COL

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Emergency Response in Challenging Terrain

by

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Abstract

Extreme outdoor recreational activities, such as rock climbing, mountain biking, and hiking, have experienced a surge in popularity, often unfolding in challenging terrains. Conventional emergency response systems and vehicles find themselves inadequately equipped to navigate these environments efficiently, resulting in prolonged wait times and diminished chances of successful rescue. This thesis aims to confront this issue by investigating ways to enhance emergency response capabilities in challenging terrain, with a primary focus on refining user interaction design and ensuring physical comfort for both patients and paramedics. The overarching goal is to elevate the overall outdoor adventure experience while prioritizing sustainability and social responsibility to minimize environmental impact. This research, centered on emergency responses in challenging terrains, is distinctive and innovative, amalgamating human-centered design, technology optimization, and environmental sustainability. Employing methodologies like literature review, data collection, and interviews with field experts, the study aims to craft a comprehensive solution that not only ensures the safety and well-being of outdoor enthusiasts but also safeguards the environments where these activities transpire.

Keywords: extreme outdoor activities, emergency response, challenging terrain, user interaction design, sustainability, social responsibility, environmental impact, safety, well-being.

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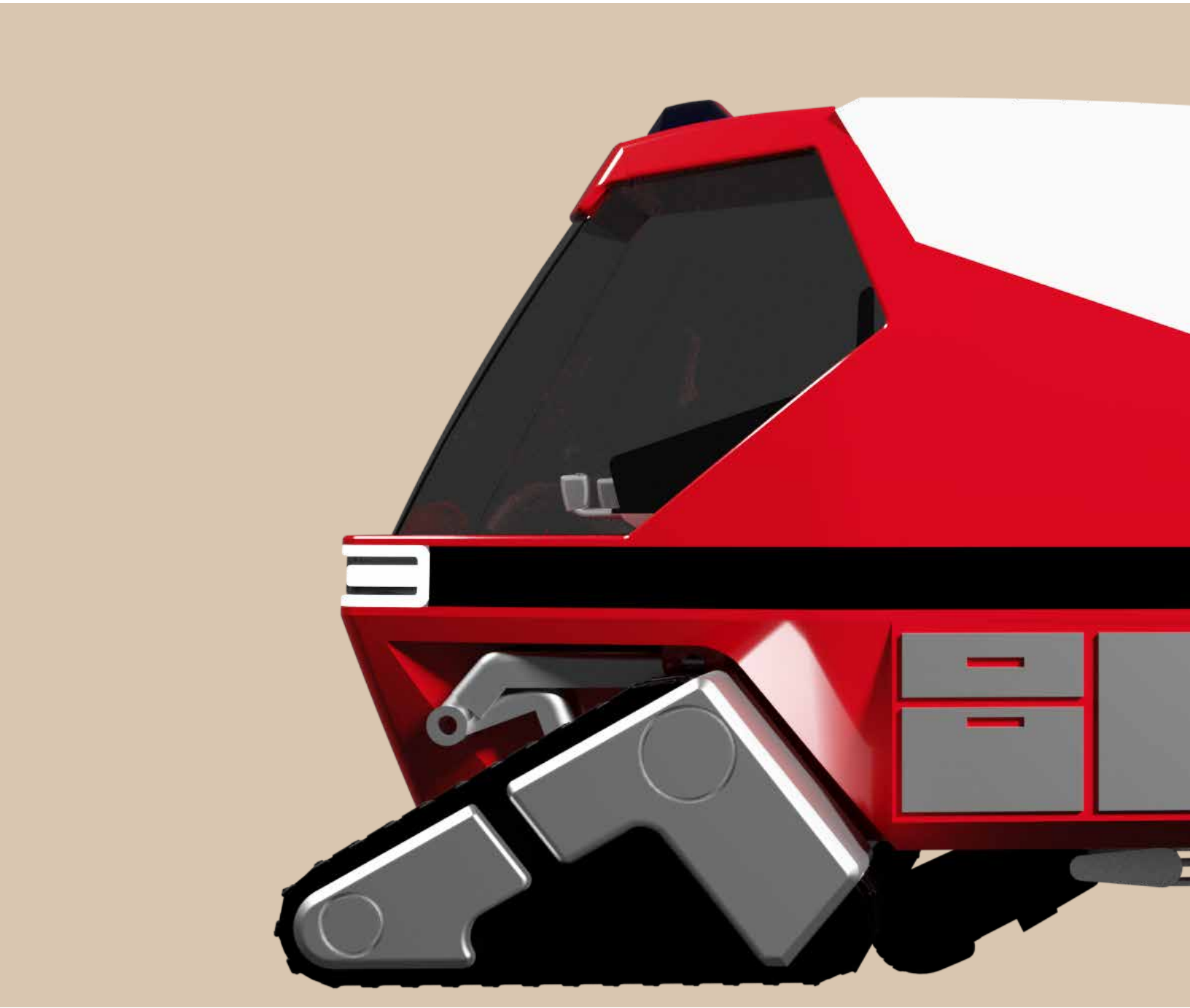


1.1 Problem definition

Emergency response in challenging terrains poses a critical problem, with traditional vehicles struggling to navigate trails, mud, parks, and crowded areas. Ambulances often prove impractical in events like mountain biking competitions or hiking, leading to the use of makeshift solutions such as bicycles and utility. However, these alternatives lack dedicated emergency features and require paramedics to carry supplies, impacting care efficiency. The existing gap becomes apparent when standard vehicles are unsuitable, causing delays in response time and suboptimal patient care. The problem extends beyond reaching the scene, emphasizing the need for a seamless transition from on-site response to hospital transportation. Improving upon emergency response in challenging terrain requires a dedicated, versatile vehicle with tailored emergency features to ensure rapid paramedic deployment and effective patient transport. The current deficiencies in crowded locations and extreme sports events necessitate a comprehensive solution that addresses both paramedic and patient needs, fostering a more integrated and efficient emergency response system. The project places a strong emphasis on providing seamless on-site response and subsequent hospital transportation, ensuring a continuous and well-coordinated emergency care process. Furthermore, the design prioritizes full-bodied human interaction by focusing on the comfort of both paramedics and patients, creating an ergonomic and user-friendly experience. Simultaneously, the incorporation of sustainable practices, such as the use of electric motors and environmentally friendly methods, underscores the commitment to safeguarding both human well-being and the natural environment. In essence, this project aligns with the core principles of the thesis, aiming to revolutionize emergency response by offering a comprehensive and innovative solution tailored to challenging terrains.

1.2 Rationale and Significance

The rationale and significance of this project lie in addressing critical gaps in the existing emergency response systems, particularly in challenging terrains. Traditional vehicles, including ambulances and bicycles, are often insufficient in providing timely and effective assistance in difficult-to-reach locations. The significance of this research becomes evident in its potential to revolutionize emergency response strategies, introducing a purpose-built vehicle that not only navigates tough terrains efficiently but also caters to the dynamic needs of paramedics and patients during the entire emergency process. By focusing on user-centered design, technological optimization, and sustainability, the project aims not only to improve the safety and well-being of individuals in remote or crowded environments but also to reduce the environmental impact associated with emergency response. This holistic approach reflects the project's broader implications for emergency medical services, outdoor adventure experiences, and the environmental footprint of rescue operations.

1.3 Background, History, and Social Context

Historical, social, and technological factors have collectively shaped the landscape of emergency response in challenging terrains. Historically, emergency response systems have primarily relied on traditional vehicles, such as ambulances, designed for urban environments. However, with the increasing popularity of outdoor and extreme recreational activities, the demand for specialized emergency response in challenging terrains has become more pronounced. Socially, there is a growing awareness of the importance of swift and effective emergency care in remote and difficult-to-access locations, influencing both public expectations and emergency service protocols. Big picture trends underscore a shift towards proactive and agile emergency response strategies, acknowledging the unique challenges posed by challenging terrains.

Demographically, the primary user, the paramedic, is faced with the need for enhanced mobility and adaptability to navigate diverse and unpredictable terrains efficiently. For the secondary user, the patient, the demand lies in receiving immediate and specialized care tailored to the circumstances of challenging terrains. Lifestyle trends reveal an increasing engagement in outdoor activities, demanding a more specialized approach to emergency response. Media trends amplify the need for real time reporting and documentation of emergency situations in challenging terrains. Product trends signal a shift towards the development of purpose-built vehicles and equipment that can withstand and effectively operate in diverse environmental conditions. In essence, the background encompasses a comprehensive exploration of historical foundations, evolving societal expectations, and emerging trends that collectively underscore the necessity and timeliness of revolutionizing emergency response in challenging terrains.

