# TYREN

LAW ENFORCEMENT URBAN MOBILITY


## INDUSTRIAL DESIGN THESIS REPORT

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# Law Enforcement Urban Mobility Vehicle

by

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## Abstract

As population increases and are migrating towards urban cities, the activities of humans are posing more obstacles for police officers that patrol the roads of the city, the increase of vehicles on the road, smaller roads and bike lanes, construction, large vehicles in condensed areas, and harsh weather conditions decrease the mobility of police officers when they are responding to calls. Current vehicles that are used by police officers are too large (Stockton, 2019) and are unable to use main roads when travelling at high speeds due to traffic congestions which also puts the safety of pedestrians and officers at risk when vehicular accidents occur. Officers are forced to use unconventional routes to reach their destination such as alleyways, building garages and residential roads, thus increasing their response time. The current response time is 15 minutes for high priority calls, when the standard provincial time is nine minutes (Toronto Police, 2002). The success of their investigation highly depends on how fast they can reach the scene to prevent contamination, crowd control and possibly catching the suspect. The purpose of thesis is to do in-depth study of daily protocols and challenges facing officers. Using data collection methods such as interviews and observational studies of officers using current solutions, a detailed analysis could be conducted focusing on the impact of the obstacles on the duties of police officers. To evaluate the ergonomics, a one-to-one scale buck that illustrates the workspace and tools that officers currently use can establish proper human factors and full-bodied human interaction design. A solution will be developed for police officers, to improve mobility to decrease response times, and provide protection to the common citizen.

# Acknowledgements

This project was one of the toughest things faced and overcame and it would not have been possible without constant support, hope, guidance, and knowledge from my parents, advisor, professors, and classmates. This project brought upon new level of need of collaboration to conduct research, develop new ideas and present new solutions various problems in the world. This motivated me and pushed me so far out my comfort zone that what I accomplished has made so proud of myself and colleagues, giving example to upcoming designers that if you put your mind to something, sky is not the limit. There are couple of individuals that I would like to thank for their support, motivation, and inspiration through the darkest of moments this project made me face and overcome.

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# CHAPTER 1 – PROBLEM DEFINATION

*Figure 1 - Retrieved From: https://unsplash.com/photos/Nyvq2juw4_o*

# CHAPTER 1
# Problem Definition

## 1.1 Problem Definition

Police Officers who patrol in dense urban cities have a really hard time moving around due to the increasing population, the roads getting more condensed and being improved to add bike lanes, construction of roads, buildings, and municipal increase the response time for officers to reach the destination of the call. Current vehicles used by Police Officers are very bulky and have very low mobility in majority of the city, where one lane roads prevent civilian vehicles to give way to emergency services. Officers are forced to take alleyways, back roads and routes that go between buildings to travel which highly impacts response time and that could determine if the crime can be solved quickly or not. This also highly impacts the safety of officers as well, as they travel at high speeds when responding to emergency, where chance of a vehicular accident is highly increased.

The goal of this thesis is to evaluate the needs of uniformed police officers that patrol in urban cities and are using current police vehicles, evaluate the safety offered in their field of law enforcement, and develop a new product that meets all the needs while improving mobility and safety of current transportation offered by law enforcement.

## 1.2 Rationale & Significance

To gain a comprehensive understanding the working routines, habits, and responsibilities of police officers, specifically who patrol and work in urban cities, several tools will be utilized for data collection and information.

The reach of these research question will jump into depths of understanding activities that are preformed daily, the order of these activities is done and their significance and relevance for the research at hand.

This thesis will ask the following questions and their respective information areas and research tools to gain insight, information, and data to develop the final design.

| **Questions addressed in this thesis:** | **Information areas Investigated:** | **Research Tools Utilized:** |
|---|---|---|
| How may we improve mobility for police officers in dense urban environments? | Current law enforcement solutions and practices | • Literature Reviews<br>• Existing Solutions / Benchmarking and current practices |
| What are the fundamental needs of Police Officers in their daily activities? | Target Demographics (Primary, Secondary, tertiary Stakeholders) | • Existing Solutions / Benchmarking and current practices<br>• Video Analysis<br>• User Interviews |
| How can the safety be enhanced of current law enforcement protocols? | Interactions with current products and humans | • Information searches<br>• User interviews / Observational studies<br>• Ergonomic studies |
| What impact can an urban environment have on the response time for Police Officers? | Risks on law enforcement by different environments | • User interviews / Observational studies |

*Table 1 - Questions Addressed In This Thesis*

The data collected from these research tools will go hand in hand into creating a thesis solution that is focused on satisfying the necessary sustainability, ergonomic and functional requirements of the thesis.

## 1.3 Background / History / Social Context

Police Officers are essential part of communities and society. We depend on them to protect us from harm and bring us justice for the harm done by others. Presently there are many obstacles that officers must deal with in their daily lives that caused by different factors in urban cities such as Toronto Canada. These obstacles decrease the mobility of officers and their transportation products that help them carry out their duties. This poses a difficult challenge for officers to have quick response times for incoming calls. It's taking police almost 20 per cent longer to respond to emergency calls than it did a decade ago (Carruthers 2019).

There are many factors that are government and society related that is preventing to address this problem. The Canadian Law Enforcement Committee is creating new transportation vehicles that are technological enhanced but do not provide solutions meet mobility and safety needs of officers. This problem revolves around full bodied and ergonomics to help police officers. By understanding the needs and their respective obstacles, there can be improvements which would help officers their daily activities more efficiently. For having a faster response time, all situations must be taken in account and resolved in a way which improves the safety, mobility, and interaction.

There are many existing challenges regarding mobility and safety in the duties of police officers, particularly in Downtown Toronto. Most of these challenges are originated by the population of the city and their daily activities. Population and employment growth in the Downtown is putting tremendous pressure on transportation and transit infrastructure (Toronto 2018). Until now the law enforcement committees have lacked a strategy that allows for more migrations of civilians without interference for the protocols, mobility, and safety of police officers. The strategy is blinded to the needs of the population, the constant improvement of infrastructure, and the increase of vehicles on the road.

# CHAPTER 2 – RESEARCH

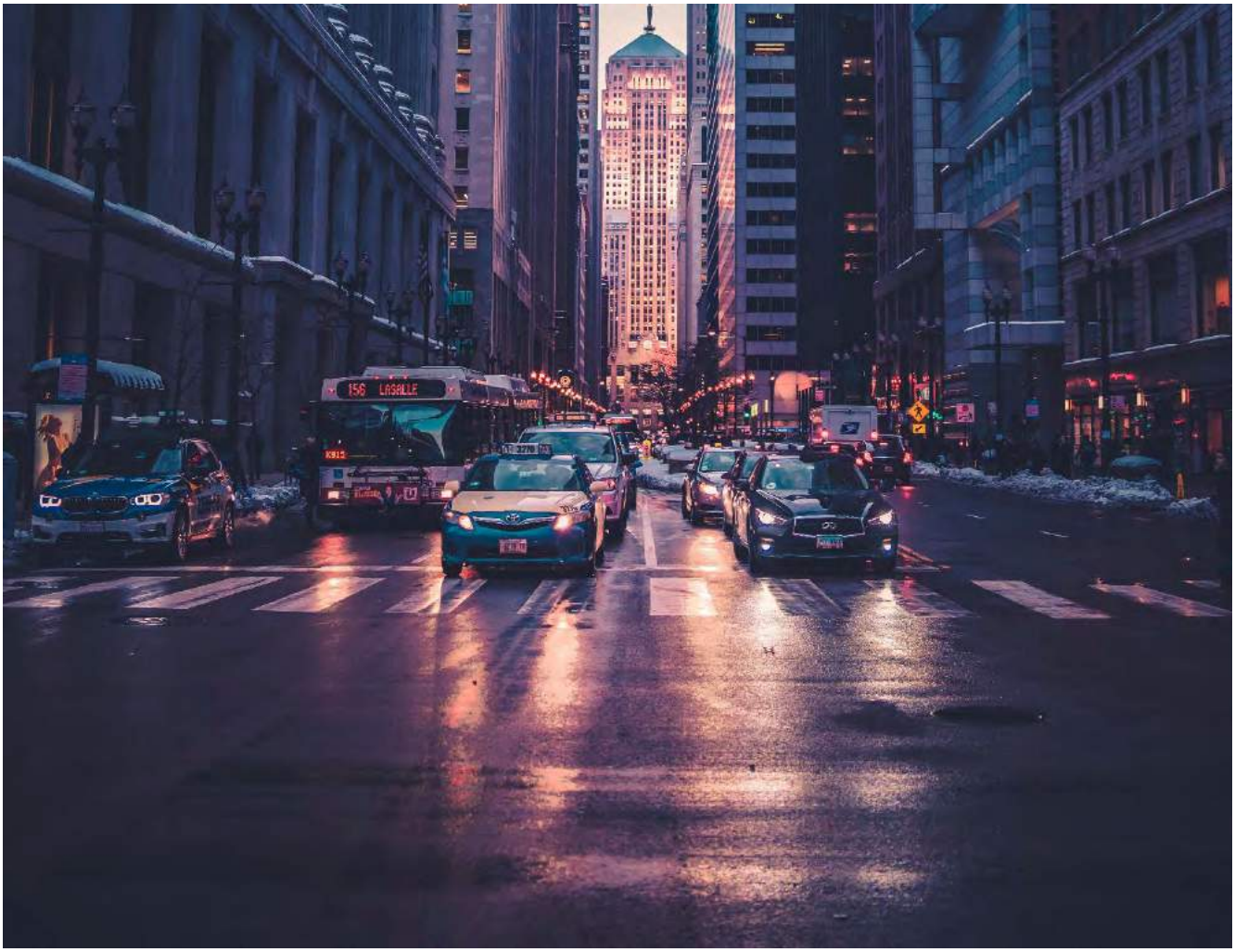



*Figure 2 - Retrieved From: https://unsplash.com/photos/VmX3vmBecFE*

# CHAPTER 2
# Research

## 2.1 User Research

The goal of this thesis and all the related research is to recognize, understand and analysis the different opportunities in a focused research topic using scholarly and consumer search tools. The research topic in question is coming up with ways to how the mobility of Police Officers can be improved in dense urban environments. "Law enforcement officers are commissioned to keep citizens safe 24 hours a day and seven days a week. The duties of police carry a great deal of risk, but many people pursue a career as a police officer because they feel a moral calling to protect and serve others" (Johnson, 2018). For in depth understanding of this topic and its respective problems associated, search tools such as Humber Library Search Engine, Library Database and Google scholar will be used. The focus of data analysis will include benchmarked products, user needs, user demographics, surveys and interviews. "They are expected to carry out their duties and responsibilities equitably and justly. Police must not show favoritism or act in a discriminatory manner recognizing that all citizens deserve respectful treatment regardless of race, ethnicity, sexual orientation, socioeconomic status, national origin or religion, for instance" (Johnson, 2018)

### *2.1.1 User Profile - Persona*

The primary, secondary, and tertiary are identified as follows:

**Primary User:** Uniformed Police Officers

**Secondary User:** Transit and railroad officers

**Tertiary User:** Police Vehicle Purchasing Department Personnel

### Age & Gender:

Based off research the Toronto Police force tend be 40 years old or older of Caucasian ethnicity. The Demographic distribution sits mostly between 35 years and 45 years old as of 2018. This mostly due to colleges and universities, obtaining the degrees and diplomas and police foundation than going on for further training for specialized roles in the police force. The police force has a total of 54,721 officers and about 78% of them were male and about 22% were females as of 2018.

### Ethnicity / Culture:

The Toronto police force mostly consists of Caucasian officers, four percent of the force self-identified as indigenous police officers and 26% of force self-identified as visible minorities.

### Education & Income:

To become a police officer, an individual would have to a Canadian High school Diploma as minimum requirement but people who have done two years of post-secondary in Police Foundation diploma program in either university or college have a better chance becoming an officer. Along with an educational background, an individual needs to meet a necessary level of physical fitness. The said Individual needs to complete 26 weeks of training at the RCMP Academy in Regina, Saskatchewan.

The starting salary for cadets in the Toronto Police Department is around $60,000 annually and after year three of service, police officers tend to get a raise around to $90,000 annually with full benefits. The median income for individual Canadians was $36,400 in 2018.

**Demographic Summary:**

Police officers have high level income, as it is a career which pays well but also demands a lot of an officer with long shifts, constant stress of danger from the challenges of the job, and learning the ability to adapt to any situation, environment, and social context. There is always an opportunity to earn more by specialized training for higher posts in the department. The minimum standards to become a police officer, allow anyone who lives in Canada pursue this as a future career. This suggests that the motivation of the career is not only about money, but the passion to protect others from harm, to spread social awareness and bring peace to communities. Specific user research can be found in Appendix B

| Demographic Of Police Officers | | Reference |
|---|---|---|
| **Age** | 35 – 45 Years | https://www150.statcan.gc.ca/n1/pub/85-002-x/2019001/article/00015-eng.htm |
| **Gender** | Mostly Male (≈ 78%) | https://www150.statcan.gc.ca/n1/pub/85-002-x/2019001/article/00015-eng.htm |
| **Culture / Ethnicity** | Caucasian | https://www150.statcan.gc.ca/n1/pub/85-002-x/2019001/article/00015-eng.htm |
| **Income** | + $60,000 | https://www150.statcan.gc.ca/n1/pub/85-002-x/2019001/article/00015-eng.htm |
| **Educational Background** | 2 years of post-secondary | https://paladinsecurity.com/law-enforcement-careers/become-police-officer-canada/#section1 |

*Table 2 - Demographic Summary of Police Officers in Canada*

Police Officers require an extensive background that is focused on fact-based knowledge, safety protocols and high degree of social skills, that are developed from high school to the end of their cadet training. Technical skills in operating sensitive equipment such as mobile data terminals, specialized vehicles, firearms (guns and Tasers) and hand to hand combat. In dense urban environments such as Downtown Toronto, improving mobility in highly populated areas is the highest priority.

**User Behavior:**

The context of the activities and the high frequency of use, shows that this is a high priority, technical, and communication-oriented field. The average working day consists of two main types of work that can branch off to other types. The first type of work is field based which involves patrolling, enforcing traffic laws, bylaws, responding to incoming calls and strengthening community relations. The second type of work is administrative and training, which involves paperwork of events of each case that was under the jurisdiction of that officer. Yearly certifications and constant training to stay fit for field work.

**Persona:**

https://medium.com/macro-tech/code-for-social-f6784624f7b7

| | |
|---|---|
| *Name* | *James Stewart* |
| *Age* | 35 |
| *Occupation* | Police Officer in Region of Toronto |
| *Income* | *+ $60,000* |
| *Education* | University graduate in Police Foundation & Graduate from Police Training Academy |
| *Family* | Married with two children |
| *Location* | Toronto, ON |
| *Main Hobbies* | Soccer League, Weight Training, & Pilot Training |
| *Frequency* | Soccer (Once/week), Weight Training (5days/week), Pilot Training (twice/month) |
| *Duration* | 3hrs |
| *Social/Solitary* | Mostly with family and Friends |

| | | |
|---|---|---|
| | *Other Activities* | Family trips (once/week) |

*Table 3 - Persona Summary*

**Profile:**

James Stewart is a 35-year-old, Caucasian police officer who is stationed in the region of Toronto. He has his undergraduate in Police Foundations and done is compulsory police training at the Police Academy. He has been working for about 15 years as a patrolling officer and his income is around $80,000. James was always around vehicles of all sorts since he was young, due to his family was business was in vehicle restoration and general mechanics. He obtained his first car when he started his undergraduate for commuting purposes. He obtained his police cruiser when he joined the force but kept his old car for recreational riding. After five years of working in the force, he got into planes and started his flight training as recreational hobby.

**User Behavior:**

James likes to go to the gym with his fellow officers after work and do weight training to stay fit to be able to work in various conditions and environments effortlessly. To de-stress himself he likes to take flight lessons twice a month mostly during April to September and during the winter months, he joins a indoor soccer league with his friends and family. To balance his work and personal time, James makes sure he goes on a trip with his family once a month to spend some quality family time and catch up with family and what's happening in their lives, due to his long 12 to 14 hour shifts he is unable to do that during weekdays.

### *2.1.2 Current User Practice*

To understand the various uses and product scenarios that officers experience, a multitude of studies were conducted to collect data on these aspects which also extended to understanding of how and why they use these products and how different contexts change their methods. The insights gained will help inform the design process for this thesis solution.

**Method:**

User Research was conducted in the form of interviews both in person and via email, as well as observational studies which were done in person and via video analysis from external sources such as YouTube. Due to the active policies of OPP, no video or audio recording was allowed during the interviews and observational studies, so all responses and insights were recorded via written notes. Personal Information is not permitted to be shared in this thesis as well so from now on, any reference made from conducted interviews and observations will be referred as anonymous. (See Appendix B – User Research for complete Overview)

Many factors become obstacles for officers, some are physical, and some are mental, both types limit the performance of an officer when on patrolling urban cities such as Toronto ON, which in turn can affect response times. As mentioned by the anonymous interviewee. These obstacles can range from environment, physical fitness, and mental readiness in the key activity's officers perform daily.

Key activities are listed below, following each other in sequential order:

- Patrolling their assigned area in the region
- Responding to incoming calls
- Conducting Investigation at the scene of call
- Data and event logging of case(s)

The methods along with corresponding pain points that officer's use in key activities are listed below are based on Domestic Violence scenario and is categorized by different stages that occur in order to help understand different areas more clearly during design process stage.

Patrolling And Responding to Calls

- Officers are given assigned areas that they must patrol each day and enforce traffic laws and bylaws

- In those assigned areas, officers must build community relationships to provide trust and confidence to the local population
- Officers respond to incoming calls from dispatch and keep constant communication with dispatch to understand and analyze the situation before reaching on scene.

Conducting Investigating at the Scene of Call

- After reaching on scene, officers must investigate and understand the event(s) that have occurred to make an informed decision by observing visually and communication clues.
- Officers separate the suspect and Victim to de-escalate the situation and calm everyone down to get a clear understanding of the events that had occurred.
- At the end of the situation, officer(s) must debrief with each other and dispatch to see if anything was missed in the investigation and then close the case.

Data and Event Logging of Case(s)

- Near the end of the shift or at the end of a case, the officer must do the data logging of the case into the system for future follow ups and contact reasons

- The officer(s) can either do it in their cruiser on the MTD or go back to the detachment and do it in their personal offices

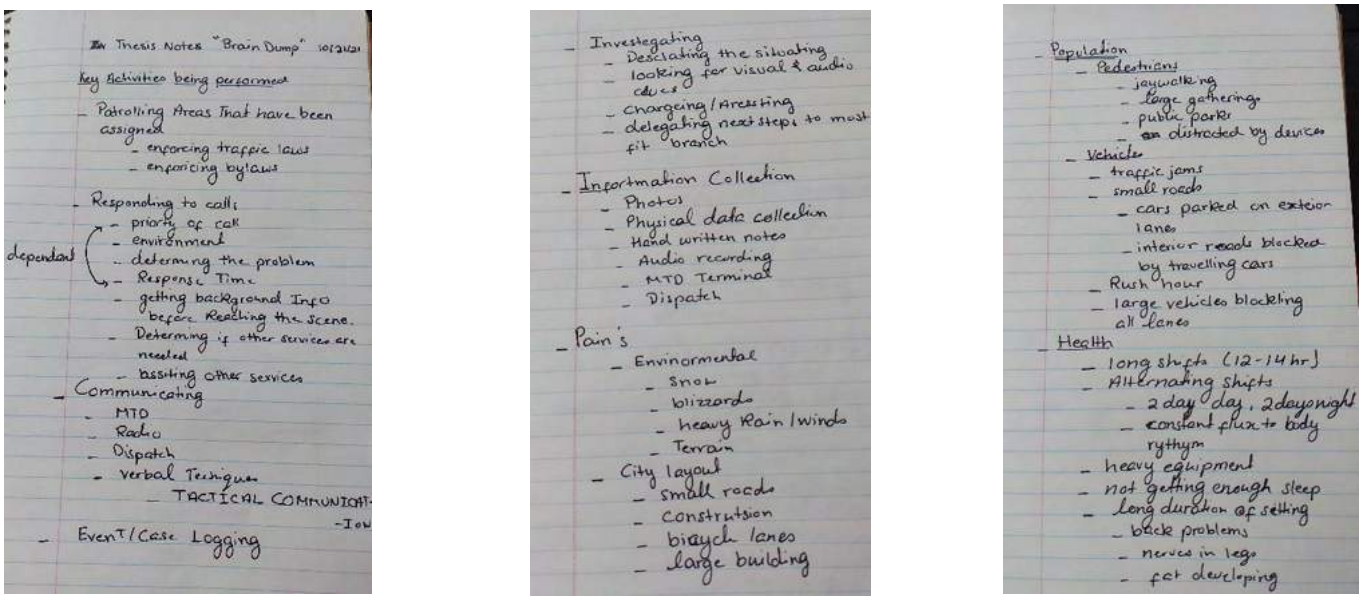



*Figure 3 - Notes Taken During Interviews*

The use of tools and technology is based on different situations and scenarios. The use of different methods and protocols is mostly the same from the start and middle of the journey (e.g., Up to when the police officer reaches the scene) from there, the methods and procedures are dependent on the case as mentioned in interview two.

Two interviews were conducted with an active OPP officer in the west region of Ontario, due to active policies of OPP, no video and audio recording were allowed. The interviewee was very gracious to do two interviews. The first interview was mostly about their profession and some background, demographic and overall information. The discussion shifted from background info to its relevance to the thesis project naturally and strengthen the relationship for future discussions. The second interview was more focused on the interactions with products, methods, procedures, and tools that officers use in different situations to gather insights into the overall lifestyle of officers on duty and then more personalized questions toward the interviewee were asked to understand their personal experiences and pain points.

Questions were prepared in advanced for both interviews and were shown to the interviewee beforehand to prevent any consequences from OPP policies and if they were any questions that the interviewee was not allowed to answer and would be avoided during the interview.

Interview One

- Can you tell me about your background?
- What are your main responsibilities in your job?
- Why did you choose to become a Police Officer?
- What are the most common types of calls do you respond to?
- What type of environment do you usually work in (eg. urban cities, residential, rural, industrial)?
- Can you tell me about the steps you take from the moment you get a call to when you reach the scene?
- Can you tell me about the reasons behind each step that you mentioned in question 4?
- What type of tools do you use on a daily basis (eg. Vehicles, hand tools, digital tools, communication tools) and what are they used for?
- What are some of the major problems you face with these tools?
- Can you describe the layout of your workspace and how the tools you mentioned in question 8 are placed?
- Describe any fears, frustrations, anxieties you feel from your response to a call and to the moment you reach the scene?
- What future advancements or tools would you like to see, that could help you minimize these fears and frustrations?
- What physical obstacles do you face in your journey as you start traveling toward where the call came from?

- How do you try to avoid or minimize these obstacles?
- What would you like to see in the future that would help to completely avoid these obstacles?
- What would make your job more productive on a day-to-day basis?

Interview two: The questions are categorized based on the context of subject matter.

Everyday Activities:

- How long are your average shifts?
- What types of work do you do in an average shift?
- Can you tell me how long you have worked in the region of Toronto?
- Can you tell me the top three types of calls you get in the region of Toronto?
- Can you describe the steps you take from start to end when you respond to a call to when you reach the scene of the crime?
- Do your steps change base off the priority of the call?
- Can you please describe the physical obstacles you face in your journey from the previous question?

Methods and Skills:

- How do you try to avoid these obstacles?

Current Product Performance and Interaction:

- Please describe the activities you perform immediately before using the vehicle?
- Please describe the activities you perform immediately after using the vehicle?
- Please comment on the vehicle's steering. How comfortable are the wheel/handlebars?

- Please comment on the vehicle's seats and the ability to move around the workspace?
- Can you suggest any changes to the seating or posture to make the experience more comfortable over extended periods of vehicle use?
- Is vehicle lighting effective at allowing you to be seen by others and avoid obstacles on the road?
- Please comment on the vehicle's acceleration speed. Do you feel that it is too slow, adequate, or too fast?
- Please comment on the vehicle's aerodynamics. Would increase/decreased aerodynamics increase driver safety in any way? Why or why not?
- Please comment on the vehicle's buttons, knobs, and switches. Are they all easy to find, access, and use?
- Please comment on the use of the mobile data terminal. Is it easy to use, change its location?
- What features would you like to have on your "dream" transportation vehicle, and why?
- Please comment on the driver collision protection that the vehicle offers. What does it offer to protect the driver and is it sufficient? Why or why not?
- Please comment on the safety that the vehicle provides from external attacks. What does it offer to protect the driver and is it sufficient? Why or why not?
- Please describe in detail your overall satisfaction and user experience with the vehicle you use most often. If not already mentioned, what are the least enjoyable parts of operating the vehicle, and what are the most enjoyable?

All the questions during both interviews were asked in simple conversation manner to influence a natural and comfortable conversion, so questions that were not prepared in advance can be asked without disrupting the flow of the interview. The phrasing of the questions was changed when asking to promote a natural style interview. The key insights and takeaways are listed below. The full interview with questions and responses in located in Appendix B.

| Key Takeaways – Interview with OPP Police Officer |
| --- |
| An average shift of a police officer is officially 12 hours, but officers must report an hour prior for initial briefing and morning administrative work and must reach the detachment one hour prior of shift end to do rest of pending administrative work. The shifts are based on two-day rotations of start times, two days the shift starts at 6:00 am and two days is at 6:00 pm and three days are off for personal time. |
| The dense environment of Toronto provides a lot of obstacles for officers on patrol that increase response time for incoming calls. The different weather conditions of Toronto vary dramatically due to large building and condensed road architecture. The road visibility can practically reach zero in winter conditions due snow, fog, and windchill. This also lowers traction and officers are forced to slow down and take longer responding to call. |
| Due to increasing population and constant changes to popular roads to accommodate for bike lanes, pedestrians create hindrance in the path of police vehicles as they jaywalk across streets and cyclists do not pay attention incoming police vehicles and often are prone to vehicular accidents. Construction sites are very popular in summer seasons because winter seasons do not allow for complex constructions. Construction sites usually block both incoming and oncoming lanes and create traffic jams for long periods of time as mentioned in the interview two. |
| Packing and supplies are done based on the requirements of the shift and assigned area of patrolling, but mostly a large duffle bag is used to keep a change of clothes, tools and external equipment and officers food supply. That bag and large firearms (if needed) are stored in the trunk of the vehicle in their assigned spaces. |
| Data logging and communication is done on the MTD (Mobile Data Terminal), the officer checks information on incoming calls before responding to the location, to understand the events that have occurred beforehand. At the end of a call, the officer logs all the activity that happened on the call to update dispatch and system database for future occurrences. The MTD can be removed from the vehicle and taken to the officer's personal office at the detachment to do the event logging at a comfortable workspace. |

*Table 4 - Key Takeaways*

Keywords and phrases extracted from the interview are:

**MTD (Mobile Data Terminal)** – a device where dispatch and officer communicate all the incoming calls in the area and their background information on each call. The device is also used of data logging and updating police system database for future occurrences.

**ASD (Approved Screening Device)** – a tool used for testing for impaired driving and pedestrian who are under the influence of drugs and/or alcohol.

**Tactical Communication** – Method used by police officers to serve the public in a way that provides a duty of care to the individual and de-escalate the situation at hand.

### *2.1.3 User Observation - Activity Mapping*

Data and information gained from the activities conducted and interviews were gathered and categorized to create potential improvements in the user experience. The steps that the activities were done in are listed below in order.

- Day Start (*Start time of shift, have to reach the detachment one hour prior)*
- Changing into uniform (*packing the required equipment for day and putting on uniform with safety vest)*
- Accessing Vehicle (*loading bags and equipment into allotted vehicle for the day and doing circle and safety checks on the vehicle)*
- Start Patrolling *(taking the vehicle out and going to assigned area for patrolling*
- Responding to Incoming Calls *(Communicating with dispatch for background information on the situation and subjects*
- Reaching the Scene of Call
- Exit the Vehicle *(monitoring the situation constantly and maintaining situational awareness)*
- Investigate the Problem
- Reach a Conclusion *(make an informative decision and close the case either by charging or arresting and delegating the next steps to the appropriate branch based on case context)*

- Going Back to the Office *(event logging and data logging into the system database for future references)*
- Going Back on Patrol
- Day End *(reach detachment one hour prior of shift end to do any pending administrative work)*

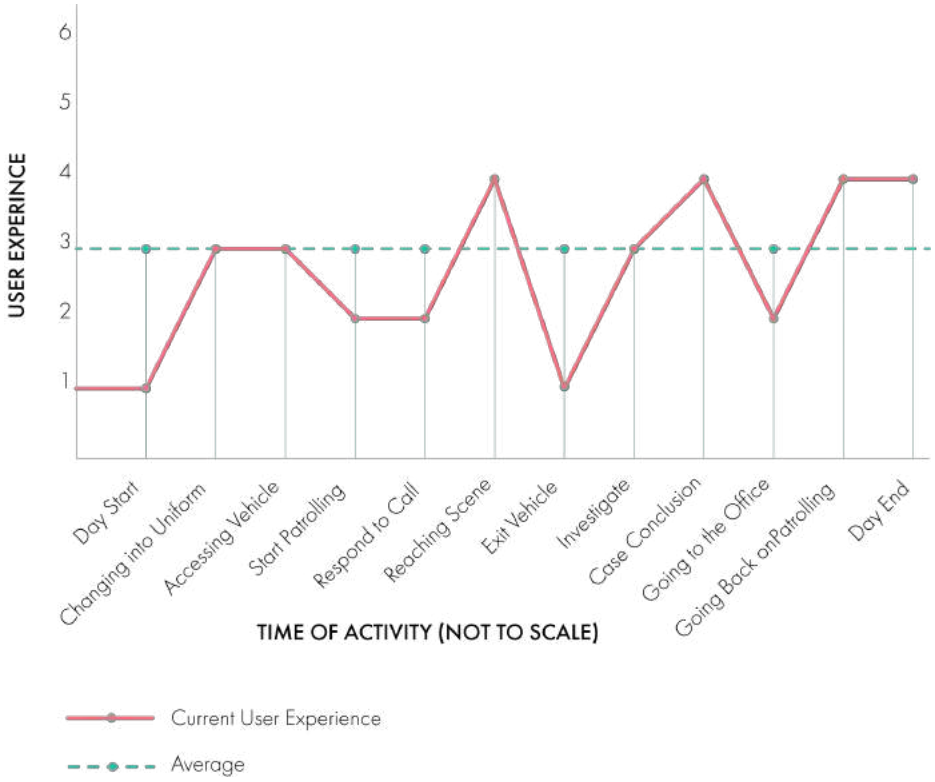



*Figure 4 - User Experience Map*

1 (Very Poor, -ve), 2 (Poor, -ve), 3 (Average), 4 (Good +ve), 5 (Very Good +ve)

### *2.1.4 User Observation - Human Factors of Current Products*

The ergonomics of police service vehicles are very different than their civilian counterparts because they were designed while keeping the needs, protocols of police duties. The way an officer interacts with the features inside the cabin to control and implement different parts of the vehicle is a very important part of design process. This will help to understand the fundamental features that need to be included in the final design and how they can be included in new innovative ways.

#### Objectives

- To identify ergonomic features of current police vehicle cabins
- To show the current existing layout of current cabins
- To compare difference between different manufactures

#### Method

Google searching existing cabins of current police vehicles, to show what is included in current designs and layout. Different manufactured to have broad range of benchmarked products.

#### Results

The following are current cabins of police vehicles in benchmarked products that will be analyzed for similarities and differences.

*Figure 5 - Dodge Charge Pursuit*

*Retrieved from: https://dodgeforum.com/how-tos/slideshows/check-out-the-newest-charger-pursuit-vehicle-514033*

*Figure 6 - Dodge Charge Pursuit*

*Retrieved from: https://www.policepursuitvehicles.com/2019-dodge-durango-pursuit-inventory-for-sale-salem/*

*Figure 7 - Ford Police Interceptor*

*Retrieved from: https://www.ford.com/police-vehicles/features/purpose-built/*

*Figure 8 - BMW R1200 RT*

*Retrieved from: https://www.pinterest.ca/navigator121/motorcycles/*

*Figure 9 - Ford F150 Police Responder*

*Retrieved from: https://uk.motor1.com/*

*Figure 10 - Jeep Grand Cherokee*

*Retrieved from: https://www.motor1.com/news/274207/jeep-grand-cherokee-carabinieri-version/*

*Figure 11 - Lamborghini Huracan*

*Retrieved from: https://www.pinterest.ca/pin/276267758364033281/*

### *2.1.5 User Observation - Safety and Health Research*

In popular urban cities as Toronto, ON, the city is alive 24/7 without any changes in population density on the streets and roads, which increases the chances for accidents. In the year of 2020, there were 80 accidents that happened, 40 were fatal and life threatening caused by vehicles and other motorized products. 21 of these accidents involved pedestrians and five involved cyclists (Toronto Police Service, 2020). Majority of these accidents happened in popular areas in the city such as Downtown Toronto and Lakeshore Toronto, where the roads are more condensed and bike lanes are more frequent.

Safety is needed in many different forms for police officers and the current vehicles that are used by officers try their best to offer these forms of safety on a daily basis. Common forms are safety from the elements, safety from external attacks, safety from vehicular and pedestrian accidents, and safety from criminals that are present in the vehicle with the officer during transportation. Below features are outlined that offer safety in all the different forms listed above.

Safety from the elements:

- High traction tires
- Heavy duty suspension
- High luminosity Head Lamps
- ABS
- Collison Warning systems
- Adaptable transmission systems

Safety from external attacks:

- Bullet proof glass (expensive, only on some vehicles)
- High strength aluminum body frame and body panels

Safety from vehicular and pedestrian accidents:

- Pre-collision warning system
- Blind spot monitoring system
- Pedestrian warning system
- Auto emergency braking system
- Proximity sensor
- High strength bumper attachments
- Six axis airbags
- Loud sirens
- Rumbler siren
- Bright siren lights

Safety during criminal transportation:

- Plexiglass barrier
- Sound barrier
- Hand cuff extension slots
- Rear auto locking doors that can only be opened by officer in charge

Health and safety with the field of police services are vital for officers and the communities

they patrol. Current procedures and practices used by officers when handling high priority calls such as domestic violence, homicides, and thefts, emphasize the importance of maintaining a safe observable distance at all times when investigating the situation and handling dangerous elements such as live firearms, suspects etc.

## 2.2 Product Research

The following sections of this thesis report will look at current products, tools and equipment used by police officers to identify key benefits and features, while looking at new innovations in the field that can be applied to final solution. A selection of 10 products were benchmarked initially but only 4 products were critically analyzed for the sake of this report.

| Product Name | Product Image | Product Reference |
|---|---|---|
| 2021 Dodge Charger Pursuit |  *Figure 12* | *Retrieved From: https://www.fcausfleet.com/dodge/charger-pursuit.html* |
| 2021 Ford Police Interceptor Utility |  *Figure 13* | *Retrieved From: https://www.ford.com/police-vehicles/hybrid-utility/* |

| | | |
|---|---|---|
| BMW R1200 RT |  Figure 14 | *Retrieved From: https://www.authorities.bmw-motorrad.com/en/models/r1250-rt-p.html* |
| 2021 Ford F150 Police Responder |   Figure 15 | *Retrieved From: https://www.ford.com/police-vehicles/f150-police-truck/* |

*Table 5 - Product Research*

### *2.2.1 Benchmarking – Benefits and Features Of Existing Products*

Benchmarking of current products used by police officers relied on data from literature available on the web on each product and feedback by the expert advisor during the interviews, the products chosen selected due to the range in price, different use of environment, function, and ergonomic aspects. The products, features and benefits have been organized thoroughly and highlighted. The full breakdown of features and benefit can be found in *Appendix C – Product Research,* along with all benchmarked products.

| Key Benefits | Key Features |
|---|---|
| Storage | Adaptable to various patrolling applications |
| Easily Seen | Low Maintenance |
| Small Ecofootprint | Low User Fatigue |

| | |
|---|---|
| Communication | Officer Safety |
| Officer Safety | Mobility |
| Speed | Accommodates more than two people |
| Traction | High Strength and Durable Materials |

*Table 6 - Key Benefits and Key Features*

### *2.2.2 Benchmarking – Functionality Of Existing Products*

After analyzing each product and breaking it down to their most essential form, four function categories were discovered during the benchmarking process. The functions were grouped into pairs of two due to the similarities between. The first pair being Safety and Comfort, all products offer variations in types of comfort and safety features depending on the size of the product and manufacturer intended design. The second pair being Mobility and transportation, each product has an intended use of environment in which they are most efficient and the transportation limitations on amount of equipment, tools, and people it can carry in that environment.

Basic Functionality of the products allows officers to respond to incoming calls in dense conditions and high traffic situations in the city along with their required equipment and tools. Safety and comfort are based on the design on the product and available features.

Products that have a less practical mode of transportation based on their environment of use often offer less comfort and safety to the user. The benchmarked products are spread widely on the X-Y axis as seen in Figure - 14, the area for innovation and design opportunity has been highlighted which paves the direction on the most efficient and useful functions and features of the design solution for this thesis.

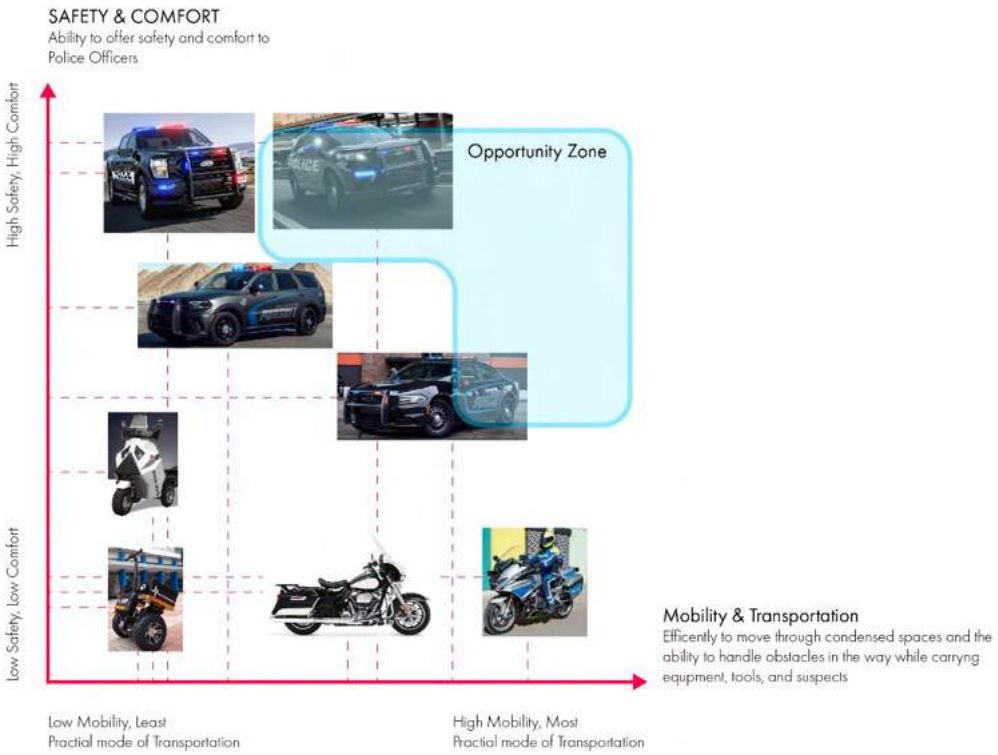



*Figure 16 - X-Y Graph of Functionality*

The area for design development is where there is an opportunity for a high level of safety with comfort for long durations of use. The end solution should have high mobility and be able support all storage needs of an officer.

### *2.2.3 Benchmarking – Aesthetics and Semantic Profile Of Existing Products*

While creating the aesthetics and semantic graph that is seen on the following page, it became quite clear that there is a lack of humanistic design consideration when producing these vehicles. Most of the vehicles presented below tend to have very rectilinear aesthetic which implies that these vehicles were designed from only a functional and utilitarian point of view.

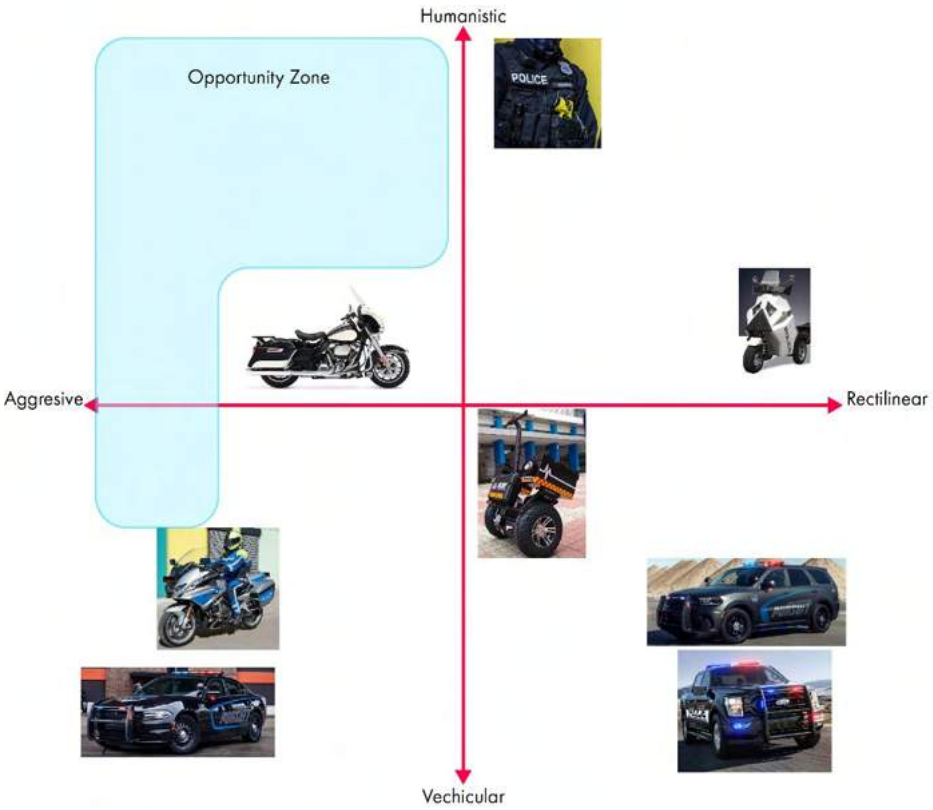



*Figure 17 - X-Y Graph of Aesthetics and Semantics*

The overall aesthetic of current existing products is very industrial, mechanical, and overwhelming in appearance. With minimal styling and aesthetic considerations, most of these products are visually heavy and lack the appeal to the general public. Reducing the visual weight and enhancing the visual appeal will improve community relations and give path to new innovations while improving the workflow of police officers.

Muted and neutral colors are often used in these products like black, white, grey and the accent color which is dependent of the area and the branding of the local police force. This contrasting color palette is used for one main reason, which to is to be easily recognizable by the general public, when officers are patrolling, responding to incoming calls, and enforcing traffic laws. Keeping this general rule of contrasting colors will be a major consideration when doing the styling and aesthetics of the final solution

Current vehicles used by police officers lack a great deal of an appeal to the general public, and they have been designed from a lens of functionality and utilitarian which provides an opportunity to create a solution which more humanistic in form while keeping and improving the current functionality.

### *2.2.4 Benchmarking – Materials and Manufacturing of Existing Products*

The analysis conducted will focus on the major components of Tyren to prioritize the major sections for sustainable development of the overall design, this involves the solar panel roof, the base battery, frame and glass. Current versions of the components mentioned in vehicles are either using recyclable materials or high polluting manufacturing processes. "Lithium mining, needed to build the lithium-ion batteries at the heart of today's EVs, has also been connected to other kinds of environmental harm. There have been mass fish kills related to lithium mining in Tibet, for example. The freshwater supply is being consumed by mines in South America's lithium-rich region. Even in North America, where mining regulations are strict, harsh chemicals are used to extract the valuable metal." (Common & English, 2019).

The benchmarking of materials will display in a chart form to better understand the benefits of each and disadvantages.

| Materials | Benefits | Disadvantages | Reference |
|---|---|---|---|
| **High Harden Ballistic Steel (Protection 400 Steel)**<br>- Vehicle Frames<br>- Chassis<br>- Door Panels | It is a version of steel that has gone under a strong heat treatment method known as Quenching, which increases resistance to wear and tear. It can protect the vehicle against high calibre AR rounds to smaller handguns | Due to Quenching, the steel less ductile and prone to brittleness | https://metalexponents.com/blog/types-steel-automotive industry/#:~:text=The%20types%20of%20steel%20used,various%20vehicle 20and%20engine%20components.<br><br>https://masteel.co.uk/armour-plate-steel/<br><br>https://www.azom.com/article.aspx?ArticleID=20758#:~:text=Ballistic%20steels%20are%20hardened%20during,as%20specialized%20heat%20treatment%20processes.<br><br>https://www.texasarmoring.com/armoring/materials/#steel |
| **Aluminum 6000 Series**<br>- Body Frame<br>- Rims<br>- Lamps<br>- Transmission<br>- Engine<br>- Body Panels | 10-40% lighter than steel and high level of rigidity. It Is up to 90% recyclable. Aluminum needs less rust repair and has a longer lifespan. | Requires special processes to be welded and is abrasive to tooling and is more expensive than steel | https://www.metalsupermarkets.com/aluminum-and-the-auto-industry/#:~:text=The%20auto%20industry%20uses%20aluminum,%2C%20tachometers%20and%20air%20bags). |

| | | | |
|---|---|---|---|
| **Ballistic Glass Curved**<br>- Windshield<br>- Back Glass<br>- Side Windows | It is toughened glass using quenching. Multiple layers of tempered glass are laminated together (10 x thicker than regular glass panel) with a thin layer of polycarbonate between each layer to prevent bullets getting through | Heavier than regular glass, more expensive and production has co2 emissions | https://www.glassbuzz.ca/how-is-bulletproof-glass-made/#:~:text=Compared%20to%20ordinary%20glass%2C%20bulletproof,This%20is%20called%20a%20laminate*.&text=All%20these%20added%20layers%20of,than%20a%20single%20glass%20pane. |
| **Natural & Synthetic Rubber**<br>- Tires | Natural and Synthetic rubbers are mixed to make tires. Natural rubber provides resistance towards tearing and fatigue cracks and Synthetic Rubber is good for durability and inflation. | Natura Rubber is expensive and has low performance in wet traction along with low resistance to weathering.<br><br>Synthetic Rubber is made from crude oil and a primary source of pollution. | https://www.ustires.org/whats-tire-0 |
| **Solar Panels** | Made from Gallium arsenide solar cells which provide an efficiency of 30 percent. The frame is made from flexible silicon | Not enough efficiency to provide a fast charge to the internal battery, has mild resistance to weathering | |
| **Li-ion batteries** | 100's of batteries are packaged together to create a pack for powering a vehicle. Higher stability and can be recharged multiple times | 2–3-year life span from production date | https://www.tennantco.com/en_ca/blog/2019/11/lithium-ion-battery-benefits.html#:~:text=Li%2Dion%20batteries%20are%20able,retention%20than%20other%20battery%20types. |

*Table 7 - Current Materials Used In the Industry*

Tire manufacturing is one of the leading causes of CO2 emissions in the world, most of it is during the production of the raw materials that are required for manufacturing the tire. "*The production of tires' raw materials currently generates four times as much CO2 emissions per tire than the manufacturing of the tires themselves.*" (Nokian Tires Contributor, 2020). Another part of lifecycle that makes a huge impact on the environment is the

process of vulcanization, which prevents the tires to recycled at the end of their life cycle and be reused, so they are sent to a landfill. Vulcanization is the process of heating and compressing multiple compounds to harden the tires.

Solar panels are meant to be humanities way forward for energy production but there are downsides as well which range from the production of materials to end the of a panel's lifecycle. The production and mining of the materials like silicon, quartz, Aluminum, and copper take up a lot of energy and produce CO2 emissions. "*The life cycle emission intensity of solar PV is approximately 40 gC02/kWh ´ (Kuby, 2019),* This is significantly lower than emissions that are produced from coal, but as solar panels are becoming more popular, the emissions will also increase. Another problem is at the end of the life cycle, there is no proper recycling method to reuse materials. The one benefit is that solar panels are not thrown into the dump but into proper e-waste processing facilities where panels are taken apart and each material is disposed properly. After all the materials are either mined or produced, they are assembled based on specifications and point of use.

