided on, based on the final 1:1 blueprint.

Phase 4: Solid works 3D model and beginning of scale model prototyping.

The 3D CAD model will be designed from the chassis- to the suspension arms and body profile.

Components will be documented separately and created into an assembly folder.

Required BOM document(s) will be generated along with each CAD model assembly. To create an overall parts list of required parts to build the prototype. Cost of manufacturing or sourcing of parts, material, and quantity of part needed to create one car will be presented.

The components will be sorted and presented as A-D class parts; where A means parts that are made up of assemblies of multiple smaller parts. D class will be the bare bones parts that make up the above classes of components/parts. For example, a D class part will be: Gr 8 (Medium Carbon Alloy Steel) M1x1.25 Bolt.

A document will be presented showing the costs of building the car 1:1, and the amount of material needed along with what manufacturing processes will be used. A finalized 3D CAD model will be presented with a scale sketch model that finalizes the scale prototype needed dimensions, details and building methods/possible materials.

K Advisor Meetings & Agreement Forms

The topic area currently being considered: *Motorsports for the physically challenged*

Name of Interviewee: ***Arlen Laro***

Background of the interviewee (relevant to this topic):

Physically challenged (lower spinal injury). Retired hydraulic technician/large equipment mechanic in a uranium mine.

Job title when employed: mechanical foreman and trainer

Other; raced hobby class oval track (1980s)

"I am currently in the discovery phase of selecting an area of interest.

This area is ……. How may we facilitate competitive motorsports for individuals with physical disabilities?

1. Top 3 challenges of having pinched nerves/spinal lower injury

What do you believe are the **top 3 challenges** or major issues facing the area today?

-getting up off the ground after doing something low down, due to knees and hips, as well as lower back

-lifting when laying on the back.

-accessing suspension and engine points like injectors/sparkplugs in modern-day layouts require extended reaching and bending

2. Top 3 trends in the past 5 years with cars in general

What are the **top 3 trends** in this area over the past 5 years facing the area today?

-push for electric vehicles

-push for vehicles that allow users to; not have to carry out tasks (ex; given; self-parking car) you feel that this is contradictory due to drivers needing to pay attention to the drive, as well as be experienced

-lane change protection- vehicles that override the driver's input like throttle and steering

3. Most common products needing replacement/repair, and best equipment used?

-tight areas connecting bolts- putting transmissions into the vehicle; pinch points, heavy parts, and tight squeezes.

-a tough job was working on oscillating vehicles like a scoop tram. Changing tires are very difficult (7 foot tall tires)

-standing on concrete floor while working at tool bench rebuilding small hydraulic pumps

-working 2600 feet underground in an underground shop, they used a diesel land rover. (very reliable underground). (This was the only vehicle which would work underground)

4. In your experience of operating vehicles and equipment on on off track, what are some big user pain points you've experienced?

-seating is a big area; comfort often lacking with the needed ergonomic support, especially post spinal injury. Especially racing harness- hard material support, had to put a pillow behind seat In order to have any bit of comfort safely (using 5 point harness, and roll cage).

-on track, pedal work; clutching in, shifting with the right hand, while having another hand on steering wheel

-going off track- didn't hurt but was startling- safety equipment required to get into each race; tech inspection. (old car driven; 1958 ford Fairlane 500, 4-speed manual- street stock v8 racing class)

FINISHING the INTERVIEW

Is there a question that I should have asked?

No, just that working and keeping equipment functional requires the knowledge to do so.

1. *Is there someone who would be good to follow up with?*

Charlie Reece- family friend, and experienced stock car builder (fabricator) and racer for over 30 years.

Thank you for your time!

Topic area currently being considered: Motorsports for the physically challenged

*Name of Interviewee: **Gary Elliot-longest sponsored driver in racing history, Canadian stock car hall of fame inducted this year!***

Background of the interviewee (relevant to this topic):

75-year-old race car driver (late-modified)

Racing for over 50 years- short track paved oval. The retired service manager at ford dealers.

"I am currently in the discovery phase of selecting an area of interest.

This area is ……. How may we facilitate competitive motorsports for individuals with physical disabilities?