Chapter 2

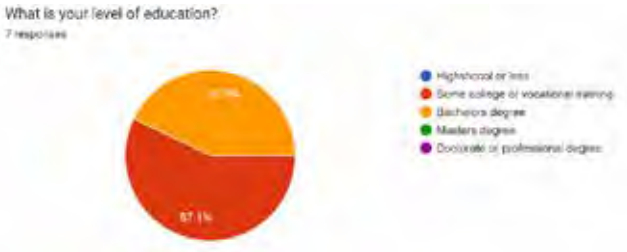
Research

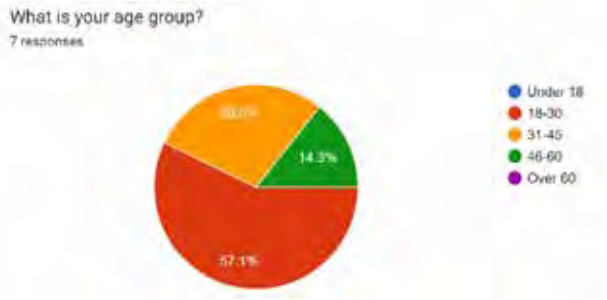
2.1 User Research

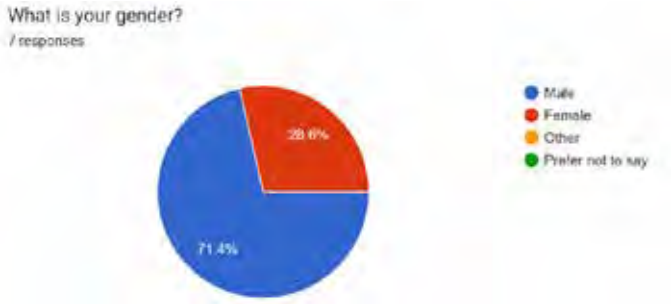
This section provides a comprehensive exploration of paramedics' demographic, opinions, needs and practices in challenging terrains. Through surveys, consultations with a paramedic advisor, and community engagement, both quantitative and qualitative insights are gathered. Observations and human factors studies offer a deep understanding of paramedics' real world experiences, uncovering hidden needs and enhancing the user-centric approach. This research sets the foundation for designing an effective emergency response solution tailored to the unique demands of challenging terrains.

2.1.1 User Profile – Persona

Primary User	Secondary User	Primary User
Paramedic	**Patient**	**Healthcare Organization**







2.1.2 Current User Practice

Current user practices in emergency situations in challenging terrains often involve traditional ambulances struggling to navigate narrow trails or remote areas where outdoor activities like mountain biking, hiking, or rock climbing take place. When an injury occurs, the process of getting help can be complex. Paramedics often need to park their ambulance at the nearest accessible point and then travel the remaining distance on foot, carrying necessary medical equipment. This approach is time-consuming and can be physically demanding, especially in rugged terrain. It also limits the types of equipment that can be brought to the patient. Additionally, traditional ambulances are often not designed for off-road use, making access to remote locations difficult and potentially delaying critical care. These challenges highlight the need for a specialized emergency response vehicle like COL, designed to navigate challenging terrains efficiently and provide timely and effective care to patients in remote areas.

Goals and Motivations

Alexander's primary goal is to provide high quality care to his patients and ensure their safety and well-being. He is motivated by the opportunity to make a positive impact on people's lives, especially in critical situations where every second counts. Alexander is also interested in new technologies and approaches that can help him perform his job more effectively and safely.

Pain Points

Limited mobility and maneuverability in challenging terrains

Fatigue and physical strain from manual handling of equipment and patients

Challenges in accessing remote or difficult to reach locations

Thinks: "I need equipment that can help me reach patients quickly and safely, especially in challenging terrains."

Feels: Frustrated with the limitations of current emergency response vehicles and equipment.

Sees: Other paramedics struggling with similar challenges and looking for innovative solutions.

Hears: About new technologies and approaches in emergency response that could improve efficiency and safety.

Says/Does: Actively seeks out training and information on new equipment and techniques to improve his skills and effectiveness.

Name: Alexander
Age: 32
Gender: Male
Education: Bachelor's Degree and Paramedic Training
Location: Whistler, BC
Work Experience: 8 Years

2.1.3 User Observation: Activity Mapping

Observing an injury, emergency response call, dispatch and patient care and transport.

About the user

Name: Cedric
Sex: Male
Location: Reunion Island (Video)
Date of observation: November 26, 2013 (video uploaded May 2022)
Experience level: Professional Mountain Biker

-The Injury-

Crashing Bike

Freinds Aiding the patient the best they can

Calling Medical services

For this study a video was reviewed with a Paramedic from the Niagara region. The video includes a mountain bike crash leading to a call for medical attention. The wait time and what occurred during it and the eventual tending and transportation of the patient.

-Emergency Response-

30 minutes for medic response

Medics were Ill equipped when arriving

Helicopter was required

Lifting and transporting patient was difficult with the supplies they had

Patient was left with a less than 50% chance of survival due to all of the complications and wait times.

Potential Improvements

- Communication issues
- Long wait times
- Lack of supplies
- Patient transport struggles

2.1.4 User Observation: Human Factors of Existing

For paramedics navigating challenging terrains, the design of vehicles and equipment plays a crucial role in accommodating the unique demands of these environments. Factors such as vehicle stability, maneuverability, and accessibility impact the paramedic's ability to reach patients swiftly and provide timely care. Additionally, ergonomic considerations in the design of medical equipment and stretcher systems are vital for ensuring ease of use and comfort during patient care. In the broader context of emergency response, communication tools, user interfaces, and the overall usability of equipment contribute to the efficiency of paramedic interventions. Addressing human factors in product design is important to enhance the performance of emergency responders, ensuring the safety of both patients and paramedics.

2.1.5 User Observation: Safety & Health of Existing Products

In challenging terrains, uneven surfaces, unpredictable weather conditions, and difficult access points pose risks to both patients and paramedics. The design of vehicles and equipment must prioritize features that mitigate these risks and ensure the safety of the paramedic during transport and the patient during care. Ergonomic considerations become crucial in preventing injuries or strains during the performance of emergency procedures. In the broader context of emergency response, the safety and health of paramedics are directly linked to the design of equipment interfaces, ensuring clear communication, intuitive controls, and minimal cognitive load in high-pressure situations. By addressing these safety and health considerations, future design interventions can significantly contribute to enhancing the overall well-being of both paramedics and patients in challenging and dynamic emergency response scenarios.

2.2 Product Research

This section involves the benchmarking of existing products in the market, focusing on understanding their features, aesthetics, functions, and materials. This analysis aims to identify key trends, strengths, and weaknesses in current emergency response vehicles and equipment. By examining these aspects, the research informs the design process, ensuring that the project meets or exceeds the standards set by current products. This research is crucial for developing a superior solution for emergency response in challenging terrains.

2.2.1Benchmarking: Benefits and Features of Existing Products

Benefits

Torsus Terrastorm	John Deere	Standard Ambulance	Rescue Helicopter
Fast	All terrain	Well eqipped	Fast
Highly manuverable	Reliable	Spacious	Capaccity
Remote areas to hospital	Small size	Accessibility	Well eqipped
spacious	High torque	Versatility	Versatility

Features

6 meters	3 meters	6-7 meters	90 meters
3.5 tons	1.158 tons	4-7 tons	7.3 tons
176 HP	20	300-400 HP	240km/h cruise speed
Manual patient loading	Manual patient loading	Manua lpatient loading	Manual patient loading
Standard ambulance required supplies	Paramedics medical bags	Standard ambulance required supplies and more	Standard ambulance required supplies

Functionality




	Torsus Terrastorm	John Deere	Standard Ambulance	Rescue Helicopter
Patient loading system	Secondary stretcher	Manual	Secondary stretcher	Manual
Communications syatem	Radio	Radio	Radio	Radio
Navigation System	Integrated GPS	N/A	Integrated GPS	Integrated GPS
Operation	Common Steering & Cameras	Common steering	Common Steering	Common Helicopter controls

Functionality Take-Aways

- Size helps with supplies but can limit accessibility
- Smaller vehicles lack speed and power
- Helicopter is by far the fastest and best equipped

2.2.2 Benchmarking: Functionality of Existing Products

When benchmarking existing rescue vehicles for challenging terrain, several key functional aspects stand out. The off-road ambulance van, designed specifically for rugged terrain, demonstrates exceptional off-road capability with features like all-wheel drive or specialized tracks. Similarly, the John Deere Gator, though not designed as an ambulance, showcases remarkable off-road performance, highlighting the importance of versatility in challenging environments. In contrast, the standard ambulance emphasizes patient care and transport, focusing on efficient access and equipment organization. The rescue helicopter provides unparalleled access to remote areas, highlighting the significance of aerial support in challenging terrain. These benchmarks underscore the diverse approaches to addressing the unique challenges of emergency response in challenging terrains, from ground-based off-road vehicles to aerial support, each serving critical roles in different scenarios.

Aesthetics




Overall form	Torsus Terrastorm	John Deere	Standard Ambulance	Rescue Helicopter
Shape	Similar to common panel van Radio	Open sides and exposed rear bed Strong look	Boxy shape Wide	Streamlined
Interior	Open Seating for paramedic alongside patient stretcher	Driver and passenger upfront separate from rear bed with room for stretcher and one paramedic	Seperate driving compartment Spacious patient area	Spacious patient care area
Access Points	Two front doors Side door Rear double door	No doors Acess to driver cabin Flat bed to be climbed up to	Driver doors Side door Rear acess	Pilot door Side entry door patient area

2.2.3 Benchmarking: Aesthetics and Semantic Profile of Existing Products

An aesthetic assessment was carried out to determine trends in styling for this product category, and to characterize the specifics of those styling trends. This was assessed by benchmarking products and applying Elements of Design across products, and then comparing two features in an x-y graph.