For electric vehicles, Li-Ion batteries is probably most important component as it is the power source. The process of creating Li-Ion batteries starts with the mining of Lithium Ore from the ground with uses up a lot of water. *"The lithium extraction process uses a lot of water—approximately 500,000 gallons per metric ton of lithium."* (IER, 2020). Then the Lithium is left in a brine pool until the water is evaporated where then the Lithium is filtered from the rest of the minerals in the pool, this one step takes about 12 to 18 months. After that the pure Lithium Ore is shipped to various companies to build batteries based on their own designs and specifications.

### *2.2.5 Benchmarking – Sustainability of Existing Products*

Sustainability is a huge aspect of vehicular design, even though it is not considered as much when designing vehicles for the police force because they are made for performance, speed, and maneuverability. These

considerations are hugely affected if they are switched with more eco-efficient or sustainable options, which in turn affects the ability of the officer and the speed of they can complete their tasks successfully.

Majority of the materials and manufacturing processes used to make law enforcement vehicles are not very sustainable other than the raw materials used such as aluminum and steel in the foundation and frames of the vehicles.

## *2.3 Summary of Chapter 2*

Current materials and process provide a large opportunity for innovation and diversion on to a more ecofriendly platform for the future vehicles in law enforcement. This includes looking at renewable energy as the power source and implanting natural products and materials to increase safety, comfort, and performance.

# CHAPTER 3 – ANALYSIS


*Figure 18 - Retrieved From: https://unsplash.com/photos/pCDOdzXHvZQ*

# CHAPTER 3
# Analysis

## *3.1 Needs Analysis*

When a police officer patrolling in a dense city like Toronto, Ontario, for public safety purposes, they put themselves at risk from the elements and collisions trying get to the location where someone is in distress and get them to safety. There is high need for a system that can help officers get to where they are called for help, with a low response time, safely by protecting themselves and everyone around them as they travel through the dense streets.

### *3.1.1 Needs/Benefits Not Met by Current Products*

Current transportation vehicles are either large vehicles such as sedans or SUV's or two wheeler's such as bicycles or motorcycles. The offer the speed and performance that leaves consumer vehicles in the dust, but they are not suited for the environment they are currently used in. Highly populated cities, dense traffic throughout the traffic, physical and elemental obstacles. Current Vehicles used by officers are not nimble enough to be operated in small streets which is most common type street architecture in Toronto, ON.

Police Officers currently lack human aesthetics in their products which leads the usability to be more of utilitarian, which can be resolved via design solutions and refinements. Current vehicular products are not that different from consumer models, other than they have a higher level of performance parts and safety systems. Current vehicles don't account for the extra duty products that officers wear such as safety vest, firearms, tools etc. which can lead to discomfort and health problems caused by the seating in the vehicles, making it very hard for officers to move around the cabin to interact with the different control panels and long-term use.

Procedurally officer(s) will head out to their assigned area for patrolling in the vehicle that is available at the precinct lot and keep constant awareness on the road for any drivers that are not following any traffic laws while keeping an eye out on the MTD (Mobile Data Terminal) for any calls that require immediate assistance. Once a such call is displayed on the MTD, the officer(s) advise dispatch that they are taking the call and start heading toward the location from where the call came from, while asking dispatch questions for all background information that is relevant to the situation. After reaching at the location, officer(s) stay in the car and visually assess the area and situation before getting out and going to commence the investigation. Depending on if the investigation results are conclusive or non-conclusive, the investigation is passed on to the appropriate branch. Officer(s) from there do all the administrative work that is related to work so it can be updated into their system for future use. More details in Appendix B. this is complex procedure of workflow that highly depends on communication and speed that is repeated multiple times in a shift that lacks proper considerations for the lifestyle, health, and safety of police officers.

Safety, Speed, and comfort will be number one priority when designing, keeping comfort high and stress low will increase productivity, efficiency in the workflow to make better informed decisions in the line of duty. Sufficient amount of storage that blends in with the overall design rather as a separate entity that has to tagged on.

### *3.1.2 Latent Needs*

| Latent Needs | Benefit Statement |
|---|---|
| Comfort | offers officers comfort, feelings of home within the design, comfortable enough to be used for long durations at a time. |
| Storage | adequate storage to store personal belongings, tools and equipment, large firearms, and extra clothing/uniform |
| Shelter | Offers Shelter from the elements (snow, harsh winds, heavy rain). Protections from suspects, vehicles, and weapons. Provides protection for bystanders and victims. |
| Transportation | Traverse the heavy traffic population of dense cities. ability to detect and avoid obstacles ahead of time. Adaptable to access and travel in different environments and spaces. |
| Work/Productivity | Provides high level of communication with dispatch, other officers, victims, suspects, and bystanders. Need of able to do administrative work in the field, eliminating travel time and fuel consumption to and from detachment. Attention paid to the ergonomics and how it relates to the rest final solution. |
| Observation | Reconnaissance of location and situation before engaging in the investigation. Visual space for long distance observation. Large area coverage observation at a safe distance. |

*Table 8 - Latent Needs*

### *3.1.3 Categorization of Needs*

After analyzing the insights from user observations, product benchmarking, and literature review, needs have been categorized based off their importance and relation to the design and functionality. This is done to link fundamental human needs with product needs, referenced from Maslow's 'Hierarchy of Human Needs', a table is created to summarize these needs and corresponding categories.

| **Immediate Needs** | **Benefit statement** | **Relationship with benefit** |
|---|---|---|
| Convenience of Controls | Ergonomic control panel for easy and fast access in stressful situations. | STRONG |
| Workspace for Paperwork | Built in workspace for administrative work. | LOW |
| Small Ecofootprint | Way to save money on fuel or eliminate the need for fuel altogether. | STRONG |
| **Latent Needs** | **Benefit statement** | |
| Comfort | offers officers comfort, feelings of home within the design, comfortable enough to be used for long durations at a time. | STRONG |
| Storage | adequate storage to store personal belongings, tools and equipment, large firearms, and extra clothing/uniform | STRONG |
| Shelter | Offers Shelter from the elements (snow, harsh winds, heavy rain). Protections from suspects, vehicles, and weapons. Provides protection for bystanders and victims. | STRONG |

| | | |
|---|---|---|
| Transportation | Traverse the heavy traffic population of dense cities. ability to detect and avoid obstacles ahead of time. Adaptable to access and travel in different environments and spaces. | STRONG |
| Work/Productivity | Provides high level of communication with dispatch, other officers, victims, suspects, and bystanders. Need of able to do administrative work in the field, eliminating travel time to and from detachment. Attention paid to the ergonomics and how it relates to the rest final solution. | STRONG |
| Observation | Reconnaissance of location and situation before engaging in the investigation. Visual space for long distance observation. Large area coverage observation at a safe distance. | MODERATE |
| **Wants / Wishes** | **Benefit statement** | |
| Safety for Pedestrians | Better safety precautions for bystanders and pedestrians that are present when traveling at high speeds | STRONG |
| Cost Effective | Easy / affordable to maintain | MODERATE |

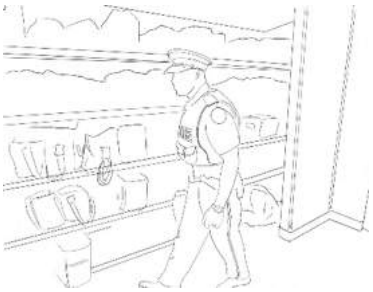
| | | |
|---|---|---|
| Stylish Aesthetics | Avoids utilitarian aspects of design aesthetics, stylish and futuristic form factor. | STRONG |

*Table 9 - Categorization of Needs*

## *3.2 Analysis - Usability*

To understand the user needs effectively is to observe them conducting their normal activities throughout the day or focused areas and analysis the steps taken and problems faced in each step and possible opportunities for improvements and enhancements.

### *3.2.1 Journey Mapping*

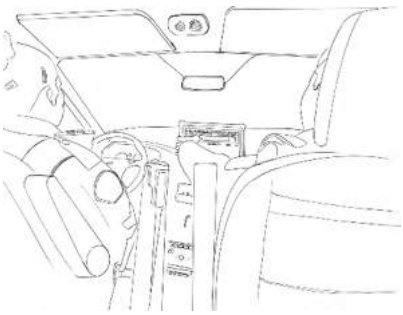


**Step 1 - Preparation**

*The officer goes to the detachment and changes into uniform* and packs equipment and firearms that are required. Looks at his MTD tablet for current status of incoming calls and tasks.

**Step 2 – Accessing Vehicle**

The officer loads his equipment into the vehicle, does a circle check of the vehicle for any issues or damage. Then sets up the MTD tablet in the vehicle and updates dispatch of status



**Step 3 – Start Patrolling**

Officer than heads out of the detachment and heads for his/her assigned area for patrolling while checking for any incoming calls in the vicinity and enforcing traffic and bylaws.

### Step 4 – Responding to Incoming Call

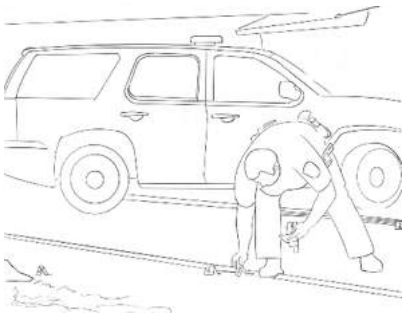
The officer updates dispatch that they are headed toward the location of call origin. The officer uses the MTD to look up any background information on the people involved and communicate with dispatch for real time updates on the situation


### Step 5 – Reach the Scene

Before exiting the vehicle, the officer scopes out the area, situation and people that are present on the scene to create situational awareness and making mental notes for safety purposes.

### Step 6 – Exit Vehicle

The officer heads towards the scene with caution, keeping constant awareness of surrounding and pedestrians in the area while keeping their hand on their firearm until it is the situation presents no danger.



### Step 7 – Investigate

The officer uses Tactical Communication method to investigate the situation while looking for visual, audio, and physical clues.

### Step 8 – Conclusion

After the investigation is done, the officer decides if the case is conclusive or non-conclusive based on the data recovered. Based on the decision the

suspect is either taken in custody or charged or given instructions on which department to contact based on the situation.

### Step 9 – Going to the Office

To do the data entry of the case, the officer heads back to the office to do all the administrative work and debrief with their supervisor.

### Step 10 – Patrolling

The officer than heads back out to their assigned area and starts patrolling and waiting for new incoming calls

### Step 11 – Day End

The officer goes back to the detachment and does shift briefing of all the cases they handled in the shift. Changes back into regular clothes and heads back home.

| Step | Base User Experience | Possible Areas for Improvement |
|---|---|---|
| 1 – preparation | - Packs equipment<br>- Changes into uniform<br>- Registers firearms that are being taken out<br>- Checks MTD tablet for current status for incoming calls | - Dedicated storage solutions with smart locks<br>- Built in gun locker to keep large firearms safe |
| 2 – Accessing Vehicle | - Takes equipment bag to the vehicle<br>- Loads the various equipment and firearms in their dedicated areas in the storage areas of the vehicle | - Self-monitoring system that checks for any damages or issues with the hardware |

| | | |
|---|---|---|
| | - Inspects the vehicle for any damages or issues | |
| 3 – Start Patrolling | - Leaves detachment and heads out to assigned area for patrolling<br>- Enforcing traffic laws and bylaws | - Smart camera system that monitors the traffic and lets officer know if anyone is violating traffic laws that they could have missed.<br>- Advanced obstacle warning system to avoid obstacles on the road |
| 4 – Responding to Incoming Call | - Responds to incoming calls on the radio and updates dispatch that they will take point<br>- Looks at MTD for updates and background information on the situation<br>- Askes dispatch for any missing information. | - |
| 5 – Reach Scene | - Scopes out area making notes of any blind spots or obstacles on the scene<br>- Creating situational awareness of the area and pedestrians in the area | - Proximity sensors<br>- A third eye which monitors the environment and checks for any obstacles or danger |
| 6 – Exit Vehicle | - Officer exits vehicle<br>- Has hand on the firearm until the situation presents no danger<br>- Heads towards scene while maintaining awareness | - Proximity sensors built in the safety vest to prevent any unexpected dangers |
| 7 - Investigate | - The officer uses Tactical Communication method to investigate the situation<br>- Looks for visual and audio clues for insight into the case | - A device that can see clues or chemicals that are not seen by the naked eye<br>- A device that can recognize different body languages and speech patterns |
| 8 – Conclusion | - Officer handcuffs suspect and takes them over to the cruiser and seats them in the back<br>- Updates dispatch on the situation and takes the suspect to the detachment for further processing | - Self-restraining cuffs that prevent the user from moving erratically while transporting |
| 9 – Going to the Office | - The officer heads to their office and does all the administrative work on their office table<br>- Checks on previous cases and their progress | - Built in workstation within the vehicle that allows for comfortable workflow. |
| 10 – Patrolling | - The officer once again heads out to patrol their assigned area | |

| | | |
|---|---|---|
| 11 – Going Home | - At the end of the day, the officer goes to the detachment and changes their uniform<br>- Signs back in all the equipment and firearms they took out and circle checks the vehicle for any damages and parks back in the lot<br>- Takes their personal vehicle and goes home | |

*Table 10 - User Journey Mapping*

### *3.2.2 User Experience*

To analyze all the journey mapping data, a visual representation was created that communicates the primary pain points as the user completes their desired task. The chart below is a tool used to benchmark the experience of each task they complete and the level of satisfaction they have during each activity. This can be used to recognize areas that can be improved and that in turn informs the proposed thesis design solution.

In the graph below, is the user experience map of an officer responding to a regular domestic violence call and the potential areas where the level of satisfaction can be increased.

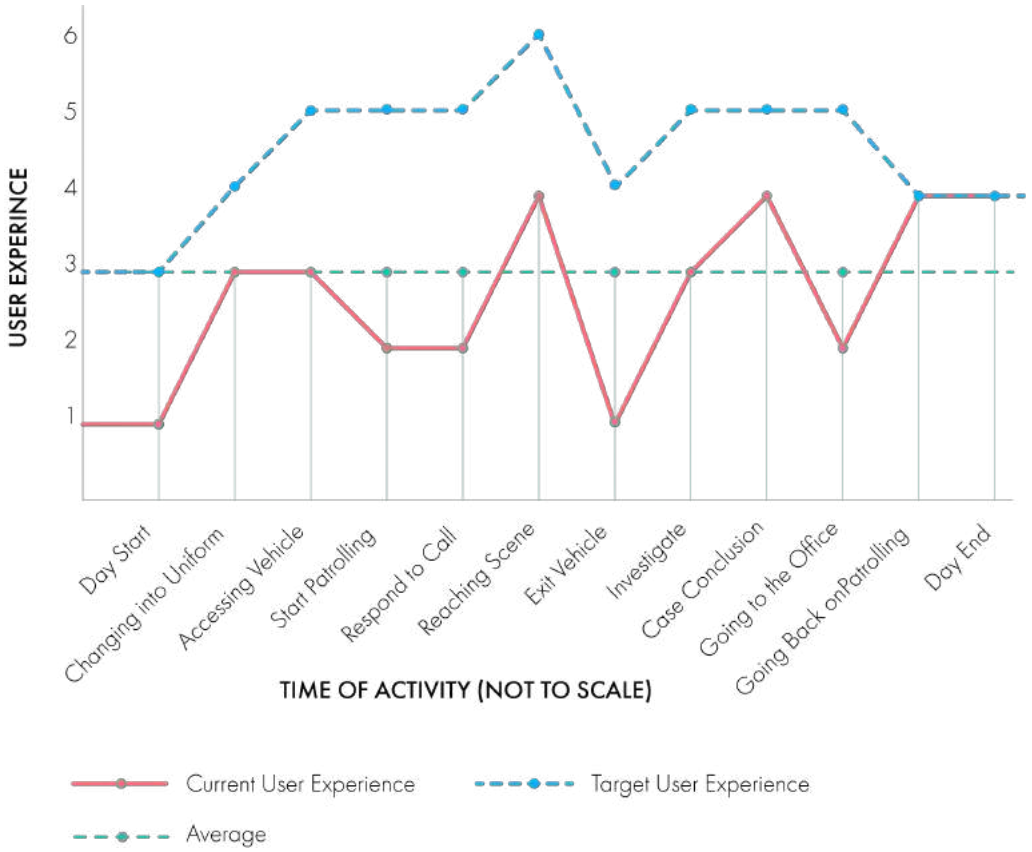



*Figure 19 - User Experience Map with Target Experience*

1 (Very Poor - ve), 2 (Poor - ve), 3 (Average), 4 (Good +ve), 5 (Very Good +ve)

As seen, the user begins with an activity with a low level of satisfaction, mostly due to long hours of duty and only getting six to seven hours of sleep the night before. Once the user gets to the detachment the level goes to average. The beginning of a shift is usually bland that is caused by morning meetings and administrative work. As the user heads to patrol their assigned area to when they reach the scene of an incoming call, the user experience rises and dips like a roller coaster which is caused by range of emotions that occur throughout these activities. The user feels scared for themselves and others around them, worried about how serious the situation is and how far has it already progressed, stressed about the level of danger that could be present at the scene, doubtful if they can handle the situation alone If they need backup units for support. The excitement has

increase by the time they start investigating the situation and figuring out what happened. As the case concludes the adrenaline dies down but the level of satisfaction rises as the suspect has been apprehended. By the time the case concludes the user returns to an average level due to having to return to the detachment and do the relative administrative work of the case they just investigated. Minimizes these pains points and providing a more stable positive experience in said area will increase the credibility and value of the final design solution.

### *3.3 Analysis – Human Factors*

**Introduction:**

Police Officers usually experience a lot of obstacles and pain in their daily shift they rely on their equipment and vehicle to keep them safe and efficiently carry out their duty. For this thesis, Officers that work in dense cities like Toronto ON, face a lot of physical obstacles such as traffic, construction, condensed areas and streets. So, the equipment and vehicles they choose must be ergonomically fit for them avoid and/or overcome said obstacles. Due to long hours of patrolling, the leg and back muscles get stiff from long durations of sitting in one place, along with the added weight of the uniform and safety vest and utility belt, minimizes mobility within the vehicle as they interact with different areas in the cabin.

**Literature Review**:

Before the ergonomic study was conducted, literature was reviewed for potential insights and guidelines to base the study on and understand the human body. For information on specific body measurements **Henry Dreyfuss “The Measure of Man and Woman”** was used as the main source along with **S. Macey & G. Wardle “H - Point the Fundamentals of Car Design and Packaging”** for different measurements for different sized cars and how they affect the space allotted for the user. Due to specific requirements of Toronto Police, the minimum height to join is 5 '7 `` and maximum height is 6’4” so for the study 89th percentile woman and 95th percentile man was used for the study.

**Methodology:**

To conduct the study, a process has to be laid out to efficiently plan and execute the study so the analysis can be made that efficiently helps the design decisions.

**Objective:**

This study intends to study the human interaction, ergonomics, functionality, and usability of the proposed design. The study focuses on Full Bodied Human Interaction Design, which will unveil areas where the design can be improved for better interactions and ergonomics.

**Decisions to be Made:**

The study provides understanding of the interactions of major body parts with the proposed design and better understanding the touch points can be improved. These include:

- Storage positioning
- Control Panel positioning
- Steering Wheel
- Touch Screen
- Foot Positions.

***3.3.1 Product Schematic – Configuration Diagram***

**Users Targeted by Study:**

Police Officers that are stationed in Toronto ON and are between the age of 25 - 45 and are earning $90,000 +. Due to height limitations to join the force, the minimum height is 5’7” and maximum is 6’4”, to accommodate these restrictions, 89$^{th}$ percentile woman and 95$^{th}$ percentile man was chosen for reference to conduct the study.

**Evaluation Process:**

The one-to-one model was created in SolidWorks using basic shapes and forms to depict the proposed design to get the most precise measurements as the 3D models of 89th and 95th percentile woman and man interact with the model in the software.

**Results:**

**Ergonomic Diagrams:**

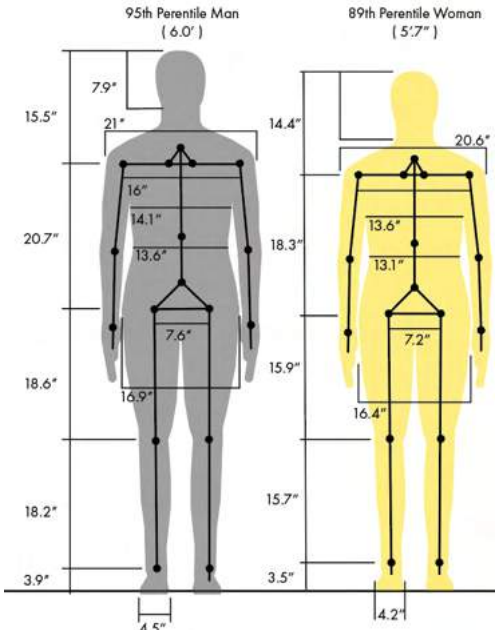



*Figure 20 - 95th Man and 89th Woman Percentile Diagrams*

The figures in the diagram above show the typical dimensions of the whole body of a 95$^{th}$ percentile man and 89$^{th}$ percentile woman. The study is for testing how the whole body will interact with the final solution, these are the necessary measurements.

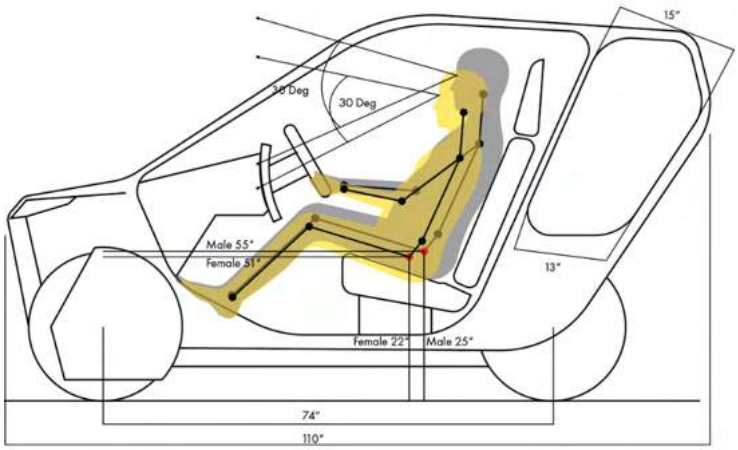



*Figure 21 - 95th Man and 89th Woman Percentile Diagrams*

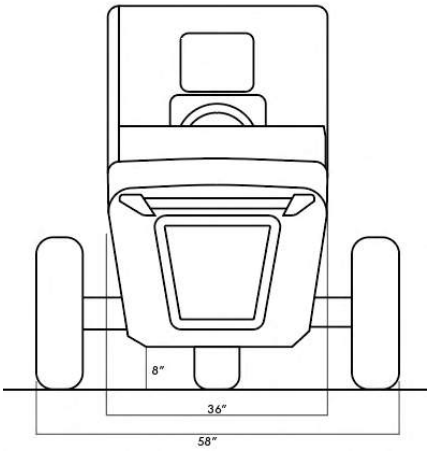



*Figure 22 - Front View Schematic*

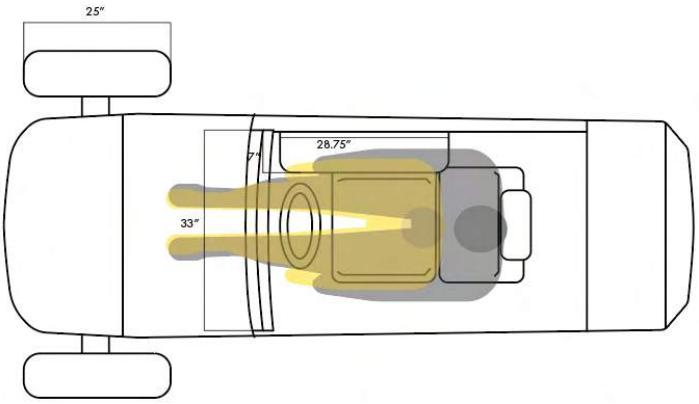



*Figure 24 - Top View Schematic*

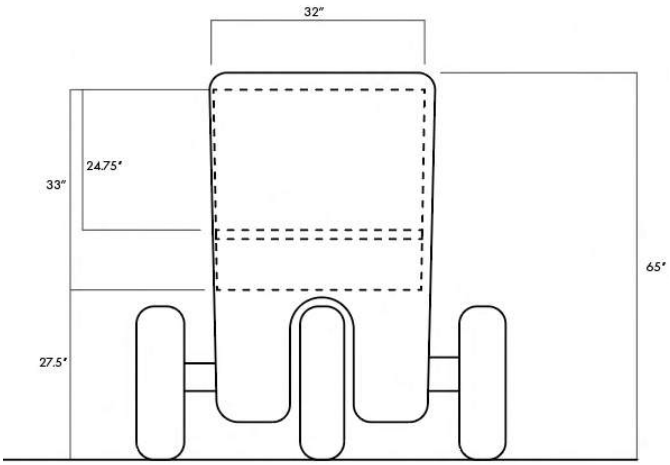



*Figure 23 - Rear View Schematic*

The above figures show the schematic layout of the 89th and 95th percentile woman and man inside the design. The diagrams show the considerations of sizes of different parts for interior of the design to create the most viable seating solution in a condensed area that can accomadate vairous percentiles.The meausrements for the design were created from referencing the body dimensions from Fig. 1 and other literature reviewed sources.

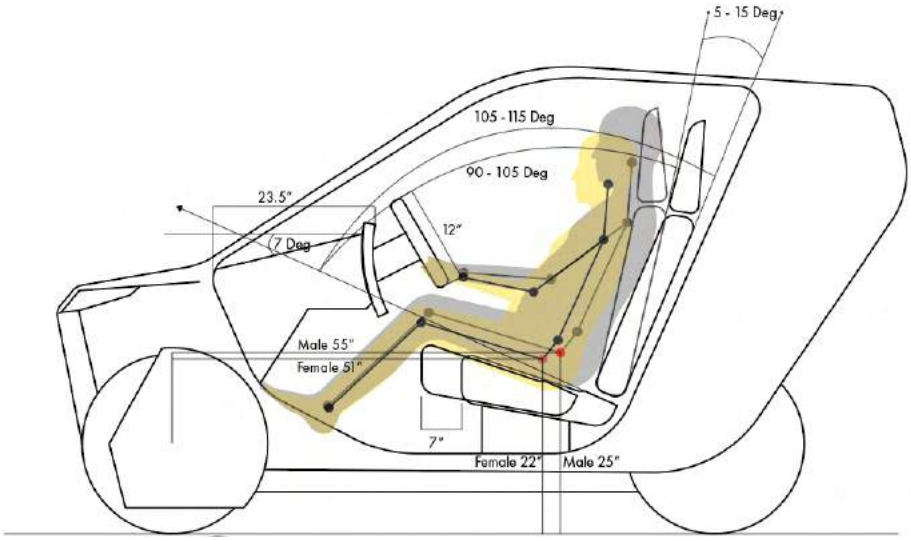



*Figure 25 - Side View Configuration Schematic*

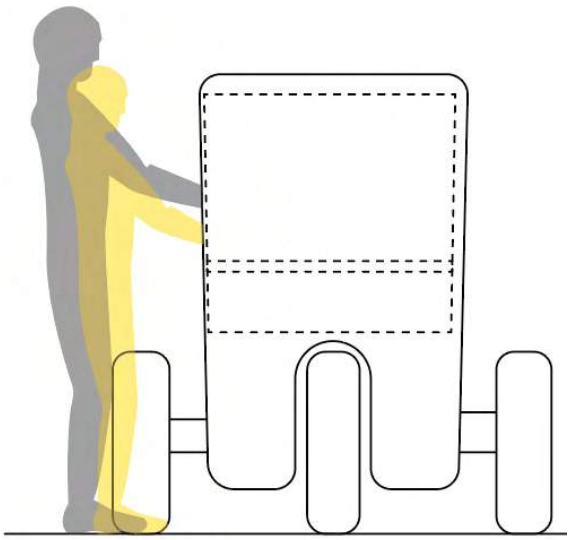


*Figure 26 - Rear View Schematic of Storage Access*

The above figures show how the seating can be adjusted to accomadate smaller percentiles by adusting the angle of the back cushions and headrest and horizontal sliding of the seat that also causes the seat to go up in height so the viewing angle stays the same as for bigger percentiles. Figure 7 shows the users accesing the exterior storage that has two compartments for equipement and large firearms. The storage compartments are placed higher for easy access and less stress on the back if the user was bending over in lower placed storage.

### *3.3.2 Ergonomic – 1:1 Human Scale Study*

The one to one model testing was conducting in SolidWorks and 89th percentile and 95th percentile users were modeled in Solidworks as well to test the ergonomics of the design and identifty potential problem areas that have to be resolved during the design refinement stage.

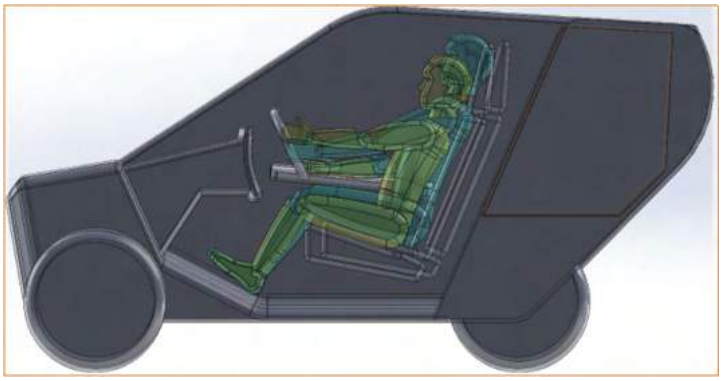


*Figure 29 - Side View of CAD Model*

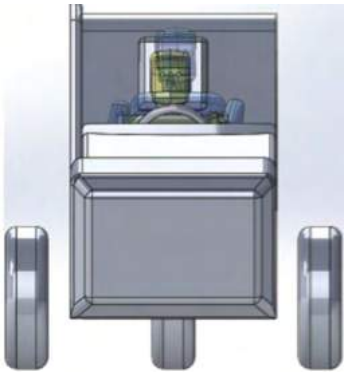


*Figure 30 - Front View of CAD Model*

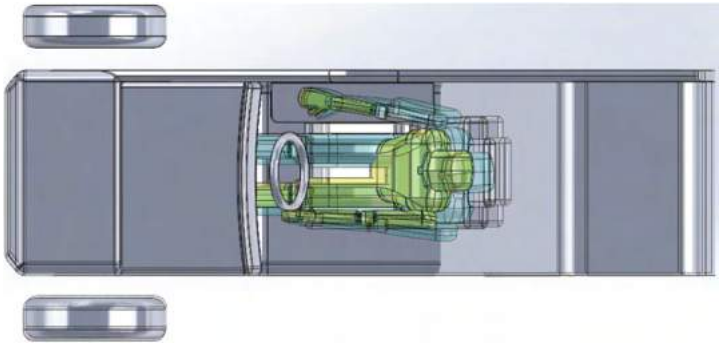


*Figure 28 - Top View of CAD Model*

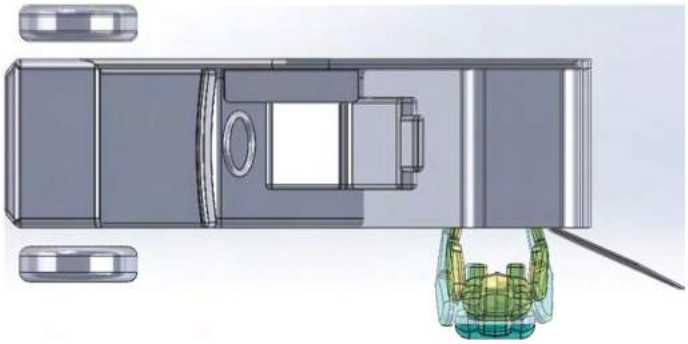


*Figure 27 - Rear Storage Access View of CAD Model*

The above figures show how the 89th and 95th percentiles interact with the model in various areas and touchpoints. In Fig. 8 for the 89th percentile user to easily access the steering wheel, the seat has to be adjusted by 4 – 7 inches forward. This also applies for the lower percentile to access the foot pedals without overextending the lower leg muscles.

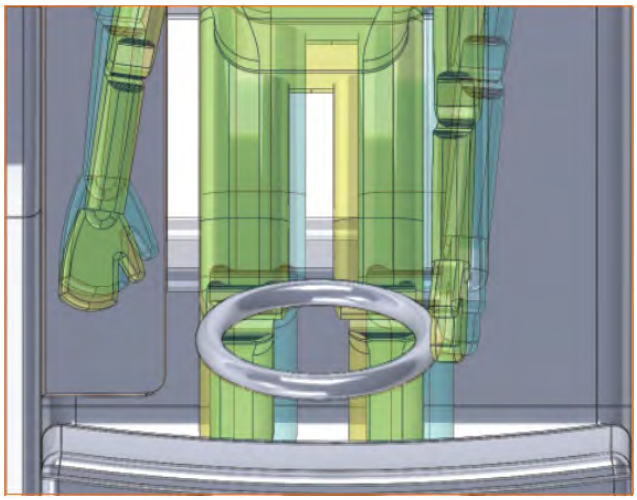


*Figure 31 - Interior Touch Points Top View*

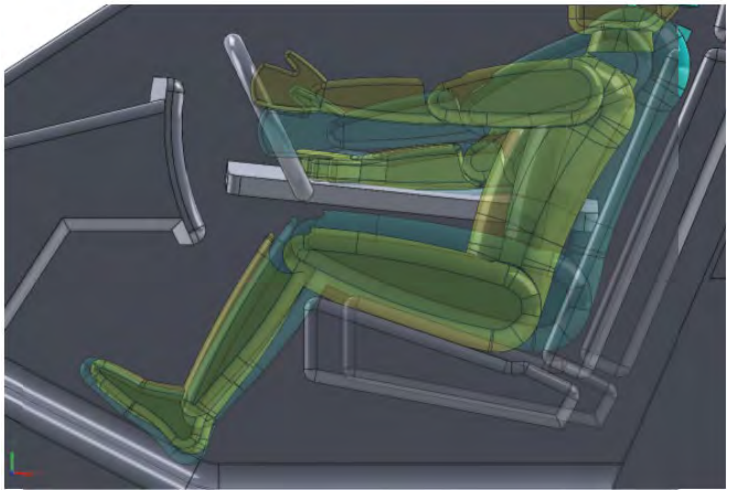


*Figure 32 - Interior Touch Points Side View*

The above figures show how the side control panel can be used by the users. The panel is a mounting location for the MTD tablet that is used by all officers. Panel than projects the information on the MTD to the front dash so it is within the viewing angle of the users as they are driving. On the panel there is also a touch screen control section which is used for inputting commands and communicating with dispatch and detachment.

## Analysis:

After conducting the study, many areas and touchpoints were analyzed to see if the dimensions chosen for the design were ergonomic to accommodate for multiple percentiles without losing usability and comfort. During the analysis, there have been areas that need further considerations, so the features of the design are viable for real users.

Observation 1:

In Fig. 13 you can see the foot positioning relative to the pedals, the seat is able to adjust by maximum 10 inches so the lower percentiles can reach the pedals to operate the vehicle. The pedals are placed at an angle of 30

degrees to sit parallel with the bottom of the foot of the driver. This done because it was pointed out during an interview with and expert advisor that the motion to press on the accelerator pedal and brake pedal using the heel and toes causes cramps and muscle aches in the lower leg over long periods of use.

Observation 2:

In Fig. 10 and 12 you can see the users interacting with the steering wheel which is 12 inches in diameter and 1.5 inches in thickness so it can fit comfortably for the 89th percentile which has a grip radius of 1.5 inches and the 95th percentile is 1.5 inches. The wheel is placed 12 inches from the dash for easy access and high control. The wheel can be adjusted vertically for different angles of use and different heights of use depending on the situation and percentile. The wheel can be adjusted by 8 – 12 degrees in angle and 2 – 6 inches in height. The wheel is not able to extend outwards due to the already condensed area of the cabin which would further only create more hindrances for the user if they needed to access something that is closer to the vehicle floor.

Observation 3:

In Fig. 12 and 13, you can see the user interacting with the right control panel that is mounted where the right door is supposed to be. The panel is placed 37 inches from the ground to support the lower percentiles and is angled on the x axis by 15 degrees and angled on the z axis by 5 degrees to follow the normal forms of the arms when bent. The panel is 7 inches wide and 30 inches long to support the windows surface tablet which is used as an MTD by officers and touch screen to input controls into the main dash screen. Upon further research and advise from the expert advisor, it would be better to consider putting the command center in the front viewing area of the user rather than behind it because it would be hard to input commands while driving if the user cannot see what they are typing. If the command center is the front, it can be adjusted in a way that can provide an easy way to input

commands without getting distracted while driving and act as a hand rest so there is no discomfort over long periods of use.

**Limitations:**

An area that poses challenges is the steering, if the user is bigger than 95th percentile, they may have a hard time sitting and using the wheel, since there is not much space in the back due to the storage unit in the back to push the seat back to make space for the legs to access the pedals without hitting the bottom of the dash. Which limits space for their arms to control the vehicle comfortably.

Another area is that due to the slimness of the design, there is not much space to move around the vehicle fluidly for the bigger percentiles and they may have a hard time reaching lower areas in the vehicle if they need access or if they dropped something. This will also affect the ability for the user to do any paperwork within the vehicle.

**Conclusion:**

The study of the one-to-one model provided insight into areas that had problems to accommodate that proposed percentiles, after the analysis the changes were made on the ergonomic drawings to accommodate for multiple different users. Further research is required to look into innovative way to accommodate the necessary needs of the user without losing space in the cabin.

### *3.4 Aesthetics and Semantic Profile*

Taking in account of the environment of use where the solution will be operated, the aesthetics and feel should match accordingly. The design will be focused on functionality for the driver with minimal space for form

exploration and expressive style. On another note, the overall branding of law enforcement will be adopted to a certain point to validate the environment of use and feasibility.

As the solution tips toward a vehicular design, the aesthetics of the body will dictate how the solution is perceived the general public and law enforcement officials. Durability and Maneuverability will be guidelines for designing the exterior features of the solution and functionality and ease of use will be for interior features. Maximum visibility is key to the viability of this solution as well protection from the elements, large physical obstacle on the road, road blockages.

Using the blue-sky technique to start the design development, it provides exciting insight to concept vehicle explorations, allowing to study forms that are unique and enable a higher level of creativity that may have been limited due to today's manufacturing capabilities. The following Mood board was created to help steer the solution towards modern and futuristic styling without sacrificing functionality.

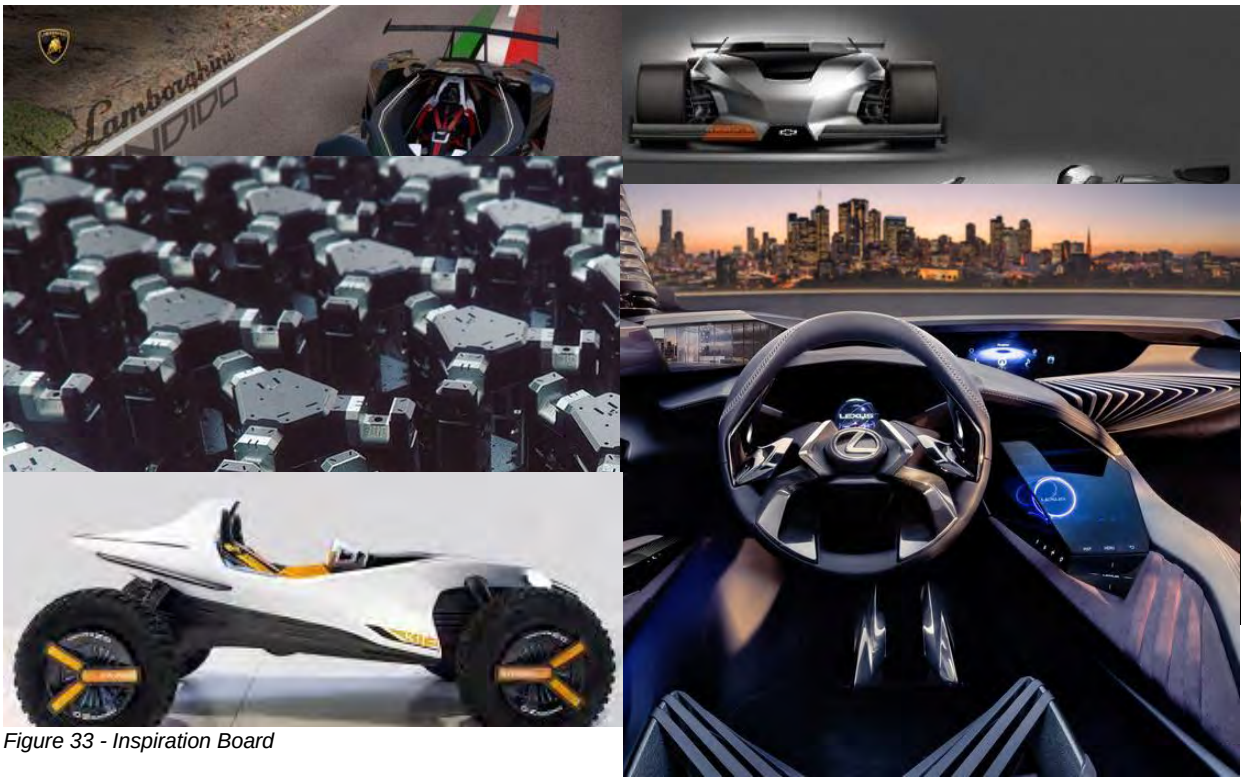


*Figure 33 - Inspiration Board*

### *3.5 Sustainability – Safety, Health and Environment*

Sustainability has become the new trend in automotive industry as each company is creating concept cars of sustainable means in their eyes, but the ultimate goal is to get rid of carbon fueled vehicles and transfer over to electric vehicles to tackle the global warming crisis. Internal Combustion vehicles are the leading cause of global warming as one vehicle produces 4.6 metric tons of CO2 emissions annually.

#### *3.5.1 Sustainability – Environmental Initiatives*

As new technology emerges as the auto industry evolves, new sustainable initiatives are also being introduced so the focus of car companies is not only on aesthetics and performance. Majority of the initiatives are being implemented by governments of various countries to lead transportation towards an emission less future. One example of this is the European Commission of the European Union, is putting pressure on European vehicle manufacturers to have 55% cut in their CO2 emissions by 2030 and 100% by 2035 making it impossible to manufacture and sell carbon fueled vehicles.

There are new start-ups and companies around the world, that are trying to solve the crisis of recycling of Li-Ion batteries. Even though the functionality of Li-Ion batteries is sustainable for the environment but the process of acquiring the base materials has a huge impact on the environment. Li-Ion batteries are not fully recyclable, about 5% of the whole battery can be recycled. To minimize the impact and increase the percentage of recyclability of Li-Ion batteries, Companies like Redwood Materials and Li-cycle are creating new technology and green processes to recycle batteries to their original grade to be used again.

### *3.5.2 Sustainability – Health Initiatives*

One new technology that is being slowly implemented in new vehicles is Facial Recognition, the main purpose of this technology is to act as a security measure to protect your vehicle being accessed by strangers. Another implementation of the tech that is focused on keeping drivers safe and focused via face tracking, this includes monitoring emotional cues on the face, driver gaze and biometrics with additional tech added into the vehicle hardware such as heartbeat reader in the steering wheel etc. All this acquired data is than combined and analyzed to provide advice to driver to keep them safe and others on the road. One example of this when the driver experience's drowsiness, the on board would recommend pulling over and get rest before continuing the journey. Visage is the new company in the market that is implementing this tech in new vehicles.

In response to Covid-19, companies have started to look toward providing a clean driving environment by adding UV lights in the cabins to kill any viruses and bacteria. Being exposed to UV rays is also harmful to humans, so creating solution that does not affect the drivers and passengers is still under development. Another feature that is being upgraded is the air filtration system, which is now being upgraded to a N95 filtration system to prevent any germs and bacteria into the cabin. This is has already been implemented in a SUV by Geely.

### *3.5.3 Sustainability – Safety Initiatives*

The major trend for safety in future vehicles is full automation, meaning the vehicle can drive in any condition and terrain while still providing the option for the driver to take control. Full automation gets rid of any human errors and everything consistent when driving, from the route, to speed and awareness of others on the road. Even though we only have minor features that are paving the way for full automation like lane assist, adaptive cruise control, and pedestrian automatic emergency braking are some to name.

Another system that has become a standard in new cars since 2020 is ADAS (Advanced Driver Assistance System). ADAS is an onboard monitoring system that monitors all the safety features in the vehicle and potential obstacles on the road such, traffic jams, pedestrian, road signs etc. After analyzing the obstacles, it than sends out insights to the driver to adjust in their routes or takes control if it is an emergency such as collision warning with automatic braking.

### *3.6 Innovation Opportunity*

After researching multiple aspects of sustainability in the automotive industry, ranging from more ecofriendly materials to new initiatives to provide a safer and aware experience, most of them can be implemented into Tyren as they are or with some upgrades as the industry evolves. Some examples of this are interior fabrics made from Econyl or Vega Leather, instead of using one time use Li-ion batteries, creating a recycling and distribution system using recycled batteries from new companies as Li-Cycle. To lower the energy consumption of raw materials to create solar panels, the solar panel can be made from peppermint and walnut aroma to decrease the impact at the end of the life cycle. As for health and safety, new technologies are headed into the right path. Monitoring facial expressions and biometrics will help police officers take care of themselves better as they are on the road for more 12 hours on the road patrolling our streets.

#### *3.6.1 Need Analysis Diagram*

After collecting data relevant to the problem definition, some key insights that were observed were that the end design solution must have a high level of ergonomics, intuitive to make every tool easily accessible to the officer when they are conducting their duties, and Safety, having a safe driving experience for the officer and pedestrians when travelling at high speeds. To fulfill all these requirements, the choice of materials, technology and sense of

functionality will play a huge role in the final solution. Below are some new materials that are just as good or better than their local counterpart in the sustainability area.

| Materials | Benefits | Disadvantages | Reference |
|---|---|---|---|
| **Econyl**<br>- Interior<br>- seating | It is made from nylon waste and recycled to make new nylon strands | Can be any color, various tensile strength, and finishes. | https://www.econyl.com/ |
| **perovskite solar cells made from peppermint oil and walnut aroma**<br>- Roof | Replaces traditional solar cells made from a hybrid form of lead and tin. Has higher efficiency levels from standard solar cells. | Environmental impacts when lead leaks due degradation of cell | https://www.advancedsciencenews.com/eco-friendly-perovskite-solar-cells-made-from-peppermint-oil-and-walnut-aroma/ |
| **Recycled Li-ion Batteries**<br>- interior | After the lifespan of Li-ion batteries are thrown into the dump, the batteries are recycled for their more internal materials, Cobalt and nickel and some part of the lithium to make the new batteries | Lower life span than new batteries. | https://www.datacenterdynamics.com/en/opinions/a-future-with-sustainable-profitable-lithium-ion-battery-recycling-is-closer-than-you-think/ |
| **Vegea Leather**<br>- **Seating** | Vegea is vegan leather made from grape skin and seeds, making it composable and easily recyclable | | https://www.vegeacompany.com/ |
| **Continental Renewable Tread Tires** | The treads can be replaced easily at least three times before disposing the complete tire. 80% of the tire is made from organic or recycled materials | | https://techcrunch.com/2021/09/08/continentals-eco-friendly-concept-tire-includes-a-renewable-tread/ |

*Table 11 - New Sustainable Materials That Are Being Implemented*

Along with new materials that are slowly emerging from all corners of the world and being applied in innovative ways in new concept vehicles, new manufacturing processes are not far behind to setting new global standards in vehicle manufacturing.