Intro question: What are the specs of the class of race car you currently drive (ex, WHP, suspension, chassis)

Answer:

Oval track, steal square tubing 2"x3" chassis. Quick change differential, change sprocket gears fast. 10 bolt quick release. Ratio selection. Center section predetermined; 4:1100, or 4:8600; to hit rev limiter just before corner. Ex; limiter hits at 4600, 400ft pounds of torque, 440 hp on 92 octane (non-race fuel), weight 2750ibs. (Pro-late model), highest late model class in Ontario, and

pro-stock in other places. Runs a GM crate motor, small block 350(cubic -inch). Re-designed racing engine (called a 604 crate motor) (602 uses cast iron heads instead of aluminum heads with very reliable crankshaft. Pistons are economical; 10-1 compression that doesn't rev high., they use 500 cfm two barrel, vs 4 barrel holly carburetor- 650 cfm) 604 crate tends to last longer than a 602. 6000 laps plus before the rebuild, other then valve springs. 604 without accessories 9000.00$ tuned to handle its own power. Don't want to hit rev limiter too much. Inch and a half cold rolled steal; for roll cage (no seems) made to flip, or take high impacts.. Front bumper designed to crush from high impact causing less force to car and driver, everything folds to save driver; car is write off after that. Collapsible steering wheel and onboard fire system, pull pin to release extinguisher; spouts to under engine, and 2 to the rear where fuel cell is, an 2 spouts around drivers hip and chest; directed to important areas. Fireproof fuel cell.

1. What are the most common areas of physical struggle with operating the race car during a race.

Answer:

Wrists and forearms take a beating due to g force, high bank

Last thing you want in paved racing is sliding. Helmet is rated for a 4-5 year life expectancy

Hans device is a head and neck restraint, made to avoid having neck broken, helps hold neck up during high g force corners. Neck takes a beating' but Hans device helps Drivers side of the roll cage from shoulders down to the front and rear hoop, steal plating in between bars of the roll cage. Powerful hinges required.

Inside the car with heat from the car (breaks, exhaust, engine) it can get to be 250 degrees inside the car on different materials like the sheet metal floor. This is part of the reason fire suites are required, as well as fireproof shoes. Heat exhaustion can really hurt a driver. Heat drains energy- cooling suites exist; plastic tubing goes around suite, and tube leads to cooling water reservoir; the water reservoir is insulated like a cooler. It gets filled with special large ice blocks, as well as water, small ice cubes could block the pump; for example, 200 lap race the ice cubes don't melt. Secured lit required. COOL-SUITE. A/c doesn't work in a race car. Cool suit costs: 1200 for everything (box, suite, lines, pump, gets installed wired to ignition.) Helps with strength and stamina

Core of your body takes a lot of the stress and heat of the body, when racing. Cooling tubes really help.

2. Top 3 most common areas of physical struggle with getting in and out of the car (specific movements, and or motor functions required physically)

Answer:

Lifting body in and out requires strength

Personally not much issues with working on the car and getting in and out

More the mental game; when being competitive; you tend to forget your age. It is easy to get discouraged when you are not winning; success brings confidence, as well as experience and having a good crew. Confidence comes with performance; statistics must be compared. During first year with a new crew and car, and tracks- it was tough, second year fun needed to be focused on, in order to improve. Looking at individual success and having fun; is the best way to do it. Not enjoying it can often lead to anger or disappointment which distracts one from the sport and actually improving. Inside the car with heat from the breaks, exhaust, and engine; it can get to be 250 degrees inside the car on different materials like the sheet metal floor. This is part of the reason fire suites are required, as well as fireproof shoes. Heat exhaustion can really hurt a driver's strength/stamina. One final thing is the funding of different teams will drastically affect how the car and driver operate throughout the season.

3. Most common products/parts on the race car needing replacement/or adjustment.

Answer:

Replacements due to wear and tear; tires are the number 1 expense by far for paved racing. APC late modifieds get 4 new tires every race, and some races are 4-8 new tires required due to 150-250 lap duration. Late-modified is not grassroots cars- cars are worth 100-125 thousand dollars brand new. Used racecars can be bought for 10-50 thousand dollars, as well as rebuilt for cheaper. Brakes and bushings must be changed at signs of exhaustion to avoid part failure on track. Some cars don't stay consistent during the race; performance-wise- the difference Is how hard on the car the driver goes for that duration of the race; due to engine heat, and tire consumption; certain parts of the car must be monitored and focused on especially during 150+ lap races.