Aesthetic Take-Aways

Shape and Size

- Small and streamlined is not seen

Interior

- Space for patient and supplies is important

Access points

- Multiple access points is common

2.2.4 Benchmarking: Materials & Manufacturing of Existing Products

EMS Helicopters: These are typically made of lightweight but strong materials like aluminum or composite materials. The interiors are designed to be ergonomic and functional, with medical equipment securely mounted for easy access.

John Deere Gators Equipped for Paramedics: These utility vehicles are often modified to include medical equipment and supplies. The materials used are durable and resistant to the elements, with added safety features for the paramedics and patients.

Ambulances: Ambulances are usually constructed with a combination of steel, aluminum, and composite materials. The interior is designed to be easily cleaned and sanitized, with modular components for flexibility in equipment layout.

Off-road Rescue Vehicles: These vehicles are designed for challenging terrains and are constructed with rugged materials like steel and heavy-duty plastics. The interiors are designed to withstand rough handling and provide a stable platform for medical procedures.

In summary, existing emergency response vehicles such as EMS helicopters, modified utility vehicles like John Deere Gators, regular ambulances, and off-road rescue vehicles offer valuable insights into materials and manufacturing practices. They prioritize durability, functionality, and safety, using materials like aluminum, steel, and composites. Interior designs focus on accessibility, cleanliness, and stability for medical procedures. Benchmarking these vehicles provides a foundation for designing our emergency response vehicle, ensuring it meets or exceeds industry standards while innovating in areas such as sustainability, user experience, and adaptability to challenging terrains.

2.2.5 Benchmarking | Sustainability of Existing Products

Currently, many emergency response vehicles rely on traditional combustion engines, contributing to environmental pollution and carbon emissions. There is a significant potential for improvement by integrating sustainable technologies such as electric motors or hybrid systems, reducing the ecological impact of emergency response operations. Incorporating lightweight yet durable materials can enhance fuel efficiency and reduce the overall environmental footprint. Moreover, advancements in renewable energy sources, such as solar or kinetic energy recovery systems, could be explored to power auxiliary systems within emergency response vehicles. By embracing sustainable practices and incorporating eco-friendly technologies, the emergency response sector can not only reduce its environmental impact but also set a precedent for responsible and conscientious practices in challenging terrains and beyond.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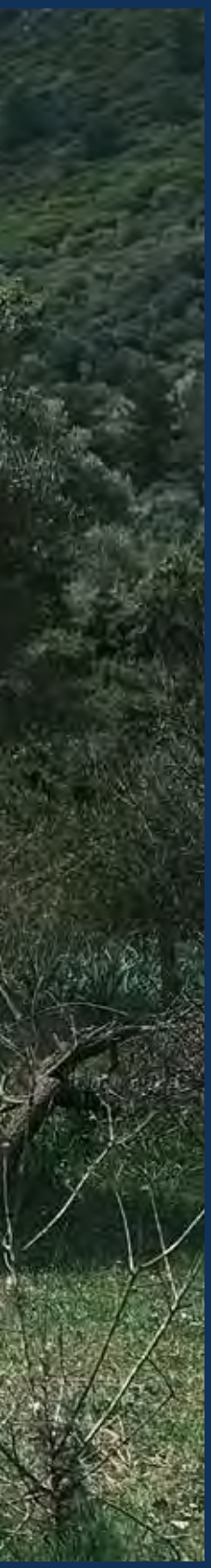


2.3 Summary of Chapter

In this chapter, extensive research was conducted to understand the needs and practices of the primary user, the paramedic, and the secondary user, the patient. The paramedic's role is crucial, as they are responsible for operating the emergency response vehicle and providing medical care in challenging terrains. The patient's experience is equally vital, as the vehicle's design directly affects the quality and timeliness of care they receive. Benchmarking existing products, such as EMS helicopters, John Deere Gators equipped for paramedics, and regular ambulances, provided insights into the benefits, features, functionality, aesthetics, materials, and sustainability of these solutions. User research, including interviews and surveys, shed light on current user practices and observations, highlighting the need for a more efficient and effective emergency response vehicle. Key takeaways from this chapter include the emphasis on user-centric design, the importance of considering both primary and secondary users, and the impact of the vehicle's design on patient outcomes.

Chapter 3

Analysis

3.1 Analysis – Needs

This section focuses on identifying and categorizing needs not met by current products, exploring usability and user experience, evaluating human factors and ergonomics, analyzing aesthetics and semantics, ensuring sustainability, and identifying innovation opportunities.

3.1.1 Needs/Benefits Not Met by Current Products

Current products utilized in emergency response, particularly in challenging terrains, often fall short in meeting specific needs and providing optimal benefits for both paramedics and patients. The existing solutions lack adaptability to diverse terrains, hindering their effectiveness in areas such as mountainous regions, dense forests, or rugged trails. This limitation compromises response times and, consequently, the overall success of emergency interventions. Moreover, the comfort and safety of both paramedics and patients are not adequately addressed in current designs. The need for versatile, ergonomic, and user-friendly solutions is apparent, as paramedics often face difficulties in accessing remote locations and providing efficient care. In such challenging environments, the potential for injuries and health complications is heightened, necessitating a comprehensive and specialized approach to emergency response design. Therefore, there is a critical need for a solution that not only addresses the specific challenges of challenging terrains but also prioritizes the well-being of both paramedics and patients, ensuring effective and compassionate emergency care.

3.1.2 Latent Needs

In addressing the latent needs of the primary user, paramedics, several critical aspects emerge as essential considerations for enhancing the effectiveness and experience of emergency response in challenging terrains. First, the integration of off-road navigation capabilities becomes vital. This feature not only contributes to faster response times but also significantly improves the overall experience for both paramedics and patients by ensuring precise and efficient navigation through challenging terrains.

Additionally, the implementation of patient compartment isolation emerges as a crucial latent need, offering a secure environment protected from the elements. This isolation is necessary for safeguarding patients during transportation, especially in adverse weather conditions or challenging terrains, providing a controlled and comfortable space for optimal care delivery. Also, recognizing the latent need for off-road training for paramedics becomes important. Providing paramedics with specialized training for navigating challenging terrains ensures better preparedness, reduces complications during emergency responses, and ultimately contributes to faster response times. These latent needs underscore the importance of a holistic approach that not only prioritizes technical functionalities but also considers the experiential and training aspects essential for the success of emergency response operations in challenging terrains.

3.1.3 Categorization of Needs

Immediate Needs	Latent Needs	Wants
Off road mobility	Off road navigation	Paramedic's Ease of use
Patient Stability and comfort	Patient compartment isolation	Extra resources
More efficient Paramedic work experience	Specific off road resources	Capable/rugged vehicles

3.2 Analysis – Usability

In this section, journey mapping and user experience mapping are utilized to gain insights into how users interact with the product. Journey mapping visually represents the user's experience from start to finish, highlighting key touchpoints, emotions, and pain points. This approach helps the design team understand the user's perspective and identify areas for improvement. User experience mapping focuses on the overall experience users have with the product, including usability, accessibility, and satisfaction. These tools provide valuable insights that inform design decisions and help create a more user-centric product.

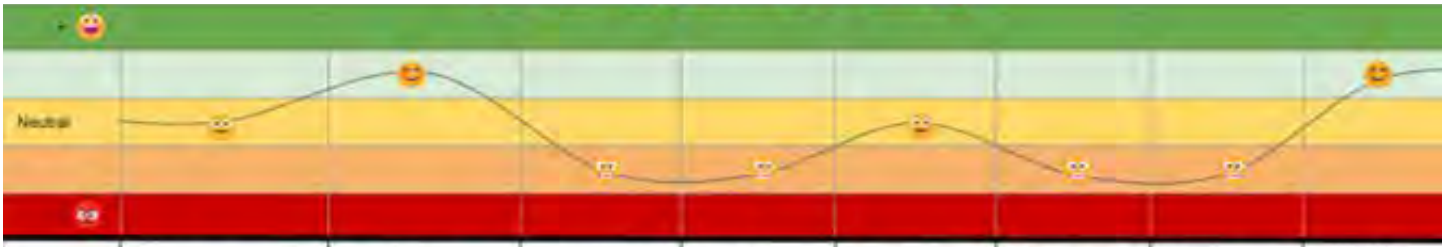
3.2.1 Journey Mapping

The journey map for paramedics encompasses the critical steps from receiving a call alert to handing off the patient at the hospital. Each phase, including preparation, on-site assessment, patient care, and coordination, is crucial and involves a range of actions, thoughts, and emotions. Understanding the paramedic's journey is key to designing a solution that enhances their experience and efficiency in providing care in challenging terrains.