Econyl is a new process for manufacturing nylon textiles from waste that floats around in our oceans and in our homes such as old fishing nets, old carpets, industrial plastics, and fabric scraps. After all the waste is delivered to the Econyl factory, it is processed and cleaned for extracting all the nylon from the waste. After that the nylon scraps are shredded and recycled back into strings as it was new. No additives or chemicals are used during this step. From there the strings are rolled into yarns and polymer rolls for various industries. Econyl can be recycled infinite times so, companies can send their old products back to the factory to go through the regeneration process repeatedly.

Goodyear has been experimenting with creating a process for extracting raw materials from cured tires (tires that have gone through Vulcanization process). The process is called Devulcanization. So far, they have been able to extract up to 80% of raw materials from scraped tires. This could be the new industry standard process once it is scaled up on a commercial level and up to 800 million tires can be recycled each year in North America alone.

### *3.6.2 Desirability, Feasibility, Viability*

When looking for justice, the public turns towards to those who are given the position to uphold the law, Police Officers, to fulfill their duties to the best of their abilities, officers need tools to help them such as transportation, safety vests, firearms, and etc. Major being transportation, if officers cannot reach the location where the public needs their help than there is no point of their existence. Now with current modes of transportation, they are not efficient enough to help carry out the duties of law enforcement due to being too big for condensed areas and small roads and being constantly halted either by traffic, construction projects, large vehicles, and even the public.

The following section analyses similar products, technological solutions, and manufacturing methods for the proposed law enforcement urban mobility vehicle to determine different materials and costs to validate the feasibility of the proposed solution.

Regarding manufacturing, the exterior manufacturing would be the same as current methods and practices used in electric automotive manufacturing. The only major addition would be the application of large solar panels being applied and acting as exterior panels. The interior would require combination of automotive methods and fashion textile production methods due to the fabrics used are most used in the fashion industry.

## *3.7 Summary of Chapter 3 – Defining Design Brief*

After the analysis conducted on various types of research, a design brief is developed. A design brief is intended to focus the research to create specific guidelines. In this case of this thesis, the brief focuses on developing a solution which increases mobility for police officers in dense city environments. The design brief will be refined and improve throughout the thesis development process.

### Thesis Design Brief

The goal of this thesis project is to design a vehicular solution for police officers that are stationed in dense urban cities. This vehicle should be able to see and overcome obstacles on the road before hand to efficiently plan out the fastest routes to location of high priority calls.

| | |
|---|---|
| Safety | Developing a safe driving environment for police officers when travelling at high speed, patrolling certain areas, avoiding obstacles on the road, and protection from potential assailants. |

| | |
|---|---|
| Ergonomics | Create a new workspace for officers with the vehicle that puts all the important features within hands reach, while maximizing visibility. |
| Aesthetics | The overall form must inspire confidence and bravery, motivating them to conduct their duties without constant stress and panic to help the person in need. |
| Intuitive and Trustworthy | The technology and tools that are considered for the design must be intuitive for the user and everything must be easily accessible. This should promote trust and confidence for the officer in the vehicle, letting them do their duties with efficiency. |
| Integration of New Technology | Adopting new technology in the automotive and safety fields will be critical for this thesis. Using AR technology to make informed decisions in stressful situations. Drones to analyze targeted areas beforehand will save time so the user can focus on more important aspects of their duties. |
| Versatile | The design has to be versatile to be able to work in all types of weather conditions and road and terrain conditions. Should be able to accommodate various types of tools and firearms. |
| Sustainability / Less Harmful to the Environment | The materials used to manufacture this solution should have minimal to no environmental impact is essential, along with converting to electric energy to power the design will help save cost of fuel and environment when driving for long durations. |
| Comfort | When operating the vehicle for long durations, it can lead to discomfort, pains and long-term medical issues in the back and leg. To provide a seating solution that adapts to the users form and promote correct posture for long term use would encourage comfort and positive emotions. |
| Storage Solutions | External storage solution that can hold extra equipment, uniforms, and tools that the officer might need in the day. A built-in smart gun |

| | |
|---|---|
| | locker to hold larger firearms that only opens with officer credentials. |
| Ease of Communication | The user must be able to instantly communicate with dispatch and other officers in the area without getting distracted while driving, so they do not put themselves and others risk but still get all the necessary information the officer needs to conduct their duties. |

*Table 12 - Thesis Design Brief*

The goal for local transportation is to transfer from combustion engines to electric powered vehicles to tackle global warming crisis and lower emissions during production, use and end of life stages of vehicle while taking away the steering wheel away from the driver and going full automation to have less accidents on the roads. While providing a unique user experience to drivers and passengers. All these new initiatives are good for consumer vehicles, but major tweaks must be made for law enforcement vehicles due to the functionality is completely different.

# CHAPTER 4 – DESIGN DEVELOPMENT

*Figure 34 - Retrieved From: https://unsplash.com/photos/XS7q-baZrmE*

# CHAPTER 4
# Design Development

## *4.1 Initial Idea Generation*

After conducting research on the various aspects of the chosen problem definition, the design process can begin. To create a path on which the design process can be focused upon, a mind map was created focusing on three categories, *User – Products – Environment*. This would help get to the root areas on which a solution can be born from. Making sure that the design did not just turn out to be another car to add to the massive fleet on the streets of Toronto was a massive challenge from the beginning of this project, this also includes styling choices, which would ultimately lead the design toward a more of a utilitarian design. The ideation phase includes many aesthetics and visual styles as inspiration leading the design toward refined aggressive forms while keeping the overall choices public friendly.

### *4.1.1 Aesthetics Approach and Semantic Profile*


*Figure 35 - Inspiration Board*

The inspiration board on the previous page, was created to have styling references for the ideation process and generate new ideas and lead away from the conventional design language of current police vehicles. Companies like Lamborghini and Lexus were used for exterior styling inspiration and Hyundai products were used for their organic forms in their interior as reference in this stage of the process.

### *4.1.2 Mind Mapping*

A mind map was developed to better understand the target audience and their preferences based on the products they currently use and the environment of use which would direct the design direction the most viable path and create a focus when generating ideas. The blue notes are the general categories and yellow are specific products and descriptions. The green notes are pros and red notes are the con's.


*Figure 36 - User - Product - Environment Mind Map*

### *4.1.3 Ideation Sketches*

During this stage six different concepts were created, which target different areas and function in the journey of police officer. The sketches were developed on Apple iPad Pro 12.9", with Procreate as the creating medium. At this point, since all the concepts were just ideations, no names were given to each concept until the final design direction is finalized. The goal of this process was to generate as many ideas as possible that are intended for completely different areas and styling aspects, so many possibilities are available that could be evolve and/or merge together for the final direction.

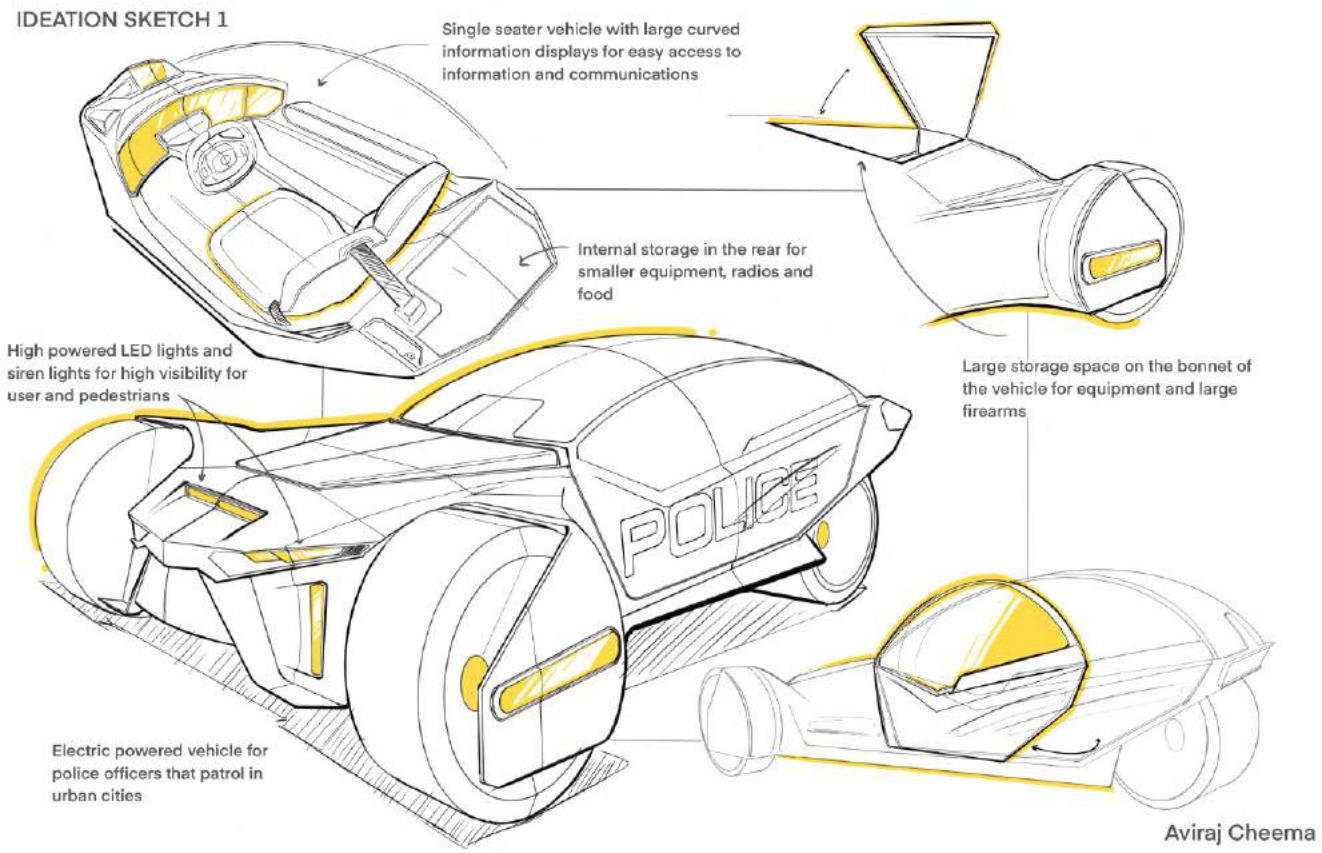



*Figure 37 - Ideation Sketch 1*

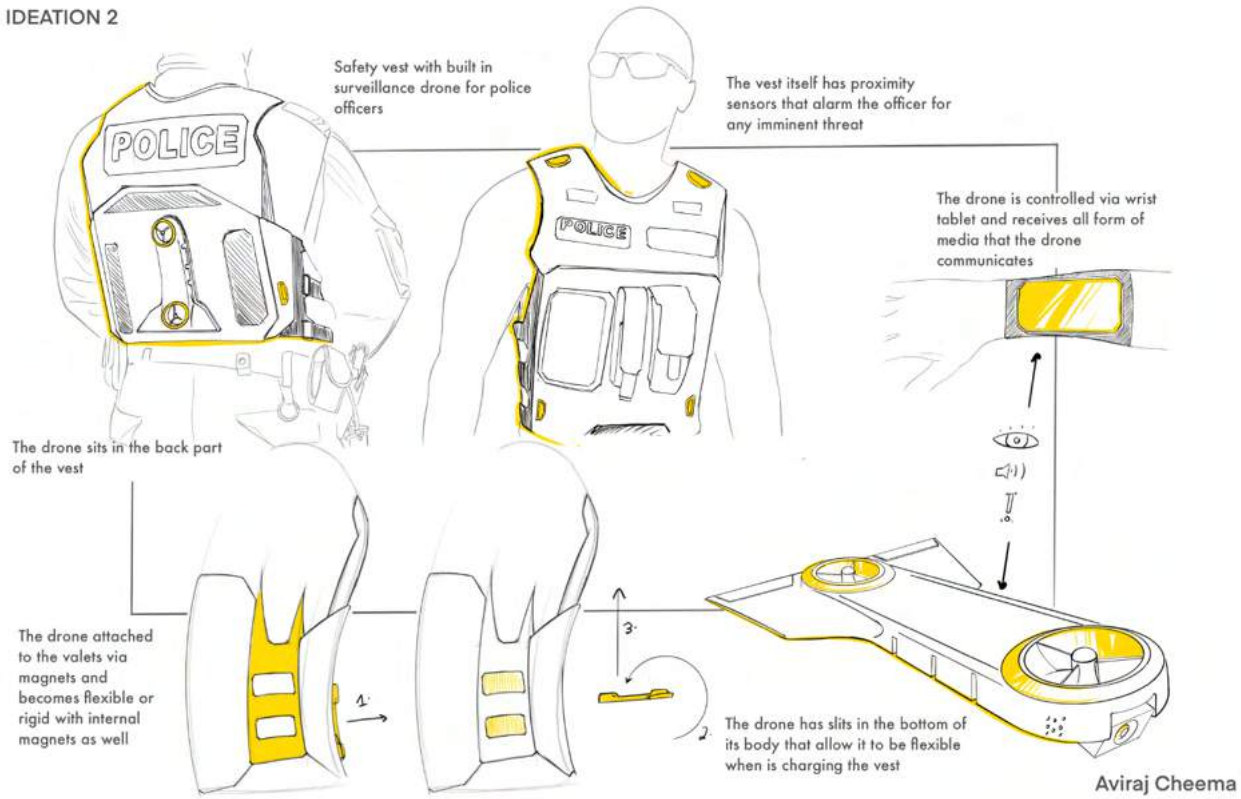



*Figure 38 - Ideation Sketch 2*

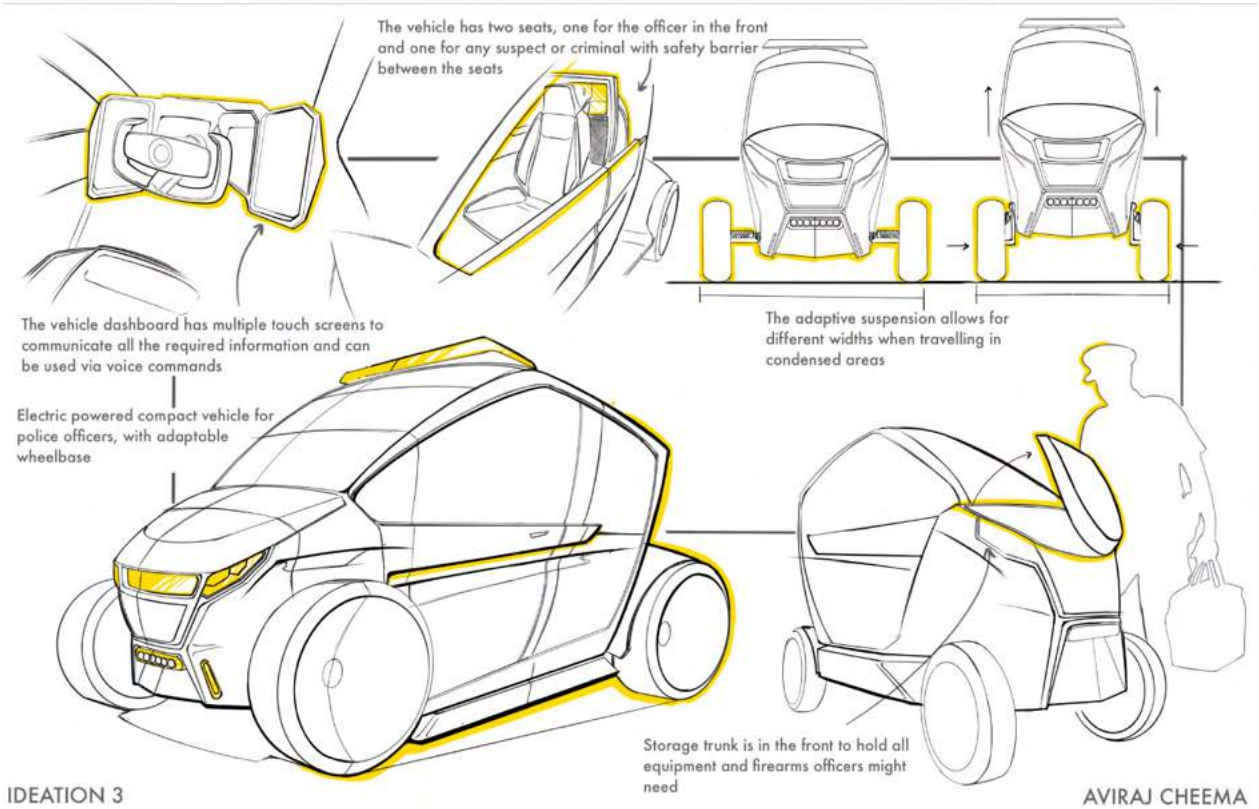



*Figure 39 - Ideation Sketch 3*

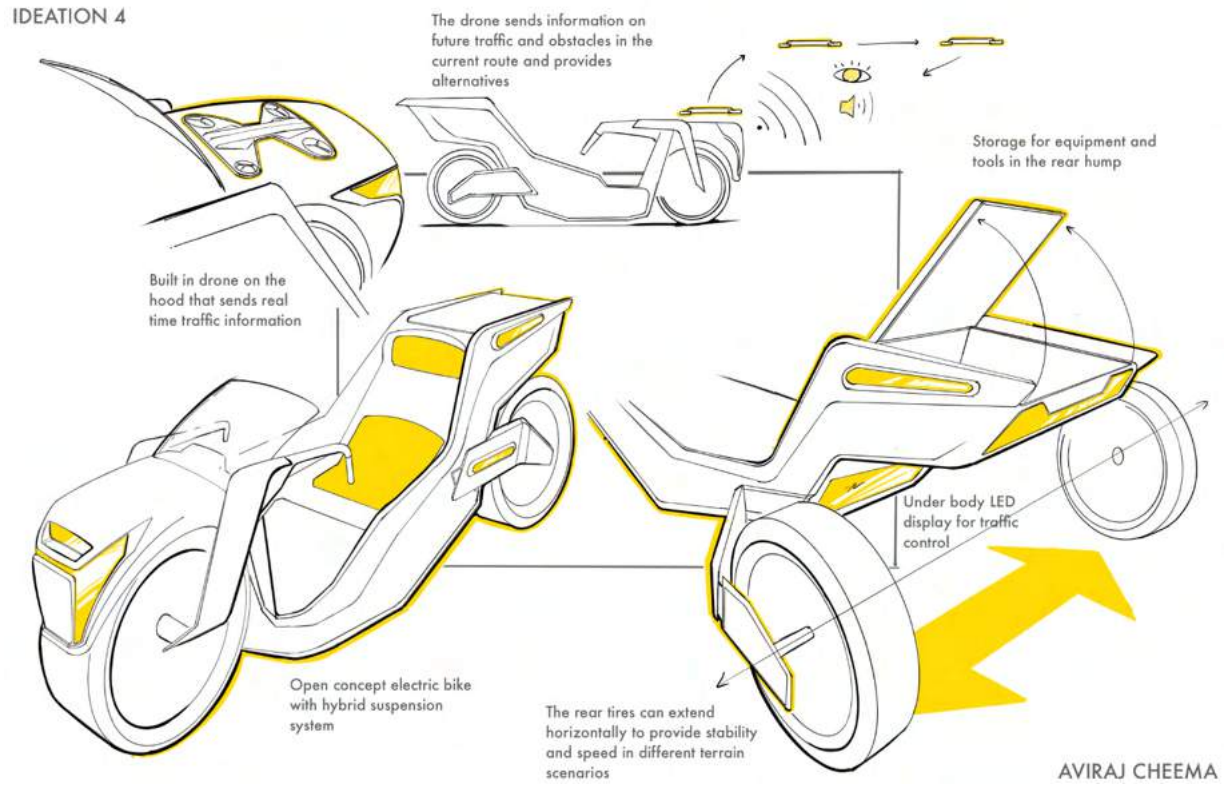



*Figure 40 - Ideation Sketch 4*

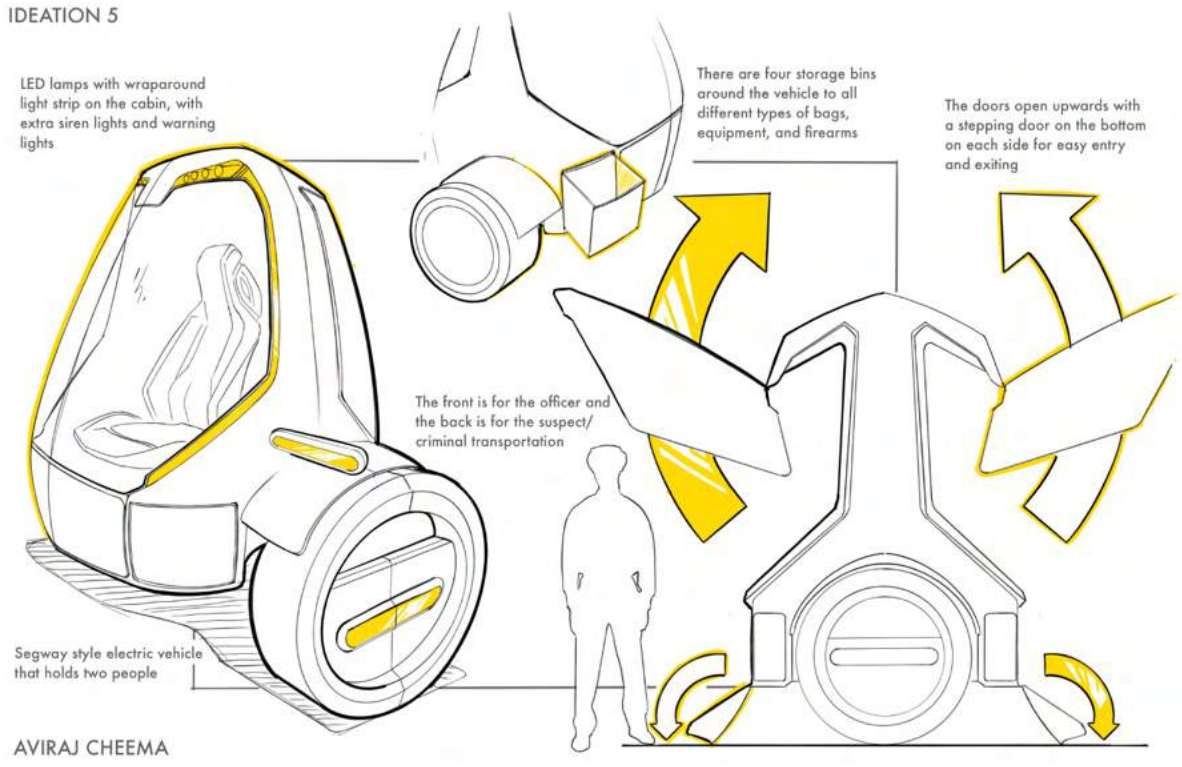



*Figure 41 - Ideation Sketch 5*

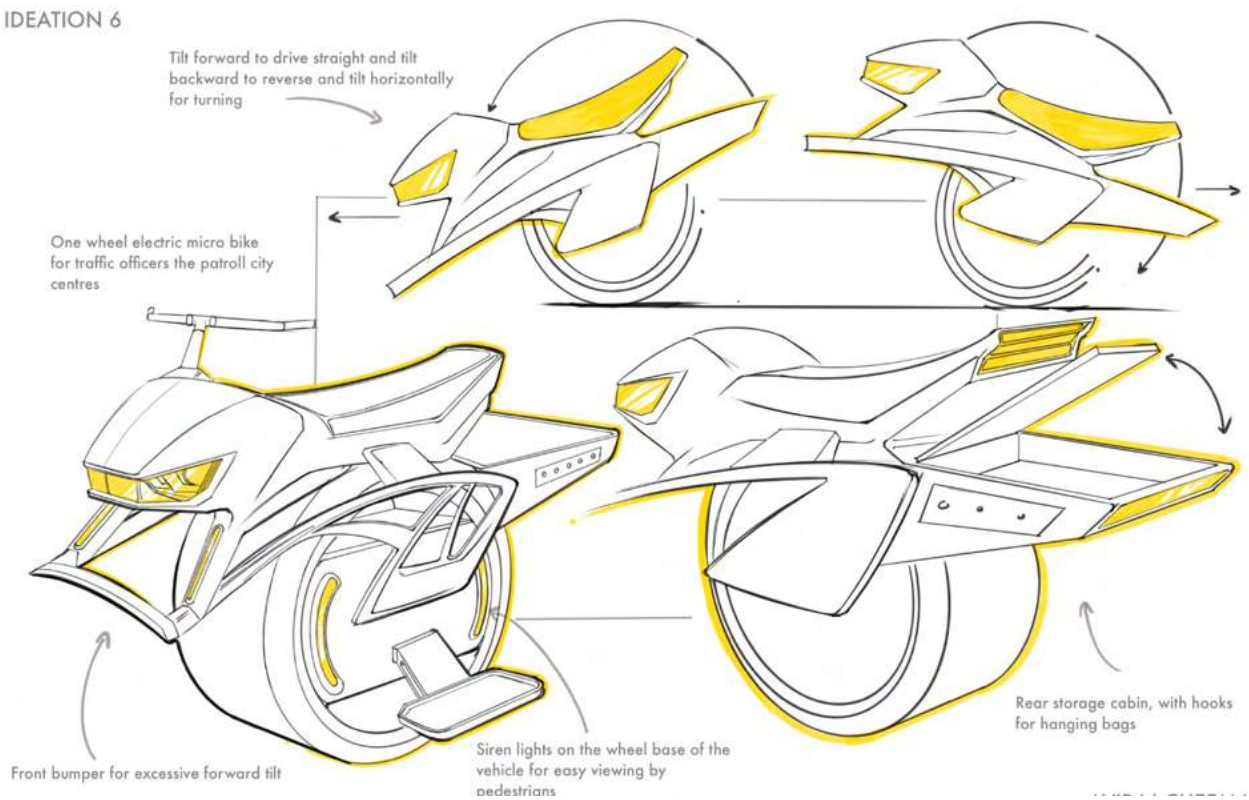



*Figure 42 - Ideation Sketch 6*

## *4.2 Concept Exploration*

From the ideation phase, three concepts were chosen that showed the most potential of evolution into a solution that can meet most of the user needs. The concepts chosen to progress were Ideation sketch one, three, and five. The major changes for ideation sketch one was to make the wheelbase smaller and condense the height a little, so it matches the proportions of the wheelbase. For ideation sketch three, the major consideration to make was to find a sustainable power source that can last for 10 to 12 hours without recharging. Ideation sketch five required major proportion changes because initially it was designed to be double the height of an average police officer, which would not be viable in a condensed traffic situation.

### *4.2.1 Concept One*

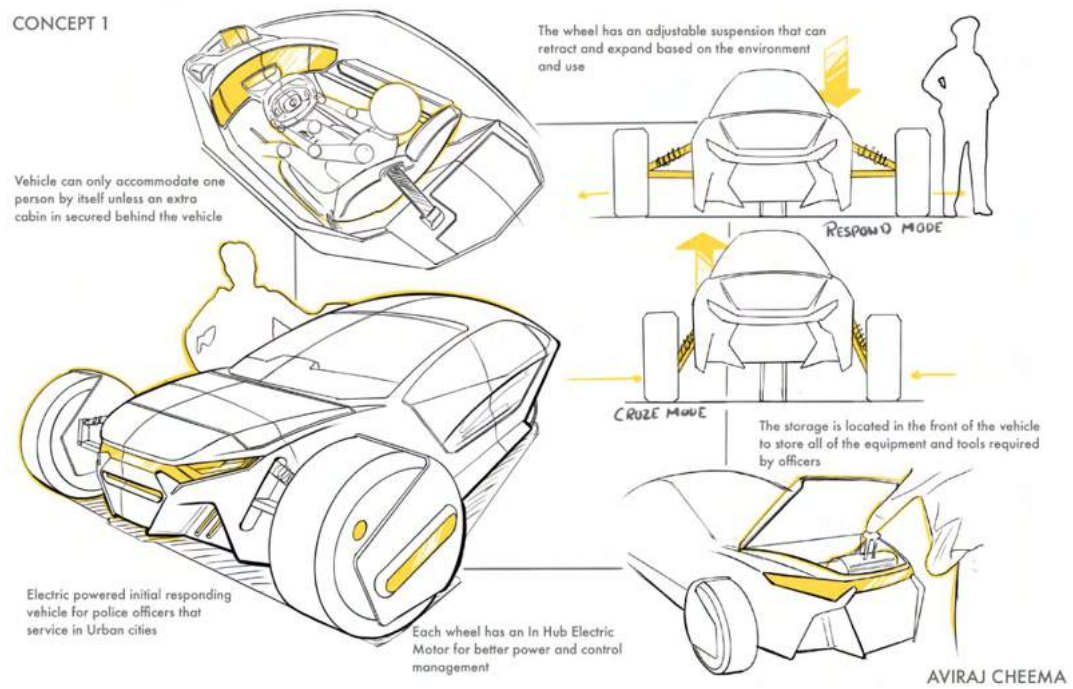



*Figure 43 - Concept 1 - P1*

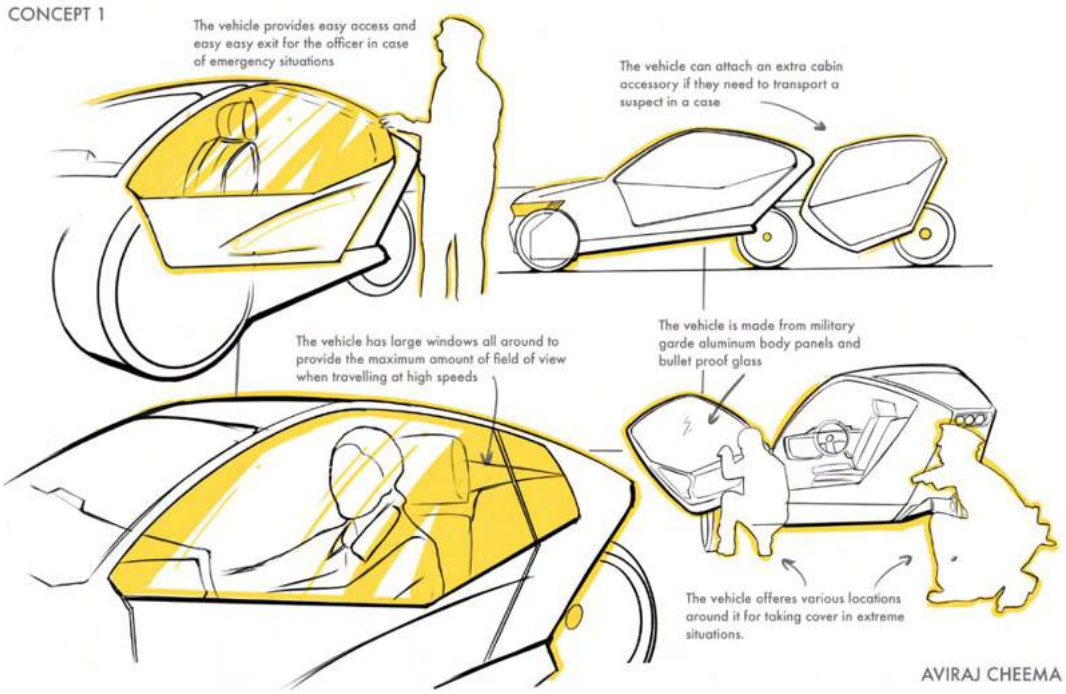



*Figure 44 - Concept 1 - P2*

Concept one is a three-wheeler solution made for one person. The focus of this concept, it is supposed to be a first responder that gets to the scene of the call first and assess the situation and reports to dispatch and services are called according to the scale of the situation. The concept provided high strength body panels with bulletproof glass. High level of safety features that ranged from proximity sensors to pedestrian warning systems. A fully electric powered vehicle that has sustainable storage to hold various types of tools, equipment, and firearms. It also has ability to for a add on carriage on the back that can carry suspects or other officers if needed. The suspension is a hydraulic based suspension which can change the ride height of the vehicle based on the situation. Such as in condensed areas the wheel width has to be smaller, so the suspension is lifted to fit tight spaces and in times of rough terrain or where high stability is required, the suspension is lowered to create more downforce and provide better maneuvering at high speeds. The interior was all digital screens that showed real time information regarding incoming calls, traffic, and other necessary information an officer might customize to their preference. The control panels were on the right door panel but there is no door on the right side, the system can also be controlled via voice commands.

### *4.2.2 Concept Two*

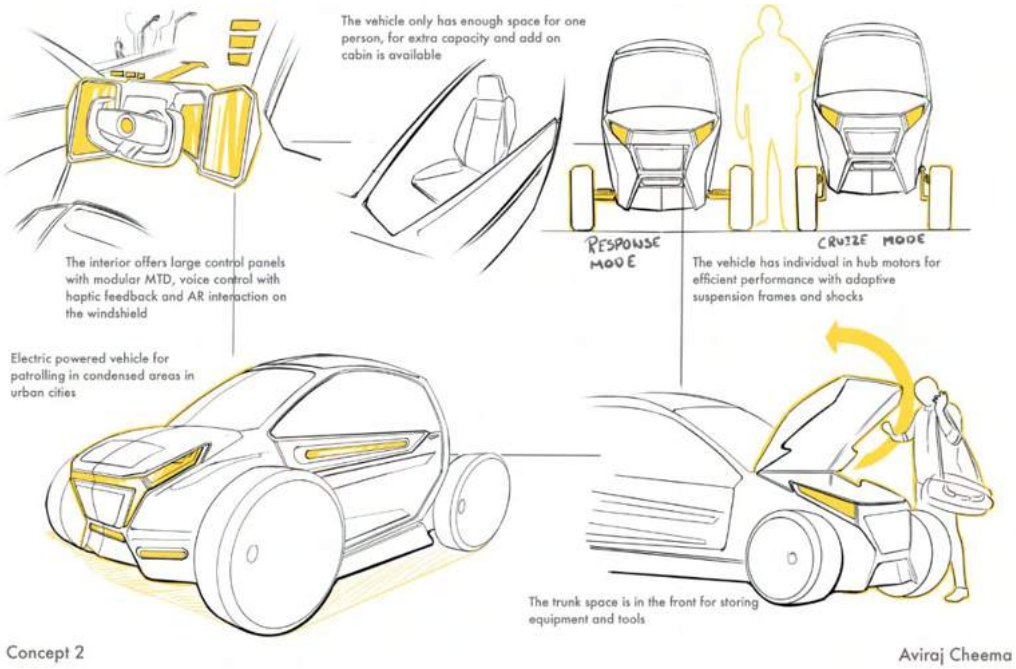



*Figure 45 - Concept 2 - P1*

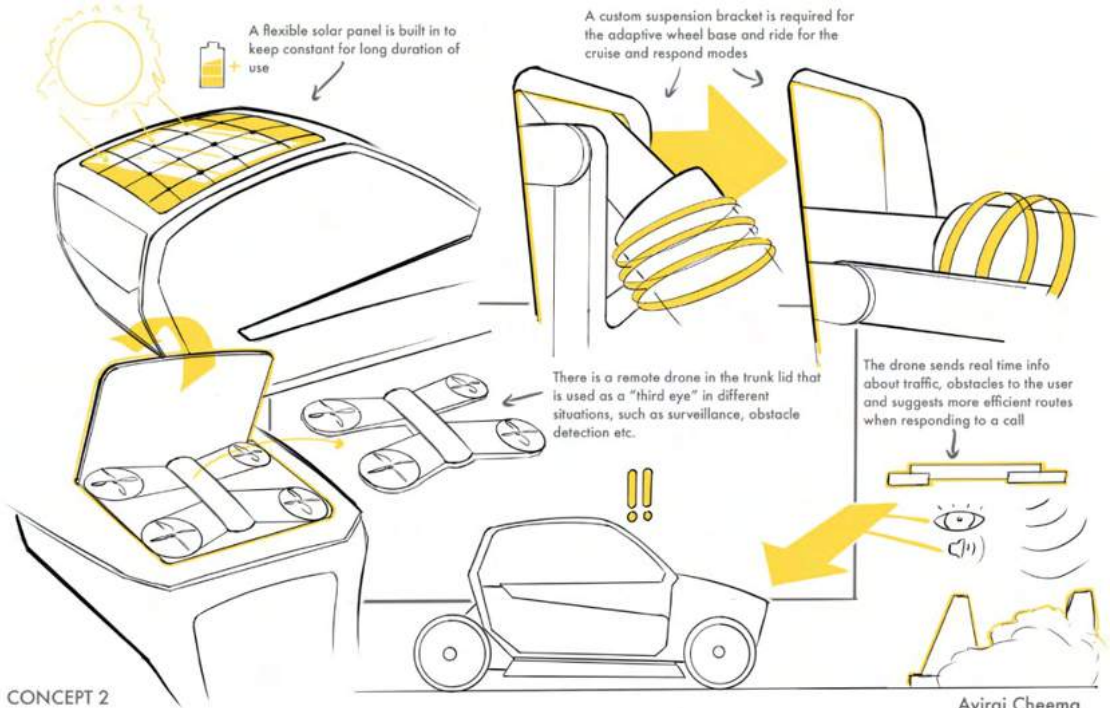



*Figure 46 - Concept 2 - P2*

The major difference in concept two from concept 1 is that the concept was designed while keeping micro vehicles in mind rather than a full-size car. The vehicle is a four-wheel drive with individual motors in each wheel to power. The power source is a full electric battery which is charged from the solar panel on the roof as the vehicle traverses the city roads. Another major feature is that the front the of vehicle holds a drone that files ahead of the vehicle and provides real time information about the traffic ahead and potential physical obstacles on the road that would increase the response time of the vehicle when responding to incoming calls. The information is than displayed on the Artificial Reality display on the windscreen and the on-board computer plans an alternate route accordingly, so no unnecessary time is lost.

### *4.2.3 Concept Three*

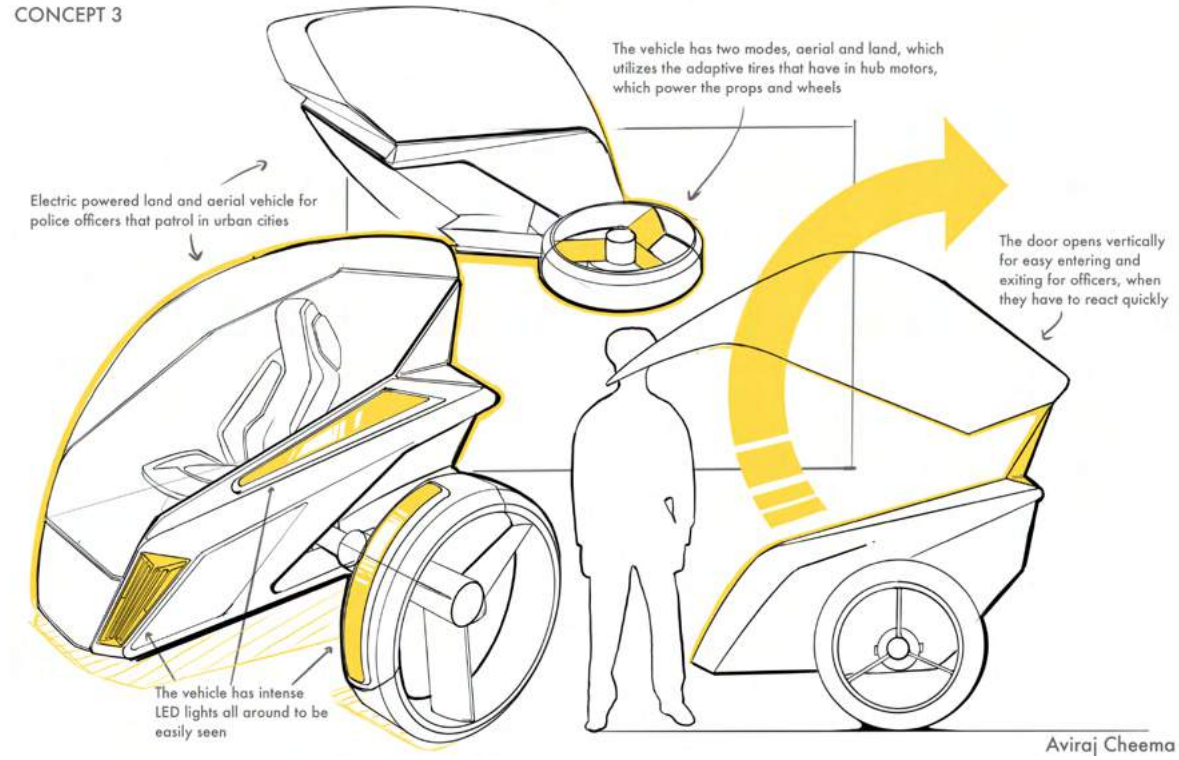



*Figure 47 - Concept 3 - P1*

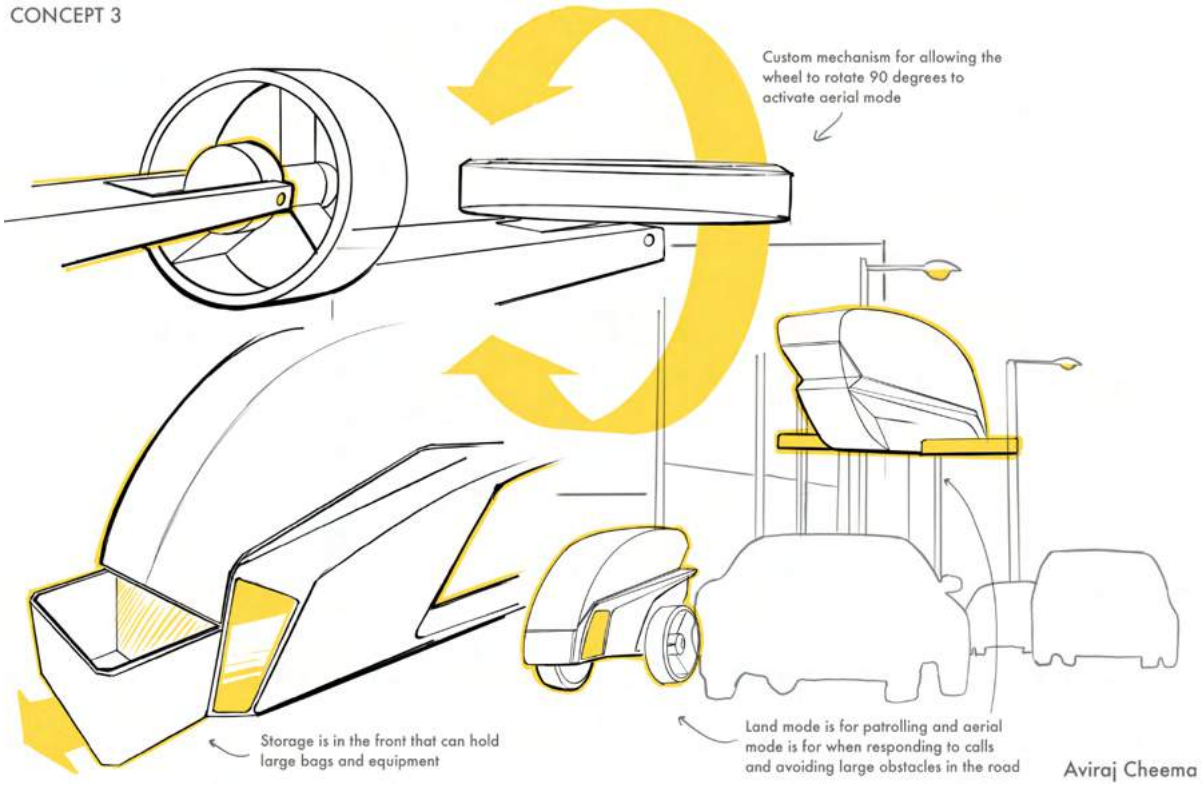



*Figure 48 - Concept 3 - P2*

Concept three took on more of a blue-sky path when developing. Other than the proportion changes, the concept took on various environments of use. The concept is an two wheel vehicle that can be used on the road and the air. The wheels have the ability to rotate 90 degrees and act as propellers that would provide the lift for the vehicle. Rather than having conventional controls like a steering wheel, the controls are swapped for two joysticks, one on either side allowing for entry and exit space for the officer.

### *4.3 Concept Strategy*

To move forward with a bit more focused direction that allowed ergonomic studies to be conducted, Concept One and Concept Three were chosen because they provided two distinct opportunities for ergonomic studies that put the user interactions in completely different realms. For the refined sketches, iPad Pro with Apple Pencil were used, along with Procreate as the developing medium. The product schematics were created using Adobe Illustrator showing elevation views for each concept with relative measurements for each percentile person and the various interactions between product and user.