4. In your experience of operating vehicles and equipment on track, what trends do you see appearing with new technology, is anything changing drastically?

Answer:

Bump stops are coil-over shocks that have built-in spring rubber bushings with different tensions; they are essentially little, tiny donuts (1.5" diameter of shock body; different compression shapes, slide over strut shaft. Shims go around the shock by sliding in, flexible material that allows you to slide it in like a horseshoe. Different sizes for different applications.

5. What control and/or safety systems on the car can be adjusted, are any of the parts custom-made to fit your body?

Answer: full containment seat. Quick-release steering wheel, padded roll cage+ chassis bars (12 point), placed x-bars behind driver and on the roof with 5-point racing harness.

Helmet is rated for a 4–5-year life expectancy.

Drivers side of the roll cage from shoulders down to the front and rear hoop, steal plating is placed in between the bars of the roll cage to protect driver from loose debris.

Inside the car with heat from the car (breaks, exhaust, engine) it can get to be 250 degrees inside the car on different materials like the sheet metal floor. This is part of the reason fire suites are required, as well as fireproof shoes. Heat exhaustion can really hurt a driver. -Fuel cell filled with a sponge; this makes it so it can't explode.

FINISHING the INTERVIEW

Is there anything on modern-day late-model race cars, or stock cars in general- that you would want to change? And why? Handles for people to grab for getting in and out of car

Gary raced for 22 years without having big money sponsors, aka racing on ones own money- back then tires would get re-used. Its all about the individual's passion, and motivation; because that will always prevail in the long run. Especially in any type of sport; at the end of the day; that's what racing is; a motor-sport.

"It's called Racing and winning is a bonus" "we all can't win, but all of us can race"

2. *Is there someone who would be good to follow up with?*

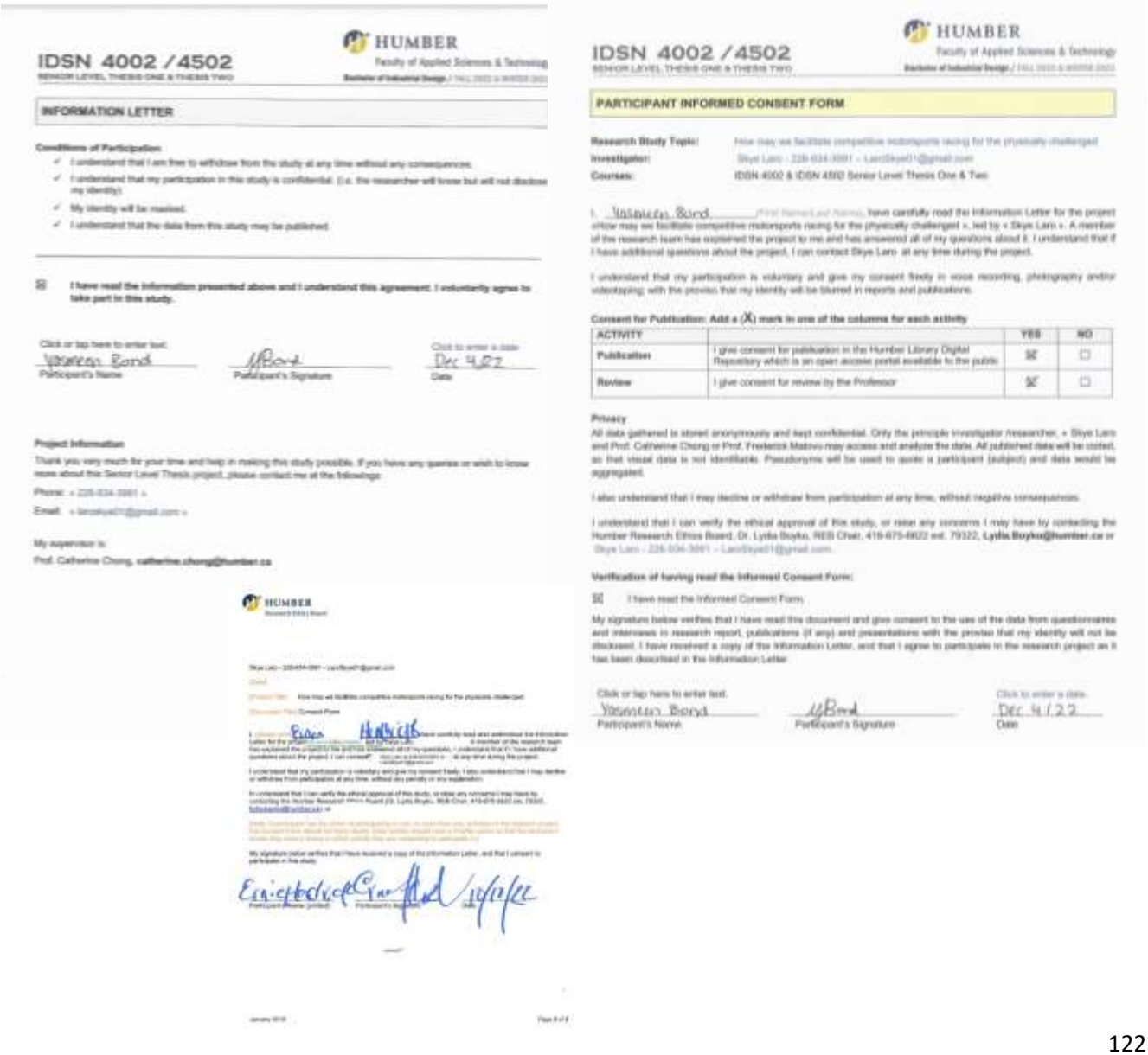
St Catherine's; Bicknell racing products (PETE) race car parts builder