3.2.2 User Experience

The journey map for paramedics encompasses the critical steps from receiving a call alert to handing off the patient at the hospital. Each phase, including preparation, on-site assessment, patient care, and coordination, is crucial and involves a range of actions, thoughts, and emotions. Understanding the paramedic's journey is key to designing a solution that enhances their experience and efficiency in providing care in challenging terrains.

	Call alert	Preparation	Transportation	On site assessment	Patient care	Coordination	Patient transport	Handoff to Hospital
User goals	Quickly assess the nature of the emergency and plan for a rapid response	Ensure they have the right equipment for the specific terrain and weather conditions	Reach the incident location swiftly while maintaining team communication	Quickly assess the situation and provide critical care	Administer comprehensive medical care, prioritize patient well-being	Collaborate effectively with the emergency response team	Safely evacuate the patient from the challenging terrain	Ensure a smooth handoff to a medical facility
Actions	Receive and assess the emergency call, gather necessary information	Check equipment, weather reports, and specialized gear	Drive, hike, or bike to the site, maintain radio contact	Assess the patient's condition, perform initial treatments	Administer treatments, ensure patient comfort and safety	Communicate with the team, request additional resources	Prepare the patient for transport, navigate the terrain	Provide detailed patient information and treatment history
Thoughts	Understanding the urgency, preparing mentally for the response	Focusing on equipment readiness and potential challenges	Monitoring the route and ensuring efficient navigation	Prioritizing patient needs and potential challenges of the terrain	Concentrating on effective treatment and monitoring	Team dynamics, resource allocation, and ensuring efficient coordination	Assessing evacuation options, patient safety, and potential obstacles	Effective communication with the medical facility and ensuring a seamless transition
Feelings	A mix of anticipation and readiness to provide assistance	Determination to be well-prepared and confident	A sense of urgency and commitment to arriving on time	Focused, concerned about the patient's condition	Determination to provide the best care under challenging conditions	Team spirit, responsibility for the patient's well-being	Concern for the patient's comfort and safety during transport	Relief and the hope for the patient's recovery



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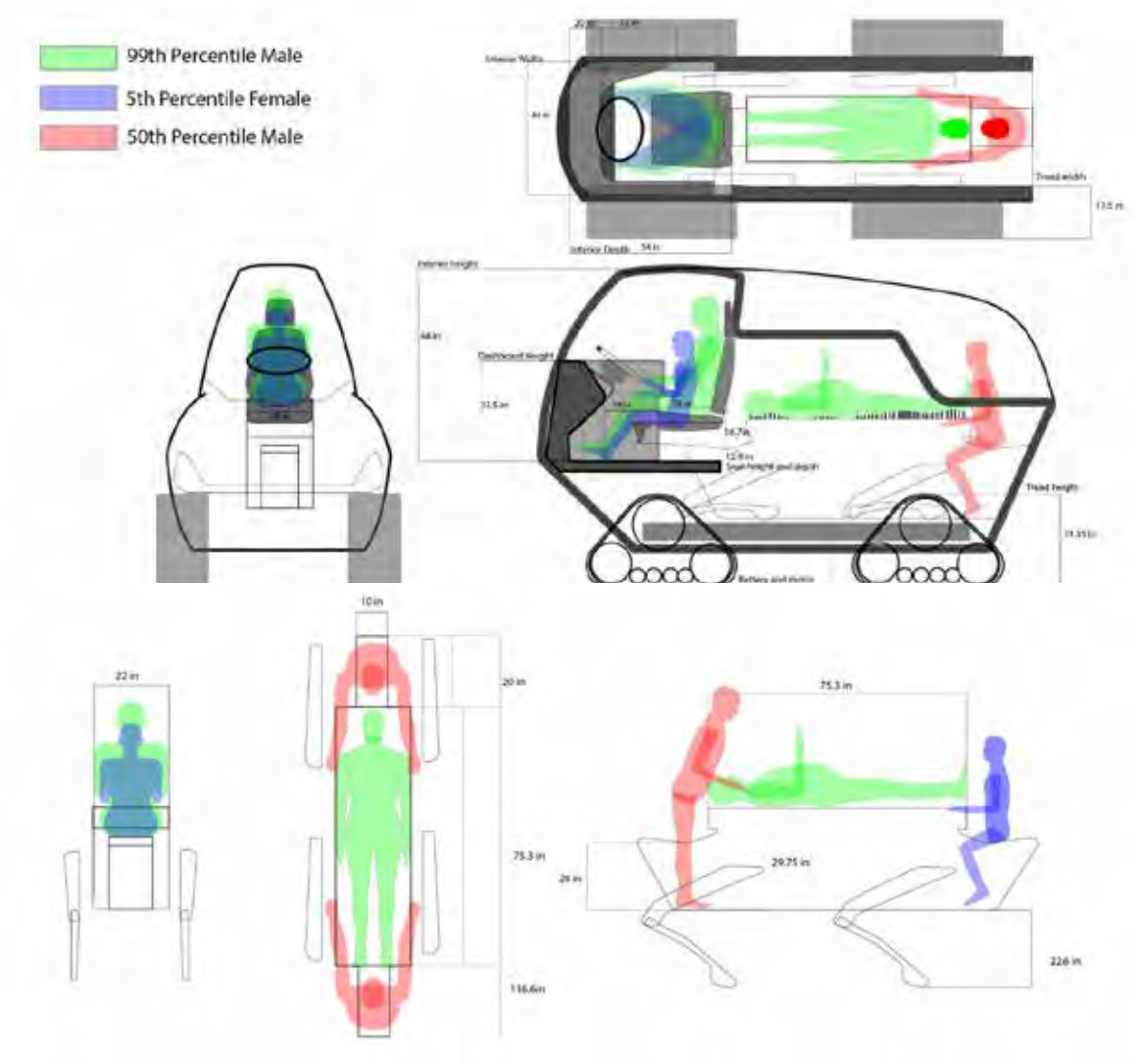
Problem, Challenges	Limited information and communication delays in remote areas	Bulky and heavy equipment that's challenging to transport	Navigation difficulties and terrain-specific obstacles	Limited visibility and accessibility in remote areas	Limited access to advanced medical equipment	Communication gaps in remote and rugged environments	Terrain-specific obstacles and patient transport difficulties	Handoff coordination and information sharing with medical facilities
Ideas/Take aways	Develop improved communication devices with long-range capabilities	Design lightweight, compact, and easy-to-carry equipment	Develop navigation aids and adaptive vehicles for challenging terrains	Design specialized diagnostic tools for challenging environments	Develop portable and ruggedized medical equipment	Create advanced communication devices for remote teamwork	Design adaptable patient transport solutions for rugged environments	Develop standardized handoff protocols and information-sharing tools

3.3 Analysis – Human Factors

In the ergonomic analysis of the driver's seat, the study involved subjects representing extreme percentiles, namely a 99th percentile male and a 3rd percentile male/50th percentile female based on height. This investigation focused on assessing the range of motion, particularly the reach to the steering wheel and the control panel situated to the left of the driver. The detailed anthropometric measurements, captured in both photographs and diagrams, elucidate the ergonomic aspects influencing the design of the driver's seat.

For the autonomous stretcher, the study featured a 99th percentile male as the patient and paramedics of varying percentiles (84th, 91st, and 3rd percentile male/50th percentile female). The primary emphasis was on evaluating the paramedics' range of motion, particularly the transition from a seated to a standing position and reaching for the patient. An important observation surfaced during the study, revealing that paramedics might encounter challenges reaching every part of the patient from their seated position. This insight suggests a potential

3.3.1 Product Schematic –Configuration Diagram



Drivers Cockpit

Autonomous Stretcher

3.3.2 Ergonomic –1:1 Human Scale Study

The evaluation process consisted of designing a full scale (1:1) ergonomic buck of the driver's cockpit including the dashboard, steering wheel and drivers seat. Additionally, the buck of the stretcher was also constructed including the patient's bed as well as the motorbike like seats for the paramedics. This allowed for critical observation of the following:

1. Seating positions of the driver
2. Interaction with the steering wheel as well as accessory features along the dash for radio, GPS, and other features on the control center
3. Size considerations for the stretcher including the seating of paramedics and the patient's bed.
4. Ability for the paramedic to provide care to the patient from seating positions on the stretcher.

3.4 Analysis – Aesthetics & Semantic Profile

In designing for aesthetics and semantics, the project aims to create a visually appealing and functional solution. Colors and materials are chosen to promote a sense of safety and reliability, while also ensuring durability and ease of maintenance. The user interface is designed to be intuitive and user-friendly, considering the high-stress nature of emergency situations. Symbolism and signage are employed to convey information quickly and effectively, enhancing the overall user experience. Cultural sensitivity is also taken into account to ensure inclusivity and respect for diverse communities. Overall, the project seeks to create a design that not only meets functional requirements but also considers the emotional and psychological impact on both users and patients.

3.5 Sustainability: Safety, Health and Environment

Based on the previous research and the unique challenges of emergency response in challenging terrains, initial thoughts on sustainability for this project are focused on minimizing environmental impact while ensuring operational efficiency. Sustainability considerations include the use of eco-friendly materials in construction, such as recyclable or biodegradable components, to reduce the environmental footprint of the vehicle. Additionally, the design aims to optimize energy efficiency, possibly incorporating renewable energy sources like solar panels to power onboard systems. The goal is to create a vehicle that not only improves emergency response but also aligns with sustainable practices, reflecting a commitment to environmental stewardship in all aspects of its design and operation.