### *4.3.1 Concept Direction and Product Schematic One*

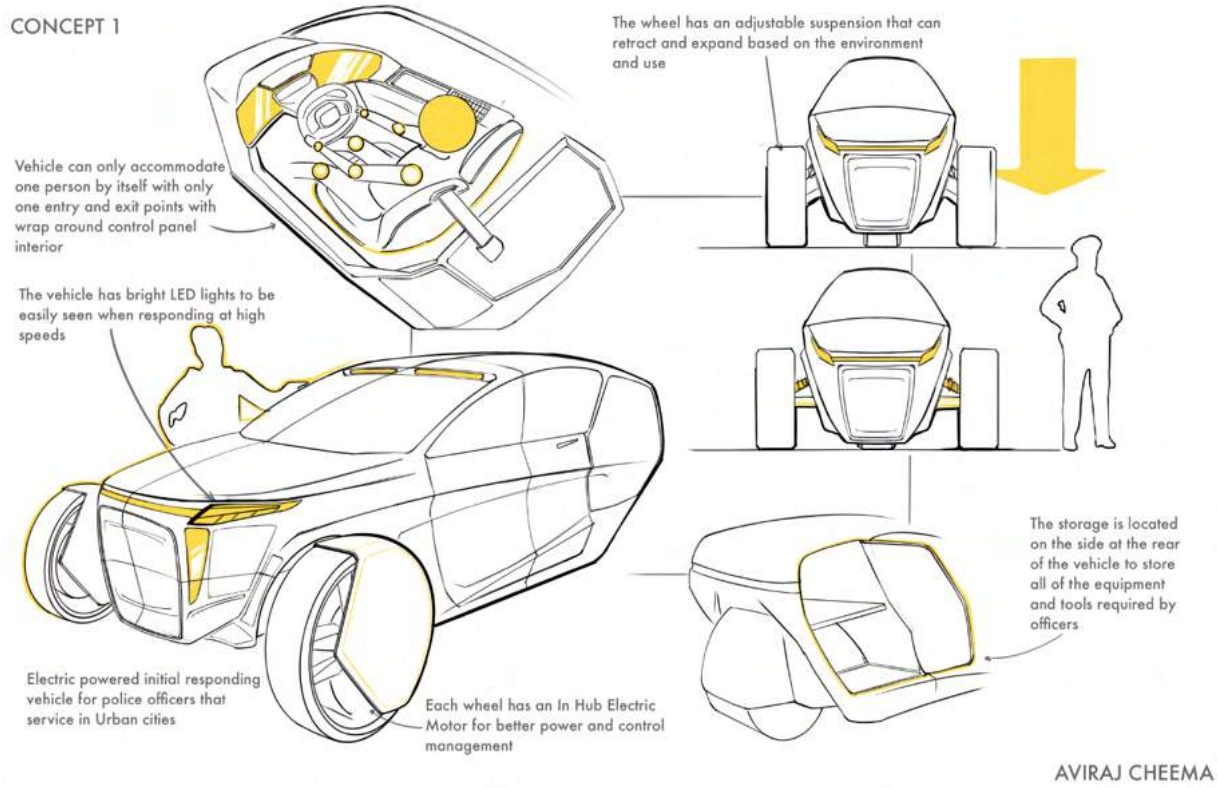



*Figure 50 - Concept 1 Refinement - P1*

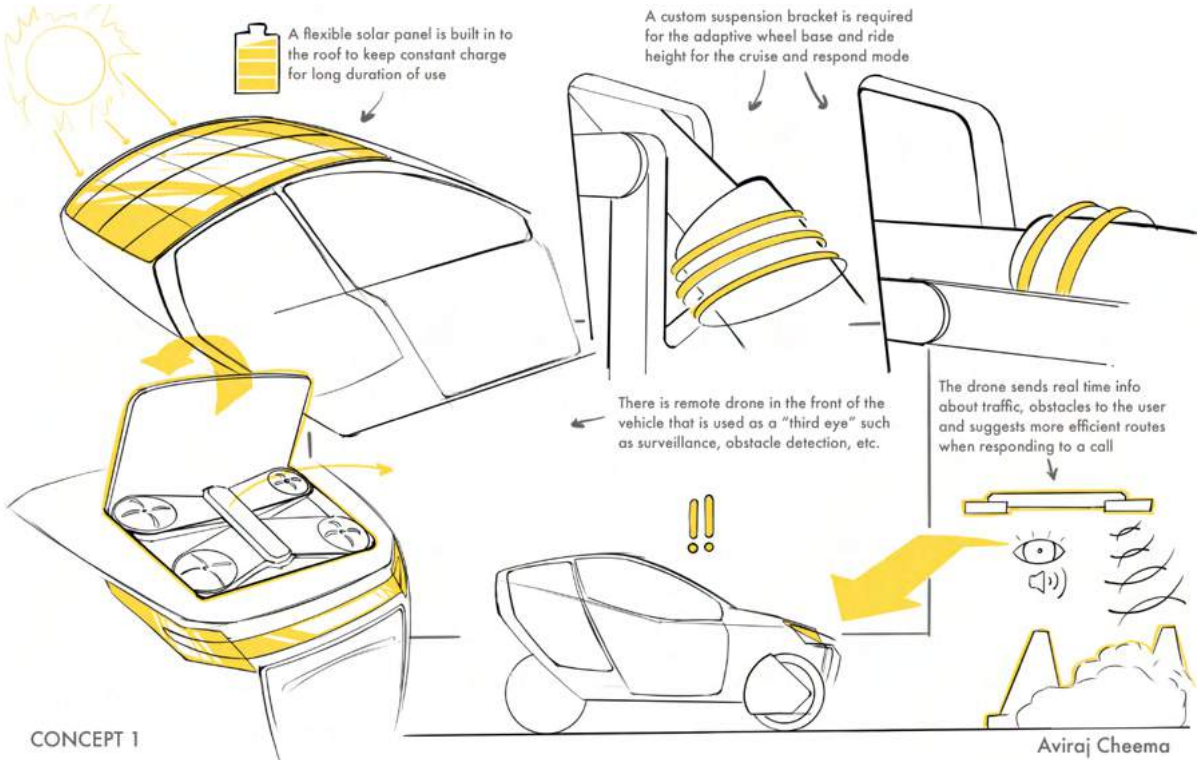



*Figure 49 - Concept 1 Refinement - P2*

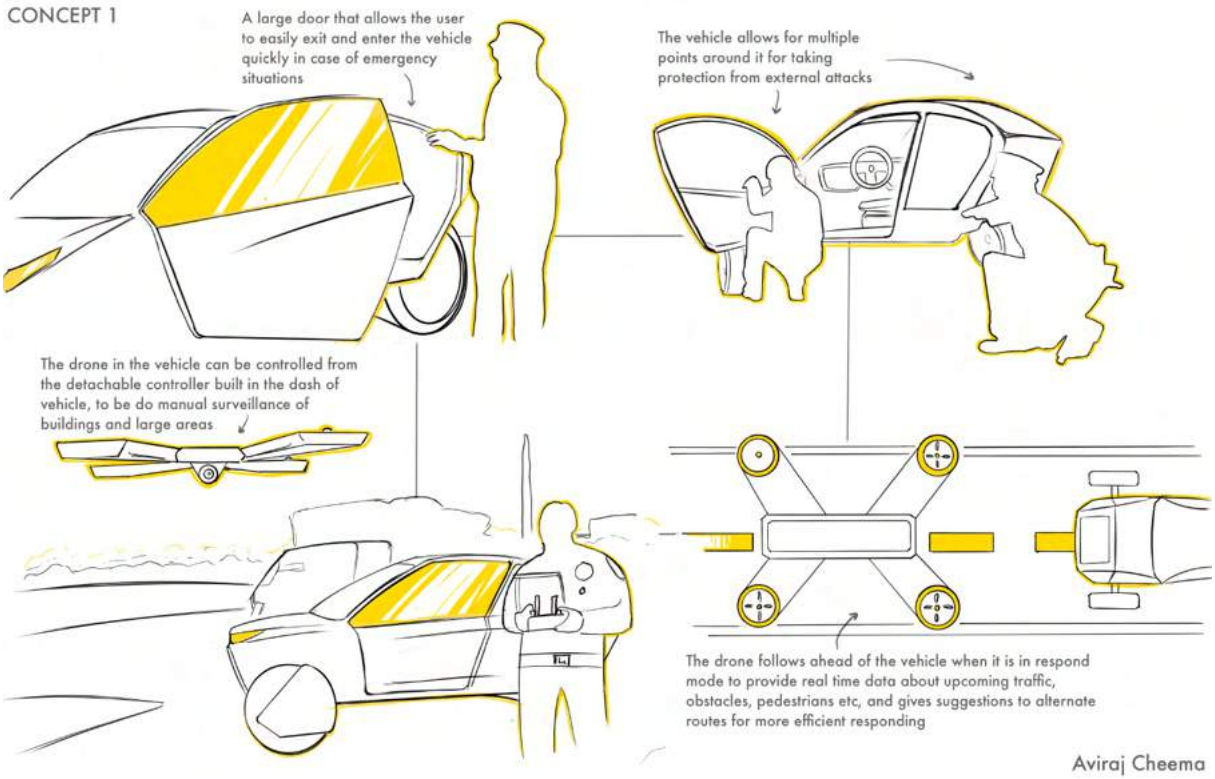



*Figure 52 - Concept 1 Refinement – P3*

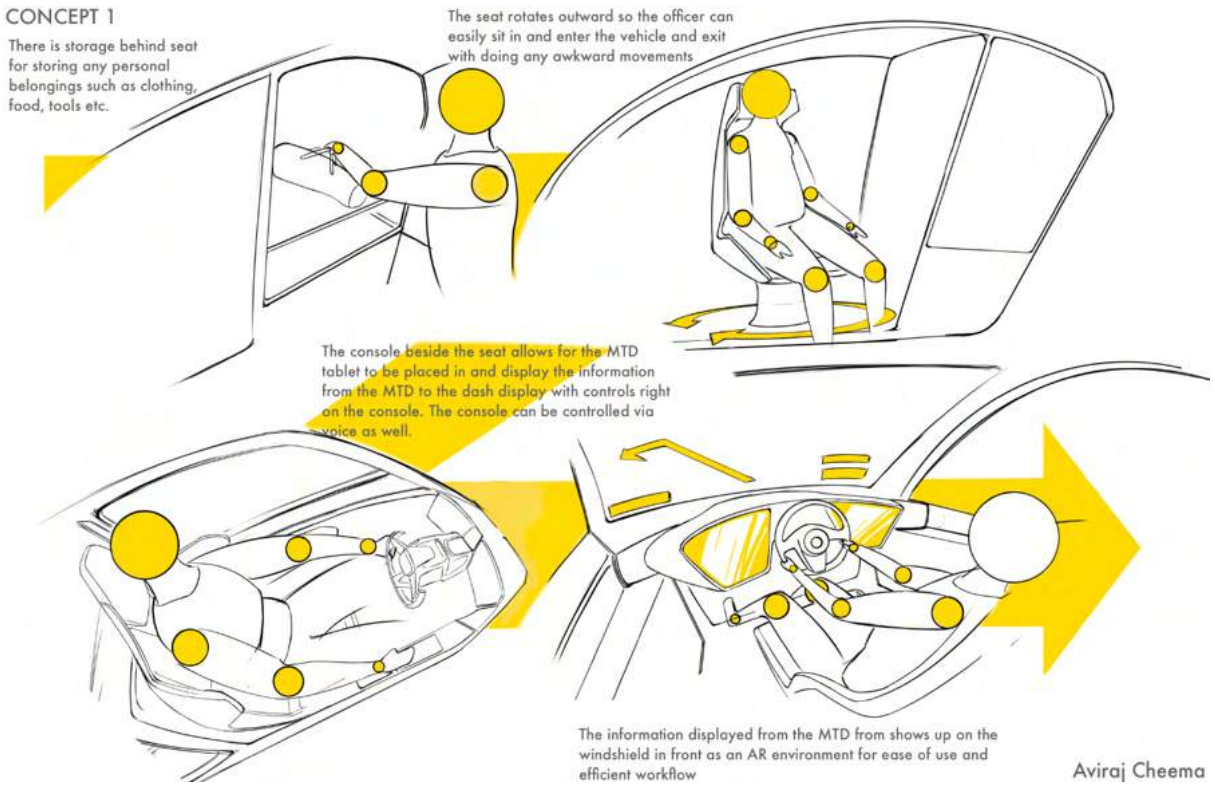



*Figure 51 - Concept 1 Refinement – P4*

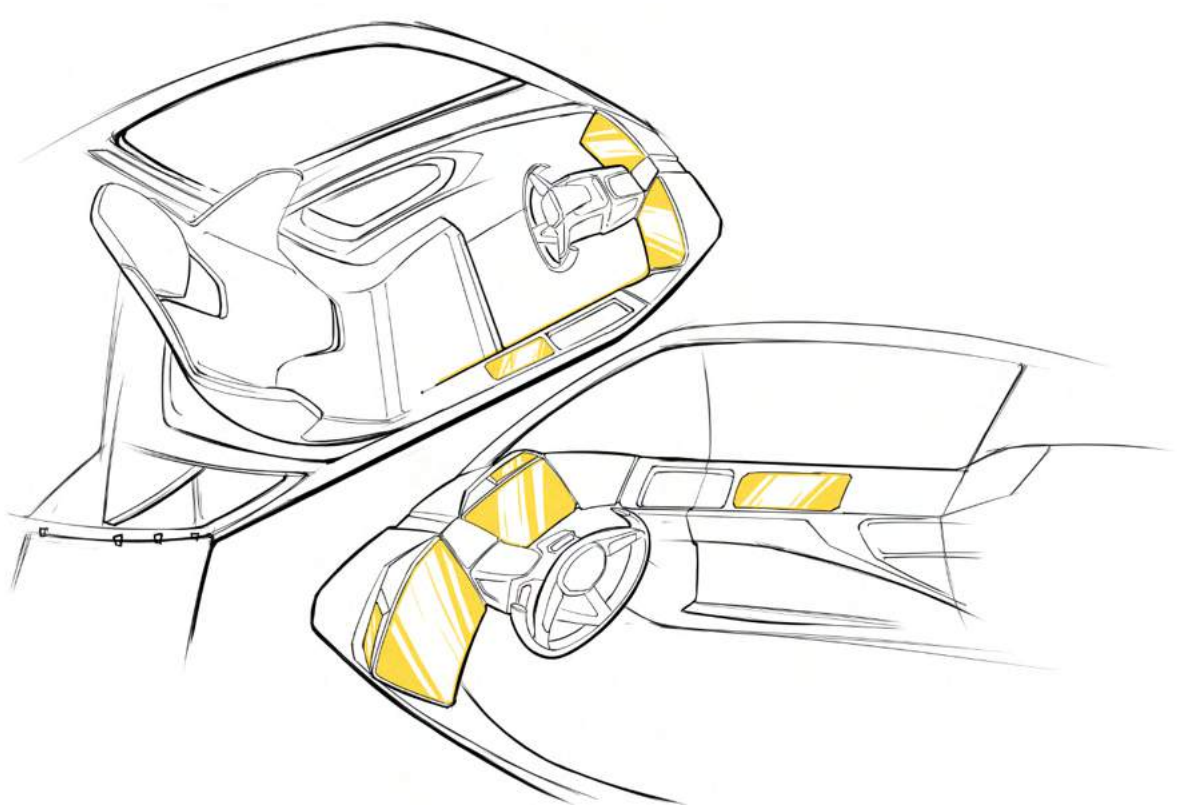


*Figure 53 - Concept 1 Refinement - P5*

## Product Schematic and Configuration Diagrams

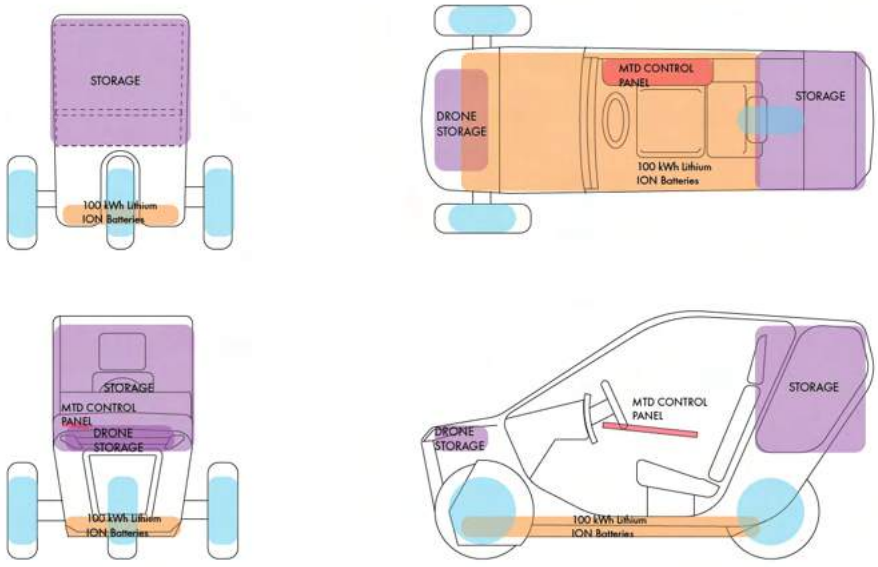



*Figure 54 - Concept 1 Configuration Diagram*

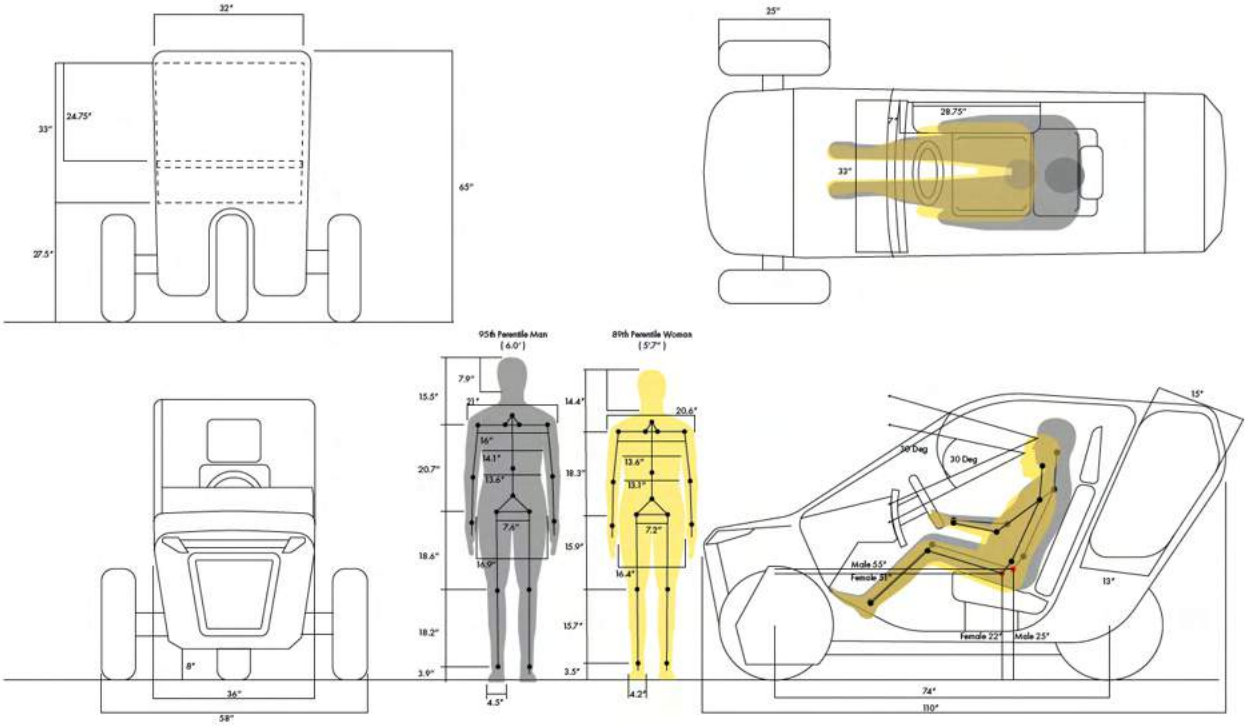



*Figure 55 - Concept 1 Product Schematic - P1*

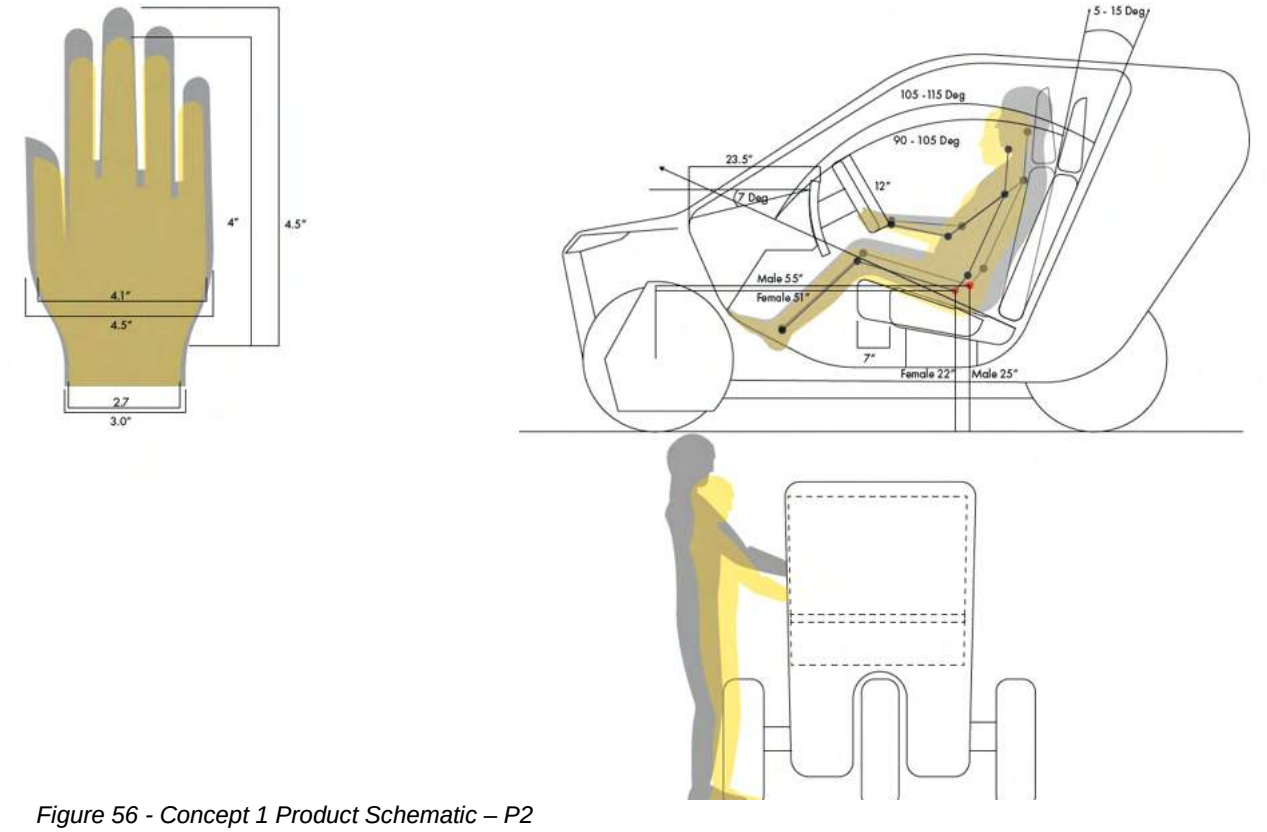



*Figure 56 - Concept 1 Product Schematic – P2*

### *4.3.2 Concept Direction and Product Schematic Two*

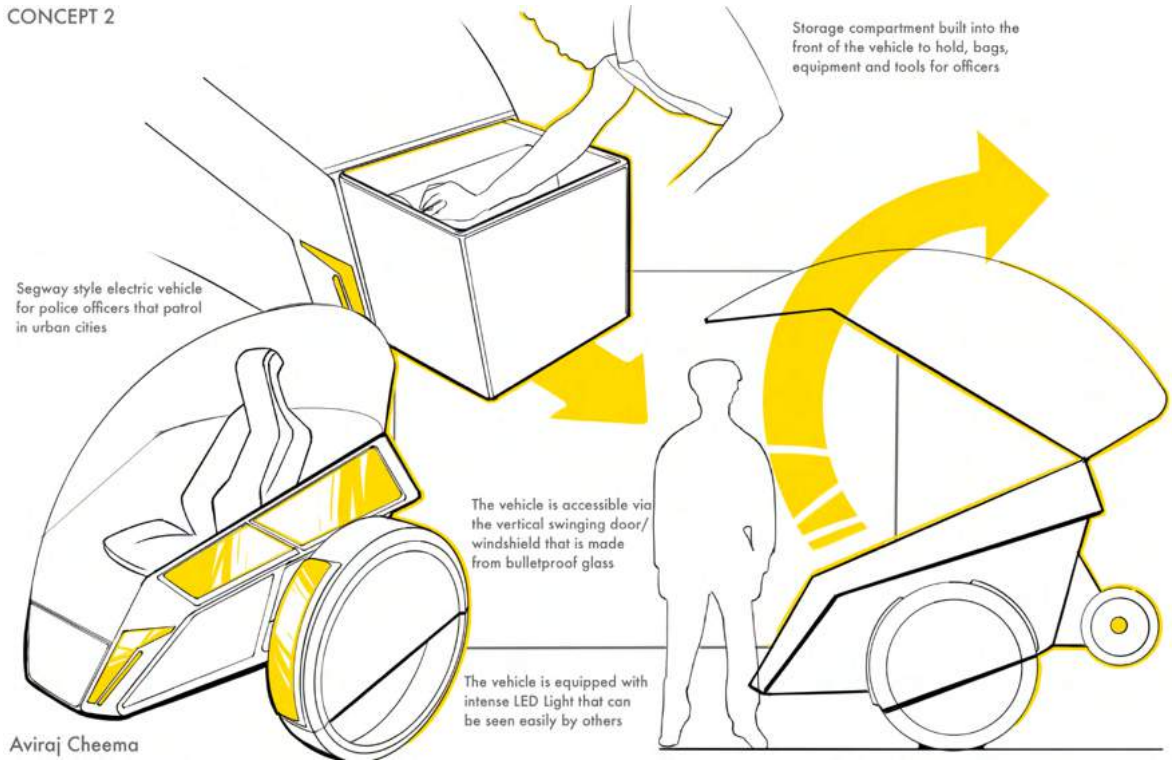



*Figure 58 - Concept 2 Refinement - P1*

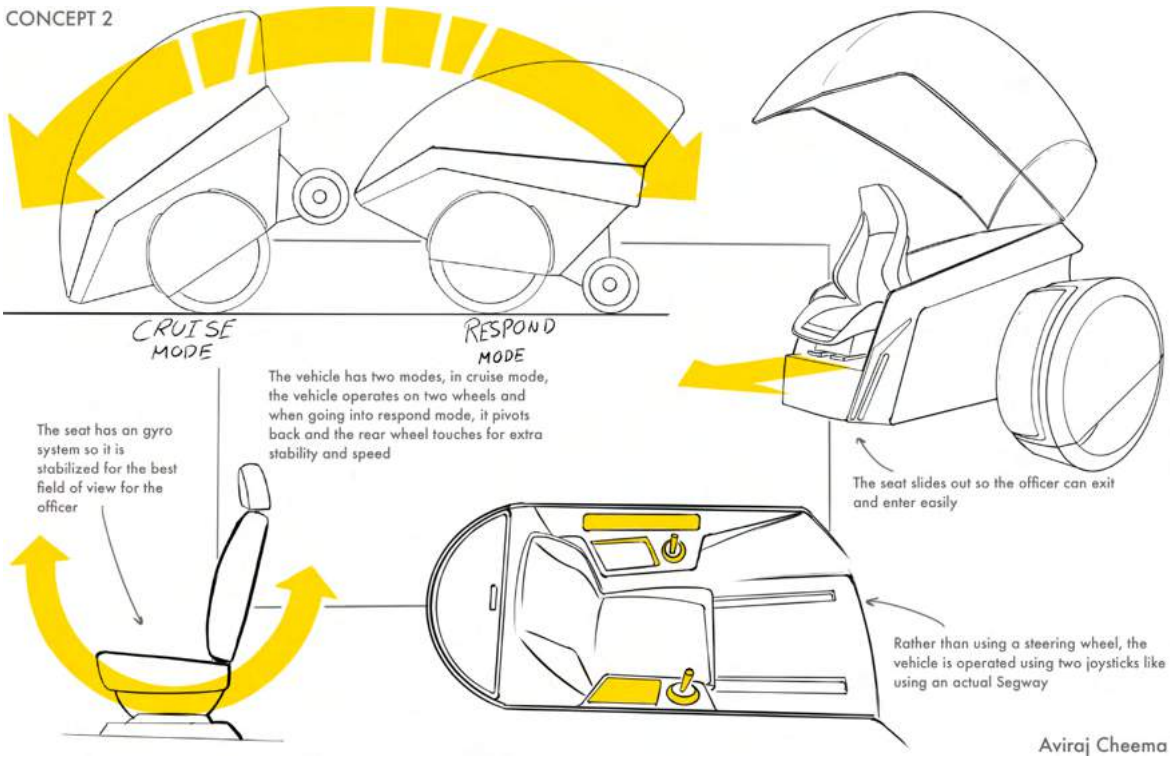



*Figure 57 - Concept 2 Refinement - P2*

Product Schematic and Configuration Diagrams

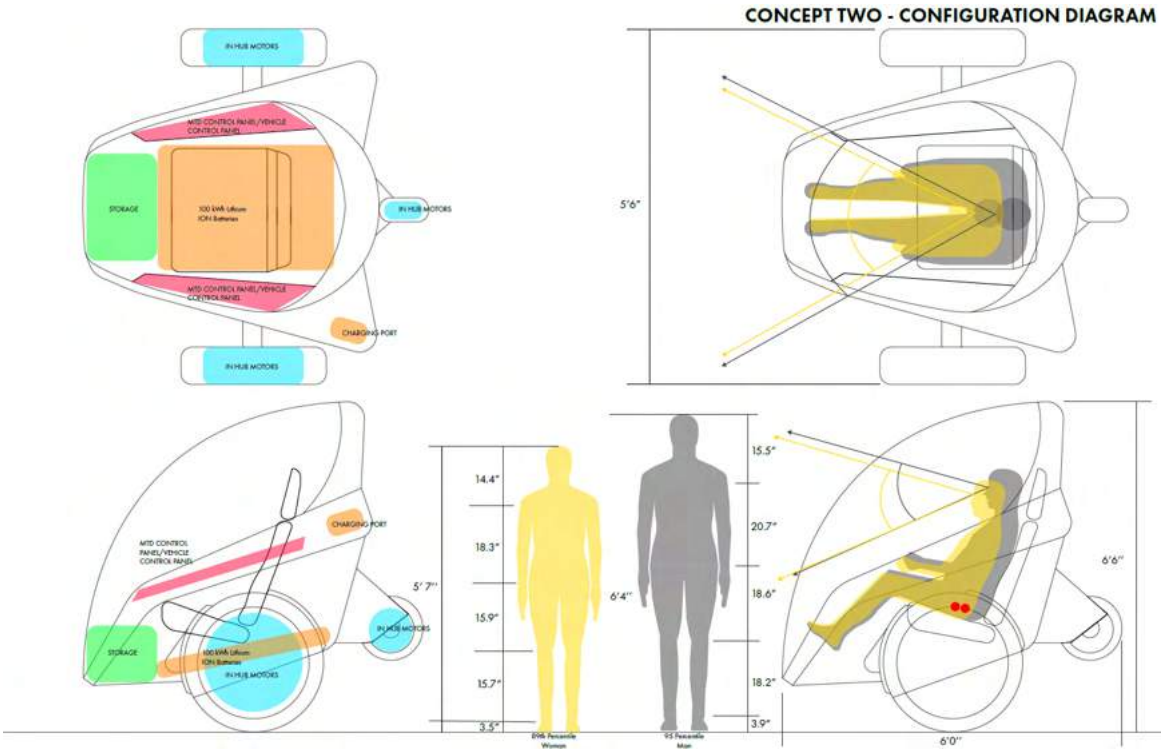



*Figure 59 – Concept 2 Product Schematic and Configuration Diagram*

## *4.4 Concept Refinement and Validation*

After careful analysis on which concept potentially be the most viable and functional solution for police officers, Concept Direction One was chosen to move forward with to further explore design aesthetics and detail refinements to validate the end solution. Concept refinement focus on taking the final design and molding the characteristics to have a consistent and unified design language that creates a new brand image of police vehicles but does not stray to far away from conventional aesthetics of current vehicles to prevent discomfort to the public if this vehicle was seen on the city roads. The detailing ranges from the exterior surface and contour lines to the interior layout of all the instrument and control panels and displays.

### *4.4.1 Design Refinement*

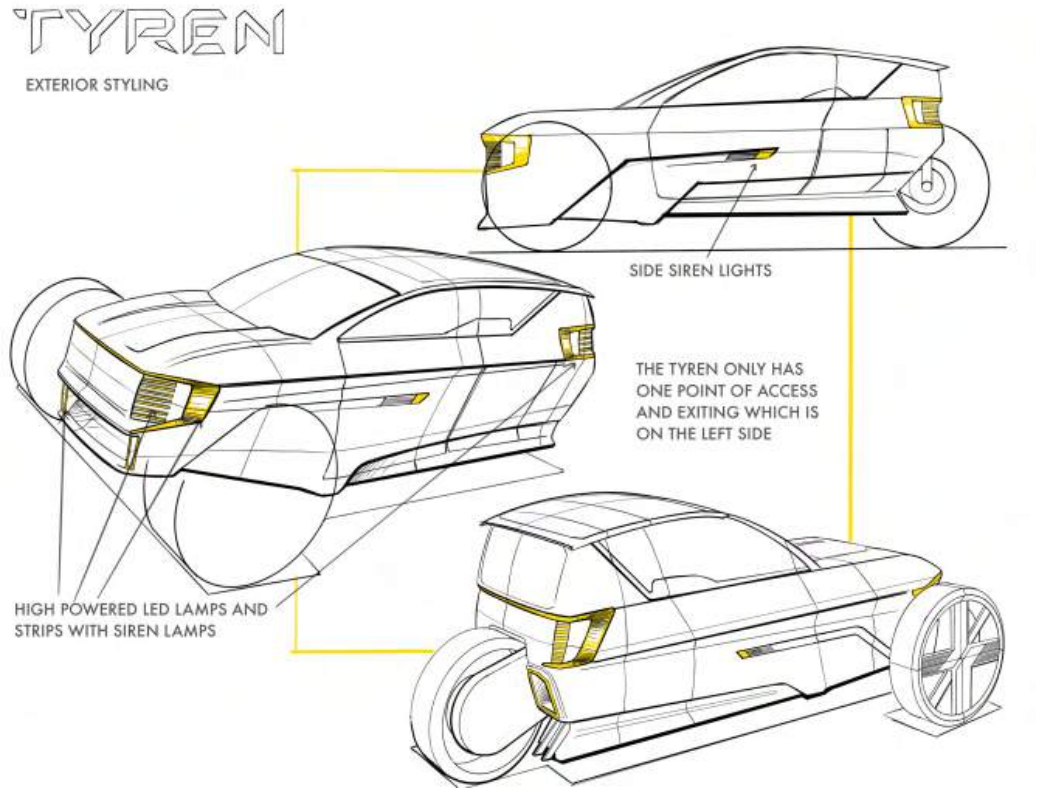



*Figure 61 - Exterior Styling*

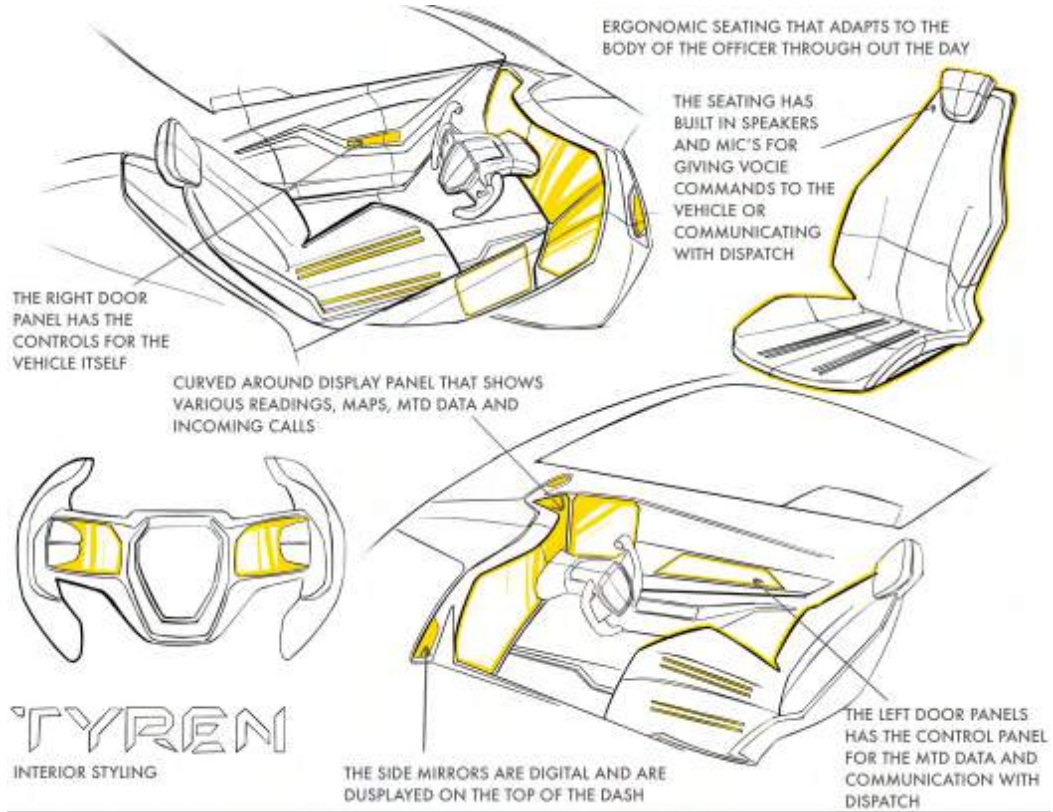



*Figure 60 - Interior Styling*

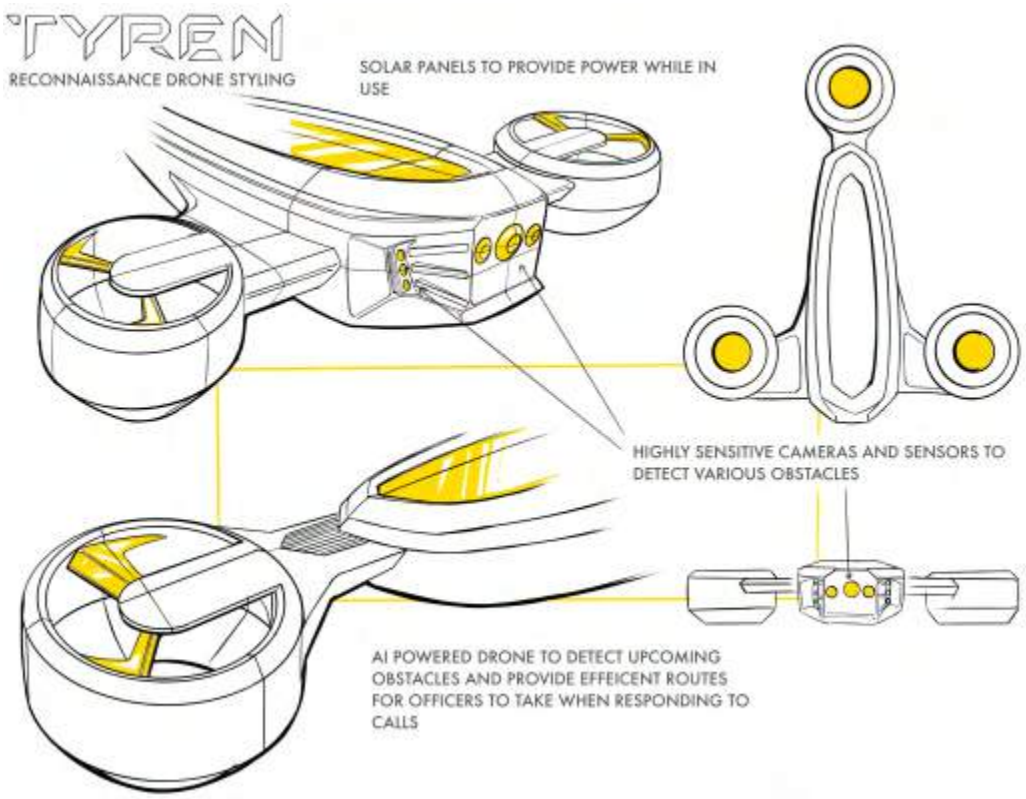



*Figure 62 - Reconnaissance Drone Styling*

The proposed name given to the vehicle is TYREN which means Taurus in Norwegian. When determining the design language of Tyren, Aggressive and Humanistic were to two keywords that were used as leaders. Sharp contour line and angles were used to create the overall form, which can be seen in the headlights, taillights and side siren light cutaway. The interior followed the same direction but with more softer curves and radius to reduce visual stress for the user. Using the findings from the ergonomic study, all the information and control panels are placed close to the user for ease of use.

### *4.4.2 Detail Development*

After the styling and design language were finalized, the focus shifted toward the details and how the end solution would function, which would credit towards its viability. This includes the power source, steering, safety, storage and interaction between product and user.

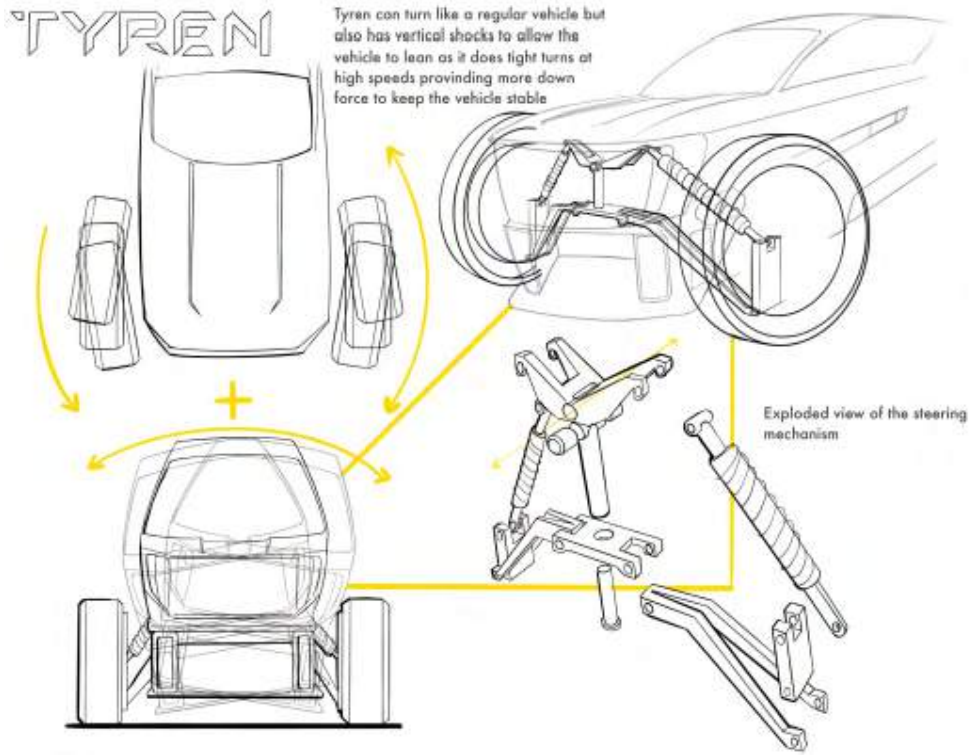



*Figure 63 - Steering Detail Development*

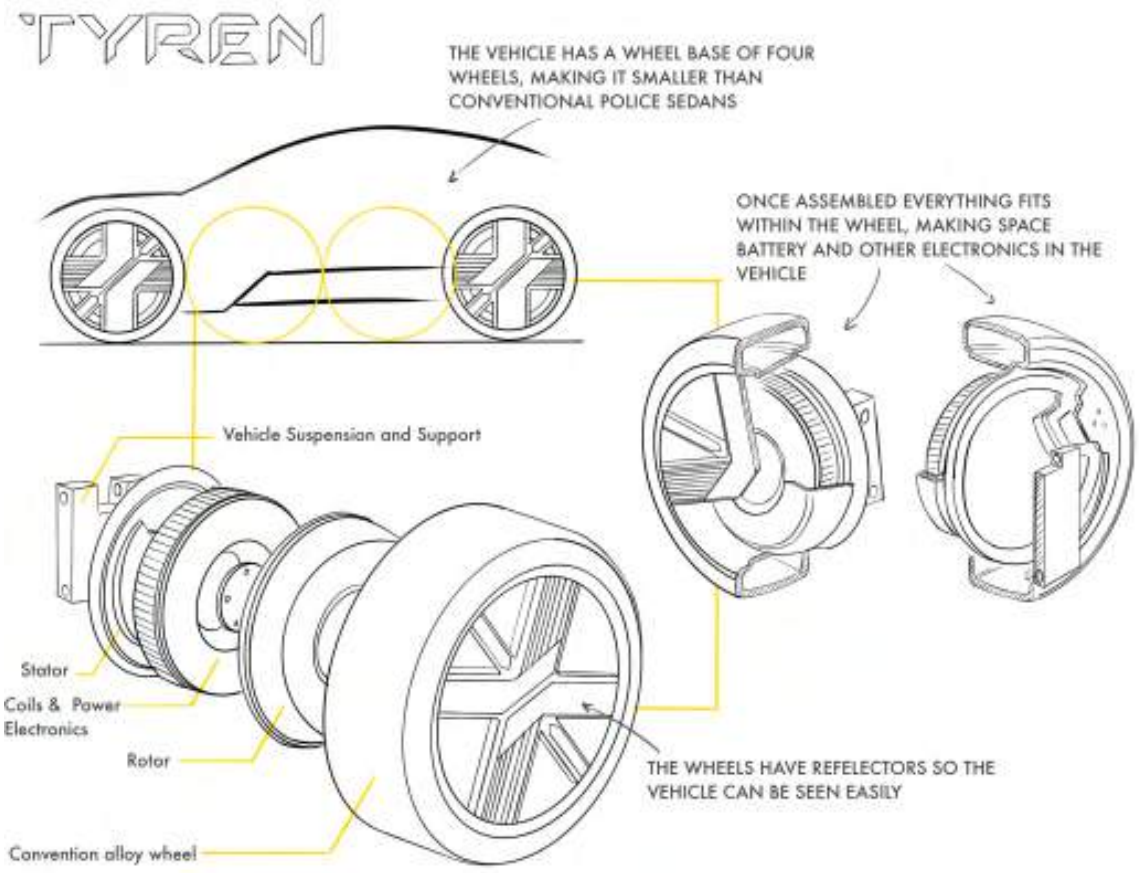



*Figure 64 - Wheel and In Hub Motor Detail Development*

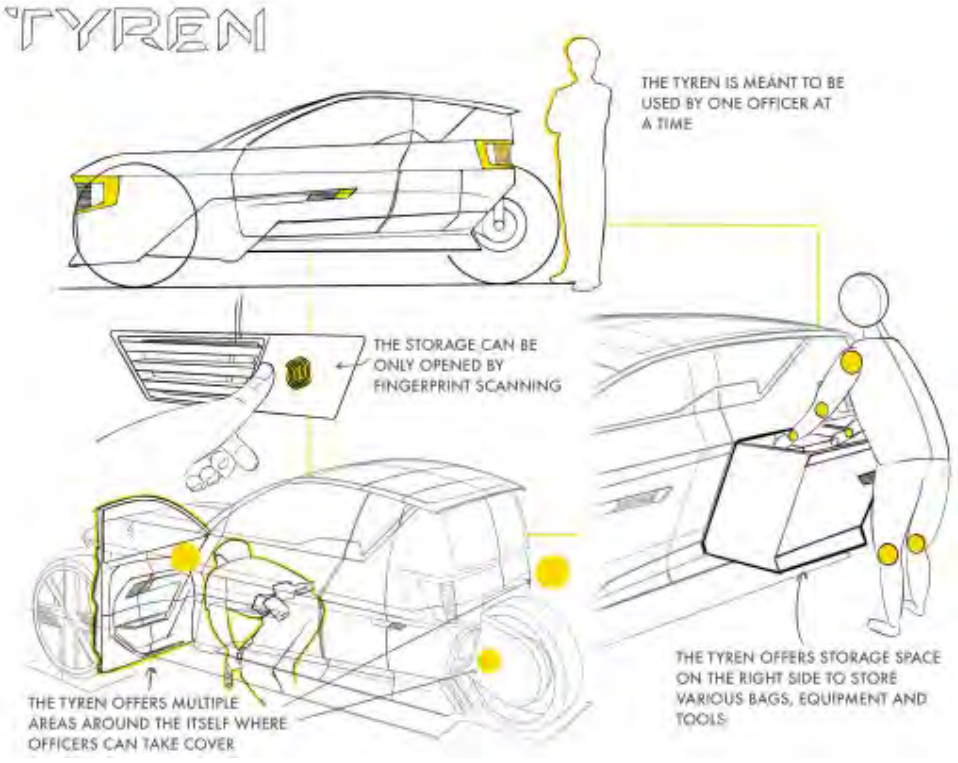



*Figure 66 - Safety and Storage Detail Development*

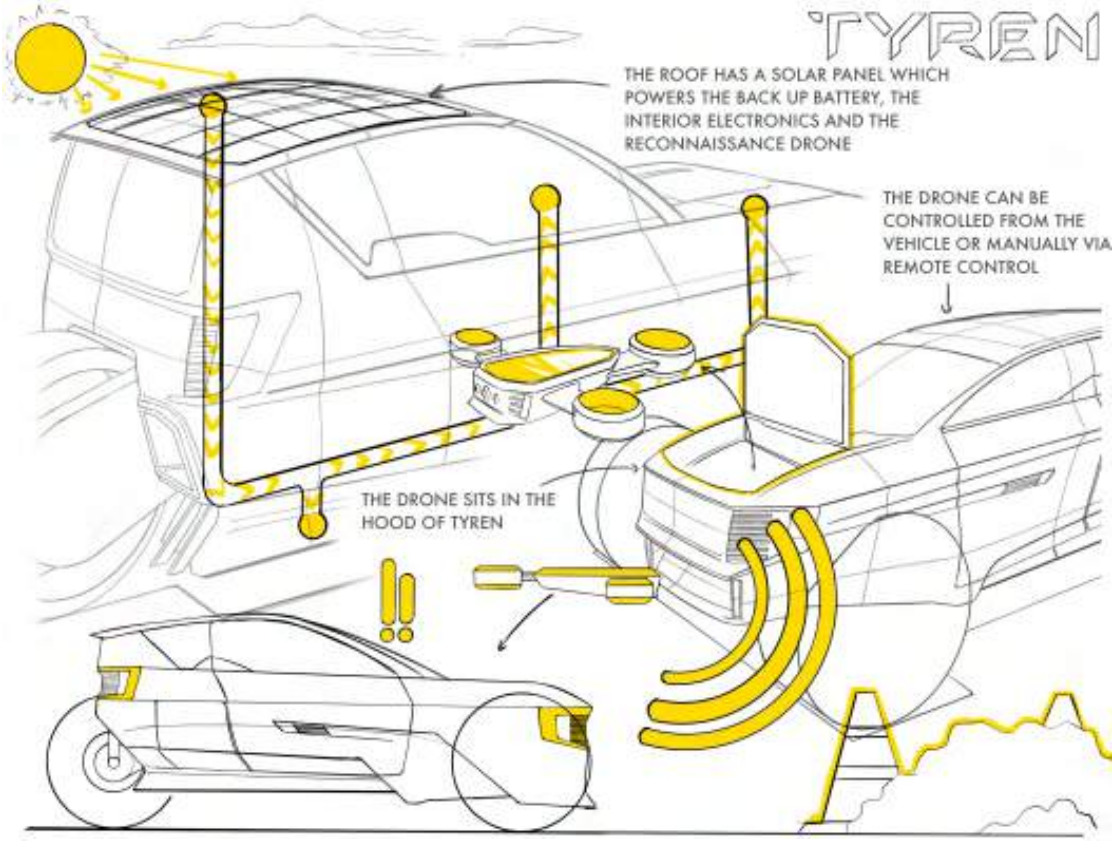



*Figure 65 - Power Source and Drone Function Detail Development*

In Figure 61, the Solar Panel on the roof of Tyren only provides power to interior instrument and control panels and displays. It also charges the reconnaissance drone when it is not in use. The vehicle itself which includes the In Hub Motors and Safety Sensors is powered by the 100 kWh Lithium-Ion Battery at the base of the car to maximize the distance the vehicle can go before it has to be charged again at the detachment. The Solar Panel on the roof does not have sufficient surface area to provide enough power to the battery along with other environmental factors which lower the efficiency of the power conversion such as tall buildings cover the sun and seasonal factors as well such as during the winter months Toronto does not get enough sunlight due to cloud cover and building cover.