London, Ontario- Mike McColl- McColl race cars. Race car Designer/builder; recommended by Gary Elliot. Builds 60-70 cars a year.

Topic area currently being considered: Motorsports for the physically challenged

4. If you could change the design of a commonly replaced part, what would u change? And why

Answer: more room in the engine bay



IDSN 4002 /4502

HUMBER Faculty of Applied Sciences & Technology

INFORMATION LETTER

Conditions of Participation

- I understand that I am free to withdraw from this study at any time without any consequences.
- I understand that my participation in this study is confidential. (i.e. the researcher will know but will not disclose my identity)
- My identity will be masked.
- I understand that the data from this study may be published.

☒ I have read the information presented above and I understand this agreement. I voluntarily agree to take part in this study.

Participant's Name: Yasmeen Bond — Participant's Signature: YBond — Date: Dec 4/22

Project Information

Thank you very much for your time and help in making this study possible. If you have any queries or wish to know more about this Senior Level Thesis project, please contact me at the followings:

Phone: [redacted]

Email: [redacted]

My supervisor is:

Prof. Catherine Chong, catherine.chong@humber.ca

IDSN 4002 /4502

HUMBER Faculty of Applied Sciences & Technology

PARTICIPANT INFORMED CONSENT FORM

Research Study Topic: How may we facilitate competitive motorsports racing for the physically challenged

Investigator: Skye Laro - 226-634-3991 - LaroSkye01@gmail.com

Courses: IDSN 4002 & IDSN 4502 Senior Level Thesis One & Two

I, Yasmeen Bond, have carefully read the Information Letter for the project «How may we facilitate competitive motorsports racing for the physically challenged », led by « Skye Laro ». A member of the research team has explained the project to me and has answered all of my questions about it. I understand that if I have additional questions about the project, I can contact Skye Laro at any time during the project.

I understand that my participation is voluntary and give my consent freely in voice recording, photography and/or videotaping; with the proviso that my identity will be blurred in reports and publications.

Consent for Publication: Add a (X) mark in one of the columns for each activity

ACTIVITY		YES	NO
Publication	I give consent for publication in the Humber Library Digital Repository which is an open access portal available to the public	☒	☐
Review	I give consent for review by the Professor	☒	☐

Privacy

All data gathered is stored anonymously and kept confidential. Only the principle investigator /researcher, « Skye Laro and Prof. Catherine Chong or Prof. Freelance Makovu may access and analyze the data. All published data will be coded, so that visual data is not identifiable. Pseudonyms will be used to quote a participant (subject) and data would be aggregated.

I also understand that I may decline or withdraw from participation at any time, without negative consequences.