3.6 Analysis – Innovation Opportunity

The project presents a significant opportunity for innovation in emergency response vehicles, particularly in challenging terrains. By addressing the limitations of current solutions, such as ambulances and off-road vehicles, there is a chance to revolutionize how emergency medical care is delivered in remote and rugged environments. Innovations in design, materials, and technology can enhance the speed, safety, and effectiveness of emergency response, ultimately saving lives and improving outcomes for patients. This project offers a platform to explore new ideas and push the boundaries of what is possible in emergency medical transportation, opening doors to advancements that could benefit not only outdoor enthusiasts but also emergency responders worldwide.

3.6.1 Needs Analysis Diagram

Needs	Importance	Benefits
Quick access to supplies	High	Improved response time, better patient outcomes, increased efficiency
Ease of patient transfer	High	Reduced risk of injury, smoother workflow, better patient care
Ergonomic Design	Medium	Reduced fatigue, improved comfort, better focus on patient care
User-friendly controls	Medium	Faster learning curve, reduced errors, improved efficiency
Effective communication	Medium	Coordinated care, timely information exchange, improved decision-making
Adaptability to terrain	High	Access to remote locations, improved reach, enhanced safety
Secure patient transport	High	Reduced risk of patient injury during transport, improved stability
Environmental sustainability	Medium	Reduced environmental impact, alignment with green initiatives

3.6.2 Desirability, Feasibility & Viability

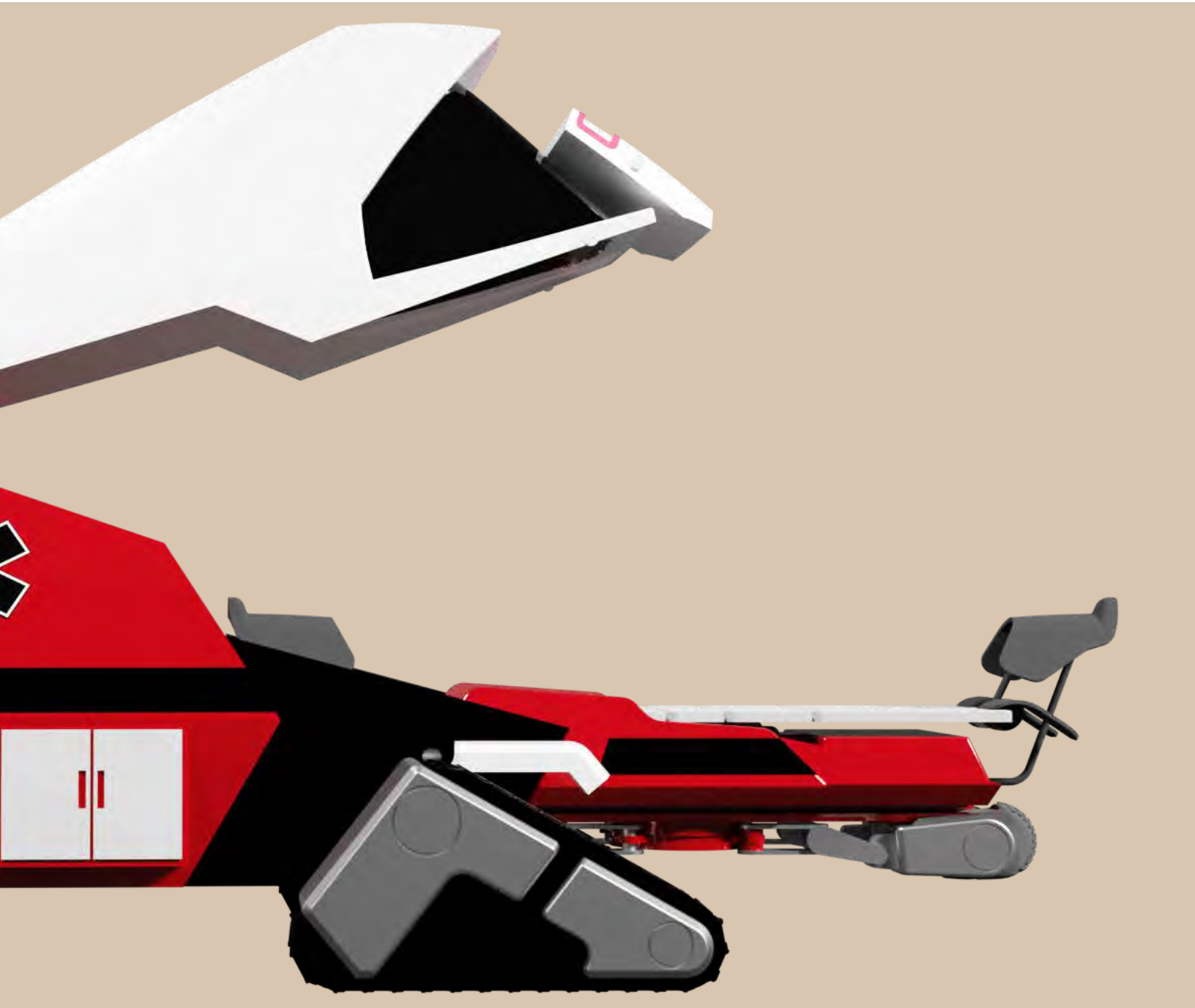
Desirability, feasibility, and viability are crucial factors in evaluating the potential success of the project. In terms of desirability, the project addresses a pressing need for improved emergency response in challenging terrains, enhancing the safety and well-being of both paramedics and patients. The innovative design, focusing on user-centric features and advanced technology, makes the project highly desirable among its target users.

The concept's feasibility relies on its practicality and compatibility with existing emergency response systems. It must be easy to deploy, integrate with current medical practices, and be cost-effective.

Viability considers the project's long-term sustainability and profitability. The project's potential for commercialization and scalability makes it a viable investment. With the increasing demand for efficient emergency response solutions, the project has the potential to not only improve lives but also generate significant returns on investment for stakeholders.

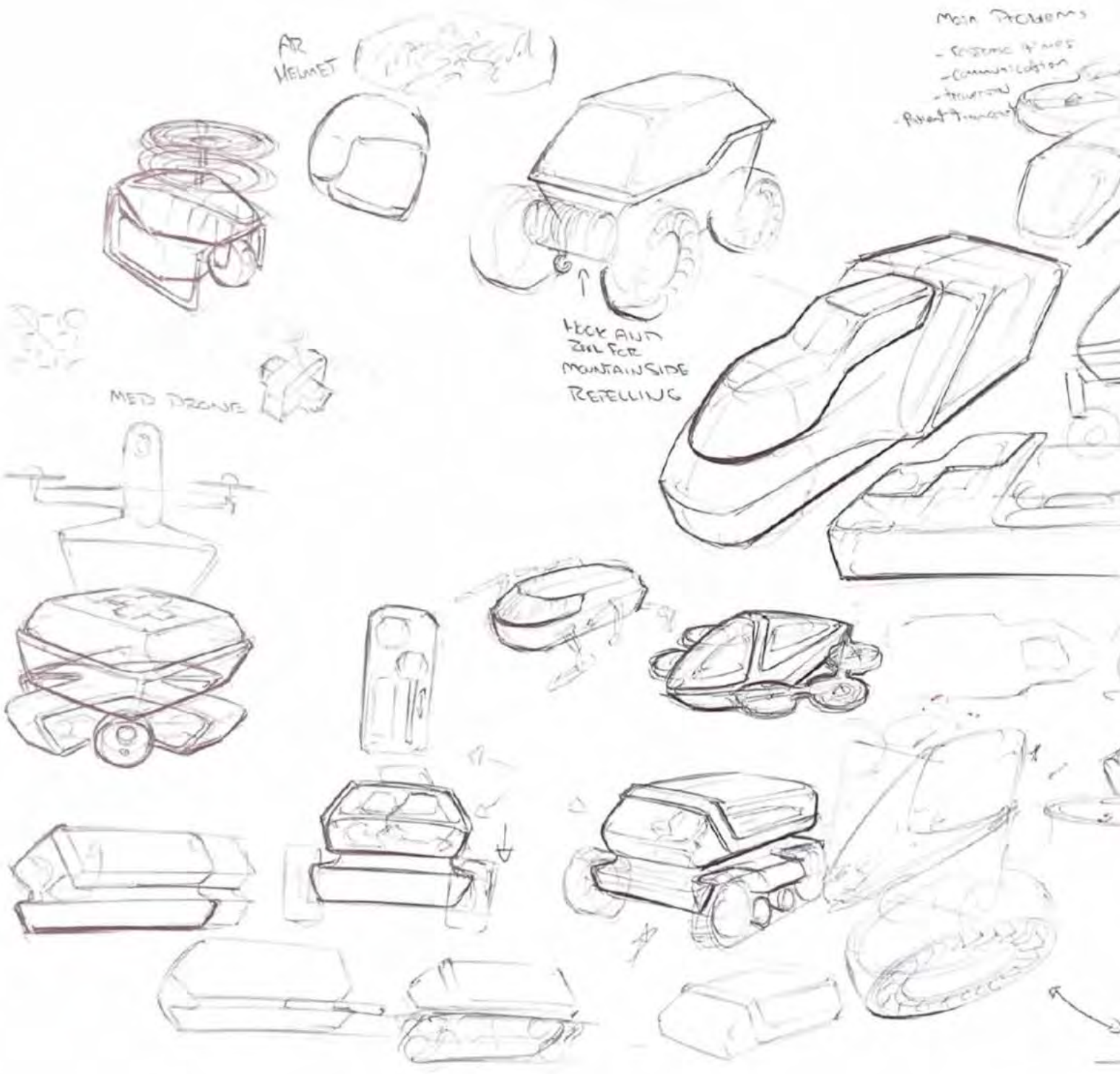
3.7 Summary of Chapter 3 – Defining Design Brief