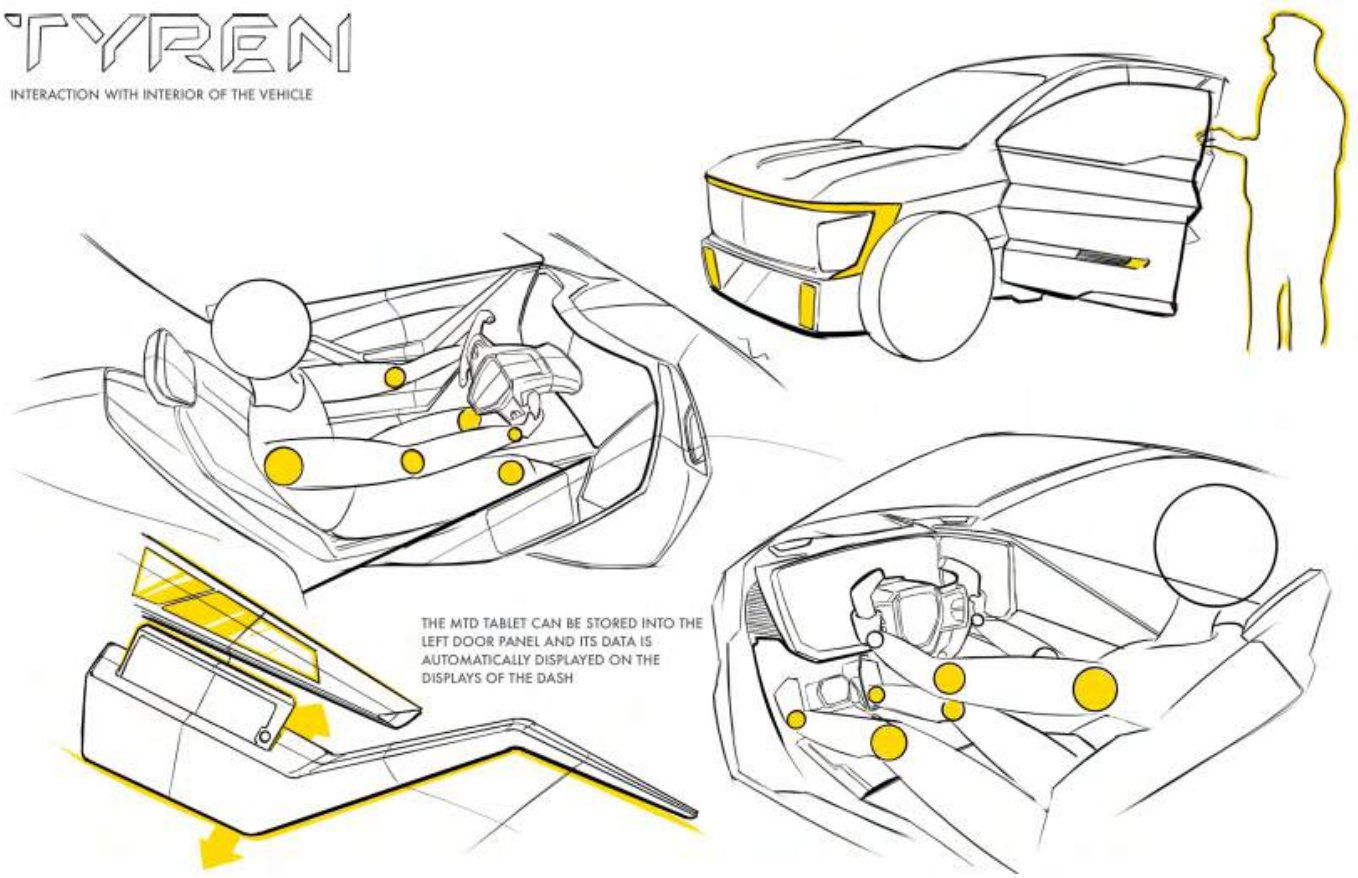



*Figure 67 - User and Interior Interaction*

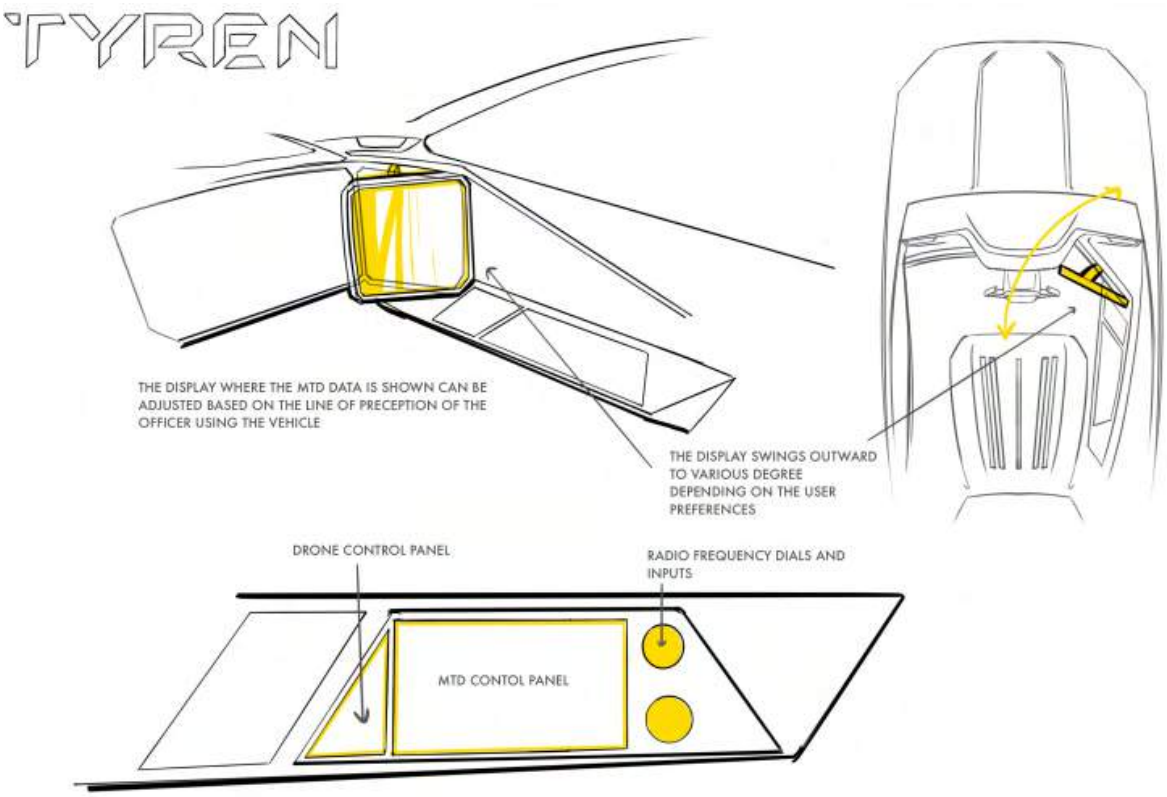



*Figure 68 - MTD Display and Control Panel Layout*

### *4.4.3 Refined Product Schematic & Key Ergonomic*

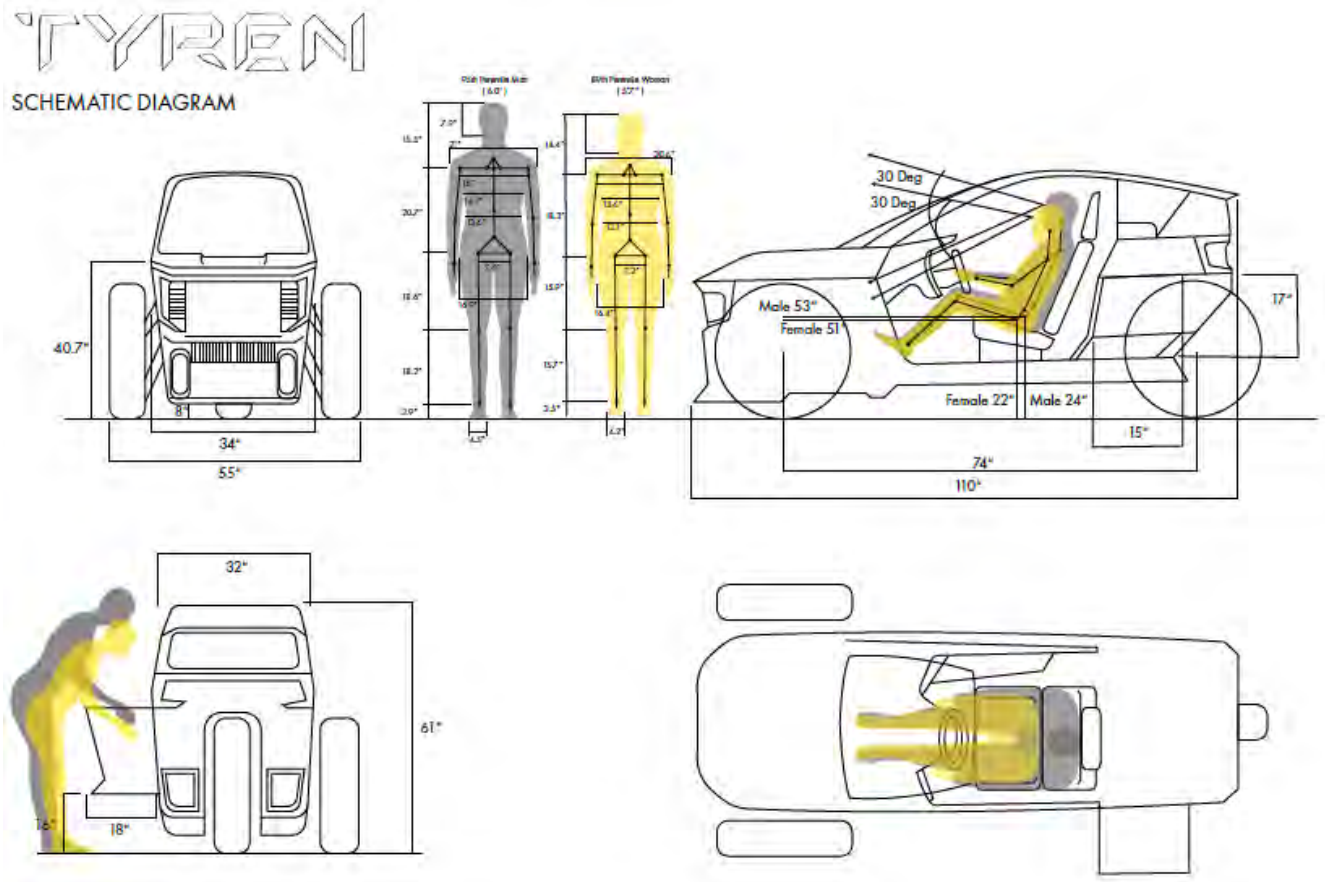



*Figure 69 - Product Schematic One*

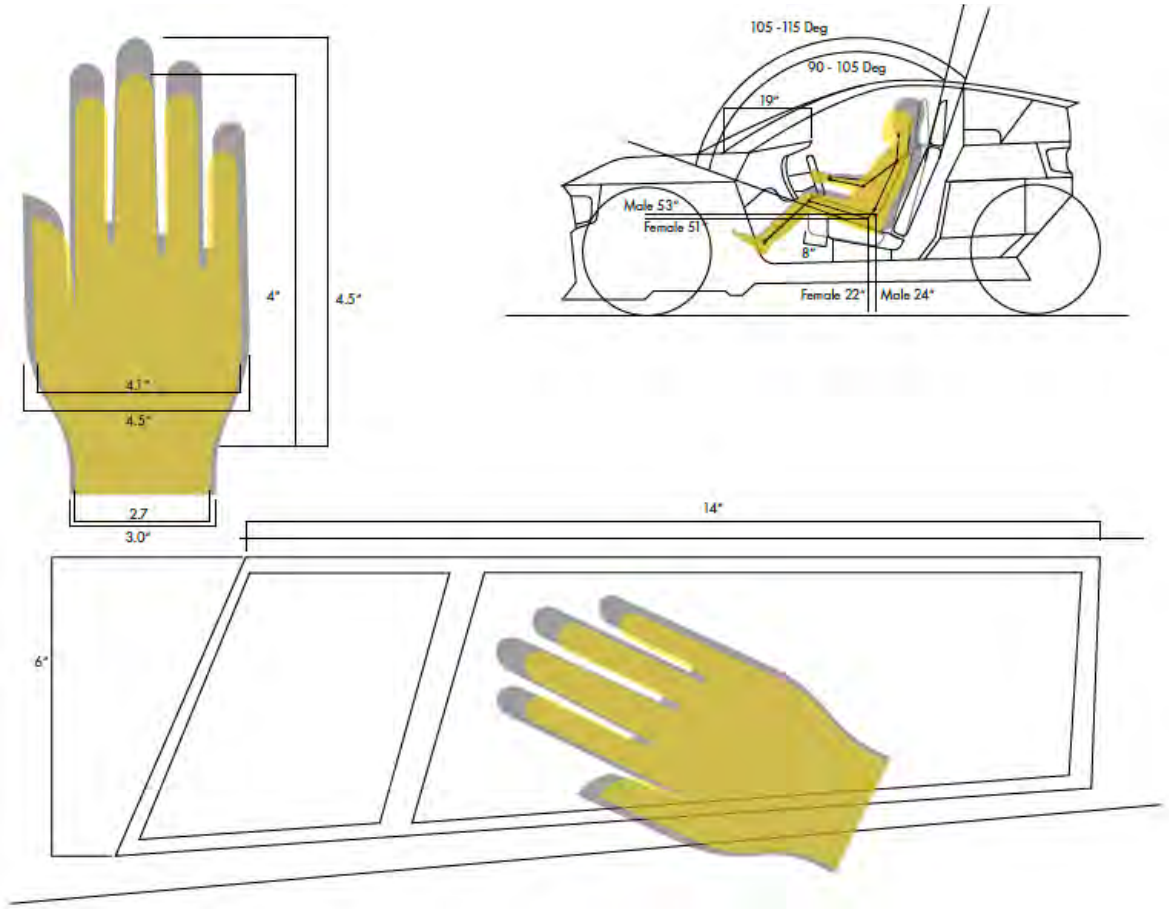



*Figure 71 - Product Schematic Two*

TYREN
CONFIGURATION DIAGRAM

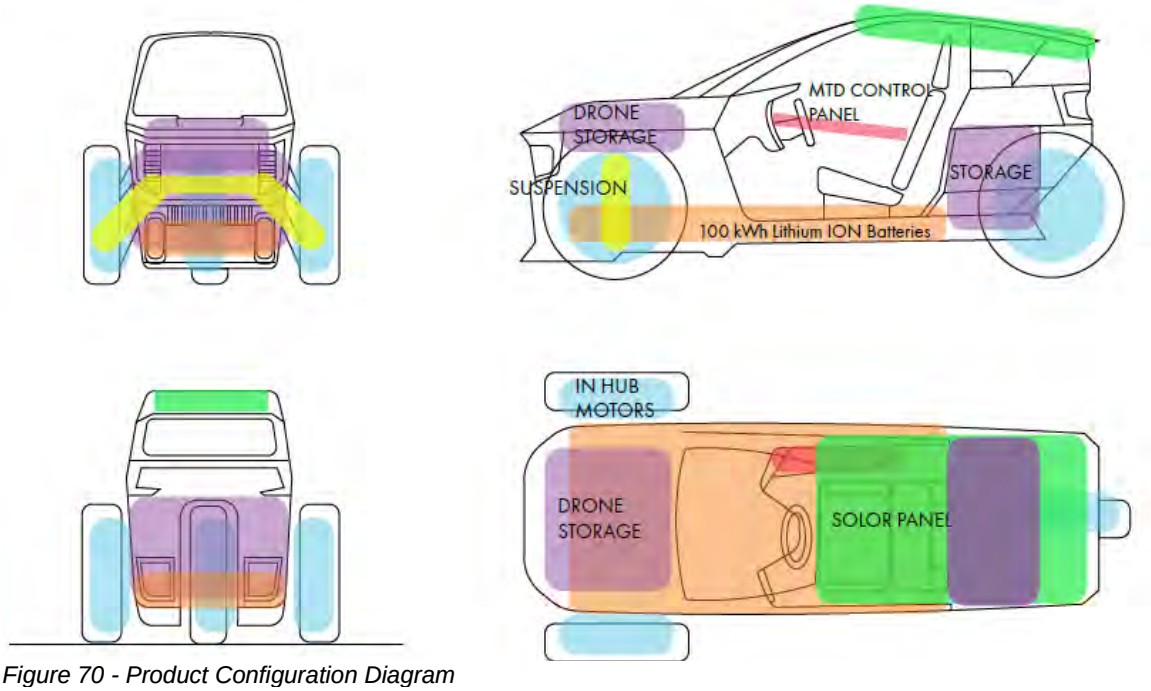



*Figure 70 - Product Configuration Diagram*

## *4.5 Concept Realization*

At this stage, some of the final changes were made to design such as form development, and exterior detailing, along with adjustments to the interior aspects. This stage became the foundation on the starting of the CAD process, which would be the final chance where changes could be made before the model fabrication begins. This stage also provides an opportunity to fine tune the finer details of the design, from the material choices to the functionality of each feature.