I understand that I can verify the ethical approval of this study, or raise any concerns I may have by contacting the Humber Research Ethics Board, Dr. Lydia Boyko, REB Chair, 416-675-6622 ext. 79322, Lydia.Boyko@humber.ca or Skye Laro - 226-634-3991 - LaroSkye01@gmail.com.

Verification of having read the Informed Consent Form:

☒ I have read the Informed Consent Form.

My signature below verifies that I have read this document and give consent to the use of the data from questionnaires and interviews in research report, publications (if any) and presentations with the proviso that my identity will not be disclosed. I have received a copy of the Information Letter, and that I agree to participate in the research project as it has been described in the Information Letter.

Participant's Name: Yasmeen Bond — Participant's Signature: YBond — Date: Dec 4/22

HUMBER

Skye Laro - 226-634-3991 - LaroSkye01@gmail.com

Dated

Project Title: How may we facilitate competitive motorsports racing for the physically challenged

Document Title: Consent Form

I, Skye Laro, have carefully read and understood the Information Letter for the project « How may we facilitate competitive motorsports racing for the physically challenged » led by « Skye Laro ». A member of the research team has explained the project to me and has answered all of my questions. I understand that if I have additional questions about the project, I can contact « ... » at any time during the project.

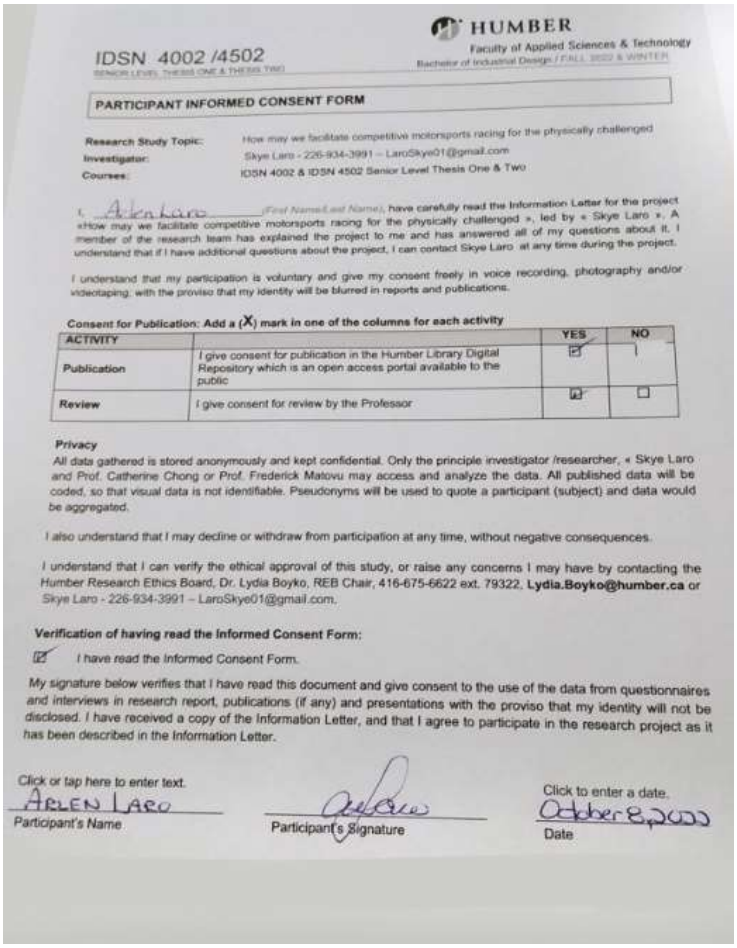
I understand that my participation is voluntary and give my consent freely. I also understand that I may decline or withdraw from participation at any time, without any penalty or any explanation.

In understand that I can verify the ethical approval of this study, or raise any concerns I may have by contacting the Humber Research Ethics Board, Dr. Lydia Boyko, REB Chair, 416-675-6622 ext. 79322, lydia.boyko@humber.ca or

Skye Laro - 226-634-3991 - LaroSkye01@gmail.com

My signature below verifies that I have received a copy of this Information Letter, and that I consent to participate in this study.