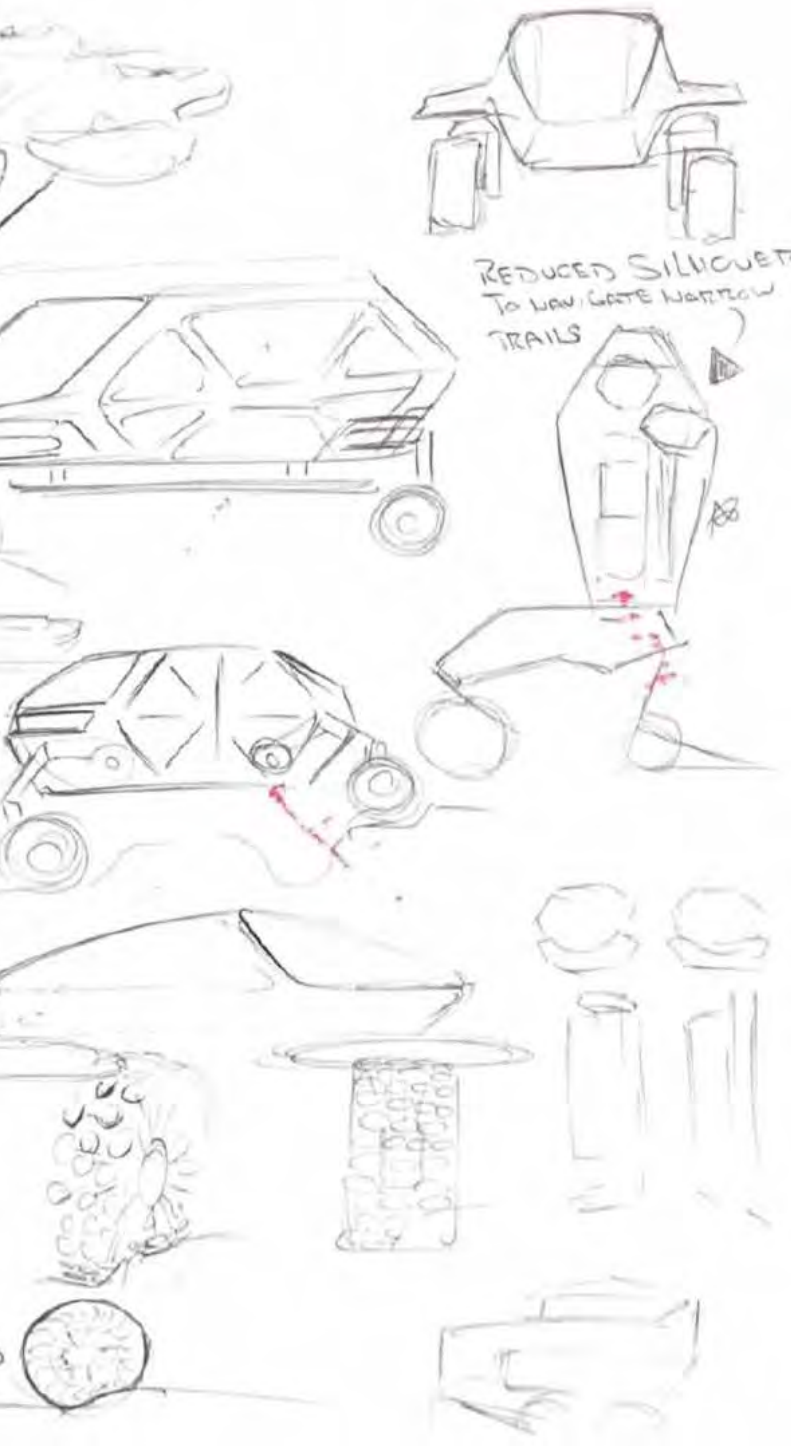
Chapter 3 provides a comprehensive analysis of various aspects critical to the project's success. It starts by identifying unmet needs and latent requirements not addressed by current products. These needs are categorized to facilitate further analysis. The usability analysis includes journey mapping and user experience evaluation, ensuring the solution meets user requirements effectively. Human factors such as product configuration and ergonomic considerations are examined through schematic diagrams and human-scale studies. Aesthetics and semantic profiles are explored to enhance user engagement and satisfaction. Sustainability is a key focus, addressing safety, health, and environmental concerns in emergency response solutions. The chapter also identifies opportunities for innovation, supported by needs analysis diagrams and assessments of desirability, feasibility, and viability. Overall, this comprehensive analysis informs the development of a solution that meets user needs while addressing sustainability and innovation requirements.



Chapter 4

Design Development


AR HELMET
MED DRONE
HOOK AND ZIP FOR MOUNTAINSIDE REFELLING



4.1 Initial Idea Generation

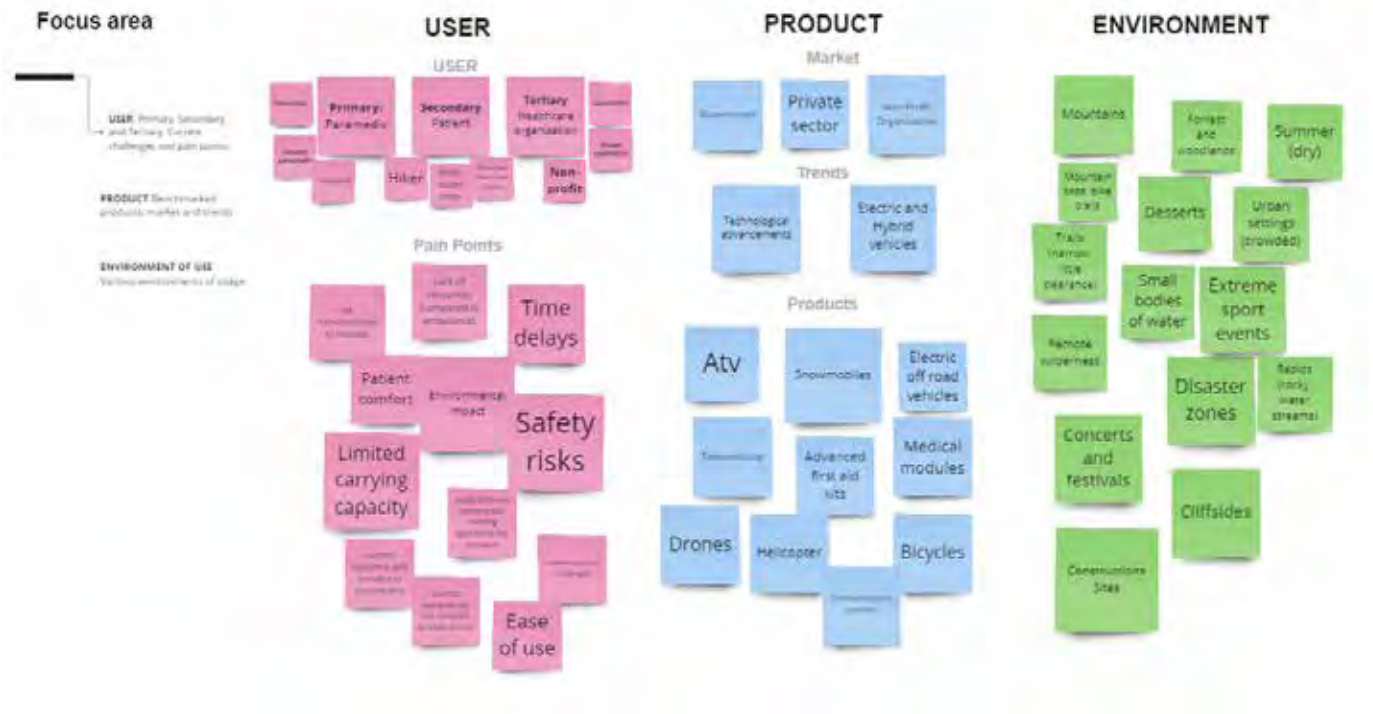
During the initial ideation phase, a range of concepts was explored to revolutionize emergency response in challenging terrains. Drones emerged as a potential solution for quick reconnaissance, providing vital information about the terrain and the location of the patient. Adaptable suspension systems were considered to ensure vehicles could traverse rough and uneven terrain, maintaining stability and safety. Extendable vehicles were conceptualized to provide the necessary reach in remote locations, ensuring timely assistance. Additionally, tandem vehicle layouts were explored to enhance maneuverability and efficiency, allowing for better navigation through challenging landscapes. These concepts aimed to address the critical challenges faced by traditional emergency response vehicles, offering innovative solutions to improve overall effectiveness and response times.