### *4.5.1 Design Finalization*

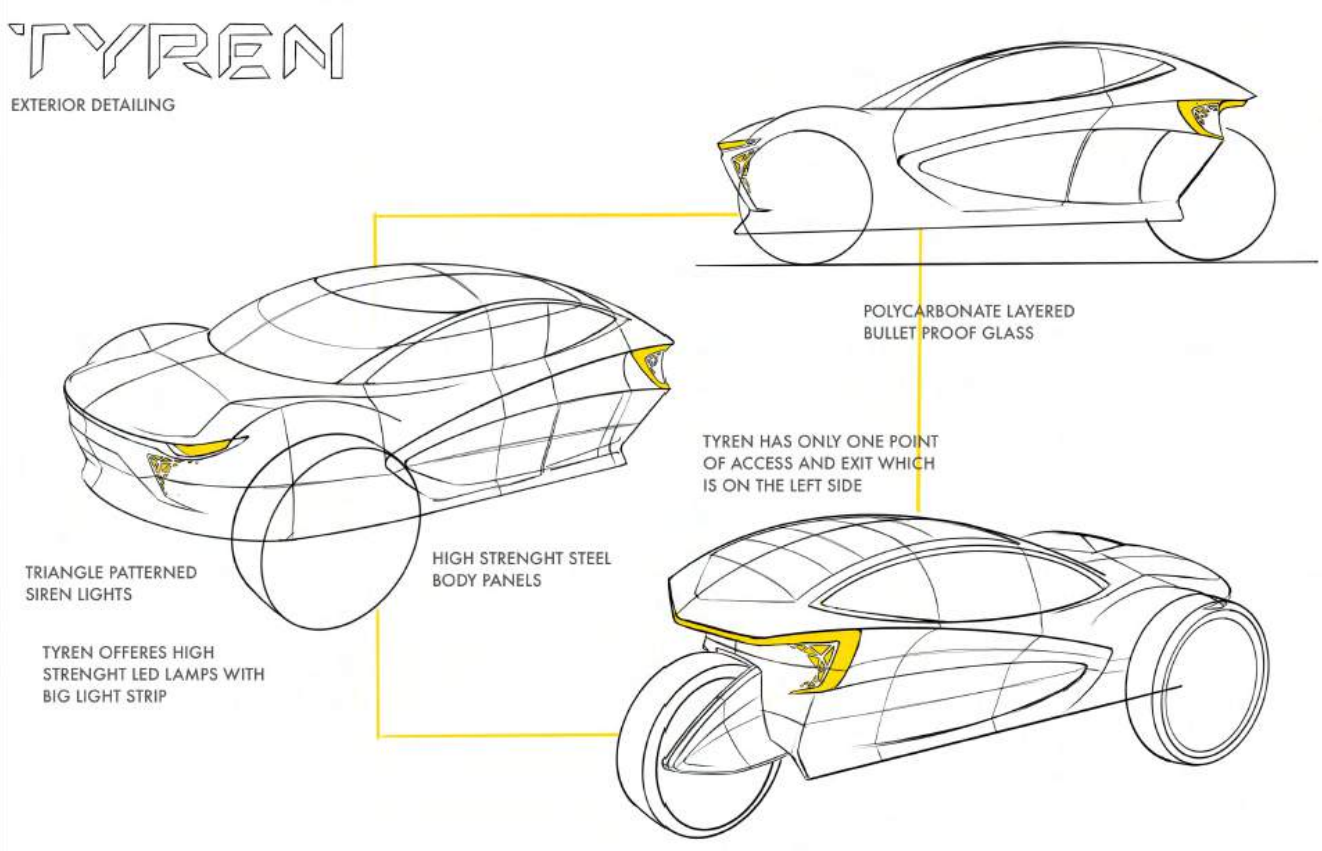



*Figure 72 - Tyren Overall Design*

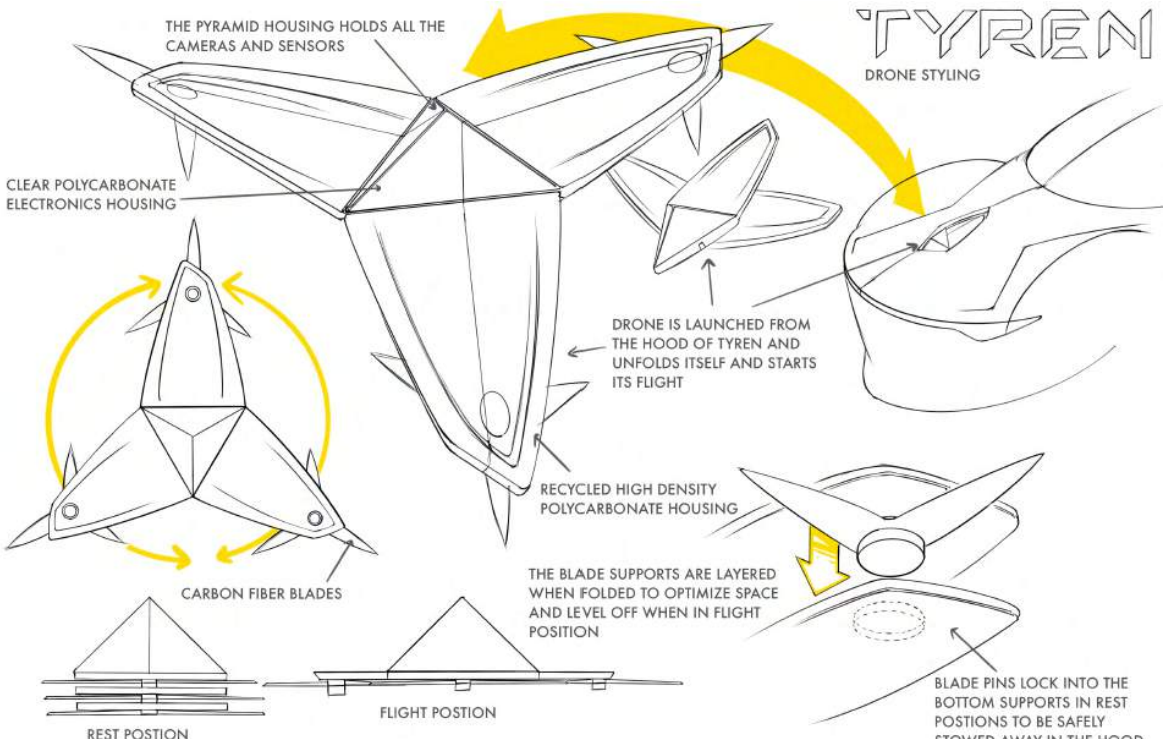



*Figure 74 - Tyren Drone Design*

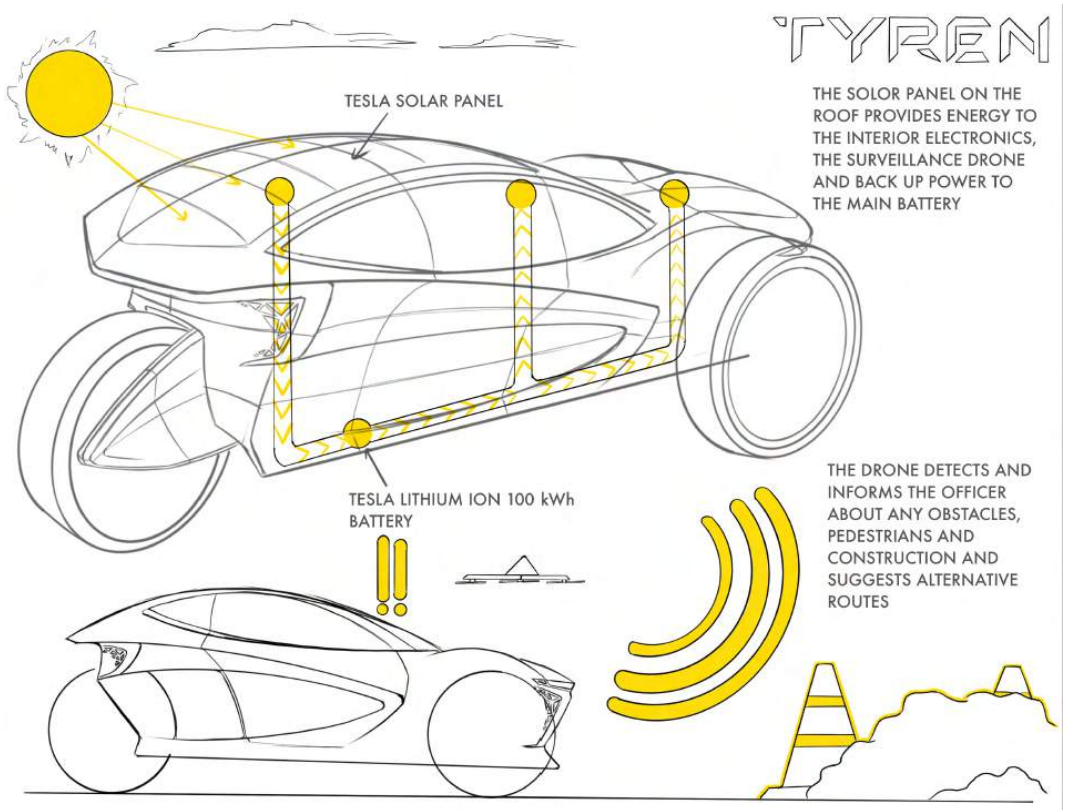



*Figure 73 - Tyren Power Source & Drone Functionality*

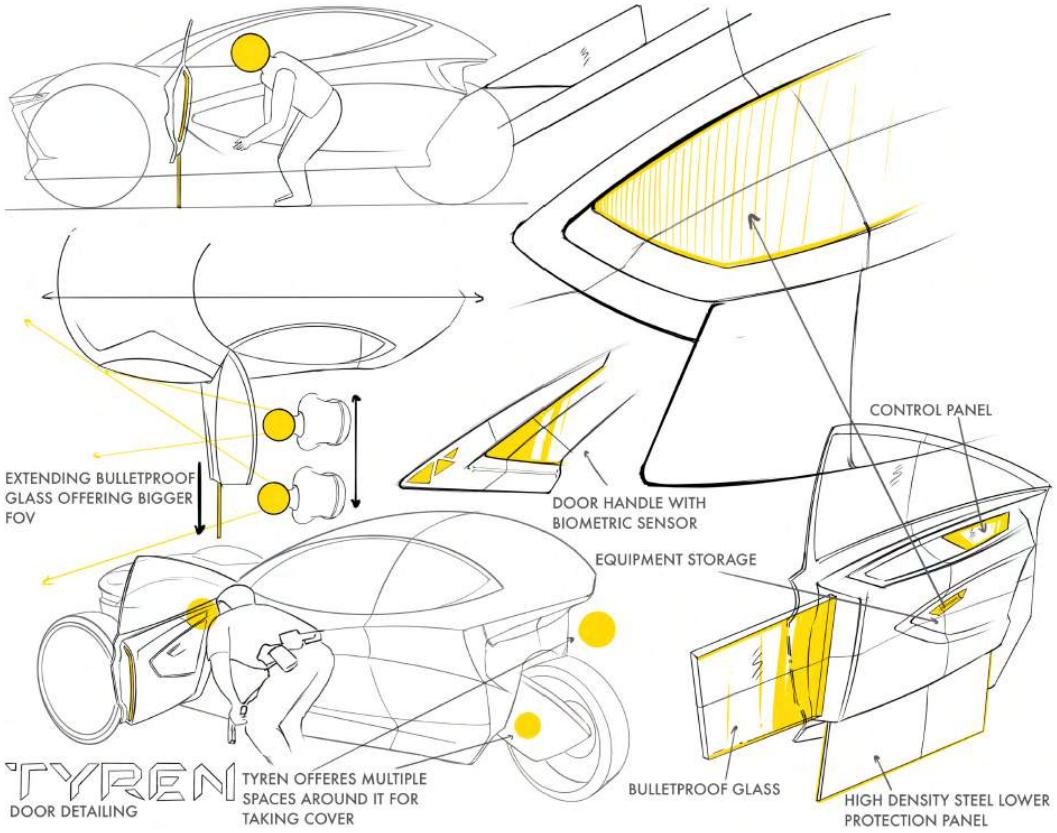



*Figure 76 - Tyren Door Shield and Storage Design*

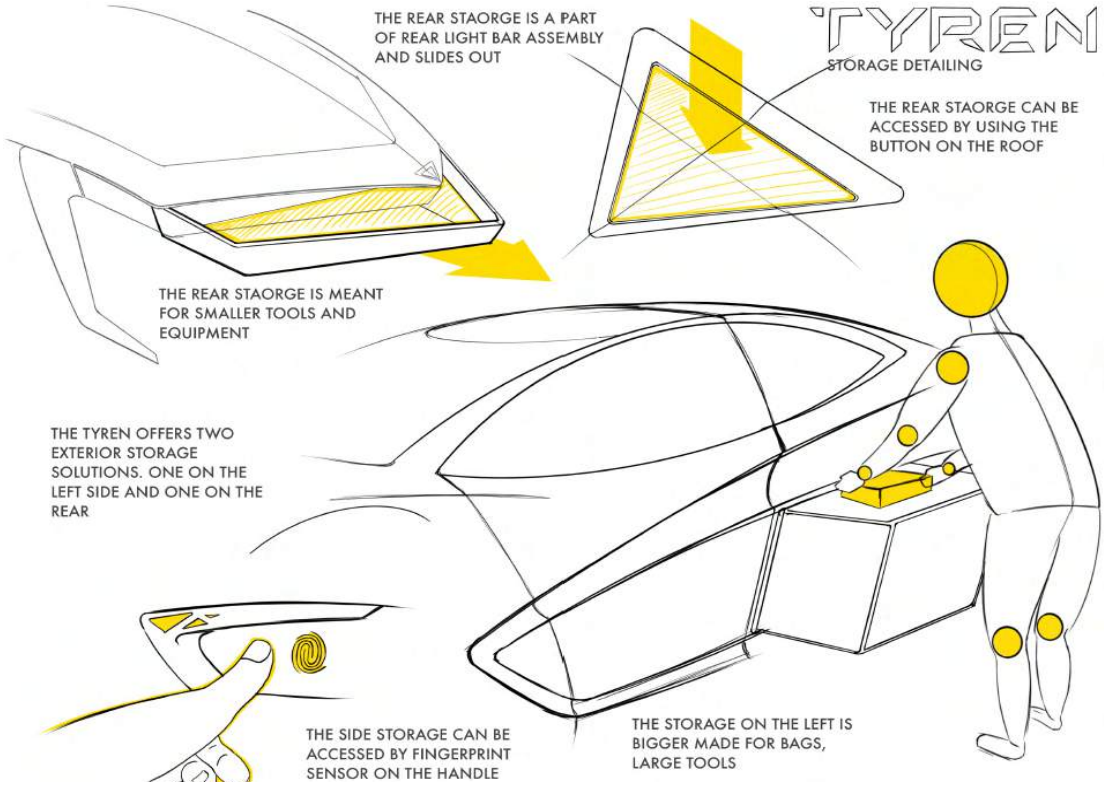



*Figure 75 – Tyren Storage Design*

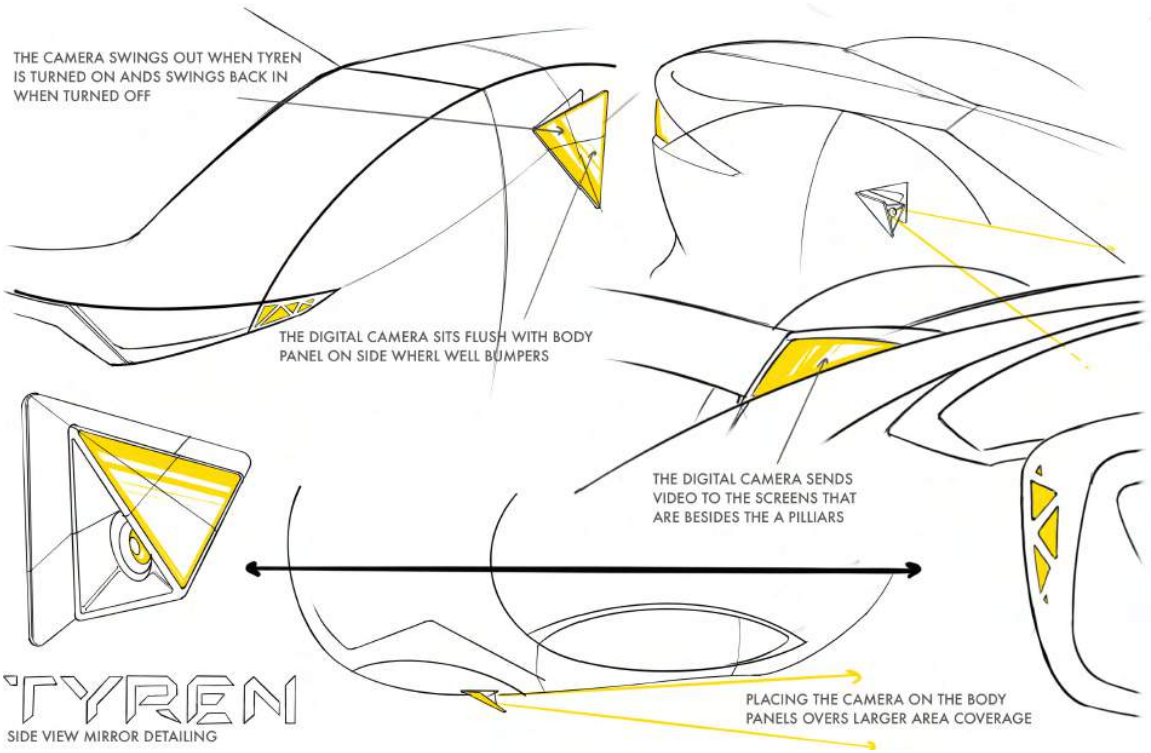



*Figure 78 – Tyren Side View Mirror Design*

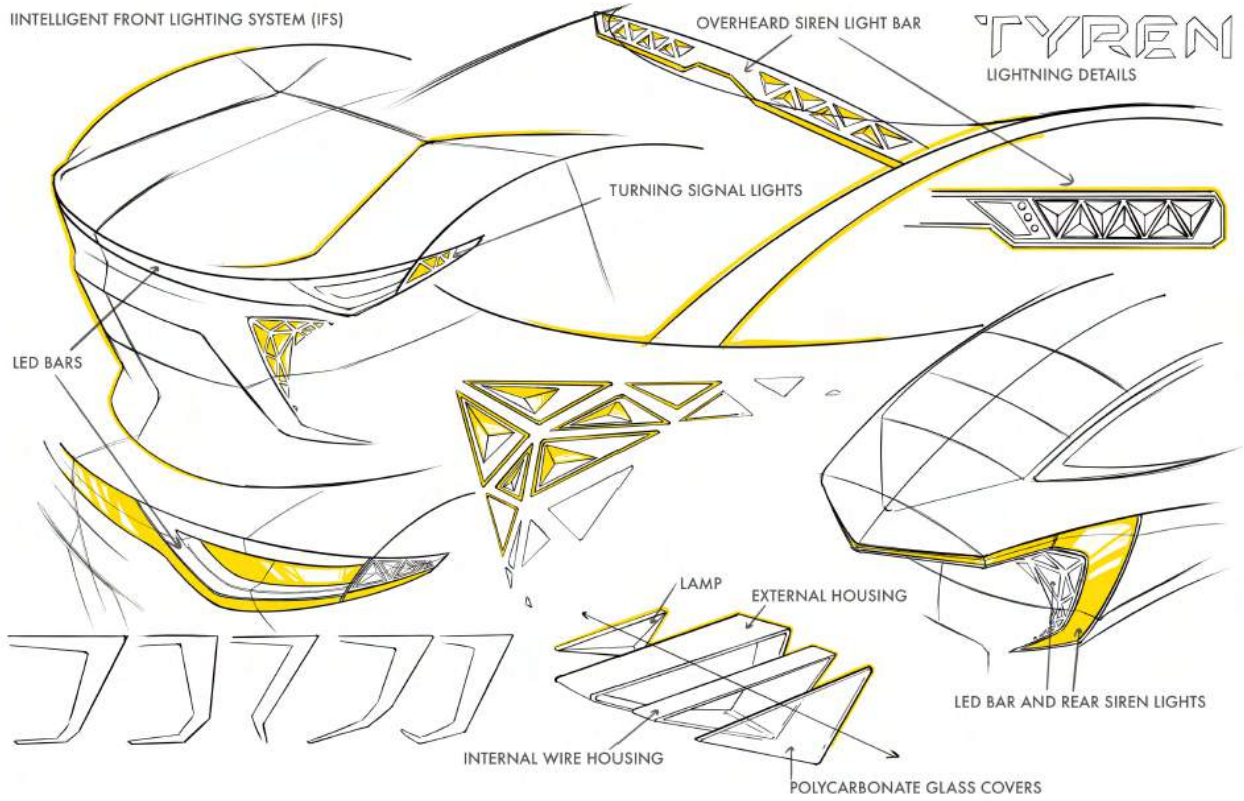



*Figure 77 – Tyren Lighting Design*

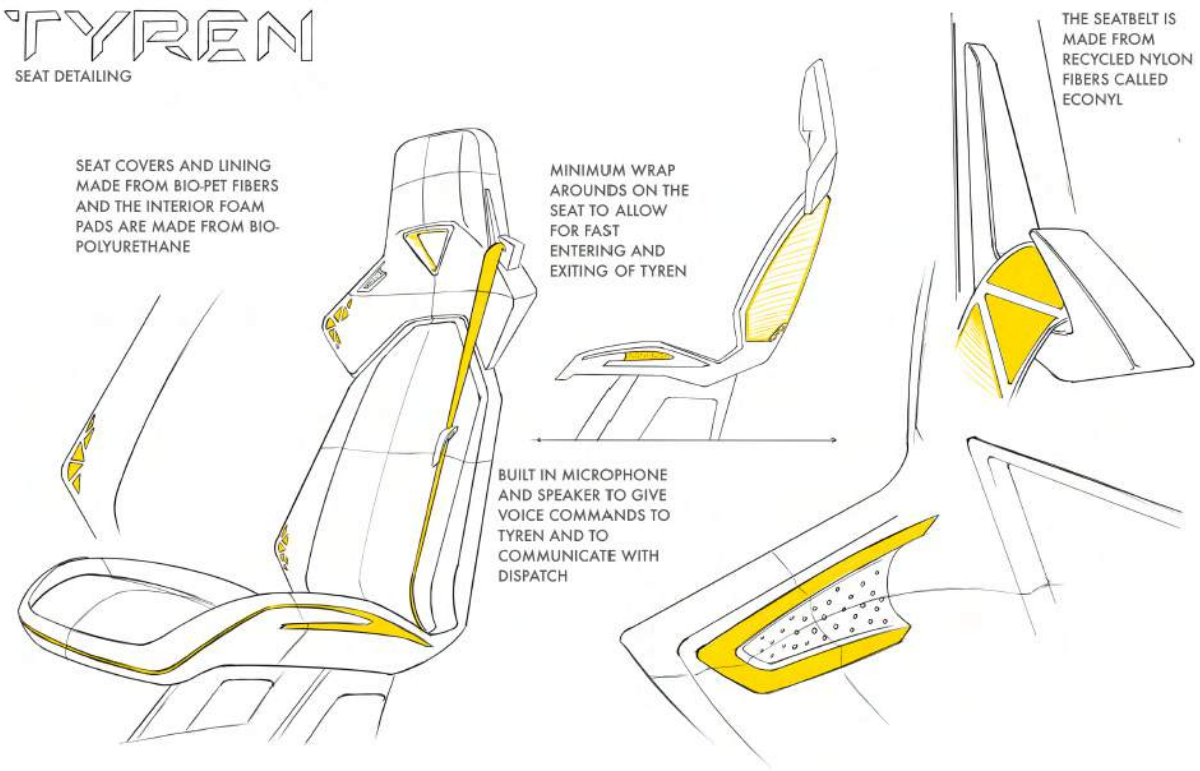



*Figure 80 - Tyren Seating Design*

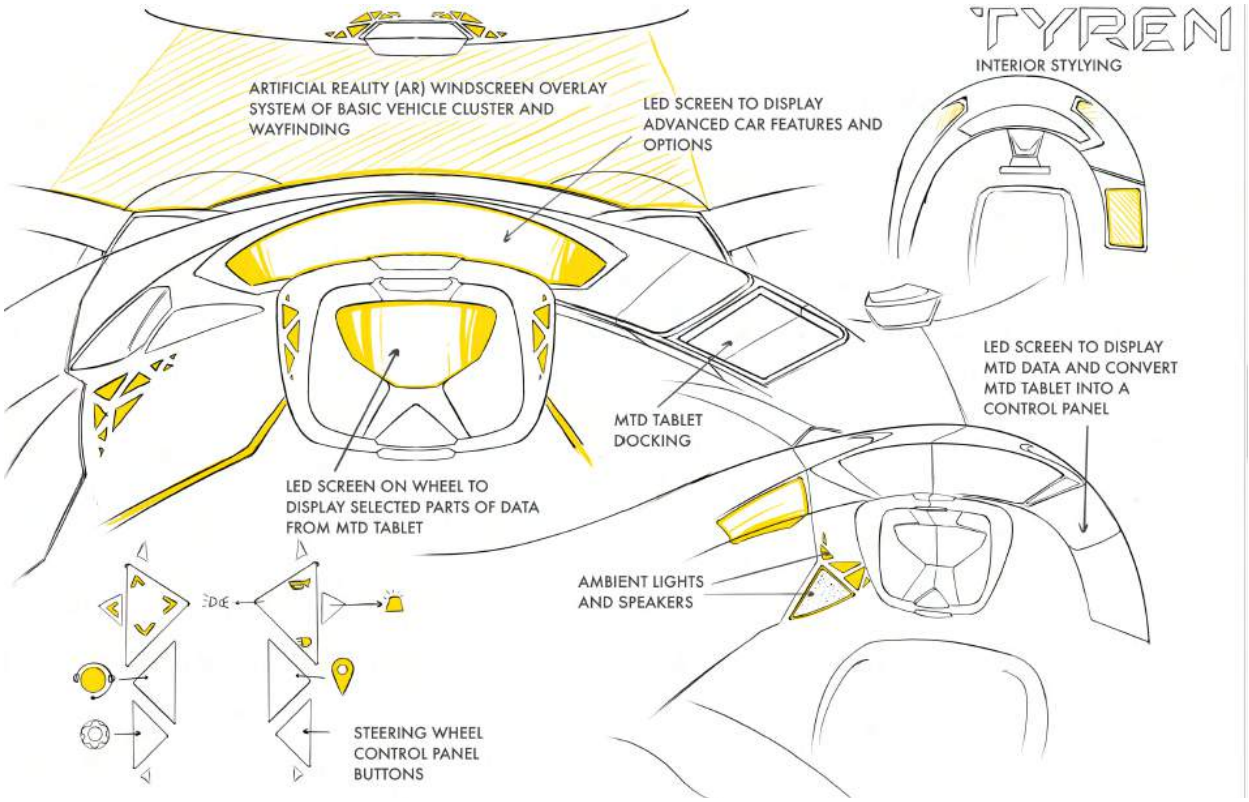



*Figure 79 - Tyren Interior Design*

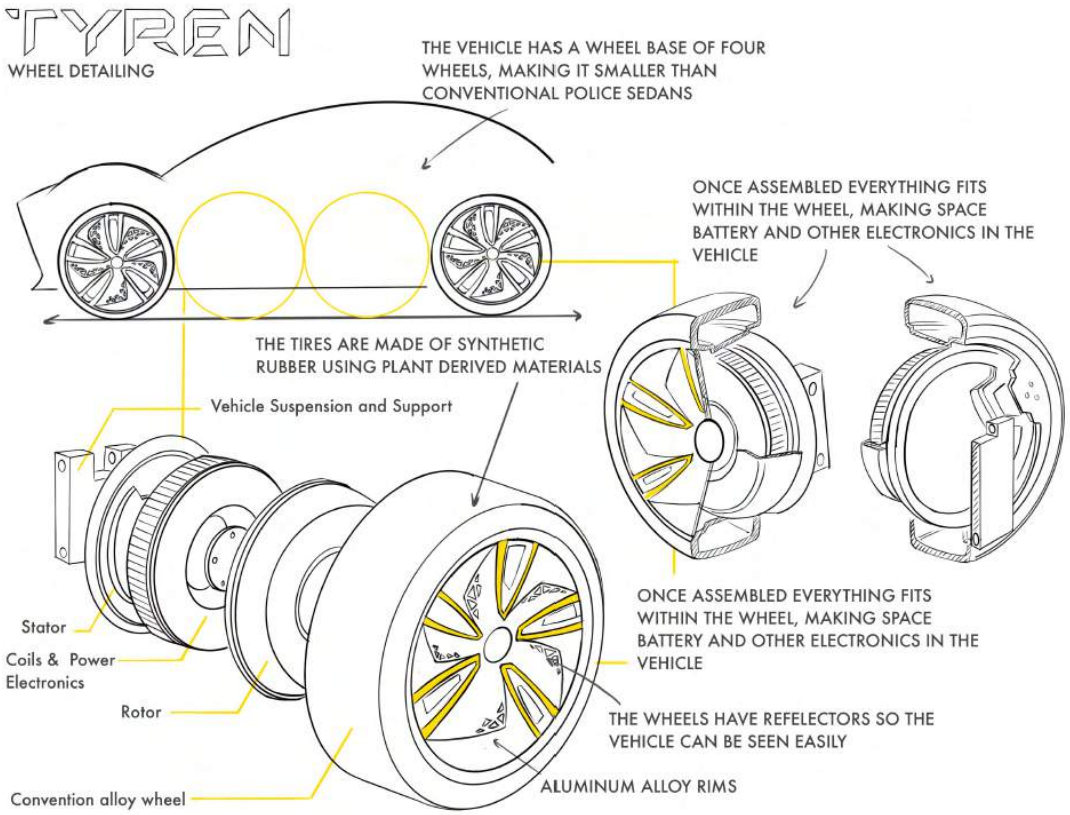



*Figure 82 - Tyren Wheel Design*

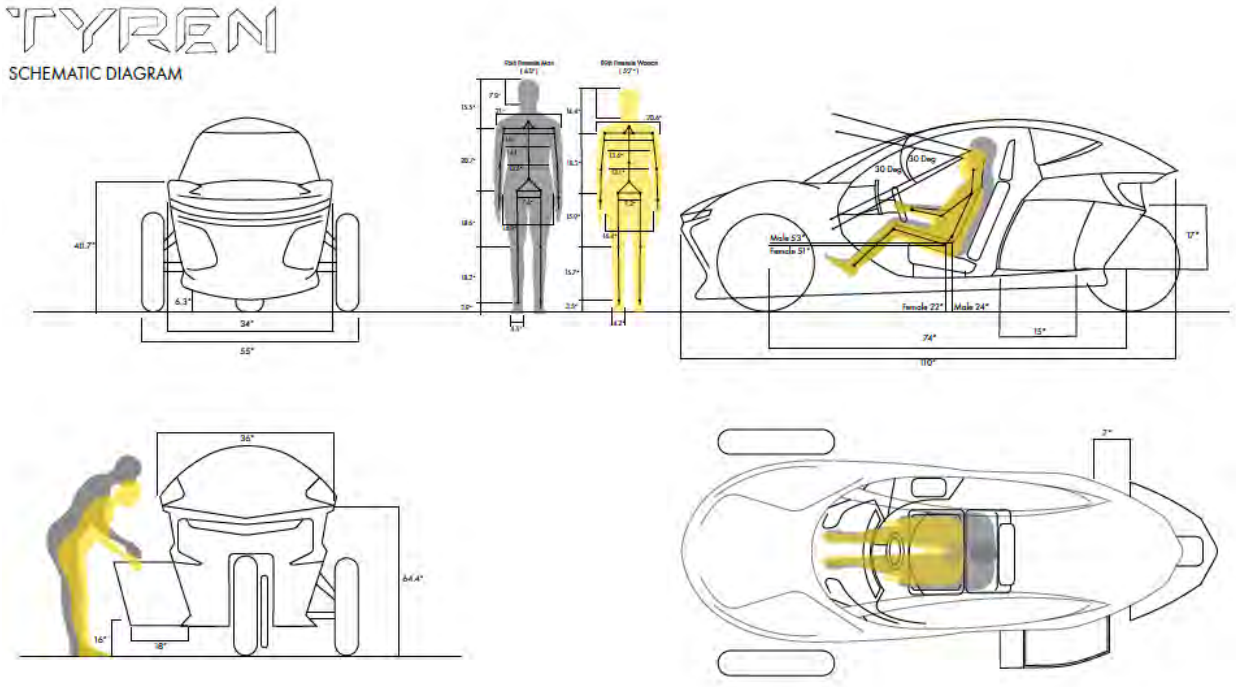



*Figure 81 - Tyren Schematic Diagram 1*

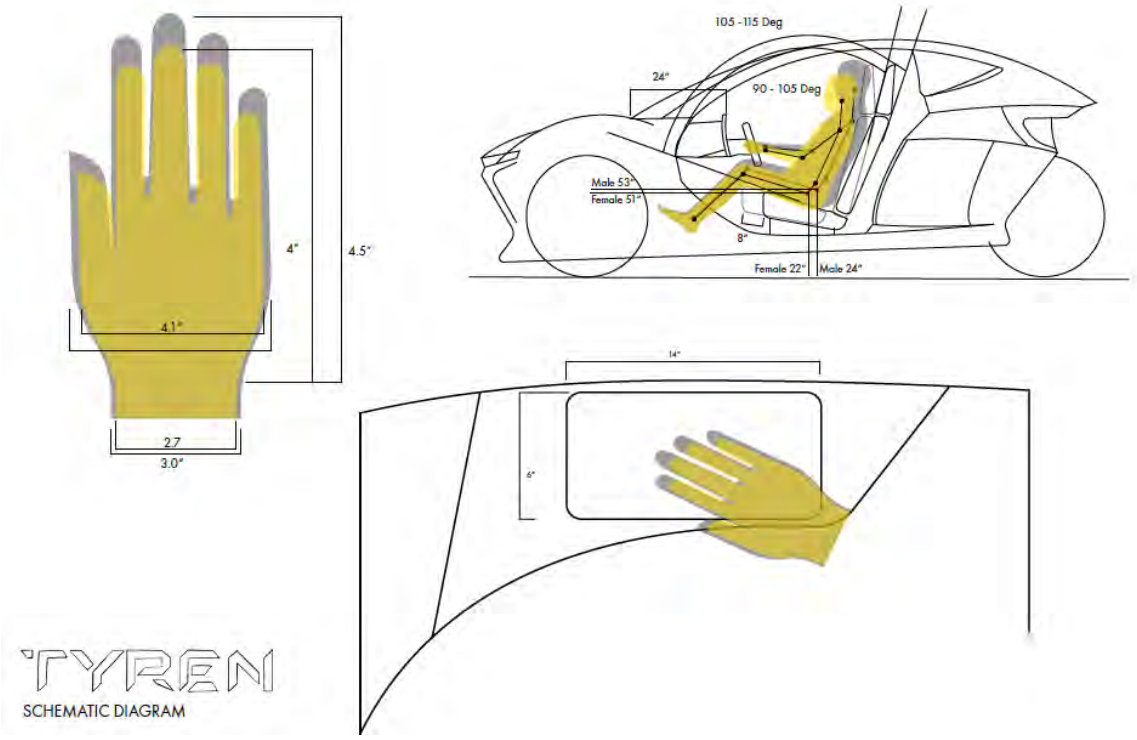



*Figure 84 - Tyren Product Schematic Diagram 2*

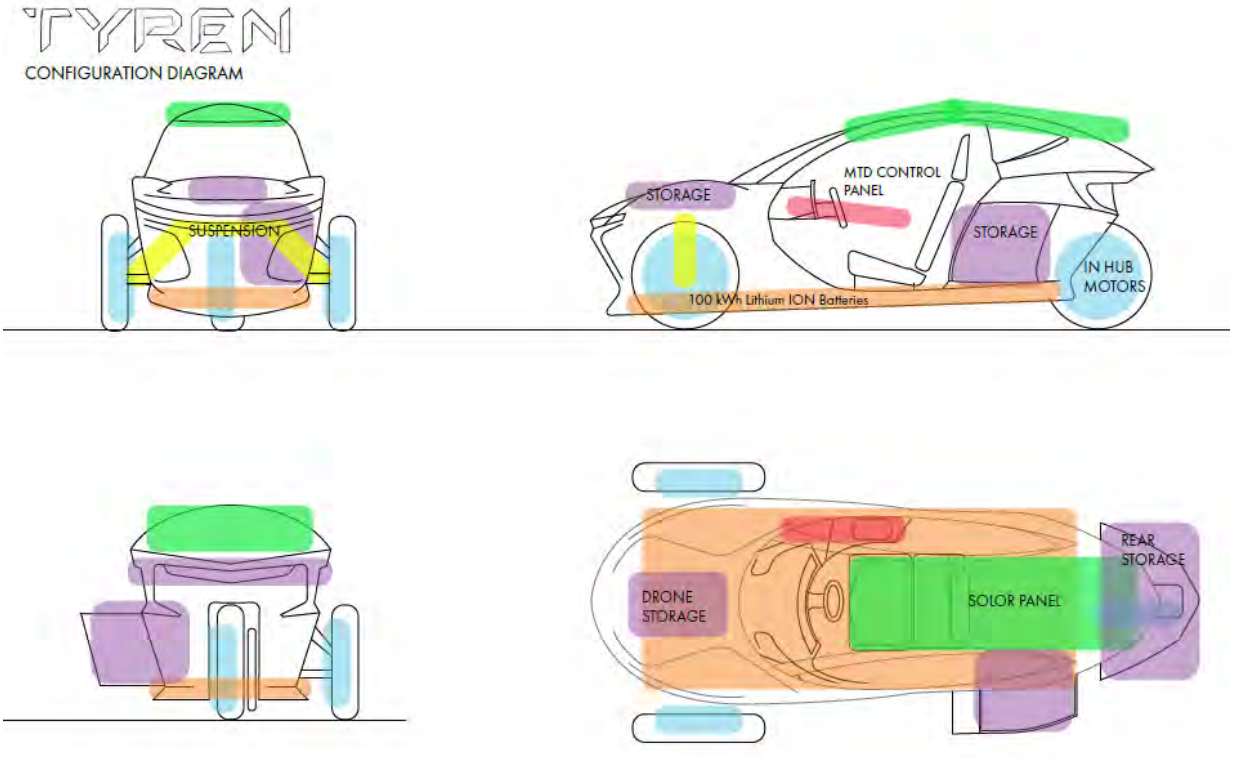



*Figure 83 - Tyren Configuration Diagram*

### *4.5.2 Physical Study Models*

A Sketch model was fabricated at 1/5$^{th}$ scale to get a better understanding of the proportions, interior ergonomics, and overall layout of various features. Foam core was the major material used to build the model along with some smaller quantities of other materials. This model helped highlight some areas in the design where problems could arise during the CAD modelling process, so some revisions were made.

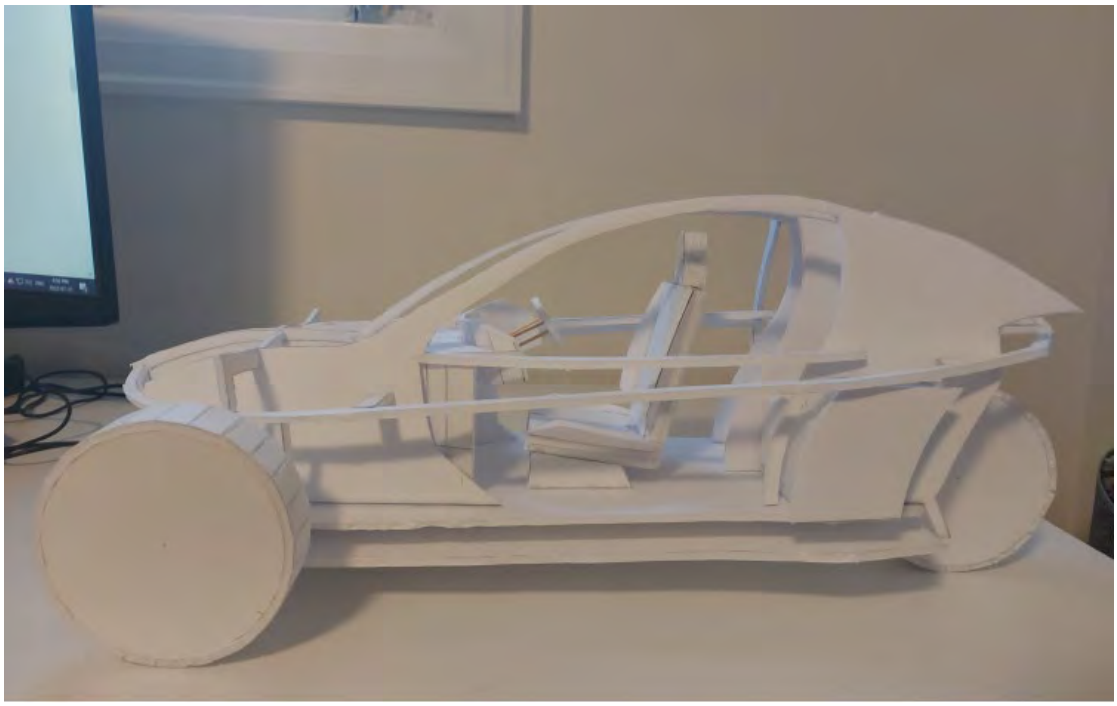


*Figure 85 - Tyren 1/5 Sketch Model Left Side View*

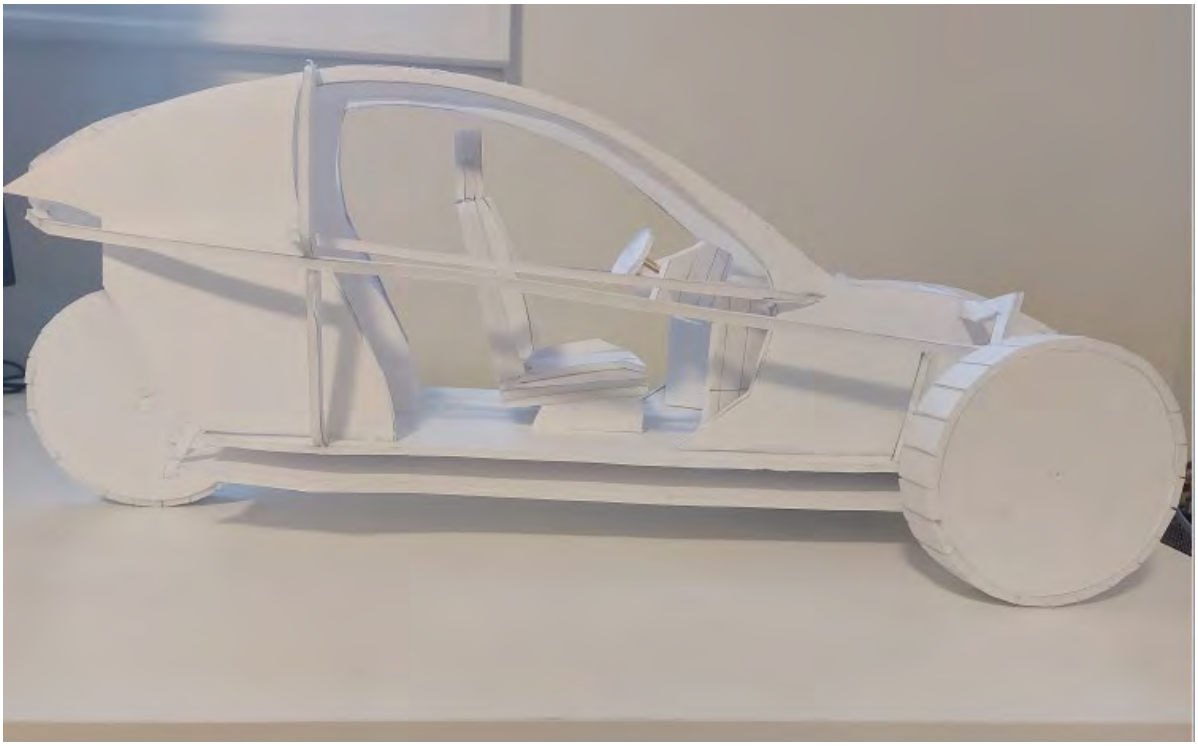


*Figure 87 - Tyren 1/5 Sketch Model Right Side View*

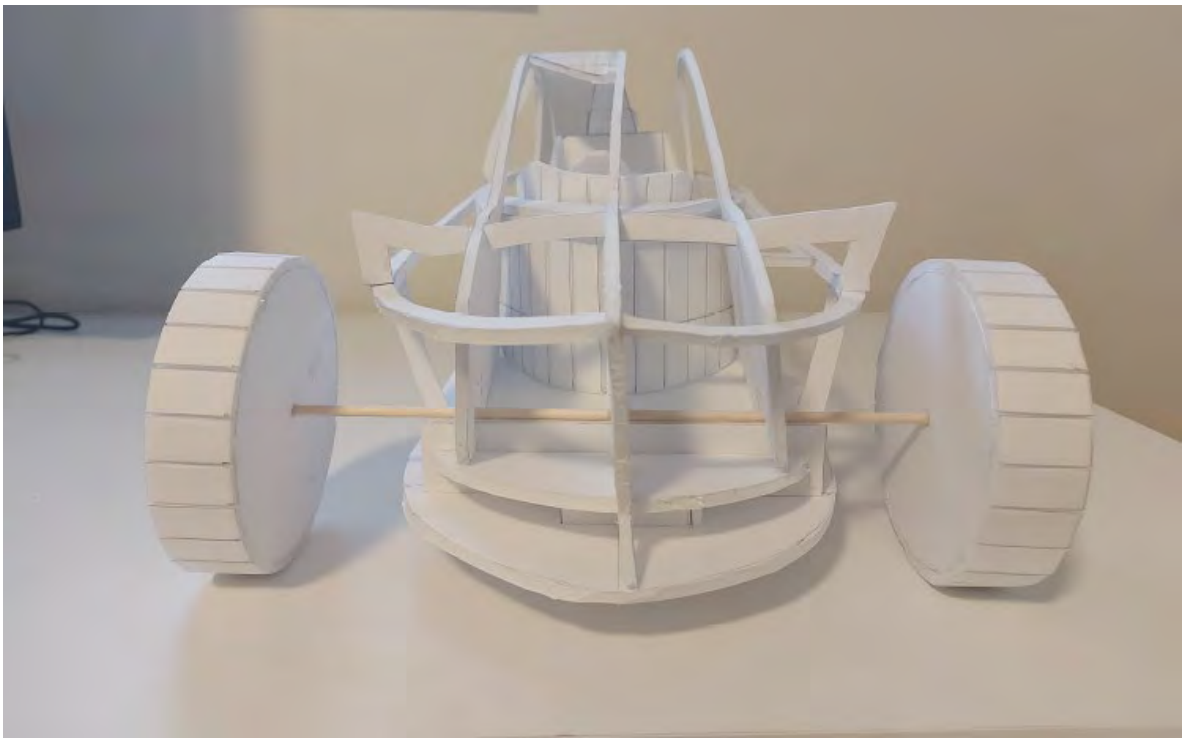


*Figure 86 - Tyren 1/5 Sketch Model Front View*

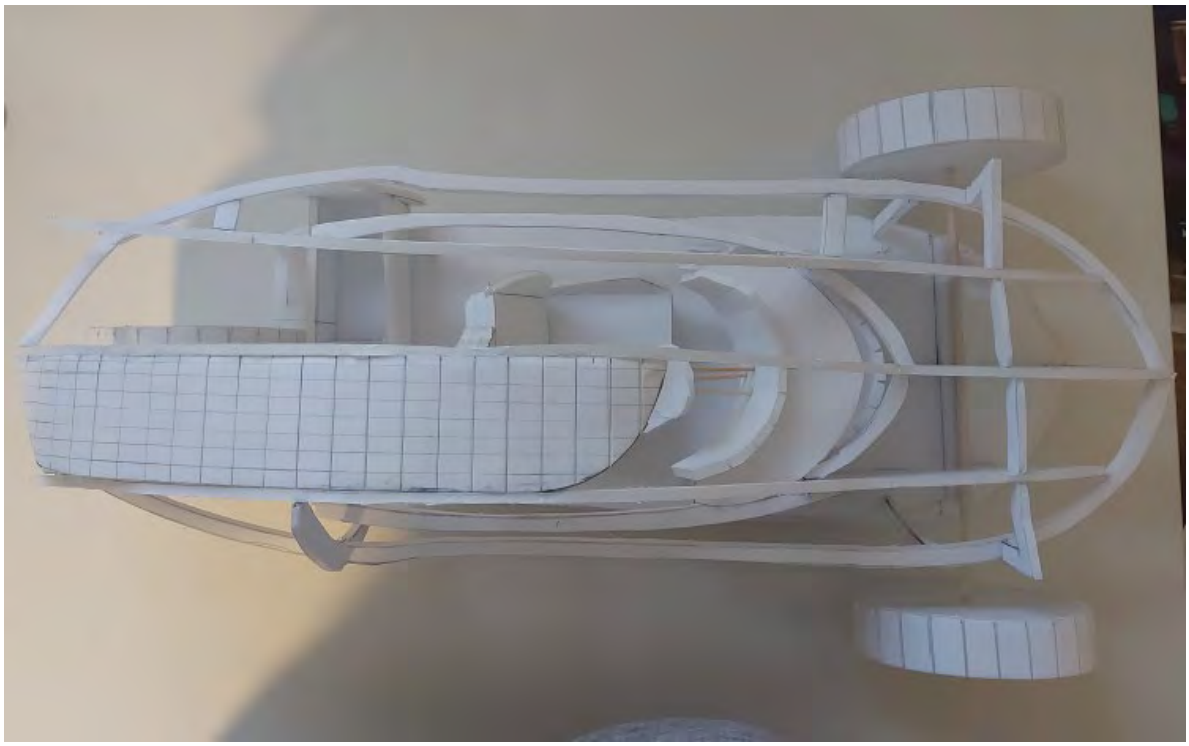


*Figure 89 - Tyren 1/5 Sketch Model Top View*

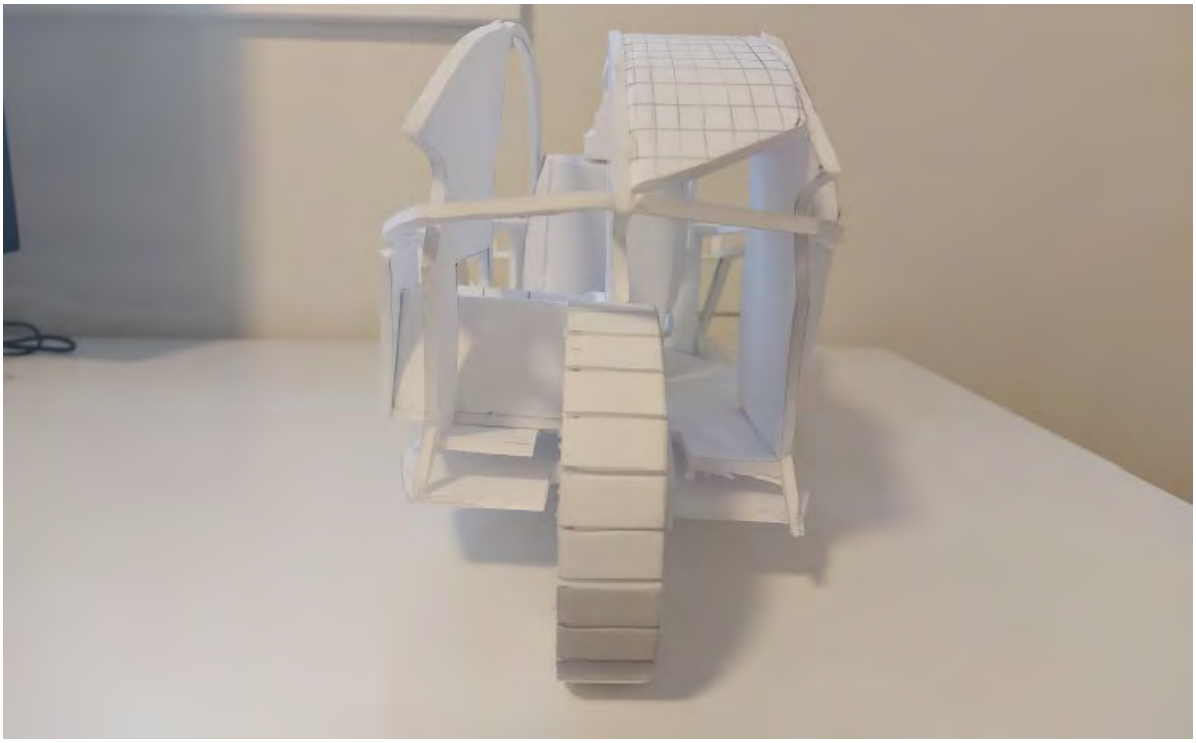


*Figure 88 - Tyren 1/5 Sketch Model Rear View*

### *4.6 Design Resolution*

Tyren's final design includes consideration of the basic needs and wants of police officers to ensure that they have a comfortable and high-performance vehicle that can tackle any obstacle in the officer's way. The increase cabin interior space has new innovative features so the user can focus on their duties and not worry about external noise that provide distractions when travelling at high speeds. The interior and exterior were designed to work together but bring out different emotions and feelings. The exterior is much more aggressive and has a low stance to mimic the bull ready to take charge to compliment the authority police officers have and the interior has much more organic forms and warm colors and lights to provide a calming environment when officers are in stressful situations. Tyren is 60% made of materials that are environmentally friendly and has an electric based power source to show that even high-performance vehicles can still have the same power and agility with a more sustainable power source. Tyren's aesthetic has changed drastically since the early phase of idea generation where the early forms were more geometric and had a lot of straight lines where now more organic form has been implemented to get of the natural aesthetics that current car manufacturers are using.

The figure shows the final form and functionality considerations that were made before jumping on CAD to make a 3D model and final renders.

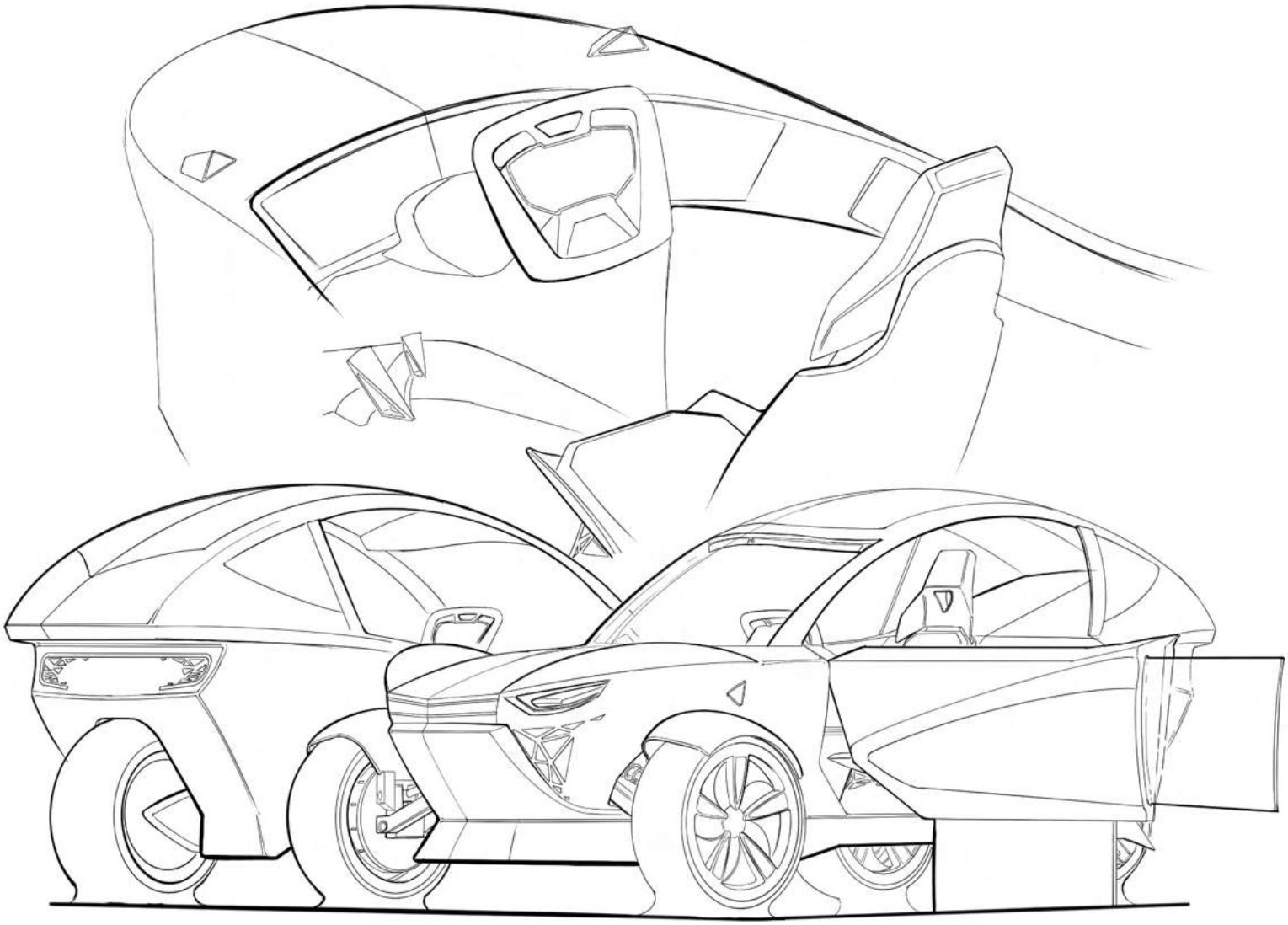
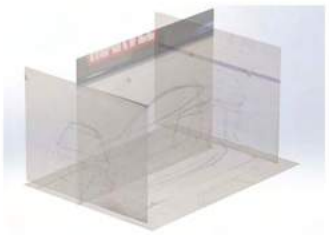
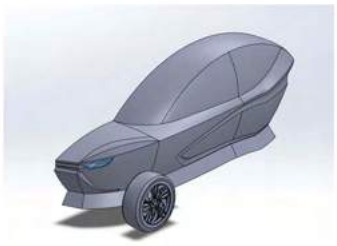


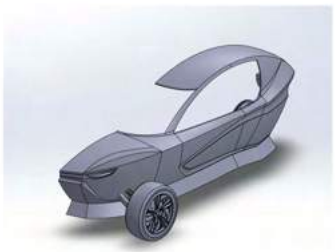
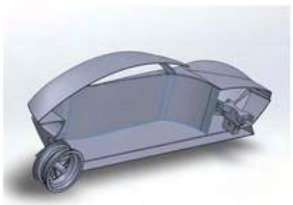
*Figure 90 - Design Resolution*

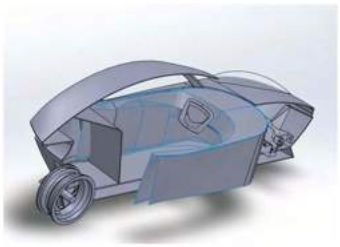
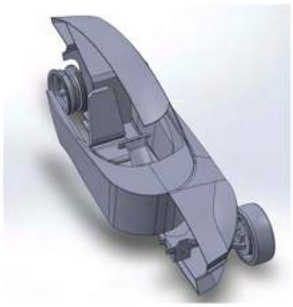
### *4.7 CAD Development*

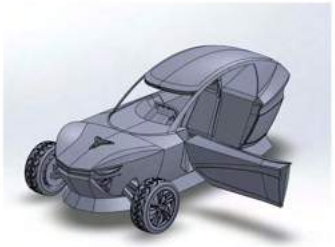
After finalizing the design form and functionality for Tyren, it was time to jump on to Solidworks to start the prototype model development which can be used to better understand the design and shed some light on problems that might not have been visible in the 2D sketches and rough model that were made prior. This CAD model will be used to 3D print out the final prototype model and be used for renders for visual presentations.






# CHAPTER 5 – FINAL DESIGN


*Figure 91 - Retreived From: https://unsplash.com/photos/ur-M2QQ6eYc*

# CHAPTER 5
# Final Design

## 5.1 Summary

### *5.1.1 Description*

Tyren is a law enforcement urban mobility vehicle designed for officers that are stationed in urban cities. Optimized for condensed spaces and high volumes of traffic, providing high levels of agility and maneuverability along with its smart drone to help officers find the most optimal routes to decrease response times in high priority situations.

### *5.1.2 Explanation*

Current methods of transportation used daily by law enforcement officers in urban are overly functional and not fit for the environment they are being used in. Even though current solutions provide everything an officer needs to effectively conduct their duties, they lack basic sense of ergonomics, agility, maneuverability, and organization. Current vehicles are big, heavy, and very poorly designed in the sense of ergonomics. These vehicles get stuck in traffic, blocked of by construction projects or large vehicles and are forced to use awkward routes to get to their destinations when responding to incoming calls. All these obstacles are fairly common all year around in urban cities where everything is designed and built for the general public without thinking about the consequences for police officers.

Tyren is a solution which addresses all these issues and the solutions that can help officers adapt and overcome the constant changes in the environment they work in on a daily basis. The concept vehicle proposes innovative technologies and features which include extendable door shield, smart drone to help decrease response times by detecting obstacles ahead of time and providing fast route adjustments, ample workspace in the cabin to

increase productivity using voice and touch commands. Making the life of a police officer easier but also increasing the efficiency of their duties was the highest priority of Tyren.

### *5.1.3 Benefit Statement*

Tyren is an urban mobility solution which includes an ergonomic and productive workspace that can provide comfort and ease of use to the officer for long periods of use. Along with smart features and tools that are embedded into exterior of the vehicle will mitigate the challenges that officers face daily in city environments, providing new and easier ways for officers to reach their destinations faster and efficiently carry out their duties.

## 5.2 Design Criteria Met

### *5.2.1 Full Bodied Interaction Design*


*Figure 92 - Full Bodied Interaction Design 1*

Full body interaction design research and development methods were used throughout the process of designing Tyren. Tyren provides a new perspective on the environment that an officer works in. To accomplish this new take, a full ergonomic study became extremely important to conduct to give viability to the design and the vehicle could be used without any effort and provide long term comfort. During the ergonomic study, the measurements of the 95$^{th}$ percentile man and 85$^{th}$ percentile woman were used to figure out the interior cabin sizes and best locations to incorporate features. Overall, the entire vehicle provides a new unique experience for police officers that serves as a effective mode transportation for first response situations.

COCKPIT

*Figure 93 - Full Bodied Interaction Design 2*

Tyren's cockpit provides a more effective layout of the essential features that are used by officers on a frequent basis such as the sirens, siren lights, radio, etc. Instead of using a full laptop that holds the law enforcement database, all the information is available on LED touch screen on the steering wheel, which provides easy access to important information even while driving. Even though the features on the dashboard and steering wheel can be

controlled via touch commands, Tyren also offers voice control to complete repetitive tasks such as filling out incident reports using speech to text functions and more. The wind shield offers artificial reality interactions such as map overlays, warnings of other vehicles not following road laws and safety precautions warnings when travelling at high speeds. The AR system works alongside the Drone, which provides all the information about road conditions, vehicle density, obstacle and more to base the route adjustments on when in response mode.

STORAGE


*Figure 94 - Full Bodied Interaction 3*

Tyren provides a large amount of storage space in its left side tool compartment, which can be used to store external tools, firearms, equipment and more without interference to interior cabin. The compartment is biometrically locked and can only be opened from the dashboard or finger print sensor on the compartment door.

SAFETY


*Figure 95 - Full Bodied Interaction Design 4*

Along with ergonomic and smart features, Tyren also provides safety features. A unique feature is that within door there is an extendable bulletproof shield that comes out when a large field of view is required by the officer but cannot go out in the open, so the clear glass helps with enlarging the officer's vision on the situation on hand while staying safe and make better informed decisions. To accommodate for multiple scenarios, there is small storage compartment in the interior door panel which can house small tools, firearms, and ammunition if they be needed.

### *5.2.2 Materials, Processes, and Technology*

Various types of materials, manufacturing methods, and technology were considered when it came to the final design of Tyren. Starting from the exterior internals, the chassis and body paneling will both be made from high strength aluminum to add extra layer of strength without sacrificing being light weight to be agile when making quick decisions on the road. The manufacturing will be the same as current industry methods using stamping, bending, and casting. The electronics and wiring will be outsourced from a company that has similar goals for green transportation.

For the tires, the selected choice was Continental Renewable Tread Tires, the grip on these tires can be renewed three times before they are disposed of. Made from organic materials, the tires are 80% recyclable. For the interior, majority of the fabrics that will used will be Econyl, a recycled form of nylon made from large fishing nets, left over nylon fabric and more. Where the company uses a fully sustainable plant to shred down old nylon into strands and reweave them into new nylon threads. This process can be done countless times on the same thread without losing any of its internal integrity. Econyl will used for the seat cushions, interior paneling and floor carpets. Tyren uses no fossil fuel-based power source, instead it uses a large Li-Ion Battery Packs, which is placed at the base of the vehicle to increase downforce of the vehicle, in turn increasing the turning performance. The batter pack only powers the In-Hub Motors that spin the tires to increase the mileage that Tyren can output on a single charge. The interior electronics and sensors are powered by the solar panel on the roof.

### *5.2.3 Design Implementation*

The cost of materials and manufacturing will need a more in-depth study if this project is taken forward. As more electric vehicles become more and more accessible, researching costs various components becomes easier. There are other vehicles that have the same layouts as Tyren but have different use cases. Based on some of these currently existing examples, a rough bill of materials was produced.

| BILL OF MATERIALS | | | | | |
|---|---|---|---|---|---|
| HIGH-COST ITEMS | | | | | |
| *Concept Item* | *Description* | *Estimated Cost* | *Similarly Produced Item* | *QTY* | *Material* |
| Lithium-Ion Batteries | Multiple | $15,000 | - | 2 | Sourced |
| Suspension System | To increase performance in rough terrains | $7,000 | - | 3 | Sourced |
| In-Hub Motors | X3 | $10,000 | Tesla In-Hub Motor | 3 | Various |

| | | | | | |
|---|---|---|---|---|---|
| Chassis | Foundation of Vehicle | $15,000 | - | 1 | High Strength Aluminum |
| Custom Windows | For AR System | $7,000 | - | 3 | High Strength Glass |
| Body Panels | High Strength Aluminum | $10,000 | - | Various | High Strength Aluminum |
| Computer | For Analyzing Data | $6,000 | - | 2 | sourced |
| AC/Heating system | All parts included | $4,000 | - | 1 | various |
| Drone | For Road Observation | $2,500 | Lockheed Martin Indago 3 | 1 | various |
| MEDIUM COST ITEMS | | | | | |
| Tires | X3 | $600 | - | 3 | Sourced |
| Rims | X3 | $500 | - | 3 | Aluminum Alloy |
| Extendable Door Shield | To provide extra safety | $400 | - | 1 | Bulletproof Glass |
| OLED Displays | Various | $2,500 | - | 3 | Various |
| Chair Frame | All parts Included | $500 | Hipoint Car Seat Structure Frame | 1 | Various |
| Chair Seat Cushions | All parts included | $400 | Kia Rio 5 Cushion | 3 | various |
| Interior Lighting | All parts included | $400 | - | 5 | LED Light strips |
| Sensors | Various | $600 | - | 8 | Source |
| LOW-COST ITEMS | | | | | |
| Nuts | All Included | $200 | - | Numerous | Steel |
| Bolts | All included | $200 | - | Numerous | Steel |
| Flooring | For cabin space | $300 | - | - | Econyl |
| Chair Padding | For comfort | $100 | - | 3 | Various |
| | | | | | |

## 5.3 Final CAD Rendering


*Figure 97 - Final Render Front*


*Figure 96 - Final Render Back*


*Figure 99 - Final Render Left*


*Figure 98 - Final Render Right*


*Figure 101 Final Render 3/4 Front*


*Figure 100 - Final Render 3/4 Back*


*Figure 102 - Final Render 3/4 Interior Back*


*Figure 103 - Final Render 3/4 Interior Front*


*Figure 105 - In Situ Render*


*Figure 104 - In Situ Render 2*

## 5.4 Physical Model


*Figure 107 - Final Model Front View*

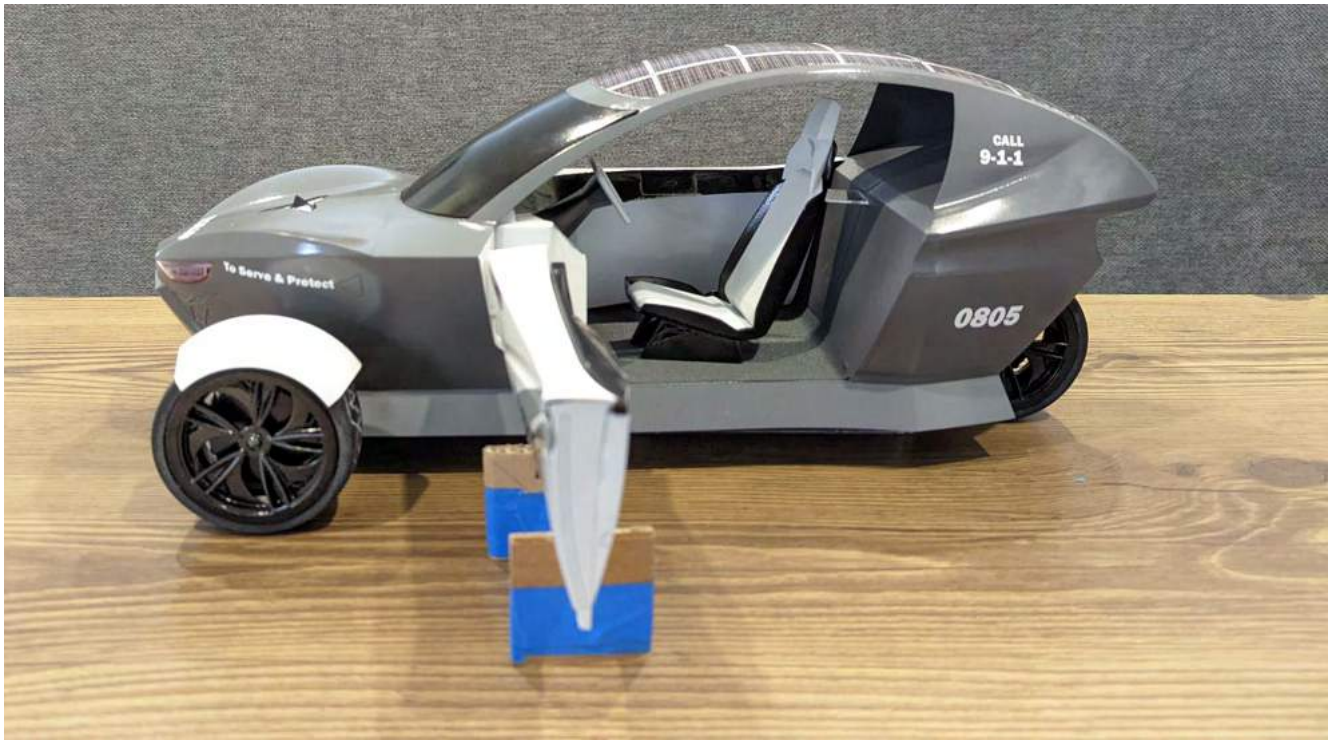



*Figure 106 - Final Model Left Side View*


*Figure 108 - Final Model Back View*


*Figure 109 - Final Model Right Side View*


*Figure 110 - Final Model Front 3/4 View*


*Figure 111 - Final Model Front 3/4 View*

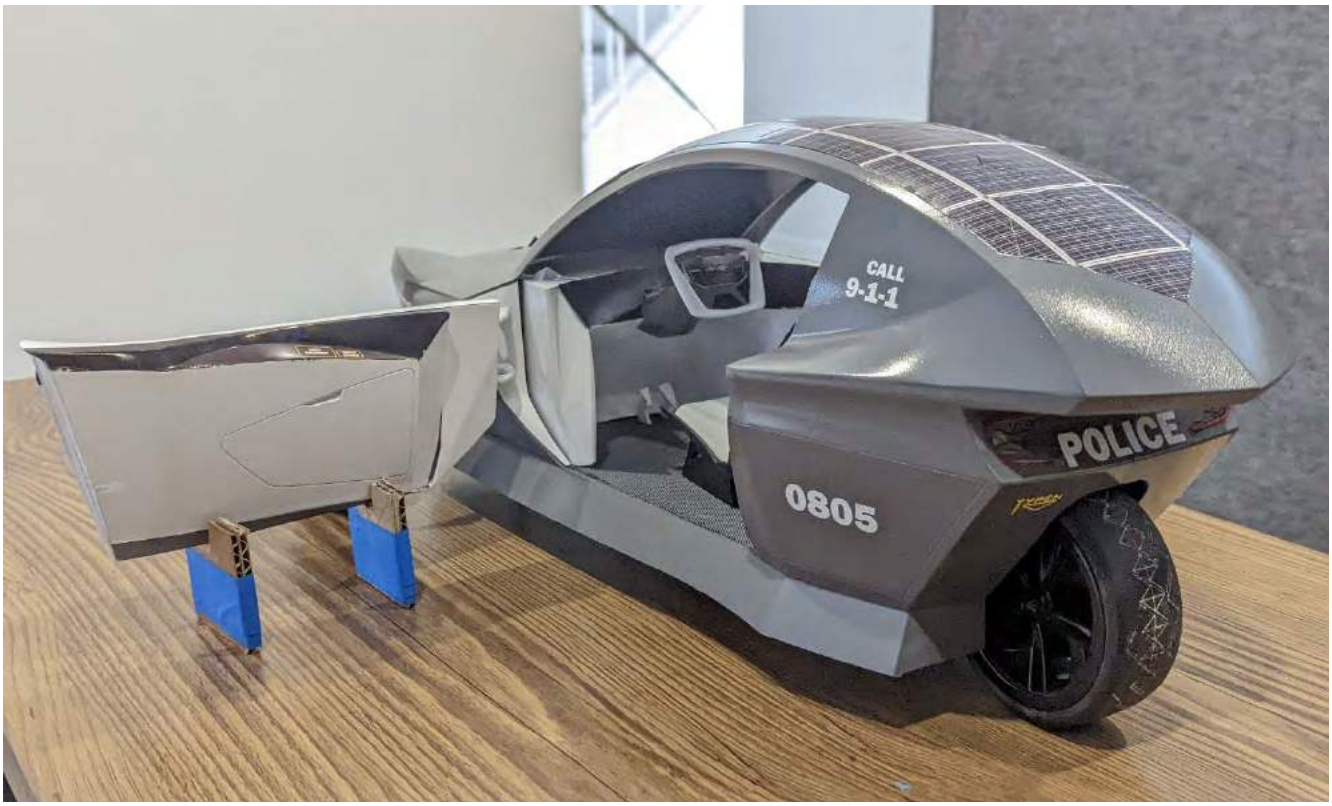



*Figure 113 - Final Model Rear 3/4 View*


*Figure 112 - Final Model Rear 3/4 View*


*Figure 115 - Final Model Drone Detail*

*Figure 114 - Final Model Door Detail*


*Figure 117 - Final Mode Interior Detail*

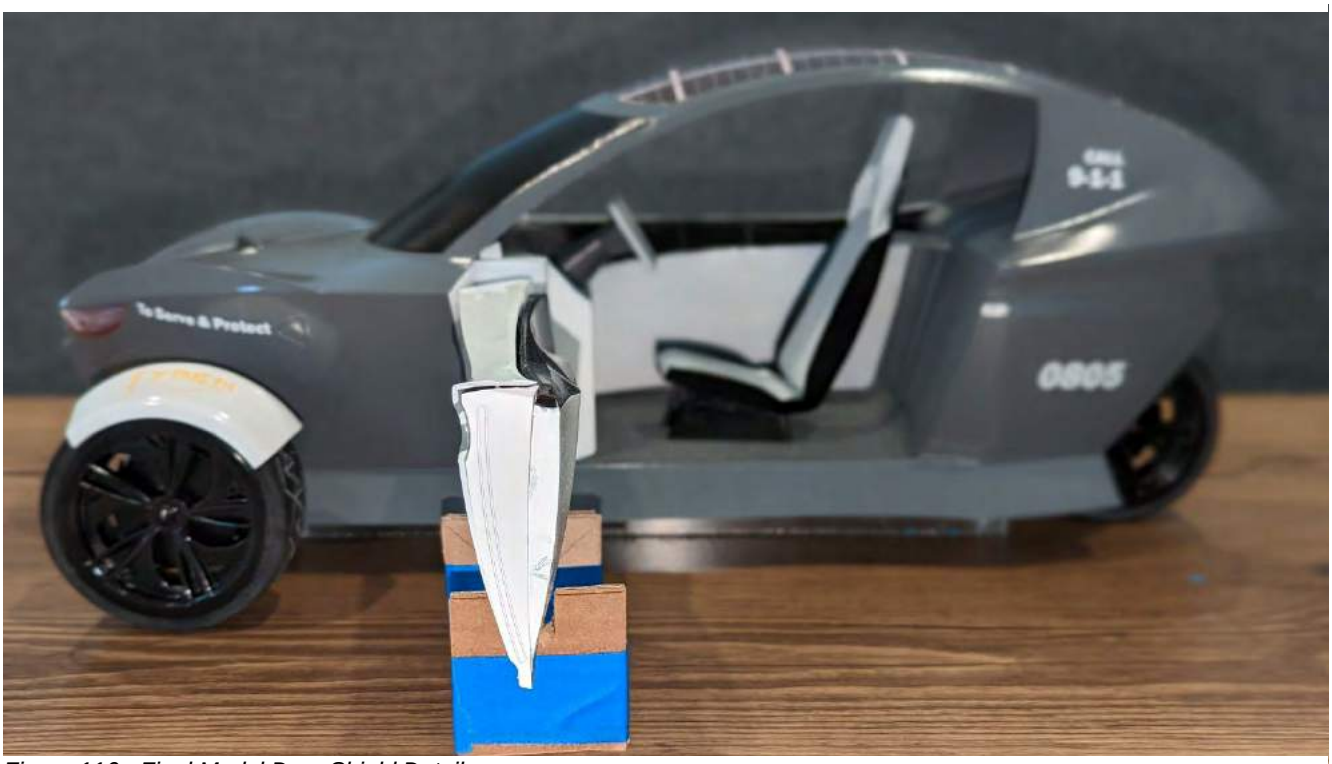
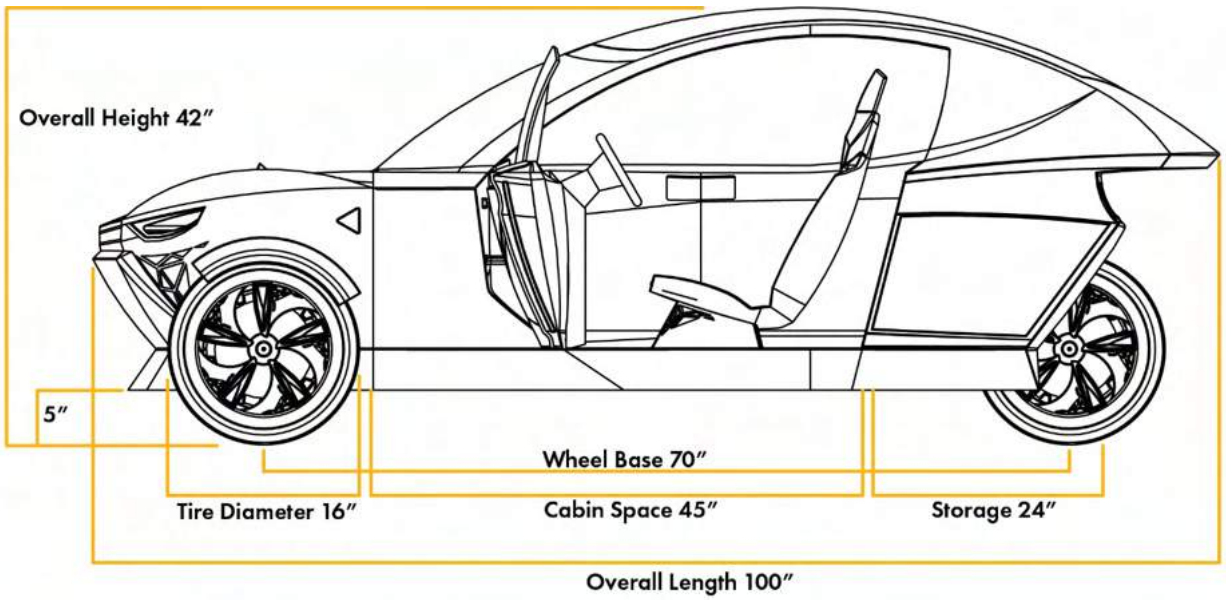
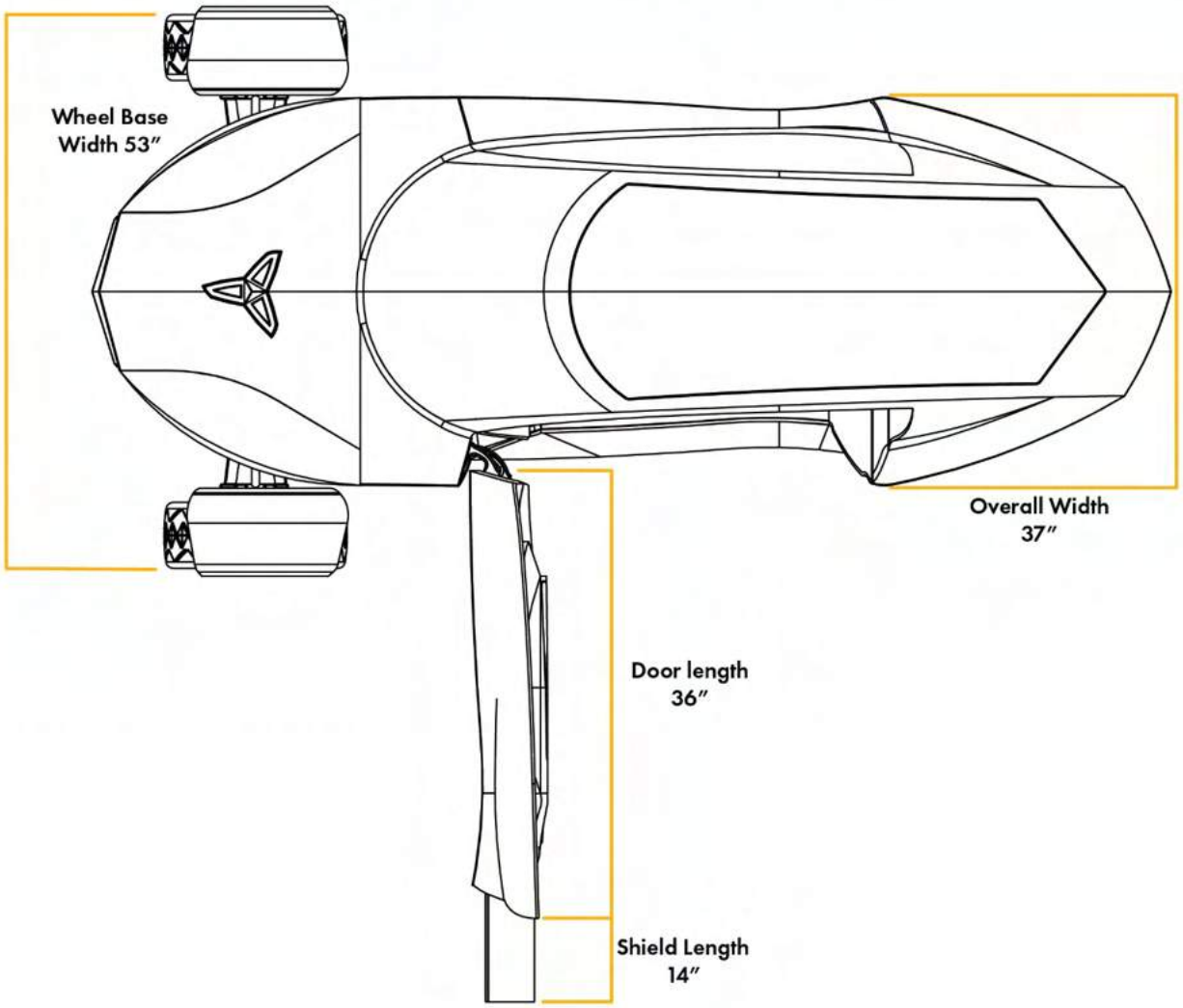