Participant's Name (printed) — Participant's Signature — Date



HUMBER
Faculty of Applied Sciences & Technology
Bachelor of Industrial Design / FALL 2022 & WINTER

IDSN 4002 /4502
SENIOR LEVEL THESIS ONE & THESIS TWO

PARTICIPANT INFORMED CONSENT FORM

Research Study Topic: How may we facilitate competitive motorsports racing for the physically challenged
Investigator: Skye Laro - 226-934-3991 – LaroSkye01@gmail.com
Courses: IDSN 4002 & IDSN 4502 Senior Level Thesis One & Two

I, Arlen Laro (First Name/Last Name), have carefully read the Information Letter for the project «How may we facilitate competitive motorsports racing for the physically challenged », led by « Skye Laro ». A member of the research team has explained the project to me and has answered all of my questions about it. I understand that if I have additional questions about the project, I can contact Skye Laro at any time during the project.

I understand that my participation is voluntary and give my consent freely in voice recording, photography and/or videotaping, with the proviso that my identity will be blurred in reports and publications.

Consent for Publication: Add a (X) mark in one of the columns for each activity

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Privacy
All data gathered is stored anonymously and kept confidential. Only the principle investigator /researcher, « Skye Laro and Prof. Catherine Chong or Prof. Frederick Matovu may access and analyze the data. All published data will be coded, so that visual data is not identifiable. Pseudonyms will be used to quote a participant (subject) and data would be aggregated.

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Verification of having read the Informed Consent Form:

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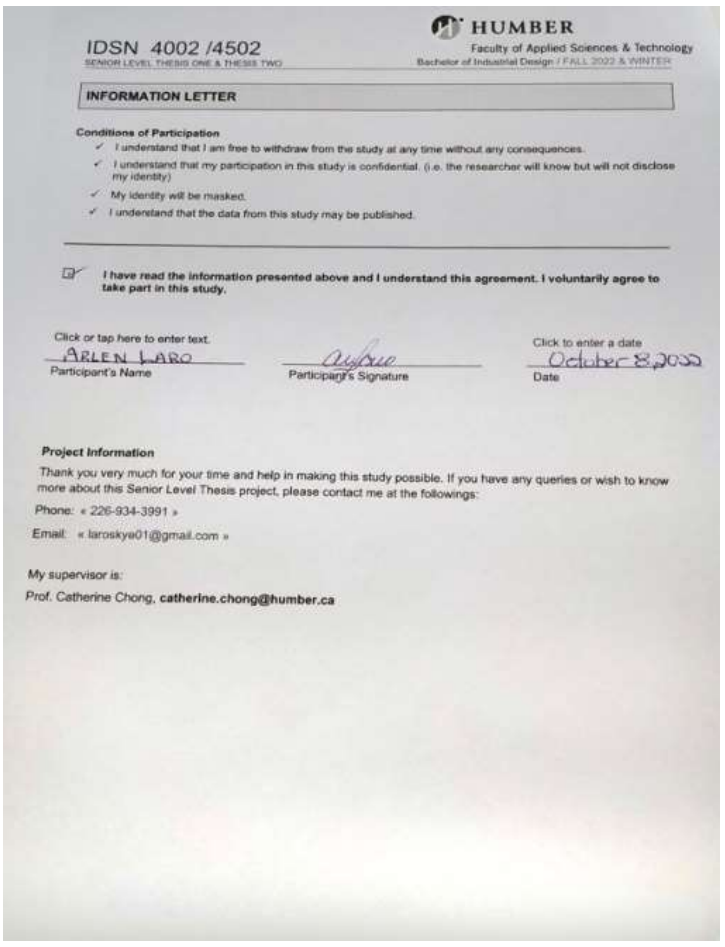
Click or tap here to enter text.
ARLEN LARO
Participant's Name

Participant's Signature

Click to enter a date.
October 8, 2022
Date



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Faculty of Applied Sciences & Technology
Bachelor of Industrial Design / FALL 2022 & WINTER

IDSN 4002 /4502
SENIOR LEVEL THESIS ONE & THESIS TWO

INFORMATION LETTER

Conditions of Participation
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- ✓ I understand that my participation in this study is confidential. (i.e. the researcher will know but will not disclose my identity)
- ✓ My identity will be masked.
- ✓ I underestand that the data from this study may be published.