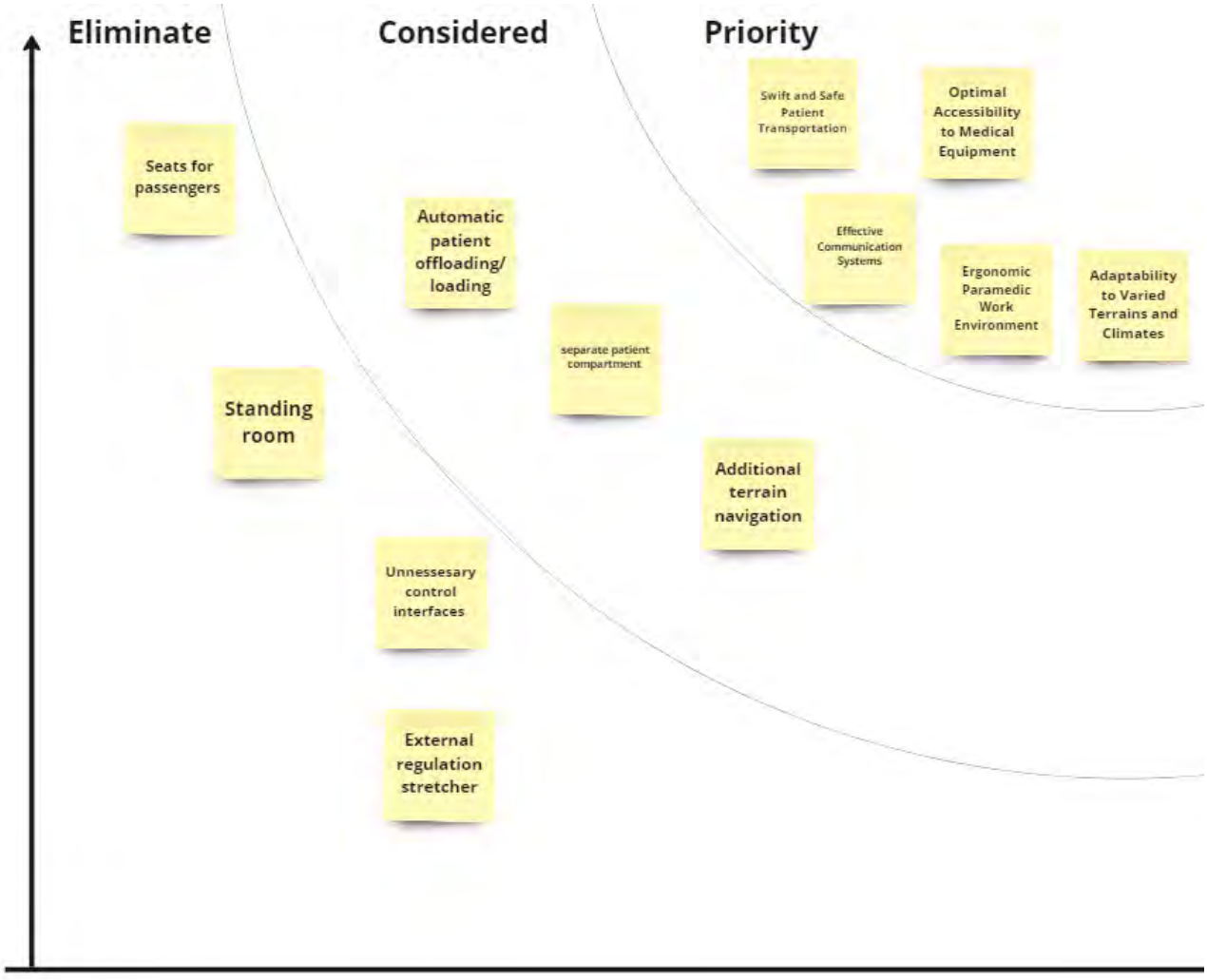
4.1.1 Aesthetics Approach and Semantic Profile

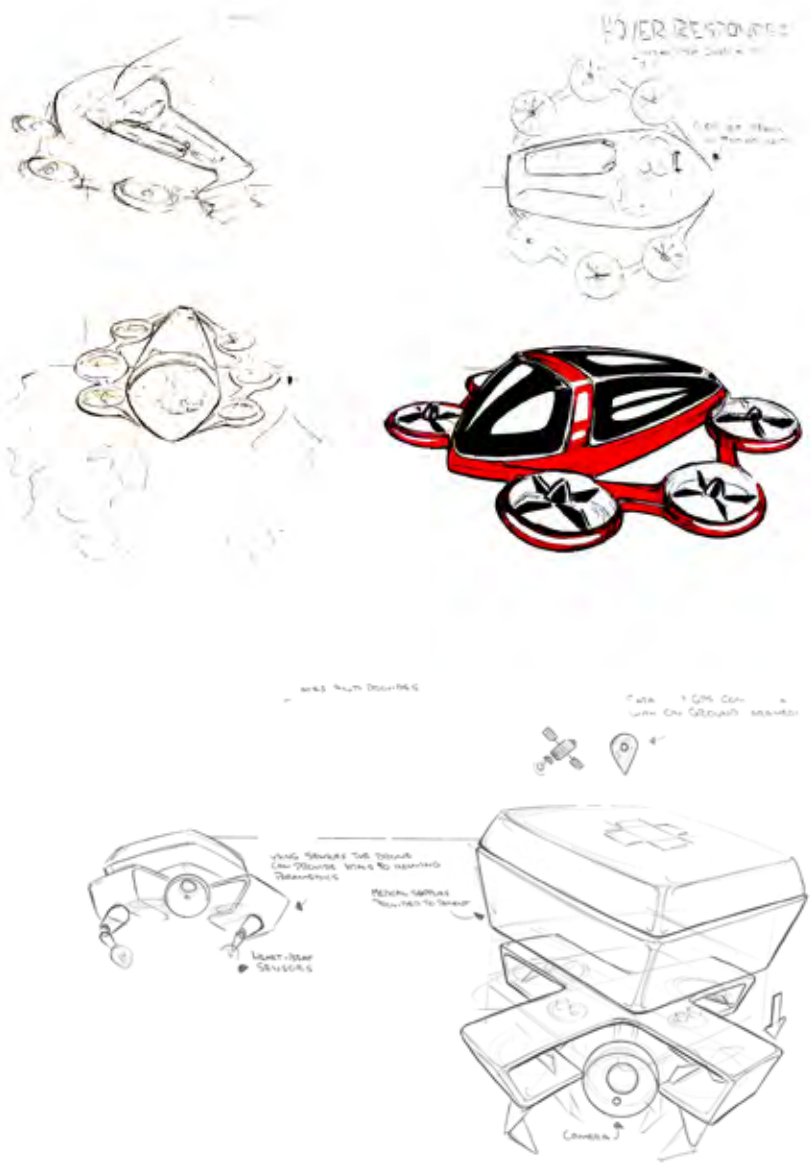
The aesthetic and semantic profile of the final design direction for the emergency response vehicle embodies a minimalist approach, drawing inspiration from the Braun design philosophy. This concept translates into a sleek and sophisticated exterior, with clean lines and a modern aesthetic. Despite its minimalist approach, the design retains a rugged and durable look, reflecting its purpose in challenging terrains. Modern lighting elements are integrated to enhance visibility and add a futuristic touch to the vehicle's appearance. Part lines are strategically utilized to not only create visual interest but also to emphasize the vehicle's design lines, highlighting its functionality and advanced features. The overall aesthetic aims to convey a sense of innovation and reliability, reflecting the vehicle's cutting-edge technology and its role in modern emergency response.

4.1.2 Mind Mapping

Mind mapping was a pivotal tool in the early stages of conceptualization. At the core of the mind map was the central theme of enhancing emergency response in challenging terrains. From this central concept, various branches extended, exploring different aspects such as user needs, technological possibilities, and design aesthetics. Each branch further branched out into subtopics, allowing for a comprehensive exploration of ideas. This method helped to visualize the interconnectedness of different design elements and facilitated a holistic approach to problem-solving. Mind mapping was instrumental in generating creative ideas and establishing a clear direction for the project, ensuring that all aspects of the design were considered and integrated into the final solution.