*Figure 116 - Final Model Door Shield Detail*

## 5.5 Technical Drawings



## *5.6 Sustainability*

Sustainable awareness has become a necessity for today's society, may this be for the environment, materials, wildlife, or humanity. Sustainability is one of the core pillars of foundation for this thesis and for the industrial design community as it evolves. Without consideration of sustainable aspects into the final design, this project has no viability for the future world. This design achieved incorporation of sustainable features, materials, and methods in every element of its design. From sustainable power sources to recycled/upcycled materials to greener manufacturing methods, this design sufficiently helps complete all duties for the user without having a negative impact of anyway on the environment.

The purpose of this design is to improve response times for police officers that work in urban cities. Being able to mitigate challenges faced on congested city roads caused by traffic jams, construction, and large vehicles was the driving force behind this thesis. Sustainable use and a recycling/upcycling policy being the "*force*" made this project a success.

Tyren uses electric batteries as its main power source to move with agility around the city which are located at the bottom of the vehicle, letting the air rushing under the vehicle to cool themselves without internal cooling systems. The solar panel on the roof powers all the internal electronics as the main energy supplier but during cloudy and colder times of the year, the main batteries help pick up the load. The heat produced from the solar panels is transferred to the cabin during winter months. This natural process of heating and cooling, diminishes the need for external products and coolants. All the internal fabric and upholstery are produced to be interchangeable so they can be recycled and reused either as same products or different use case scenarios. The fabrics used are produced using green manufacturing methods where every strand of the fabric can be recycled and reused repeatedly. Econyl

uses nylon found in large industrial fishing nets, thrown away clothing, etc. to separate each strand of nylon and mesh it with others to make new threads and this process produces no greenhouse gases or emissions of any sort.

The tires used on Tyren are the Conti GreenConcept where the more than half of the materials are renewable and recyclable, the biggest feature being able to be re-treaded up to three times before they become disposable. Even at the end life, a new process has been developed where the effects of vulcanization can be reversed with up to 80% efficiency. With devulcanization process majority of the raw materials can extracted from scraped tires before they end up in the landfill. Tires are one of the products that have large quantities of being thrown into landfills each year. This process can help reverse the negative impacts of tires or at least lower the effects.

# CHAPTER 6 – CONCLUSION

*Figure 118 - Retrieved From: https://unsplash.com/photos/10sT1XNZS78*

# CHAPTER 6
# Conclusion


*Figure 119 – In-Stiu Render*

Current methods of transportation offered to police officers in city environments offer very little help to complete duties and help the public effectively and on time. Effective responding to incoming calls requires instant adaptation to situations that arise on city roads which is not possible for current vehicles used by officers. Vehicles used currently have numerous risks and are too large for current city environments to be able to travel fast and safely mostly due to congested roads, construction, and large vehicles blocking roads. Tyren is an effective solution to tackle all these challenges head on with adaptive features that can overcome any type of obstacle that might arise.

Tyren is an law enforcement urban mobility vehicle that was designed with a human centered approach to be more ergonomic and agile for users to help complete duties faster and more effectively. The exterior of the vehicle

gives more ergonomic control and long durations of comfort, offering more optimal layout of features and buttons that are standard in current police cruisers for easier administrative tasks and communications with dispatch/officers.

Tyren is a concept vehicle that addresses issues of sustainability and functionality, letting users conduct their duties more effectively without having a negative impact on the environment. The final solutions also incorporates unique and innovative technologies and features such as a built in drone for road condition observation, area surveillance, and providing extra safety for the user. Ample space has been developed in the cabin to freely move around and conduct tasks that would have straining current solutions.

# CHAPTER 7 – REFERENCES


*Figure 120 - Retrieved From: https://unsplash.com/photos/R1i_0mLWSpU*

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# Appendix A – Discovery

## Method

A key article for this topic was sourced and selected. Required article content (Abstract, Introduction, and Conclusion sections) was copied and highlighted.

· Search Engine: Humber Library Discover

· Key Words: “police response times”

## Findings

**Citation:** Lee, J., Lee, J., & Hoover, L. T. (2017). What conditions affect police response time? examining situational and neighborhood factors. *Police Quarterly, 20*(1), 61-80. https://doi.org/10.1177/1098611116657327

**Abstract**

Police response time to calls for service is a crucial factor in evaluation of police performance. While domestic violence is now considered serious interpersonal violence, factors associated with response time to domestic violence incidents are underexplored. Using hierarchical linear modeling, over 10,000 cases of calls for service for domestic violence across 438 census tracts in Houston, Texas, were examined. The result of multilevel analysis revealed that complainant's race, weapon involvement, and day and time of incidents were associated with response time at the situational level. At the neighborhood level, concentrated disadvantage, immigration concentration, and residential stability were significantly associated with response time.

**Introduction**

While domestic violence is now considered serious interpersonal violence, it had not been treated as such until the 1970s in the United States (Erez, 1986; Fagan, 1996; Johnson, 2007). The social movement for women's rights during the late 1960s and 1970s reframed the societal perception of violence against women. Subsequently, the criminal justice system has enforced Draconian measures to promote specific and general deterrence of domestic violence (Melton, 1999; Lee, Zhang, & Hoover, 2013b). An example would be the nation-wide adoption of a mandatory arrest policy by law enforcement agencies during the 1980s (Johnson, 2007; Sherman, & Berk, 1984). Additionally, domestic violence has received a great deal of academic attention, leading researchers to examine not only its correlates but also how the justice system responds to it.

The importance of police response time has been highlighted in the literature (Eck, & Rosenbaum, 1994; McEwen, Connors, & Cohen, 1986). Studies found that police rapid response increased citizens' satisfaction with police (McEwen et al., 1986) and arrest rates (Cihan, Zhang, & Hoover, 2012; Clawson & Chang, 1977; Isaacs, 1967; Kansas City (MO) Police Department & United States of America, 1978). Sherman (1992) pointed out that practitioners recognize response time as an indispensable factor to evaluate police performance. Hence, police response time to calls for service (CFS) has been one of the crucial criteria to evaluate police work (Kelling & Moore, 1988; Sherman, 1992). However, police response time in domestic violence has been underexplored.

Findings in the previous studies suggest that there exists a relationship between police response time and ecological characteristics (Mladenka & Hill, 1978; Stevens, Webster, & Stipak, 1980). For example, Klinger (1997) posited that police would become more cynical and their vigor to respond to citizens' demands would be diminished after responding to repeated CFS from a high crime neighborhood. Accordingly, the current study attempts to examine the situational factors affecting police response time to domestic violence incidents. Examining police response time from an ecological perspective provides insight into the association of police strategy for patrol operations and allocation of patrol resources.

**Summary Statements:**

1. Some of the factors that affect a police officer’s response time are not physical but also social.

2. Smaller response times increase community satisfaction rates and build confidence

3. Police strategies and allocations are determined by the rates of crime in different areas and neighborhoods.

**Professional Interview – OPP Officer in West Ontario**

The interviews conducted for this thesis project was with and OPP Police Officer that is stationed in West Ontario. Due to active Police policies the identity cannot be revealed and published publicly for further questions contact the author. *“Every person engaged in the administration of this Part shall preserve secrecy with respect to all information obtained in the course of his or her duties under this Part and shall not communicate such information to any other person except,*

*(a) as may be required in connection with the administration of this Act and the regulations.*

*(b) to his or her counsel.*

*(c) as may be required for law enforcement purposes; or*

*(d) with the consent of the person, if any, to whom the information relates. 2007, c. 5, s. 10.”* (Police Services Act 2021)

## PARTICIPANT INFORMED CONSENT FORM

**Research Study Topic:** How may we improve mobility for police officers in dense urban environment?

**Investigator:** Aviraj Cheema / 647-608-1115 / avirajcheema56@gmail.com

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

I, ____Anonymous_____*(First Name/Last Name)*, have carefully read the Information Letter for the project How Might We Improve Mobility for Police Officers in Dense Urban Environments, led by Aviraj Cheema. 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 Aviraj Cheema 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, « insert student Name here » and Prof. Catherine Chong or Prof. Sandro Zaccolo 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, 416-675-6822 ext. 79322, **Lydia.Boyko@humber.ca** or « insert student Name /Phone Number /Email Address ».

**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.

| Anonymous | OPP Officer In London Ontario | 2021-10-17 |
|---|---|---|
| Participant's Name | Participant's Signature | Date |

IDSN 4002 / 4502

**INFORMATION LETTER**

**Conditions of Participation**

- ✓ I understand that I am free to withdraw from the 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 date 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.**

| Anonymous | OPP Officer In London Ontario | 2021-10-17 |
|---|---|---|
| Participant's Name | Participant's Signature | 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: 647-608-1115

Email: avirajcheema56@gmail.com

My supervisors are:

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

Prof. Sandro Zaccolo, **sandro.zaccolo@humber.ca**

| Name | Phone | Email | Basis of Expertise |
|---|---|---|---|
| Anonymous | Contact Author | Contact Author | Police Services, Procedures, Methods. |

**Method:**

Questions were prepared prior of the interview. The structure was very rudimentary to force an natural conversation. The desired outcome of this interview was to gain insight on the personal experiences, procedures and methods used by officers in different scenarios and the various tools and

vehicles they operate. Due to active police confidentiality policies, no audio or video recording occurred during the interview rather notes were taken by hand to record the important points as the interview progressed. The questions are in black, and answers recorded were in red. In some questions, the answers were not clear and due to time restraints further discussion was required.

Can you tell me about your background?
16-year veteran Police Constable working with the Ontario Provincial Police. I have worked in various capacities as a Police Officer in numerous fields of Investigation pertaining to law enforcement.

What are your main responsibilities in your job?
Ensuring the safety and security of all people and property in Ontario. Safeguarding the fundamental rights guaranteed by the Canadian Charter of Rights and Freedoms and the Ontario Human Rights Code. Working closely with the communities they serve.
A) Enforcing municipal, Provincial, and federal laws.
B) Patrolling assigned geographic zones and responding to calls.
C) Apprehending and transporting suspects.
D) Interviewing victims, witnesses, and suspects.
E) Gathering and logging evidence.
F) Writing citations, delivering warrants, and testifying in court.
G) Preparing and providing accurate reports documenting incidents and activities.
H) Responding to emergency and non-emergency situations.
I) Preventing and investigating illegal activities, domestic disturbances, accidents, etc

Why did you choose to become a Police Officer?
- Making a meaningful impact on the betterment of society.
- Your job is vital to the community.
- No two days (or offices) are the same.
- Self-respect and pride.
- Good salary and employee benefits
- Understanding how the preservation of rule of law molds our communities
- Care towards making a difference in the community.
- Addressing the wants and needs of the communities
- Wanting to work as part of a reputable and efficient team that makes our communities safer.
- Opportunity to continuously grow and improve myself through the experience of social work and service to the community.

What are the most common types of calls do you respond to?
911's – Abandon Vehicle -Alarm- Robbery– Animal Complaint – Arson ASL– Assault – Assault – Assist Fire Department - Assist Outside agency - Assist Paramedics-Assist Person -Break and enter – Civil Standby keep the PEACE– Criminal Mischief – Sudden Deaths(suspicious or not)- Motor Vehicle Collisions-Aircraft incidents-– Domestic Disturbance- Noise Complaints - Disturbances – Disturbance W/Weapon – Drownings – Impaired DrivingDrunk Drive– Fraud – Harassment– Traffic Hazards– Missing persons – Littering / Dumping – Mental Health - Minor and Major Possession of Alcohol / Drugs- Watercraft Violations – Parking Complaint – Premise / Security Check – Found Property – Suspicious vehicles /persons – Pursuits – Recovered Stolen Vehicle– Robbery – Search & Rescue – Stolen Vehicle – Suicide Threats – Thefts– Theft Shoplifter – Theft From Vehicle – Traffic Complaints - Traffic Detail TS - Traffic Stops – Train Accidents – Trespassers – Unwanted parties– Violation or breaches of orders /conditions– Warrants – Welfare Check– Prisoner Transport

What type of environment do you usually work in (eg. urban cities, residential, rural, industrial)?
Areas policed: A) Rural areas embedded with small urban centers/ population in and around 20k.( hybrid neighborhoods consisting of urban and rural communities).
B) We also extend our policing jurisdiction in a coordinated manner with larger urban centers such

Toronto, Peel, York, Halton-Assisting other urban centers such as the GTA.
C) All provincial highways are also the jurisdiction of the Ontario Provincial Police which supersede many rural and urban centers throughout the Province of Ontario.

Can you tell me about the steps you take from the moment you get a call to when you reach the scene?
When a call for service is received by a dispatcher, it is assigned a priority level based on the severity of the incident and is used to prioritize the police response. A call for service can be escalated to a higher priority before being cleared if the nature of the incident changes and more police units are necessary.
**High: In progress events where persons or high-value property are in danger. Requires multiple-unit response**.
**Medium: In progress events without immediate danger to persons or property.where persons or high-value property are in danger. May require multiple unit responses.**
**Low: Events that may no longer be in progress, so immediate response is not urgent. Generally single unit call.**

Can you tell me the reasons behind each step that you mentioned in question 4?
Further discussion required
What type of tools do you use on a daily basis (eg. Vehicles, hand tools, digital tools,

communication tools) and what are they used for?
tools: Ammunition, bulletproof vest, drones, body cameras, duty belt, flashlight, firearm(s), taser, Oleoresin Capsicum, radio, baton, Mobile data terminal.

What are some of the major problems you face with these tools?
Further discussion required

Can you describe the layout of your workspace and how the tools you mentioned in question 8 are placed?
Further discussion required

Describe any fears, frustrations, anxieties you feel from your response to a call and to the moment you reach the scene.
Police stress arises from several features of police work. Alterations in body rhythms from monthly shift rotation, for example, reduce productivity. The change from a day to a swing, or graveyard, shift not only requires biological adjustment but also complicates officers' personal lives. Role conflicts between the job—serving the public, enforcing the law, and upholding ethical standards—and personal responsibilities as spouse, parent, and friend act as stressors. Other stressors in police work include:
• Threats to officers' health and safety
• Boredom, alternating with the need for sudden alertness and mobilized energy.
• Responsibility for protecting the lives of others.
• Continual exposure to people in pain or distress.
• The need to control emotions even when provoked.
• The presence of a gun, even during off-duty hours.
• The fragmented nature of police work, with only rare opportunities to follow cases to conclusions or even to obtain feedback or follow-up information.
Administrative policies and procedures, which officers rarely participate in formulating, can add to the stress. One-officer patrol cars create anxiety and a reduced sense of safety. Internal investigation practices create the feeling of being watched and not trusted, even during off-duty hours. Officers sometimes feel they have fewer rights than the criminals they apprehend. Lack of rewards for good job performance, insufficient training, and excessive paperwork can also contribute to police stress
The criminal justice system creates additional stress. Court appearances interfere with police officers' work assignments, personal time, and even sleeping schedules. Turf battles among agencies, court decisions curtailing discretion, perceived leniency of the courts, and release of offenders on bail, probation, or parole also lead to stress. Further stress arises from perceived lack of support and negative attitudes toward police from the larger society. (Most public opinion surveys, however, show strong

support for and positive attitudes toward police.) Stress also stems from distorted and/or unfavorable news accounts of incidents involving police. The inaccessibility and perceived ineffectiveness of social service and rehabilitation agencies to whom officers refer individuals act as further stressors

What future advancements or tools would you like to see, that could help you minimize these fears and frustrations?
Law Enforcement leaders are increasingly going to lean into analytical methods and deploy technologies that will enable their officers to maintain a high degree of situational awareness while physically intervening only when needed.

What physical obstacles do you face in your journey as you start traveling toward where the call came from?
Physical obstacles: Weather, geography, wild animals, general public whether on foot or their vehicles.

How do you try to avoid or minimize these obstacles?
preparation for duty /situational awareness/ physical health/mental health

What would you like to see in the future that would help to completely avoid these obstacles?
The very nature of the aforementioned problems is not going to be completely solvable. Though the further focus on addressing and educating officers on mental health issues will only aid in the betterment of policing and the officers, themselves.

What would make your job more productive on a day-to-day basis?
Shift work and its challenges

How long are your average shifts?
4 day shifts that alternate night and day
2 day nights and 2 days day shift
12 hours shifts (6 am - 6 pm and vice versa)
Rotates weekly
Pains
Time management skills
Body rhythm is in constant flux
Unhealthy
Start earlier than the actual shift time (30 mins)
Do's-
Gear, change uniform, readying cruiser, duty duffle bag.
Terminal setup (MTD) (is modular)
Cruiser safety check and initial check.

What types of work do you do in an average shift?
Three types of work in an average shift
Patrolling
Responding to calls (any vehicle) (the vehicle is not fixed to the officer, based on what is available)
Community-based policing
Engaging with community, hotspots
Responding through a chain of command
Traffic Enforcement
RIOT Program
Bylaw Enforcement
Assisting EMS and Firefighters
Administrative Work
Report writing of calls that were responded to throughout the day

Can be done in cruiser if they are too many calls coming in
Dictation service of events of calls
Training
Mind and Physical training
Online seminar training
In person training
Yearly qualification testing
Night firearm training
Extra courses that are offered
Community-based training (new methods and protocols)

Can you tell me how long you have worked in the region of Toronto?
Was never stationed in Toronto, but have worked on cases in and around Toronto and the GTA area

Can you tell me the top three types of calls you get in the region of Toronto?
911 misdials, traffic-related calls (accidents, impaired driving, etc.), and mental health calls (use of drugs, self-harm)
Policing areas where other community jurisdiction is not available, including provincial highways

Can you describe the steps you take from start to end when you respond to a call to when you reach the scene of the crime?
Step 1:
Start at the detachment (do everything in question 2)
On the MTD, the priority of calls dispatched calls via communication center &/or it shows on the MTD.
Dispatch fills in event information in real-time and communicates with the officer

Step 2:
Proceed with cruiser and head to call, and as traveling, check for any changes in the event of call, background information, determine if extra units are needed.

Step 3:
The driving speed is based on the priority of call and weather conditions, traffic conditions, urgency of the call, and time of day.

Step 4:
Arriving at scene
Scoping out the situation from inside the vehicle, keeping a constant awareness
Checking background on everything and everyone that is related to the call
Feelings: Trained to follow procedures, engaged emotionally, and going through ranges of emotions (fear, anxiety, etc.)

Step 5:
Exit Vehicle
Proceeding with caution in the event area

Step 6:
Listening, Looking for activities to help the investigation and helping anyone in potential harm
Tactical Communication: the specific method used by police to serve the public in

a way that provides a duty of care to individual
Acting on background information
Using an approach to prevent further escalation
Investigating method to find the offense through observation, communication, objectively and subjectively

Step 7:
The investigation is either inconclusive or conclusive
Finding the right branch to delegate the next steps of the procedure. Eg. criminal offense goes to arrest and/or charge a suspect. Or non-criminal goes to trying to prevent further escalation if required

Step 8:
Update dispatch on the result of the call and receive further instructions or leave the scene and go back on patrol

Step 9:
Debriefing with other officers that were present on scene or supervisor via cellphone, email, and dispatch

Step 10:
Data entry of report
Can be done by going back to the office
Has ergonomic workstation to do administrative work comfortably
Can be done on cruiser MTD if there are back-to-back calls
Park the cruiser and fill in reports

Step 11:
Back to patrolling

Step 12:
Go to the detachment at the end of shift (reach detachment an hour prior to the shift end)
Do shift briefing
Overlook of the entire shift
Finish pending administrative work
Daily activity report
If there is an officer shortage, then extra shift time if required (necessary due to lack of officers or important call has come in
Empty cruiser, return and register firearms, fill up gas, circle check for any damage, and meter reading
Go change and store uniform

Step 13:
Go Home
Start new day (out of the house by 5 am
8 to 9 hours of sleep is recommended
The average sleep received is around 6 to 7 hours

Do your steps change based on the priority of the call?
Overall steps in the day stay the same but individual steps may change if there is a high priority call or there is an obstacle in the way that is preventing further

progress.

Can you please describe the physical obstacles you face in your journey from the previous question?
Pedestrians walking in streets and not paying attention to oncoming vehicles
Concentration (lack of sleep, health issues, workspace is not comfortable)
Cyclists in bike lanes coming without any warning and not paying attention to incoming traffic
Vehicle congestion
Overall population
Streets (large buildings preventing signal blocks with detachment and dispatch, and obscures field of view)
Weather-related elements
Construction
Rallies, parades, street concerts
School zones
Terrain (slopes, rough roads, off-roading, etc.)
Road engineering, road population

How do you try to avoid these obstacles?
Mental preparation
Experience
Training
Physiology (potential degradation of motor skills)

Can you tell me what vehicles you used while you were working in Toronto?
The Chevrolet Tahoe, Ford Explorer, and bicycles

Please describe the activities you perform immediately before using the vehicle?
Did circle checks on the vehicles, wrote down all the reading on the meters
Load my equipment in the vehicle
See every feature is working such as lights, sirens, etc.

Please describe the activities you perform immediately after using the vehicle?
Do final circle check
See for any damage
Report all the events this vehicle was used for
Report end of daily readings on meters and fill it up with gas
Report any damage that the vehicle took and send it to the shop to be repaired if needed
Please comment on the vehicle's steering. How comfortable are the wheel/handlebars?
Moderate steering
Stiff when it comes to high-speed turns
Overall good

Please comment on the vehicle's seats and the ability to move around the workspace?
Seating is good
Need more space to move around in the cabin of sedans
Long hours in the vehicle can give back pain and back issues
Uncomfortable after a long duration of sitting
Fat around the heart starts to build up when you sit for to long
Nerves in the legs get damaged after a long time

The weight of the uniform, safety vest, and utility belt does not help with the ergonomics

Can you suggest any changes to the seating or posture to make the experience more comfortable over extended periods of vehicle use?
The seats are wider and adaptable to the officer's posture
The seats encourage good posture but still provide comfort for long durations
The seat needs to allow for airflow to cool the officer in stressful situations

Is vehicle lighting effective at allowing you to be seen by others and avoid obstacles on the road?
Very efficient based on power usage
Easily seen by others
Bright and works very well in the dark environments
Needs night time lighting so it does obscure the officers night time vision
Need interior red filters

Please comment on the vehicle's acceleration speed. Do you feel that it is too slow, adequate, or too fast?
Strong acceleration
Depends on the transmission (AWD or RWD)
Large engine so it can reach high speeds pretty quickly

Please comment on the vehicle's aerodynamics. Would increase/decreased aerodynamics increase driver safety in any way? Why or why not?
Overall police vehicles are big and bulky and looking cubes so they are not the most aerodynamic but provide extreme safety at high speeds because of that.
It would be preferred if the vehicles are a little more aerodynamic so the control of the car is easy to maintain at high speeds.

Please comment on the vehicle's buttons, knobs, and switches. Are they all easy to find, access, and use?
Easy to reach and access
Not in constrained areas
Uncomfortable to use after long periods of time

Please comment on the use of the mobile data terminal. Is it easy to use, change its location?
The mobile terminal is a tablet that can be removed and used in your hands
Can be used through voice commands when driving
Is transferable to workspace in office to continue working when not in the vehicle

What features would you like to have on your "dream" transportation vehicle, and why?
More integrated MTD system
Better use of constrained space in the vehicle
Ergonomically friendly
Better seats
Most systems are integrated into the dash and available right in front to not distract user when driving

Please comment on the driver collision protection that the vehicle offers. What does it offer to protect the driver and is it sufficient? Why or why not?

Safety is very good
Steel safety frame
Roll cage
Front and back crumple zones
High strength bumpers
More than sufficient

Please comment on the safety that the vehicle provides from external attacks. What does it offer to protect the driver and is it sufficient? Why or why not?
Due to the large size of the vehicle, it provides lots of different spaces around the car to take cover from attacks, such as the rear of the car, the sides etc.
Taking cover in these places, forces the attacker to shoot through the vehicle and the vehicle protects the user by all the obstacles it gives to the attacker.


PANEL ON RESEARCH ETHICS
Navigating the ethics of human research

TCPS 2: CORE

Certificate of Completion

This document certifies that

Aviraj Cheema

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

N01283493

Date of Issue: 1 September, 2021

## Appendix B – Contextual Research (User)

**User Profile:**

Primary – Uniformed Police Officers

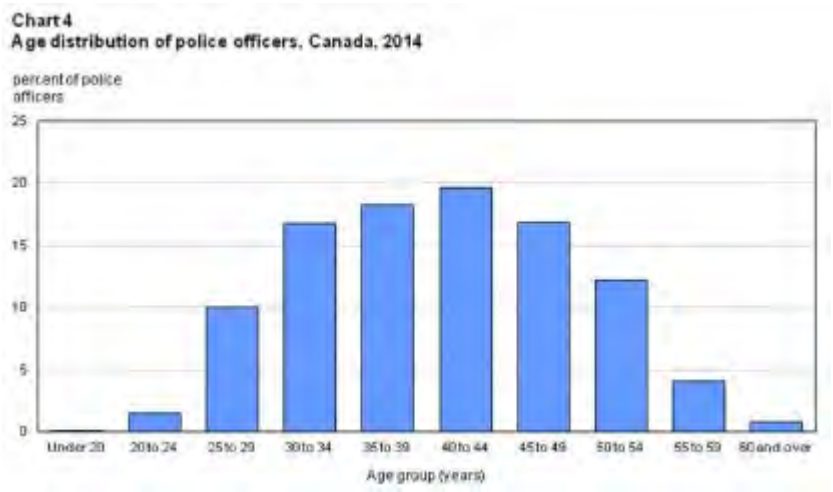
Secondary - Transit and Railroad Officers

Tertiary - Police Vehicle Purchasing Department Personnel

**Findings:**

| **Demographic Of Police Officers** | | **Reference** |
|---|---|---|
| **Age** | 35 – 45 Years | https://www150.statcan.gc.ca/n1/pub/85-002-x/2019001/article/00015-eng.htm |
| **Gender** | Mostly Male (≈ 78%) | https://www150.statcan.gc.ca/n1/pub/85-002-x/2019001/article/00015-eng.htm |
| **Culture / Ethnicity** | Caucasian | https://www150.statcan.gc.ca/n1/pub/85-002-x/2019001/article/00015-eng.htm |
| **Income** | + $60,000 | https://www150.statcan.gc.ca/n1/pub/85-002-x/2019001/article/00015-eng.htm |
| **Educational Background** | 2 years of post-secondary | https://paladinsecurity.com/law-enforcement-careers/become-police-officer-canada/#section1 |

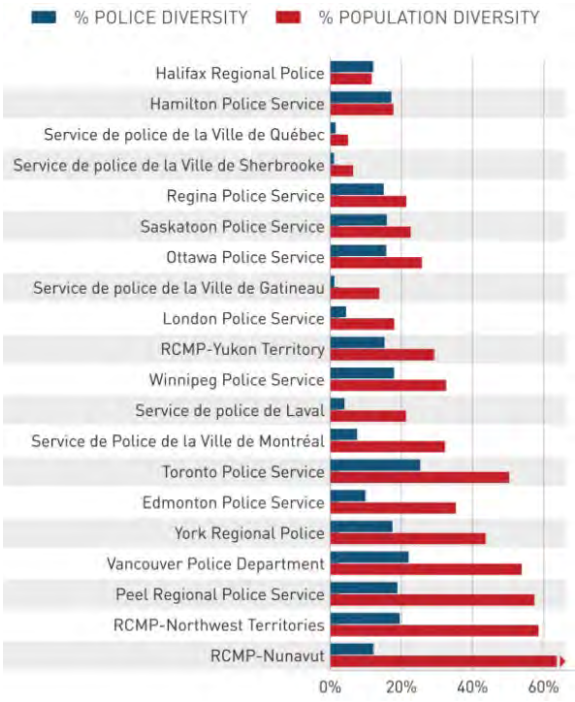
**Age & Gender:**




Retrieved From: https://www150.statcan.gc.ca/n1/pub/85-002-x/2019001/article/00015-eng.htm

The above chart shows the age distribution of police officers in Canada in the year 2014, where the majority of the officers were from 34 to 45 years old. The police force has a total of 54,721 officers and about 78% of them were male and about 22% were females as of 2018 (StatCan, 2018)

**Ethnicity and Culture:**




This chart represents the various ethnicity diversity in Canada relative to the population of same area. Based on the chart, Toronto Police Services have 28% diversity within their ranks where the majority of the force identifies as Caucasian and four percent of the force self-identified as indigenous police officers and 26% of force self-identified as visible minorities. (StatCan, 2018)

Retrieved From: https://www150.statcan.gc.ca/n1/pub/85-002-x/2019001/article/00015-eng.htm

**Education and Income:**


*Retrieved From: https://paladinsecurity.com/law-enforcement-careers/become-police-officer-canada/#section1*

The starting salary for cadets in the Toronto Police Department is around $60,000 annually and after year three of service, police officers tend to get a raise around to $90,000 annually with full benefits. The median income for individual Canadians was $36,400 in 2018

## MINIMUM REQUIREMENTS FOR POLICE OFFICER APPLICANTS

Prior to the application process, potential candidates need to meet the minimum requirements. The following list of application requirements applies to most police agencies in Canada:

- Be a Canadian citizen or a permanent resident of Canada.
- Be proficient in the English and/or French languages
- Have a Canadian high school diploma or equivalent
- Be in good health
- Meet the vision standards
- Meet the hearing standards
- Meet the necessary level of physical abilities
- Have good character
- Have no criminal convictions and no criminal charges pending

*Retrieved From: https://paladinsecurity.com/law-enforcement-careers/become-police-officer-canada/#section1*

To become a police officer, an individual would have to a Canadian High school Diploma as minimum requirement but people who have done two years of post-secondary in Police Foundation diploma program in either university or college have a better chance becoming an officer. Along with an educational background, an individual needs to meet a necessary level of physical fitness. The said Individual needs to complete 26 weeks of training at the RCMP Academy in Regina, Saskatchewan.

**Persona:**

*https://medium.com/macro-tech/code-for-social-f6784624f7b7*

| | |
|---|---|
| **Name** | *James Stewart* |
| ***Age*** | 35 |
| ***Occupation*** | Police Officer in Region of Toronto |
| ***Income*** | *+ $60,000* |
| ***Education*** | University graduate in Police Foundation & Graduate from Police Training Academy |
| ***Family*** | Married with two children |
| ***Location*** | Toronto, ON |
| ***Main Hobbies*** | Soccer League, Weight Training, & Pilot Training |
| ***Frequency*** | Soccer (Once/week), Weight Training (5days/week), Pilot Training (twice/month) |
| ***Duration*** | 3hrs |
| ***Social/Solitary*** | Mostly with family and Friends |
| ***Other Activities*** | Family trips (once/week) |

A fictious profile is created that fits the demographic of police officers in Ontario, Canada. The goal of the persona is to focus the design intent on the relationship between the product and user.

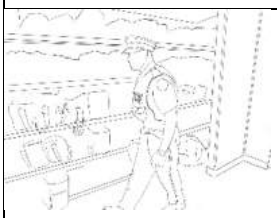
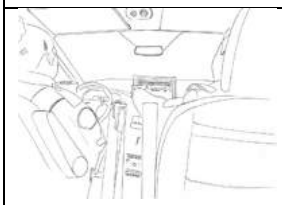
**User Behavior:**

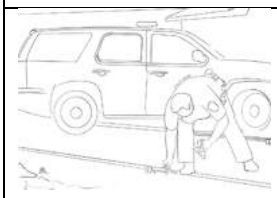
The context and the frequency of the activity, suggests that this a field that requires high level of training, discipline, and communication skills. An average day has two main types of work, field and administrative work. The field work relates to patrolling assigned areas in the city and enforcing traffic laws, bylaws and responding to incoming calls and investigating the situation. The administrative work is all the paperwork that has to be done relating to each case handled during the shift and vehicle information which is updated into the police database for future use.

An average shift can last from 10 to 12 hours depending on the officers available at the detachment which is divided into 7-8 hours of field work and 2-3 hours of administrative work. The shifts are based on rotation with a 4-3 schedule. An officer works 4 days in a week with 2 consecutive day shift and 2 consecutive night shift with a three-day break. During their down time, officer often engage in physical activities to keep them fit such as soccer leagues, gym training etc., along with some hobbies that are personal or involve the whole family such as learning a new skill or spending family quality time.

**User Observation – In Person Observation**

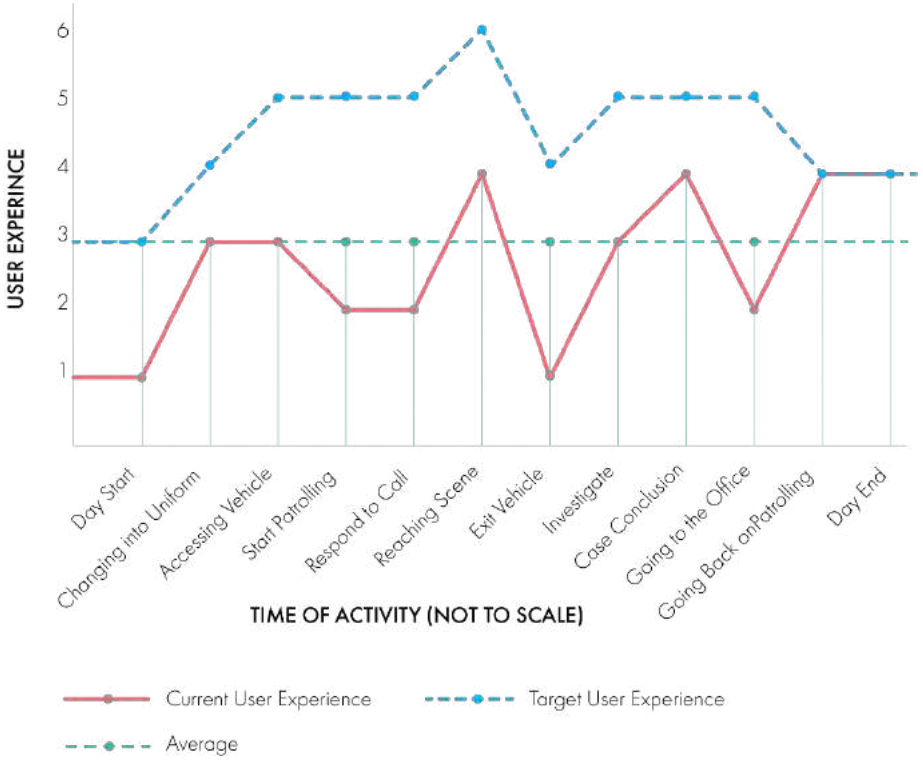
Due to active police policies no video or audio recording occurred, instead written notes were taken on different activities that officers do when handling an incoming call. Below, there are digital sketches of different observations in chronological order with description of each observation.

| Sketch | Step | Description | Area for Improvement |
|---|---|---|---|
|  | Preparation | The officer goes to the detachment and changes into uniform and packs equipment and firearms that are required. Looks at his MTD tablet for current status of incoming calls and tasks. | Dedicated storage solutions with smart locks<br><br>Built in gun locker to keep large firearms safe |
|  | Accessing Vehicle | The officer loads his equipment into the vehicle, does a circle check of the vehicle for any issues or damage. Then sets up the MTD tablet in the vehicle and updates dispatch of status | Self-monitoring system that checks for any damages or issues with the hardware |
|  | Start Patrolling | Officer than heads out of the detachment and heads for his/her assigned area for patrolling while checking for any incoming calls in the vicinity and enforcing traffic and bylaws. | Smart camera system that monitors the traffic and lets officer know if anyone is violating traffic laws that they could have missed. |

| | | | |
|---|---|---|---|
| | | | Advanced obstacle warning system to avoid obstacles on the road |
|  | Responding to Incoming Call | The officer updates dispatch that they are headed toward the location of call origin. The officer uses the MTD to look up any background information on the people involved and communicate with dispatch for real time updates on the situation | |
|  | Reach the Scene | Before exiting the vehicle, the officer scopes out the area, situation and people that are present on the scene to create situational awareness and making mental notes for safety purposes. | Proximity sensors<br>A third eye which monitors the environment and checks for any obstacles or danger |
|  | Exit the Vehicle | The officer heads towards the scene with caution, keeping constant awareness of surrounding and pedestrians in the area while keeping their hand on their firearm until it is the situation presents no danger. | Proximity sensors built in the safety vest to prevent any unexpected dangers |
|  | Investigate | The officer uses Tactical Communication method to investigate the situation while looking for visual, audio, and physical clues. | A device that can see clues or chemicals that are not seen by the naked eye<br><br>A device that can recognize different body languages and speech patterns |
|  | Conclusion | After the investigation is done, the officer decides if the case is conclusive or non-conclusive based on the data recovered. Based on the decision the suspect is either taken in custody or charged or given instructions on which department to contact based on the situation. | Self-restraining cuffs that prevent the user from moving erratically while transporting |

| | | | |
|---|---|---|---|
|  | Going to the Office | To do the data entry of the case, the officer heads back to the office to do all the administrative work and debrief with their supervisor. | Built in workstation within the vehicle that allows for comfortable workflow. |
|  | Patrolling | The officer than heads back out to their assigned area and starts patrolling and waiting for new incoming calls | |
|  | Day End | The officer goes back to the detachment and does shift briefing of all the cases they handled in the shift. Changes back into regular clothes and heads back home. | |

**User Experience Map:**




The user experience map is ranked from 1 – 6 with 3 neutral experience, 1 to 2 as negative experience and 4 to 5 has positive experience and 6 as beyond positive experience.

# Appendix C – Field Research (Product)

« Continue with the rest of Appendix where applicable. Refer to the Thesis Report Reference Content document for detail »

Product benchmarking allowed to get a better understanding of current market and trends in design, technology, materials, and sustainability areas. This allowed to create an analysis of product schematics, different interaction points and potential areas for improvement. Existing products will be benchmarked through various X-Y graphs that compare, aesthetics, functionality, and usability and through feature and benefit frequency chart. This will help determine what benefits and features have the highest importance and how to create innovative ways to add them to the proposed areas.

In the following product descriptions, the benefits will be highlighted in blue, and features will be highlighted in red.

**Product 1**
*2021 Dodge Charger Pursuit*
*https://www.fcausfleet.com/dodge/charger-pursuit.html*


**Description:** The dodge charger pursuit is a vehicle that is meant for long-distance patrolling and high-speed maneuvers while being capable of holding all the tools of officers such as onboard information terminal, organized storage in the back while providing top-class safety.

**Features:**

- 3.6L PENTASTAR® V6 ENGINE
- 5.7L HEMI® V8 ENGINE WITH FUEL SAVER TECHNOLOGY - that automatically deactivates four cylinders when eight are unnecessary.
- REAR-WHEEL-DRIVE SYSTEM - delivers excellent and responsive acceleration with outstanding handling and maneuverability -
- ALL-WHEEL-DRIVE SYSTEM- the nimble maneuverability and four-corner control

- BALLISTIC DOOR PANELS - help protect officers while on the job.
- SECURE PARK - rake transmission switch interlock to prevent the transmission from shifting out of the park when engaged.
- STEEL SAFETY FRAME CONSTRUCTION - is strong and helps protect occupants by managing and controlling energy in the event of an impact.
- FRONT AND REAR CRUMPLE ZONES - help absorb energy during an impact and redirect it away from passengers to help reduce the risk of injury.
- UCONNECT® 12.1-INCH TOUCHSCREEN-helps drivers park and back out with confidence.
- MOBILE COMMAND CENTER - system interface module for easy equipment integration, police-duty front seats with distinctive bolstering to accommodate officers' duty belt gear, and a column-mounted shifter with AutoStick to free up space for center console-mounted equipment.
- VEHICLE SYSTEMS INTERFACE MODULE - features a radio mute input, pulse width modulation vehicle speed output (VSS), reverse position output, and drive position output.
- LED LAMPS - the Dodge Charger Pursuit makes a bold statement on the road with Bifunctional Halogen Projector Headlamps and LED Daytime Running Lamps. Available single or dual LED spotlights aid search capability.
- BOLD EXTERIOR - stands out with its easily recognizable design, scalloped bodysides, impressive front crosshair grille, and aggressive stance.
- KEYLESS ENTER 'N GO™ - entry to the vehicle and push-button vehicle ignition when the key fob is nearby.
- SPACIOUS TRUNK - offers a large and spacious trunk with plenty of room for police equipment.

## Product 2

*2021 Dodge Durango Pursuit*

*https://www.fcausfleet.com/dodge/durango-pursuit.html*

**Description:** The dodge Durango pursuit is a vehicle that is meant for long-distance patrolling and high-speed maneuvers and used for creating blockades on all types of roads to prevent further damage or prevent suspects from getting away. They are meant to carry K-9 units and large firearms for intense situations. while being capable of holding all the tools of officers such as onboard information terminal, organized storage in the back while providing top-class safety.