☑ **I have read the information presented above and I understand this agreement. I voluntarily agree to take part in this study.**

Click or tap here to enter text.
ARLEN LARO
Participant's Name

Participant's Signature

Click to enter a date
October 8, 2022
Date

Project Information

Thank you very much for your time and help in making this study possible. If you have any queries or wish to know more about this Senior Level Thesis project, please contact me at the followings:

Phone: « 226-934-3991 »

Email: « laroskye01@gmail.com »

My supervisor is:

Prof. Catherine Chong, **catherine.chong@humber.ca**

HUMBER
Faculty of Applied Sciences & Technology
Bachelor of Industrial Design / FALL 2022 & WINTER

IDSN 4002 /4502
SENIOR LEVEL THESIS ONE & THESIS TWO

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Date

Project Information

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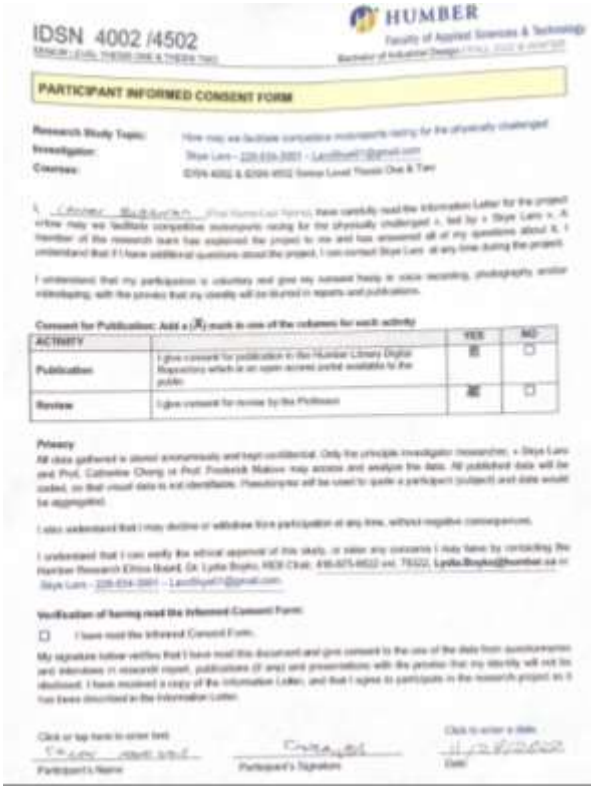
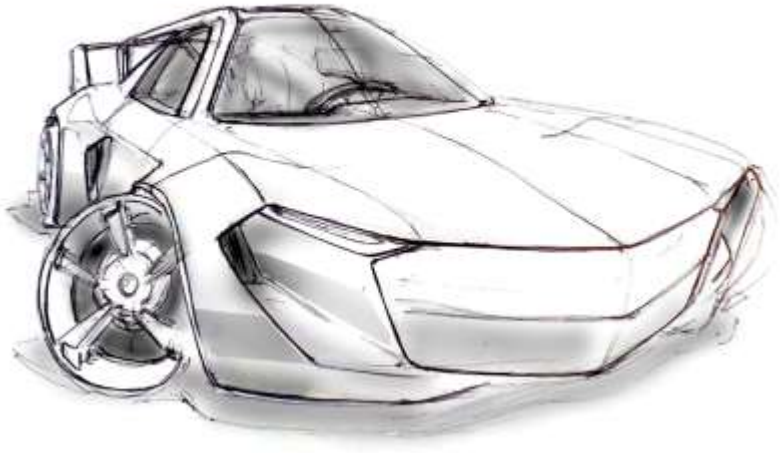


L Supportive Data



Motorsports are a complex group of challenges implemented into a competition format. Unlike many sports, there are few ways to get involved, and it can be challenging to see the sport as viable when only a select few can do it. To improve the inclusion of people into the industry of motorsports; data is needed to figure out the demand of certain demographics. The focus of the project is to design for individuals paralyzed from the waist down. This is a demographic which has not been focused on in the motorsport realm. The issue is this leaves innovation out for adaptive vehicles from competitive testing because racing also helps the development of OEM cars. Racing tests the high limits of the products we have available for cars, the hardware those cars utilize, and how the user interacts with the vehicle to control it in a racing environment/scenario. With that innovation, the goal is to apply the same process for the physically challenged.