**Features**

- LEGENDARY 5.7L HEMI® V8 ENGINE. - The legend lives on with powerful performance and impressive efficiency. The available 5.7L HEMI® V8 engine gets up to 22 highway mpg while Variable Valve Timing (VVT) maximizes fuel efficiency and performance.
- EIGHT-SPEED AUTOMATIC TRANSMISSION
- SUSPENSION - The performance-tuned, load-leveling suspension on the Dodge Durango Pursuit features Nivomat® self-leveling dampers and upgraded anti-roll bars that provide optimum handling, a constant vehicle ride height, and full wheel travel even under maximum load.
- ALL-WHEEL DRIVE (AWD) - The Dodge Durango Pursuit features a technologically advanced AWD system. The system helps give the driver added control, especially in harsh conditions.
- SEVEN STANDARD AIRBAGS - Advanced multistage front airbags supplemental side-curtain airbags, front seat-mounted side airbags, and a driver's knee bolster airbag all come standard and help add an extra level of protection.
- STEEL SAFETY FRAME - The steel safety frame construction in the Dodge Durango Pursuit is strong and helps protect occupants by managing and controlling energy in the event of an impact.
- HIGH-PERFORMANCE BRAKES - The Durango Pursuit comes standard with large, heavy-duty Four-Wheel Disc Antilock Brakes.
- READY ALERT BRAKING - Ready Alert Braking anticipates situations when the driver may initiate an emergency stop and sets the brake pads against the rotors, decreasing the time required for full brake application.
- K-9 FRIENDLY THREE-ZONE AUTOMATIC TEMPERATURE CONTROL - Four-legged members of the police department will ride in comfort along with their partners, with the K-9 friendly Three-Zone Automatic Temperature Control
- COMFORT AND CAPACITY - Ample legroom and headroom make any ride in the Dodge Durango Pursuit a comfortable one.

- POWER ADJUSTABLE SEAT CONTROLS - The eight-way power-adjustable driver seat controls provide comfort for those on long patrols.
- 7-INCH DRIVER INFORMATION DIGITAL CLUSTER DISPLAY -
- VINYL FLOOR COVERING - The hard-wearing vinyl floor covering wipes clean for easy interior maintenance on the Dodge Durango Pursuit and stands up to almost any job.
- POLICE-SPECIFIC SEATS - The front buckets seats in the Dodge Durango Pursuit are designed for an officer's comfort and are sculpted to accommodate a full-service duty belt when seated.
- SPACE-SAVING - With clever space-saving measures like the instrument panel-mounted shifter, the driver is provided with more space and overall cabin room.
- BOLD EXTERIOR - The Pursuit stands out from the crowd with its sleek lines and bold profile, including a performance style front fascia with integrated brake-cooling air ducts. These air ducts help optimize braking and brake cooling for the beefy 14.4-inch front rotors.
- GROUND CLEARANCE - The Dodge Durango Pursuit offers an impressive ground clearance of 8.1 inches.
- SENTRY KEY® ANTI-THEFT IMMOBILIZATION - The standard Sentry Key® anti-theft engine immobilizer allows only key fobs that are programmed to the vehicle to start the engine.

## Product 3

*2021 Ford Police Interceptor Utlity*

*https://www.ford.com/police-vehicles/hybrid-utility/*


**Description:** Pulling from nearly 70 years of expertise working alongside law-enforcement professionals, Ford presents its current-generation Police Interceptor Utility as the first-ever pursuit-rated hybrid police SUV. It provides police agencies with improved power and performance, with no trade-offs when it comes to safety or interior passenger/cargo space when compared to the previous-generation vehicle. It's smart for community budgets, too – with significant potential fuel savings and reduced CO2 emissions, * potentially fewer fill-ups** and less downtime to keep both vehicles and officers on the road.

**Features**

- **Standard Hybrid/AWD Powertrain -** Police vehicles spend a lot of time idling on the job. That's what makes the standard hybrid powertrain on the Police Interceptor Utility ideal for law enforcement. On-board electrical equipment can be powered using the lithium-ion hybrid battery, allowing the gasoline engine to shut off – running only intermittently to charge the battery. The standard Intelligent AWD drivetrain provides improved handling stability and traction in all driving conditions. It also offers significant improvements in fuel economy and reduced engine idle time (compared with the previous model), along with across-the-board improvements in performance and capability.
- **Available 12.1-inch Integrated Computer Screen -** The available 12.1-inch Integrated Computer Screen on the Ford Police Interceptor® Utility reduces clutter and frees up valuable space in the front passenger cabin by allowing on-board laptops to be relocated to the rear cargo area. The touchscreen display takes place of the laptop display and can potentially eliminate the need for a keyboard in the cabin as well. With an easy connection in the cargo area, and no special software required to operate, laptop setup is streamlined. The available 12.1-inch Integrated Computer Screen also includes SYNC® with vehicle audio controls integrated right into the display.
- **Available Police Perimeter Alert -** Police Perimeter Alert is a much-improved, factory-installed version of Surveillance Mode. It uses BLIS® (Blind Spot Information System) sensors for approximately 270-degree monitoring outside of the vehicle and analyzes the motion to determine if a behavior is a potential threat. It features a visual display in the instrument panel cluster that shows moving objects, the motion trail and potential threat level. When potentially threatening behavior is detected, it also will sound a chime, activate the Rear-View Camera, and automatically roll up the windows and lock the doors.
- **Ford Telematics -** very new Ford Police Interceptor Utility comes with a built-in Ford modem and complimentary two-year Ford TelematicsTM subscription. * Potential fuel savings, CO2 emissions, vehicle health and more – this simple-to-use yet powerful tool delivers manufacturer-grade information, insights, and solutions right to your fingertips.

## Product 4

*2021 Police Harley Davidson Electra Glide*
*file:///D:/Sem%207/Thesis/Research%20Links/flhtp-spec-sheet.pdf*

**Description:** The all-new 2021 Harley Davidson Electra Glide Police Cruiser is a vehicle used by officers who patrol in dense urban environments due to high traffic. The high maneuverability and compact design allows the Bike to access small alleyways and uncommon routes to respond to calls/

**Features**

- • RDRS Rider Safety Enhancements
- - Cornering Enhanced ABS (C-ABS)
- - Cornering Enhanced Electronic Linked
- Braking (C-ELB)
- - Cornering Enhanced Traction Control System
- (C-TCS)
- - Drag-Torque Slip Control System (DSCS)
- - Vehicle Hold Control (VHC)
- - Tire Pressure Monitoring System (TPMS)
- • Handlebar with bar ends turned higher to provide
- more clearance to the operator's legs
- • Fan-assisted oil cooler
- • Batwing fairing
- • Floating, dual-front open brake rotors
- • Heated hand grips with adjustable six-setting
- heat control
- • 2-1-2 exhaust with dual tapered mufflers
- • Dual law enforcement blue license plate marker
- lamps (OEM standard)
- • Pivoting footboards with heel/toe shift lever
- • Daymaker® LED headlight
- • Reflex™ Linked Brembo® Brakes with ABS
- • 4-piston front and rear caliper
- • Trigger switch activation allows approx. 15 minutes
- of power to police emergency equipment with
- ignition off
- • Independent hazard warning switch
- • Emergency light switch with 4 functions and
- individual indicator lights for: Off, Both Front and
- Rear On, Front On only, Rear On only
- • Saddlebags with One-Touch latch, standard
- saddlebag guard and luggage locks, common
- with ignition key

## Product 5

*BMW R1200 RT*
*https://www.authorities.bmw-motorrad.com/en/models/r1250-rt-p.html*

**Description:** BMW Motorrad has been a proven partner to public authorities, the police, rescue forces, and escort services all over the world for more than 100 years. For generations, professional users whose motorcycle is their workstation have placed their trust in the outstanding, comprehensive quality standards of BMW motorcycles. After all: they know they can rely on the consistent synthesis of ergonomic comfort, well-developed safety, and excellent performance – in every situation and for every type of operation. This is demonstrated impressively by the fact that BMW has supplied more than 155,000 authorities vehicles to all corners of the globe ever since 1970. The numerous BMW 1250 RT-P models have no small part to play in this success story: the current version offers an even wider range of equipment components and lowers fuel consumption, making even more of a mark when it comes to supremacy, agility, power, and dynamic performance. The BMW R 1250 RT-P is an all-rounder that performs excellently on every type of terrain. Whether police operations on the motorway or city escorts: the intelligent concept is characterized by ergonomic long-distance comfort as well as enormous power potential and flexible handling. Powered by a high-performance BMW ShiftCam boxer engine, this concept defines a perfect synthesis of power and efficiency.

**Features:**

- **COCKPIT** - Everything in view: The large, uncluttered 10.25” TFT screen with Full HD resolution combines instrument cluster and onboard computer. the clearly structured and ergonomically arranged instruments in the cockpit allow the rider to relax and concentrate on the traffic.
- **CONTROLS** - Everything under control: Newly developed additional switch units allow individual programming of special functions. The logically arranged and illuminated controls ensure simple handling. The LED status display for the handlebar switch (on/off) offers excellent operating properties and ensures the rider has a clear overview at all times.
- **ROTATING BEACONS** - Impressive signaling effect: The LED flashlight and rotating beacons with a telescopic rod can be controlled separately at the front and rear and can be ordered in blue, red, or yellow. White LED lights with switches are integrated into the lower edge of the rotating beacon to protect dangerous spots in the dark.
- **STOP-SIGNAL UNIT** - The stop-signal unit enables stop signals to be varied depending on the equipment and customer requirements. A wide range of text modules are available for the LED display, for example: Stop, Police, Please Follow, etc. These can be programmed in 10 different languages.
- **ACTIVE CRUISE CONTROL** - Relaxed cruising with Active Cruise Control (ACC). Three letters that guarantee a big plus in terms of safety: This innovative system automatically maintains the desired speed as well as ensuring a distance is maintained from the vehicle in front by means of a radar sensor.
- **WEATHER PROTECTION** - The newly developed weather protection package ensures resilience to dirt, rain, and sprays water even in the most adverse weather conditions.
- **RELEASE** - Smart detail: The electrical release has a run-on feature which means that the radio box can still be easily opened for up to 40 seconds after the ignition has been switched off.
- **RADIO BOX** · Analog and digital radio end devices can be used at the same time: they are securely stowed in the radio box with an electrical release function. A microphone is integrated into the radio box for PA announcements.
- **ACOUSTIC SIGNAL SYSTEM** · Safety is significantly enhanced by means of the speed-related volume of the acoustic signal system and the high-performance supplementary headlamps.
- **WIRELESS CHARGING** - For excellent connections: The wireless charging system allows a smartphone to be charged via induction or USB in the practical storage compartment, where it is protected from spray water. Navigation and telephony can be used simultaneously at any time.
- **WINDSHIELD** · The electric windshield is continuously adjustable and adapts perfectly to the rider’s ergonomic requirements thanks to its patented airflow design. This reduces noise levels, forward suction, and air movement on the upper body to a minimum.
- **CASE** · A perfect solution: The two waterproof cases provide more flexible storage space, including plenty of room for emergency materials such as fire extinguishers and signaling discs.

## Product 4
*2021 Ford F150 Police Responder*

*https://www.ford.com/police-vehicles/f150-police-truck/*

**Description:** The all-new 2021 Ford F-150 Police Responder® continues to be the only pursuit-rated pickup truck on the market. And now, thanks to on-the-beat insights from law enforcement professionals, it's been enhanced to an even higher degree of street performance and off-road capability. It is used for blockades and high-speed chases that are off-road or on rough terrain, another major purpose it is used for is towing suspect vehicles to investigate at precincts and service centers.

**Benefits:**

- Torque On Demand (different Power configurations for the Drivetrain)
- Pre Collison-Assist with Auto Emergency Braking
- Police Specialized All-terrain tires - With the demands of law enforcement, standard tires just won't cut it. New police-specialized all-terrain tires allow for both exceptional off-road capability and the improved top-speed on-road performance of the 2021 Ford F-150 Police Responder. ®
- Police Engine Idle system (won't turn on without authorization key)
- Ford Telematics
- SYNC® 4 with Over-the-Air Updates
- BLIS® (Blind Spot Information System) with Cross-Traffic Alert
- Easier Towing and a 360° View

**Product Benchmarking**

|  |  |  |  |  |  |
|---|---|---|---|---|---|
| 1. | 2. | 3. | 4. | 5. | 6. |
| 2021 Dodge Charger Pursuit | 2021 Dodge Durango Pursuit | 2021 Ford Police Interceptor Utility | 2021 Police Harley Davidson Electra Glide | BMW R1200 RT | 2021 Ford F150 Police Responder |
| **Benefits** | | | | | |
| - Fuel Saver Technology<br>- Outstanding Handling and Maneuverability<br>- Four Corner Control<br>- High Standards of Safety<br>- Adaptable Onboard Information Terminal<br>- Adaptive LED Lamps<br>- Bold Exterior<br>- Spacious Trunk | - Fuel Saver Technology<br>- High Performance Suspension<br>- Steel Safety Frame<br>- Large Cabin Space<br>- Adaptable Seats<br>- Adaptable Onboard Information Terminal<br>- Spacious Trunk<br>- Bold Exterior<br>- Police Specific Seats | - Hybrid Engine<br>- Fuel Saver Technology<br>- High performance suspension and transmission<br>- Large passenger and cargo space<br>- High stability and traction in all terrains<br>- Large Onboard Information terminal<br>- 270 degree monitoring<br>- Onboard real time diagnostic system<br>- High standards of Safety | - Rider Safety Enhancements<br>- Traction Control System<br>- High performance Brakes<br>- LED Lamps<br>- Built in power source for external equipment<br>- Individual indicator lights<br>- Saddle bags for storage | - Ergonomic Seating and User Interface<br>- High Agility and performance engine, suspension<br>- All terrain traction<br>- Long distance comfort<br>- Touch onboard information terminal<br>- Bold Look<br>- LED lamps<br>- Weather protection<br>- Active cruise control<br>- Rotation beacons<br>- Multi-language stop signal display<br>- Wireless charging for equipment | - Different Power configuration drivetrain<br>- Pre collision Assist and emergency braking<br>- All terrain traction<br>- Onboard diagnostic system<br>- 360 monitoring system<br>- Steel safety frame<br>- High performance suspension<br>- High performance engine<br>- Large onboard information terminal<br>- Larger passenger and cargo space<br>- Large cabin space |

On the following chart, key benefits have been grouped from promotional literature of benchmarked products into four columns. The first column has benefits have been listed in the order they appeared in the literature. In the second category the benefits have been color coded based on various categories. In the third column, the benefits have been organized based on the category they belong to. In the last column, the frequency of each benefit category has been shown.

| | | | |
|---|---|---|---|
| weather protection package | Ergonomics | Seven Airbags | |
| adaptabilty | Ergonomics | Energy Dispersion | |
| terrain | Weather Protection Package | Safety | |
| dense environments | Weather Protection Package | Safety | |
| ergonomics | Adaptability | 360 Monitoring | |
| low maintenace | Adaptability | 360 Monitoring | |
| low maintenace | Terrain | **Mobility** | 9 |
| terrain | Terrain | Handling & Manuverability | |
| off road | Off Road | Handling & Manuverability | |
| adaptabilty | Low Maintainence | Handling & Manuverability | |
| 360 monitoring | Low Maintainence | Handling & Manuverability | |
| | | Handling & Manuverability | |
| | | Handling & Manuverability | |
| | | Handling & Manuverability | |
| | | Handling & Manuverability | |
| top class safety | Handling & Manuverability | Weather Protection Package | |
| safety | Handling & Manuverability | Low Maintenace | |
| fuel savings | Energy Dispersion | Low Maintenace | |
| Handling & Manuverablity | Ample Head and Leg Room | **Low User Fatigue** | 9 |
| handling & Manuverablity | Easy Interior Maintainence | Ample Head & Leg Room | |
| handling & Manuverablity | Officer Comfort Seats | Officer Comfort Seats | |
| handling & Manuverablity | Big Cabin Room | Big Cabin Room | |
| handling & Manuverablity | Long Distance Patrolling | Organized Trunk | |
| dense environments | Safety | Ergonomics | |
| handling & Manuverablity | Safety | Ergonomics | |
| ergonomics | Ergonomics | Ergonomics | |
| safety | 360 Monitoring | **Officer Safety** | 11 |
| handling & Manuverablity | 360 Monitoring | Top Class Safety | |
| Long Distance patrolling | Harsh Conditions | Top Class Safety | |
| handling & Manuverablity | Dense Environments | Top Class Safety | |
| ergonomics | Dense Environments | Protection | |
| weather protection package | Ergonomics | Search Capabilities | |

On the following chart, key Features have been grouped from promotional literature of benchmarked products into four columns. The first column has features have been listed in the order they appeared in the literature. In the second category the features have been color coded based on various categories. In the third column, the features have been organized based on the category they belong to. In the last column, the frequency of each feature category has been Shown.

| Features | Features Organized | Features By Category | |
|---|---|---|---|
| Fuel saver technology | Fuel Saver Technology | **Storage** | **7** |
| RWD System | Fuel Saver Technology | Spacious Trunk | |
| AWD System | Fuel Saver Technology | Spacious Trunk | |
| Ballistic door Panels | Fuel Saver Technology | Cargo Space | |
| Secure Park | Fuel Saver Technology | Saddle Bags | |
| Front and Rear Crumple Zones | Fuel Saver Technology | Storage | |
| UConnect Display | RWD System | Storage | |
| LED Lamps | AWD System | Storage | |
| Spacious Trunk | AWD System | **Easily Seen** | **8** |
| Ballistic door Panels | AWD System | Led Lamps | |
| Fuel saver technology | Radios | Led Lamps | |
| AWD System | Ballistic Door Panels | Led Lamps | |
| steel safety frame | Ballistic Door Panels | Led Lamps | |
| steel safety frame | Secure Park | Led Lamps | |
| Spacious Trunk | Front And Rear Crumple Zones | Led Lamps | |
| bold exterior | UConnect Display | Bold Exterior | |
| bold exterior | LED Lamps | Bold Exterior | |

| | | | |
|---|---|---|---|
| suspension | LED Lamps | **Small Ecofootprint** | **7** |
| onboard information terminal | LED Lamps | Fuel Saver Technology | |
| onboard information terminal | LED Lamps | Fuel Saver Technology | |
| onboard information terminal | LED Lamps | Fuel Saver Technology | |
| hybrid engine | LED Lamps | Fuel Saver Technology | |
| cargo space | spacious Trunk | Fuel Saver Technology | |
| AWD System | spacious Trunk | Fuel Saver Technology | |
| AWD System | Steel Safety Frame | Hybrid Engine | |
| onboard information terminal | Steel Safety Frame | **Communication** | **7** |
| fuel saver technology | Bold Exterior | UConnect Display | |
| rider safety | Bold Exterior | Onboard Information Terminal | |
| LED Lamps | suspension | Onboard Information Terminal | |
| LED Lamps | Onboard Information terminal | Onboard Information Terminal | |
| saddle bags | Onboard Information terminal | Onboard Information Terminal | |
| fuel saver technology | Onboard Information terminal | Onboard Information Terminal | |
| onboard information terminal | Onboard Information terminal | Onboard Information Terminal | |
| LED Lamps | Onboard Information terminal | Radios | |
| LED Lamps | Onboard Information terminal | **Officer Safety** | **12** |
| LED Lamps | Hybrid Engine | Ballistic Door Panels | |
| safety | Cargo Space | Ballistic Door Panels | |
| radios | Rider Safety | Secure Park | |
| storage | Saddle Bags | Front and Rear Crumple Zones | |
| safety | Safety | Steel Safety Frame | |
| onboard information terminal | Safety | Steel Safety Frame | |
| fuel saver technology | Storage | Rider Safety | |
| collison assist | Storage | Safety | |
| collison assist | Storage | Safety | |
| collison assist | collison Assist | Collison Assist | |
| collison assist | collison Assist | Collison Assist | |
| storage | collison Assist | Collison Assist | |
| storage | collison Assist | Collison Assist | |
| | | **Speed** | **5** |
| | | RWD System | |
| | | AWD System | |
| | | AWD System | |
| | | AWD System | |
| | | Suspension | |

# Appendix D – Needs Analysis

**Statement Of Need - 3**

Officer patrolling is an important activity based on the ease of function, adaptability to various obstacles in condensed spaces **(Control and Mastery)**, Safety from external threats and safety for pedestrians **(Security),** and comfort afforded to the officer **(Comfort and Security).** Durability can be achieved based on the choice of materials and structural design.

Officer Mobility is also a **social** activity, since from the start to the end of the journey, they are interacting with dispatch,
suspects, victims, and witness as they are conducting investigation.

**Control** and **Mastery** of the vehicle is related to the performance of the machine (**Effectiveness, Ease and Comfort).**

**Specific Needs Include:**

- Being able to navigate the dense city roads without interacting with upcoming obstacles to minimize the response time for incoming calls.
- Ease of use of control panels in stressful situations, allowing the user to make quick decisions when needed.
- Comfort that can last for long durations and adapt to the user's workflow
- Safety from external threats and safety for pedestrians that are in harm's way.
- Durability that can handle the elements all year long
- Minimizing or removing the need for fuel as a power source.

**Root Cause Analysis**

**Problem 1:** Police Officers have to patrol for long durations at a time

- **Why:** officers have to make constant rounds around their assigned areas to make sure everyone is safe
- **Why:** so, officers can be ready if an incoming call comes in from their area
- **Why:** so, they can reach the scene quickly since they are the closest and assess the situation
- **Why:** so, they can prevent bystanders and pedestrians from ruining the investigation scene and preserve any clues left behind by the incident
- **Why:** so, when the case goes to court, all the evidence is there to make an informed decision
- on the verdict

**Problem 2:** Police Officers have a large response time to high priority calls in urban cities.

- **Why:** Due to heavily population of vehicles, cause traffic jams throughout the day
- **Why:** frequent construction projects, large vehicles blocking the roads, rush hours
- **Why:** to meet the people's need for recreational activities such bike lanes, parks, public transit.
- **Why:** More people are migrating to urban cities for a chance at a better life and career options
- **Why:** not enough job opportunities in other areas and lifestyle of are is not preferred by people

# Appendix J – Approval Forms and Plans

## IDSN 4002/4502
SENIOR LEVEL THESIS ONE AND TWO

Humber ITAL / Faculty of Applied Sciences & Technology
Bachelor of Industrial Design / FALL 2021
Catherine Chong / Sandro Zaccolo

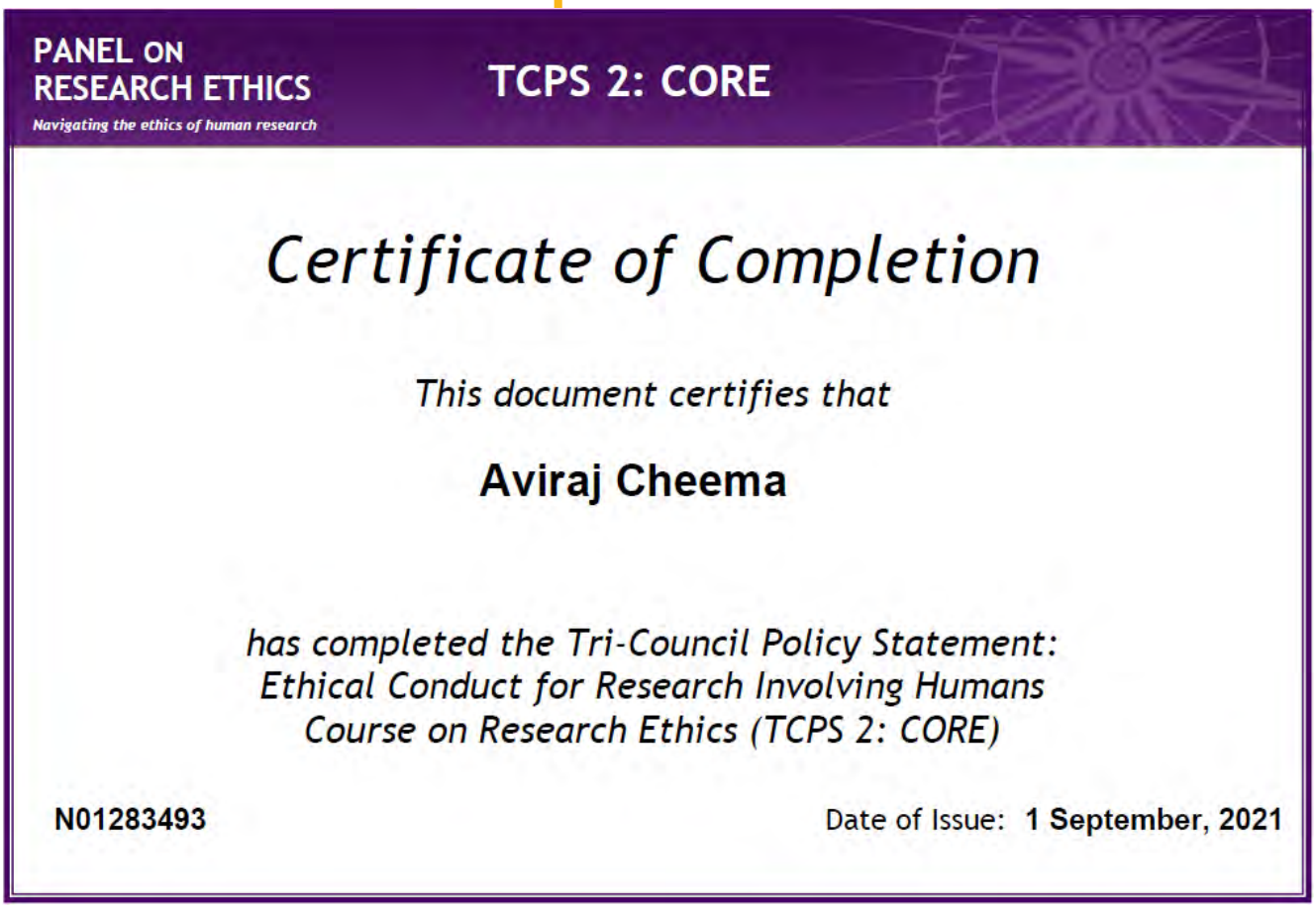
**THESIS TOPIC APPROVAL:**

| | |
|---|---|
| **Student Name:** | Aviraj Cheema |
| **Topic / Problem Definition:** | How may we improve mobility for police services in dense urban environment? |

**TOPIC DESCRIPTIVE SUMMARY (Preliminary Abstract)**

As population increases and are migrating towards urban cities, the activities of humans are posing more obstacles for police officers that patrol the roads of the city, the increase of vehicles on the road, smaller road and bike lanes, construction, large vehicles in condensed areas, and harsh weather conditions decrease the mobility of police officers when they are responding to calls. Current vehicles that are used by police officers are too large (Stockton, 2019) and are unable to use main roads when travelling at high speeds due to traffic congestions which also puts the safety of pedestrians and officers at risk when vehicular accidents occur. Officers are forced to use unconventional routes to reach their destination such as alleyways, building garages and residential roads, thus increasing their response time. The current response time is 15 minutes for high priority calls, when the standard provincial time is nine minutes (Toronto Police, 2002). The success of their investigation highly depends on how fast they can reach the scene to prevent contamination, crowd control and possibly catching the suspect. The purpose of thesis is to do in-depth study of daily protocols and challenges facing officers. Using data collection methods such as interviews and observational studies of officers using current solutions, a detailed analysis could be conducted focusing on the impact of the obstacles on the duties of police officers. To evaluate the ergonomics, a one-to-one scale buck that illustrates the workspace and tools that officers currently use can establish proper human factors and full-bodied human interaction design. A solution will be developed for police officers, to improve mobility to decrease response times, and provide protection to the common citizen.

| | |
|---|---|
| **Student Signature(s):** Aviraj Cheema | **Instructor Signature(s):** Catherine Chong Sandro Zaccolo |
| **Date:** 22/09/2021 | **Date:** 07 October 2021 |



PANEL ON RESEARCH ETHICS
Navigating the ethics of human research

TCPS 2: CORE

Certificate of Completion

This document certifies that

Aviraj Cheema

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

N01283493

Date of Issue: 1 September, 2021

**Introduction:**

The purpose of this initiative is to gain insight into the daily life of police officers when they are on duty, learning about the steps they take when they respond to calls, the protocols they have to use for different situations, and the different physical and mental obstacles they face on their journey.

**Research Plans:**

RESEARCH ELEMENTS:

● User Profile – How officer go about their daily life and what activities they take part in.

● User Observation – How officers interact with different products when conducting various activities and duties.

● Current User Behavior – how they like to spend their down time and what activities that are not related to their work, they take part in.

● Current Product(s) Use – what are the current products and vehicles officers use, how they use them and, why do they use those specific products

● Activity Mapping and Journey Mapping – mapping out the journey of a specific scenario that and officer is involved in and how that scenario affects their interactions and choices they make.

● Product Benchmarking – determining the most important features and benefits of current products used by officers.

RESEARCH SOURCES / METHODS

● Expert Interviews with a Police officer or related field

● Reddit Forums targeting police officers in general and not based on the location of occupation

● Literature Research

● Video Analysis

INTERVIEW / SURVEY

1. Start the conversation
2. How long are your average shifts?
3. Can you tell me how long you have worked in the region of Toronto?
4. Can you tell me the top three types of calls you get in the region of Toronto?
5. Can you describe the steps you take from start to end when you respond to a call to when you reach the scene of the crime?
6. Do your steps change based on the priority of the call?
7. Can you please describe the physical obstacles you face in your journey from the previous question?
8. How do you try to avoid these obstacles?
9. Can you tell me what vehicles you used while you were working in Toronto?
10. Please describe the activities you perform immediately before using the vehicle?
11. Please describe the activities you perform immediately after using the vehicle?
12. Please comment on the vehicle's steering. How comfortable are the wheel/handlebars?
13. Under what conditions is the steering ineffective?
14. Please comment on the vehicle's seats and the ability to move around the workspace?
15. Can you suggest any changes to the seating or posture to make the experience more comfortable over extended periods of vehicle use?
16. Is the vehicle lighting effective at allowing you to be seen by others and avoid obstacles on the road?
17. Please comment on the vehicle's acceleration speed. Do you feel that it is too slow, adequate, or too fast?

18. Please comment on the vehicle's aerodynamics. Would increase/decreased aerodynamics increase driver
safety in any way? Why or why not?
19. Please comment on the vehicle's buttons, knobs, and switches. Are they all easy to find, access, and use?
20. Please comment on the use of the mobile data terminal. Is it easy to use, change its location?
21. What features would you like to have on your "dream" transportation vehicle, and why?
22. Please comment on the driver collision protection that the vehicle offers. What does it offer to protect the driver and is it sufficient? Why or why not?
23. Please comment on the safety that the vehicle provides from external attacks. What does it offer to protect the driver and is it sufficient? Why or why not?
24. Please describe in detail your overall satisfaction and user experience with the vehicle you use most often. If not already mentioned, what are the least enjoyable parts of operating the vehicle, and what are the most
enjoyable?

**Advisor Initiatives**

ADVISOR ENGAGEMENT - **Confirmed**

**NAME OCCUPATION CONTACT INFORMATION**

Anonymous Active OPP officer in the west region of Ontario

Contact Author for contact information

CURRENT AND FUTURE SCHEDULE

Current: Due to the shifting schedules of duty of the advisor, at the start of each

week, a day, and time will be discussed to meet for further progress advising and Q&A.

Future: When the creative execution phase starts, two days will be discussed for

progress advising and further Q&A

**Conclusion**

An expert in the field of Law Enforcement has agreed to become an advisor for this

thesis project, providing insights into their life, duty, and advising on how to make an effective

solution that would improve the mobility of officers when responding high priority calls in urban

cities.

# IDSN 4502

SENIOR LEVEL THESIS TWO

Humber ITAL / Faculty of Applied Sciences & Technology
Bachelor of Industrial Design / WINTER 2022
Catherine Chong / Sandro Zaccolo

## CRITICAL MILESTONES: APPROVAL FOR CAD DEVELOPMENT & MODEL FABRICATION

| | |
|---|---|
| **Student Name:** | AVIRAJ CHEEMA |
| **Topic / Thesis Title:** | **LAW ENFORCEMENT URBAN MOBILITY** |

## THESIS PROJECT – DESIGN APPROVAL FORM

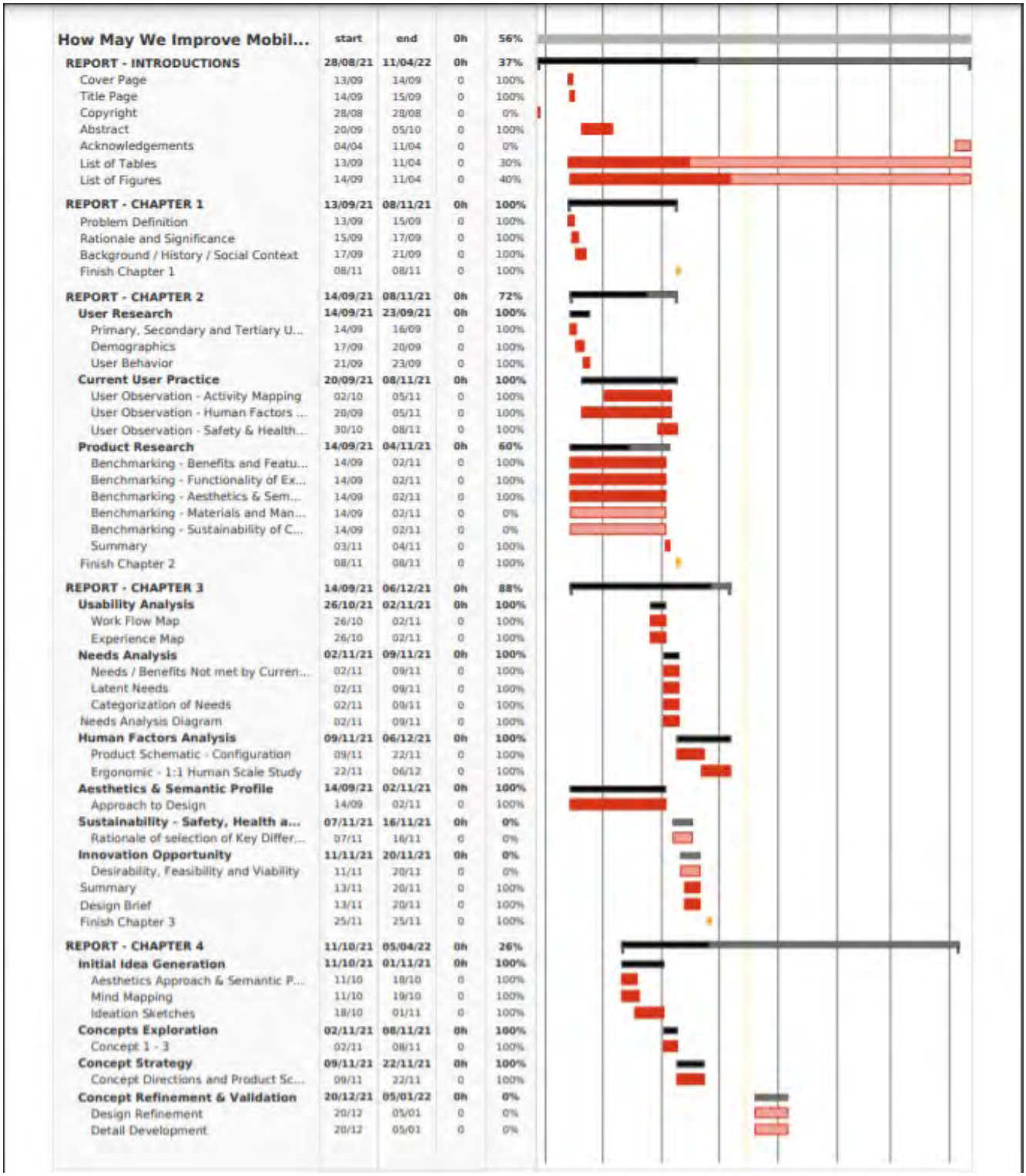
| | | |
|---|---|---|
| **Design is reviewed and approved to proceed for the following:** | X | **CAD Design and Development Phase** |
| **Comment:** - Initial CAD started well as of week #7/February 22nd, continue with detailing and refinement, especially interior design.<br>- Refinement CAD progress well as of week #8/March 8th. | | |

| | | |
|---|---|---|
| **Design is reviewed and approved to proceed for the following:** | X | **Model Fabrication Including Rapid Prototyping / 3D Printing and Model Building Phase** |
| **Comment:** - Once CAD is completed, can move forward to model fabrication from week #9 onward. | | |

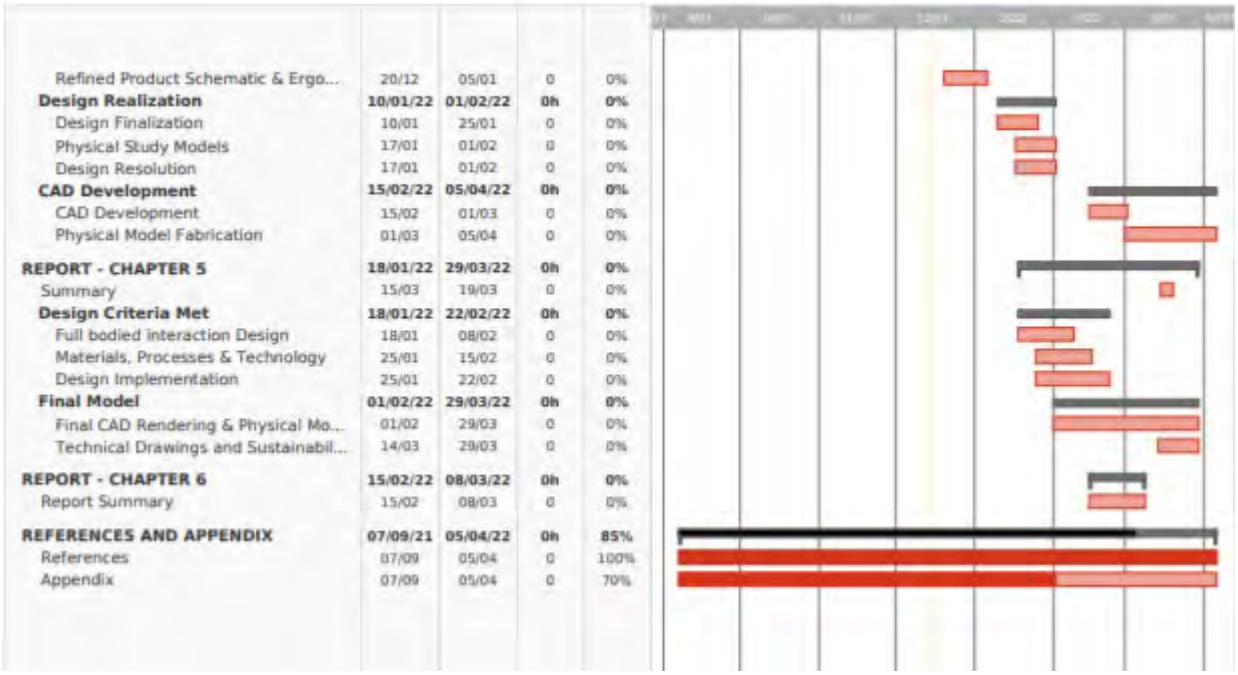
| | |
|---|---|
| **Instructor Signature(s):** | |
| **Date:** | 8th March, 2022 |

Chong, Kappen, Thomson, Zaccolo

## Project Timeline:



| How May We Improve Mobil... | start | end | 0h | 56% |
|---|---|---|---|---|
| **REPORT - INTRODUCTIONS** | **28/08/21** | **11/04/22** | **0h** | **37%** |
| Cover Page | 13/09 | 14/09 | 0 | 100% |
| Title Page | 14/09 | 15/09 | 0 | 100% |
| Copyright | 28/08 | 28/08 | 0 | 0% |
| Abstract | 20/09 | 05/10 | 0 | 100% |
| Acknowledgements | 04/04 | 11/04 | 0 | 0% |
| List of Tables | 13/09 | 11/04 | 0 | 30% |
| List of Figures | 14/09 | 11/04 | 0 | 40% |
| **REPORT - CHAPTER 1** | **13/09/21** | **08/11/21** | **0h** | **100%** |
| Problem Definition | 13/09 | 15/09 | 0 | 100% |
| Rationale and Significance | 15/09 | 17/09 | 0 | 100% |
| Background / History / Social Context | 17/09 | 21/09 | 0 | 100% |
| Finish Chapter 1 | 08/11 | 08/11 | 0 | 100% |
| **REPORT - CHAPTER 2** | **14/09/21** | **08/11/21** | **0h** | **72%** |
| **User Research** | **14/09/21** | **23/09/21** | **0h** | **100%** |
| Primary, Secondary and Tertiary U... | 14/09 | 16/09 | 0 | 100% |
| Demographics | 17/09 | 20/09 | 0 | 100% |
| User Behavior | 21/09 | 23/09 | 0 | 100% |
| **Current User Practice** | **20/09/21** | **08/11/21** | **0h** | **100%** |
| User Observation - Activity Mapping | 02/10 | 05/11 | 0 | 100% |
| User Observation - Human Factors ... | 20/09 | 05/11 | 0 | 100% |
| User Observation - Safety & Health... | 30/10 | 08/11 | 0 | 100% |
| **Product Research** | **14/09/21** | **04/11/21** | **0h** | **60%** |
| Benchmarking - Benefits and Featu... | 14/09 | 02/11 | 0 | 100% |
| Benchmarking - Functionality of Ex... | 14/09 | 02/11 | 0 | 100% |
| Benchmarking - Aesthetics & Sem... | 14/09 | 02/11 | 0 | 100% |
| Benchmarking - Materials and Man... | 14/09 | 02/11 | 0 | 0% |
| Benchmarking - Sustainability of C... | 14/09 | 02/11 | 0 | 0% |
| Summary | 03/11 | 04/11 | 0 | 100% |
| Finish Chapter 2 | 08/11 | 08/11 | 0 | 100% |
| **REPORT - CHAPTER 3** | **14/09/21** | **06/12/21** | **0h** | **88%** |
| **Usability Analysis** | **26/10/21** | **02/11/21** | **0h** | **100%** |
| Work Flow Map | 26/10 | 02/11 | 0 | 100% |
| Experience Map | 26/10 | 02/11 | 0 | 100% |
| **Needs Analysis** | **02/11/21** | **09/11/21** | **0h** | **100%** |
| Needs / Benefits Not met by Curren... | 02/11 | 09/11 | 0 | 100% |
| Latent Needs | 02/11 | 09/11 | 0 | 100% |
| Categorization of Needs | 02/11 | 09/11 | 0 | 100% |
| Needs Analysis Diagram | 02/11 | 09/11 | 0 | 100% |
| **Human Factors Analysis** | **09/11/21** | **06/12/21** | **0h** | **100%** |
| Product Schematic - Configuration | 09/11 | 22/11 | 0 | 100% |
| Ergonomic - 1:1 Human Scale Study | 22/11 | 06/12 | 0 | 100% |
| **Aesthetics & Semantic Profile** | **14/09/21** | **02/11/21** | **0h** | **100%** |
| Approach to Design | 14/09 | 02/11 | 0 | 100% |
| **Sustainability - Safety, Health a...** | **07/11/21** | **16/11/21** | **0h** | **0%** |
| Rationale of selection of Key Differ... | 07/11 | 16/11 | 0 | 0% |
| **Innovation Opportunity** | **11/11/21** | **20/11/21** | **0h** | **0%** |
| Desirability, Feasibility and Viability | 11/11 | 20/11 | 0 | 0% |
| Summary | 13/11 | 20/11 | 0 | 100% |
| Design Brief | 13/11 | 20/11 | 0 | 100% |
| Finish Chapter 3 | 25/11 | 25/11 | 0 | 100% |
| **REPORT - CHAPTER 4** | **11/10/21** | **05/04/22** | **0h** | **26%** |
| **Initial Idea Generation** | **11/10/21** | **01/11/21** | **0h** | **100%** |
| Aesthetics Approach & Semantic P... | 11/10 | 18/10 | 0 | 100% |
| Mind Mapping | 11/10 | 19/10 | 0 | 100% |
| Ideation Sketches | 18/10 | 01/11 | 0 | 100% |
| **Concepts Exploration** | **02/11/21** | **08/11/21** | **0h** | **100%** |
| Concept 1 - 3 | 02/11 | 08/11 | 0 | 100% |
| **Concept Strategy** | **09/11/21** | **22/11/21** | **0h** | **100%** |
| Concept Directions and Product Sc... | 09/11 | 22/11 | 0 | 100% |
| **Concept Refinement & Validation** | **20/12/21** | **05/01/22** | **0h** | **0%** |
| Design Refinement | 20/12 | 05/01 | 0 | 0% |
| Detail Development | 20/12 | 05/01 | 0 | 0% |



| | | | | |
|---|---|---|---|---|
| Refined Product Schematic & Ergo... | 20/12 | 05/01 | 0 | 0% |
| **Design Realization** | **10/01/22** | **01/02/22** | **0h** | **0%** |
| Design Finalization | 10/01 | 25/01 | 0 | 0% |
| Physical Study Models | 17/01 | 01/02 | 0 | 0% |
| Design Resolution | 17/01 | 01/02 | 0 | 0% |
| **CAD Development** | **15/02/22** | **05/04/22** | **0h** | **0%** |
| CAD Development | 15/02 | 01/03 | 0 | 0% |
| Physical Model Fabrication | 01/03 | 05/04 | 0 | 0% |
| **REPORT - CHAPTER 5** | **18/01/22** | **29/03/22** | **0h** | **0%** |
| Summary | 15/03 | 19/03 | 0 | 0% |
| **Design Criteria Met** | **18/01/22** | **22/02/22** | **0h** | **0%** |
| Full bodied Interaction Design | 18/01 | 08/02 | 0 | 0% |
| Materials, Processes & Technology | 25/01 | 15/02 | 0 | 0% |
| Design Implementation | 25/01 | 22/02 | 0 | 0% |
| **Final Model** | **01/02/22** | **29/03/22** | **0h** | **0%** |
| Final CAD Rendering & Physical Mo... | 01/02 | 29/03 | 0 | 0% |
| Technical Drawings and Sustainabil... | 14/03 | 29/03 | 0 | 0% |
| **REPORT - CHAPTER 6** | **15/02/22** | **08/03/22** | **0h** | **0%** |
| Report Summary | 15/02 | 08/03 | 0 | 0% |
| **REFERENCES AND APPENDIX** | **07/09/21** | **05/04/22** | **0h** | **85%** |
| References | 07/09 | 05/04 | 0 | 100% |
| Appendix | 07/09 | 05/04 | 0 | 70% |

# Appendix K – Advisor Meetings and Agreement Forms

IDSN 4002 / 4502
SENIOR LEVEL THESIS ONE & THESIS TWO

HUMBER
Faculty of Applied Sciences & Technology
Bachelor of Industrial Design / FALL 2021 & WINTER 2022

## INFORMATION LETTER

**Conditions of Participation**

- ✓ I understand that I am free to withdraw from the 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.**

| Anonymous | Anonymous | 2021-10-17 |
|---|---|---|
| Participant's Name | Participant's Signature | 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: 647-608-1115

Email: avirajcheema56@gmail.com

My supervisors are:

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

Prof. Sandro Zaccolo, **sandro.zaccolo@humber.ca**

HUMBER
Faculty of Applied Sciences & Technology
Bachelor of Industrial Design / FALL 2021 & WINTER 2022

# IDSN 4002 / 4502
SENIOR LEVEL THESIS ONE & THESIS TWO

## PARTICIPANT INFORMED CONSENT FORM

**Research Study Topic:** How may we improve mobility for police officers in dense urban environment?
**Investigator:** Aviraj Cheema / 647-808-1115 / avirajcheema56@gmail.com
**Courses:** IDSN 4002 & IDSN 4502 Senior Level Thesis One & Two

I, ____Anonymous_____*(First Name/Last Name)*, have carefully read the Information Letter for the project How Might We Improve Mobility for Police Officers in Dense Urban Environments, led by Aviraj Cheema. 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 Aviraj Cheema 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, « insert student Name here » and Prof. Catherine Chong or Prof. Sandro Zaccolo 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, 416-675-6822 ext. 79322, **Lydia.Boyko@humber.ca** or « insert student Name /Phone Number /Email Address ».

**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.

| Anonymous | Anonymous | 2021-10-17 |
|---|---|---|
| Participant's Name | Participant's Signature | Date |

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**Project Management:**

**Interview 1**

Date: Sept 21st, 2021

Duration: 2 days

Method: Via Email

Topics Covered: Basic user profile, user behavior, and police procedures, methods, and duties

**Interview 2**

Date: Oct 7th, 2021

Duration: 3 Hours

Method: in Person

Topics Covered: In depth product benchmarking, user journey mapping, user observation studies