Looking at events like the Paralympics, it is clear to see the high demand for inclusive sports, for the physically challenged athletes and fans, is very prominent and an industry. Sports like hockey have been modified with different equipment to allow for physically challenged individuals from the waist down (paralyzed) to play and compete. Sled hockey is the perfect example of a sport being modified to innovate and include a demographic; that otherwise; would not have been able to play hockey. Racing cars have an opportunity to be designed for a similar reason but have not yet been done. Current cars that have been made for paralyzed users- are simply one off builds that provide the driver with the opportunity to race against able-bodied competitors- but no class or select car has ever been created for the physically challenged, to compete in racing against other non-able-bodied competitors.

M Info/Papers

Industry Standards:

PARASTOCK will be designed with its own chassis and roll-cage from the ground up- but legally the car will need to follow certain requirements from racing sanctioning bodies to be viable, and able to be on North American Racetracks. The Sanctioning bodies which facilitate racing events at tracks all have their own rules, but modern-day racing in North America tries to keep their rules the same across both countries- per class of car. The PARASTOCK chassis will follow minimum length and width requirements, along with cage safety specifications. NOTE THE PARASTOCK CAR WILL NOT BE ATTEMPTING TO COMPETE IN MODIFIED SERIES EVENTS; IT USES THE SAFETY REQUIREMENTS TO ENSURE DRIVER SECURITY AND LEGAL LIABILITY IN CONSIDERATION TO A NEW CAR CLASS/CHASSIS.

Modified has been selected due to its geometric similarities to the required size needed with PARASTOCK, but modifieds can have a lower roof height due to driver seating position. The PARASTOCK racecar will be designed to follow the rules required to be allowed to race in these sanctioning bodies/event holders:

NASCAR WHELEN MODEFIEDS SERIES

(National-The United States)

OSCAAR MODIFIEDS

Ontario Stock-Car Association of Asphalt Racing. (Ontario, Canada)

SFI FOUNDATION INC. (SEMA IFOUNDATION INC)

SFI deals with and certifies products, which are tested and then licensed for a certain amount of time; for example, a harness belt has an expiration date; after 5 years; it will not be valid. PARASTOCK will have its harnessing system tested for certification from SFI in order to receive North American Standard motorsports safety ratings with the product that is a race car and needs to be trusted with safety specifications.

SLD

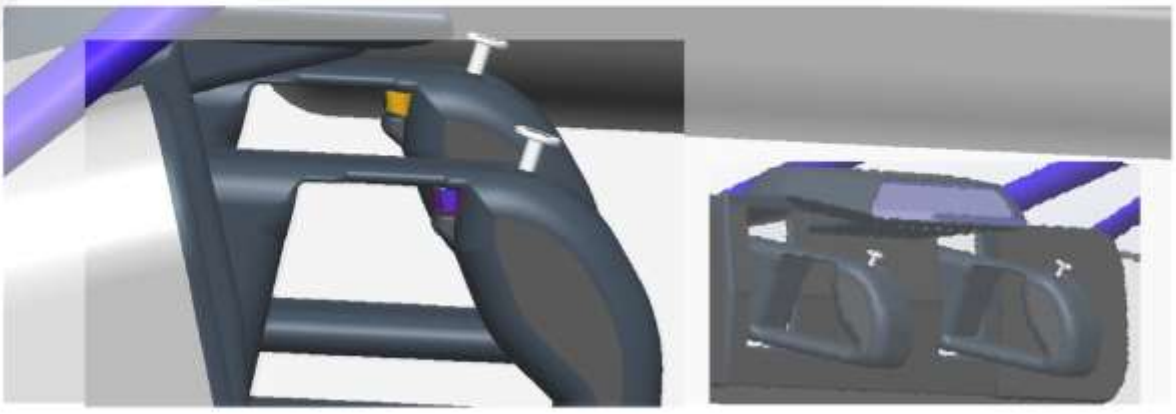
SKYE LARO DESIGN

PARA-STOCK

RACING FOR THE PHYSICALLY CHALLENGED

The End.

Thankyou For Reading



SLD

SKYE LARO DESIGN

Thankyou to the Industrial/Automotive Design Faculty at Humber College for helping me pursue my dreams!