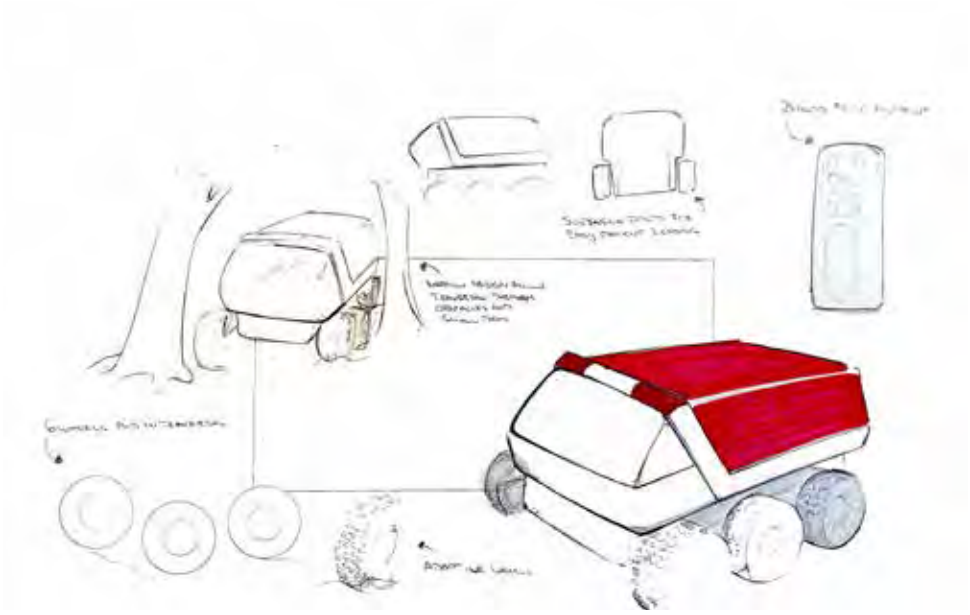

Focus area
USER
PRODUCT
ENVIRONMENT
USER
Primary: Paramedic
Secondary Patient
Tertiary Healthcare organization
Hiker
Non-profit
Pain Points
Time delays
Patient comfort
Environmental impact
Safety risks
Limited carrying capacity
Ease of use
Market
Private sector
Trends
Technological advancements
Electric and Hybrid vehicles
Products
Atv
Snowmobiles
Electric off road vehicles
Advanced first aid kits
Medical modules
Drones
Helicopter
Bicycles
Mountains
Summer (dry)
Deserts
Urban settings (crowded)
Small bodies of water
Extreme sport events
Disaster zones
Concerts and festivals
Cliffsides

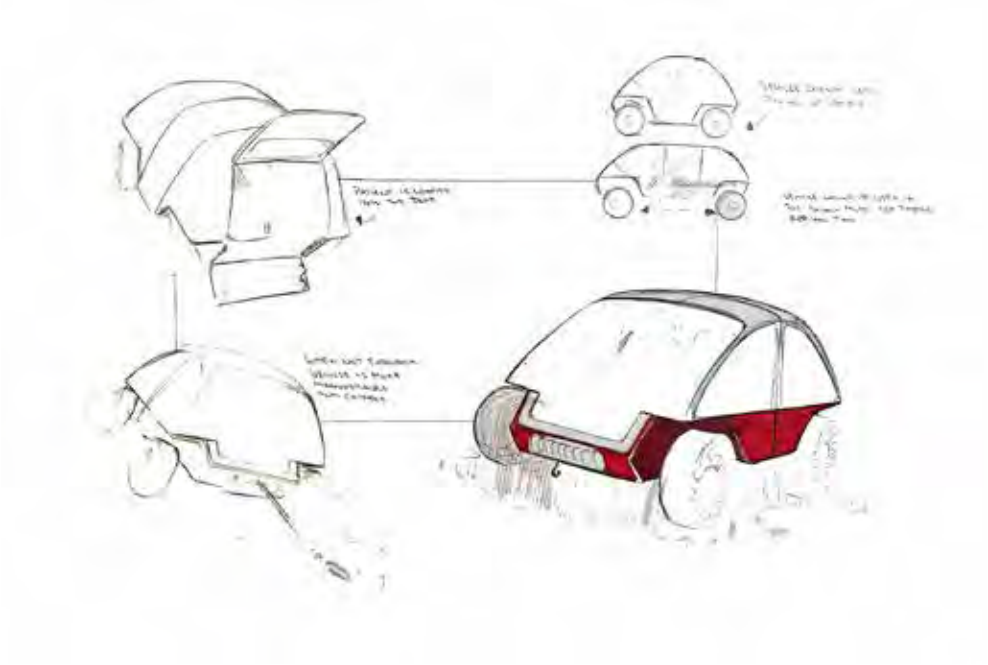

Eliminate
Considered
Priority
Seats for passengers
Automatic patient offloading/ loading
Swift and Safe Patient Transportation
Optimal Accessibility to Medical Equipment
Effective Communication Systems
Ergonomic Paramedic Work Environment
Adaptability to Varied Terrains and Climates
separate patient compartment
Standing room
Additional terrain navigation
Unnessesary control interfaces
External regulation stretcher



4.1.3 Ideation Sketches

During the initial concept phase of the project, the ideation process was expansive, exploring a wide range of vehicle types beyond conventional ambulances. Concepts included adaptable vehicles with variable suspension systems, drones for aerial support, and even wearables for paramedics to aid in mobility and patient care. The focus was on finding the most efficient and effective means of traversing challenging, narrow terrain while ensuring the safety and comfort of both paramedics and patients. This phase was characterized by creative exploration and experimentation, pushing the boundaries of traditional emergency response vehicles to create a solution tailored to the unique demands of outdoor rescue operations.



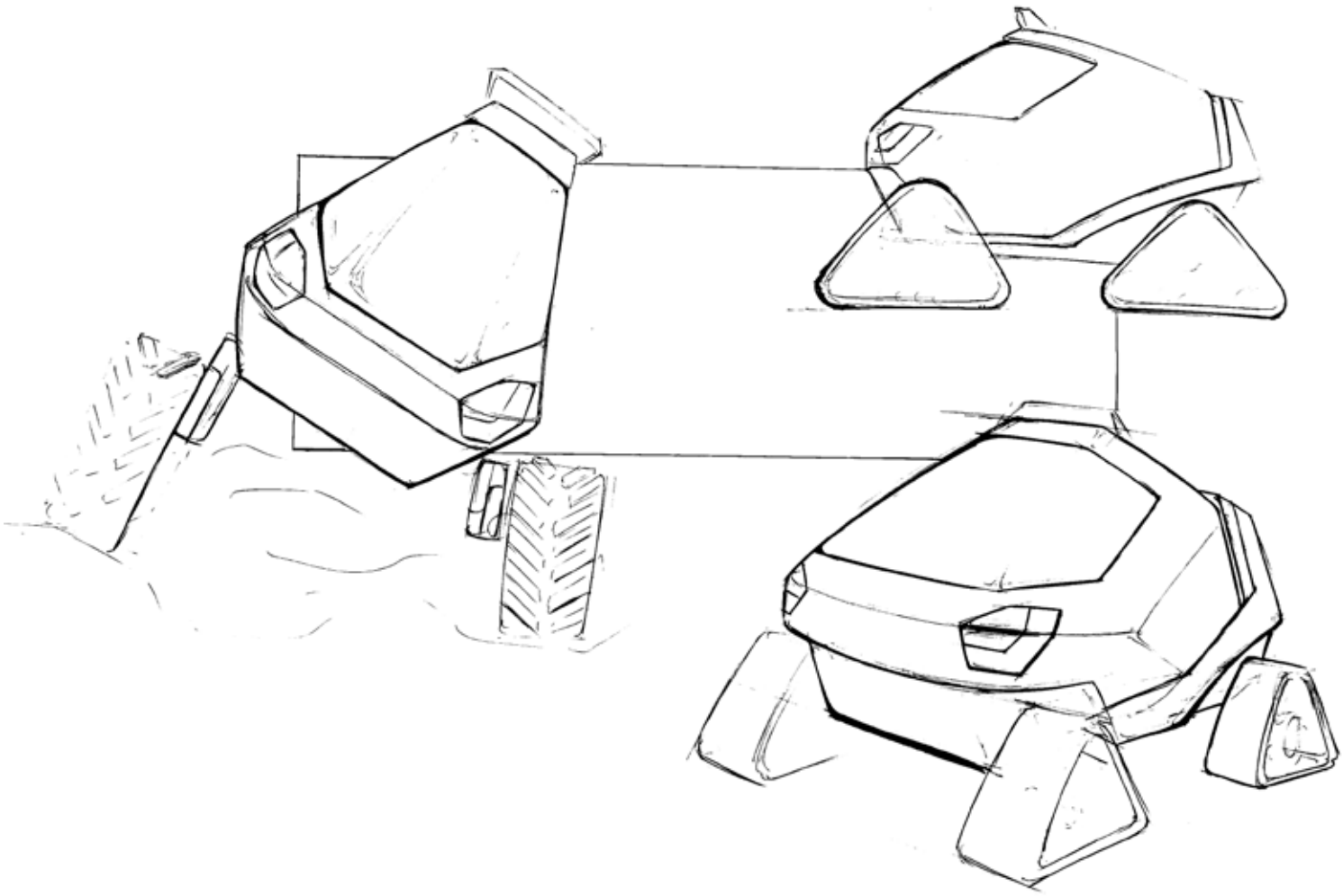


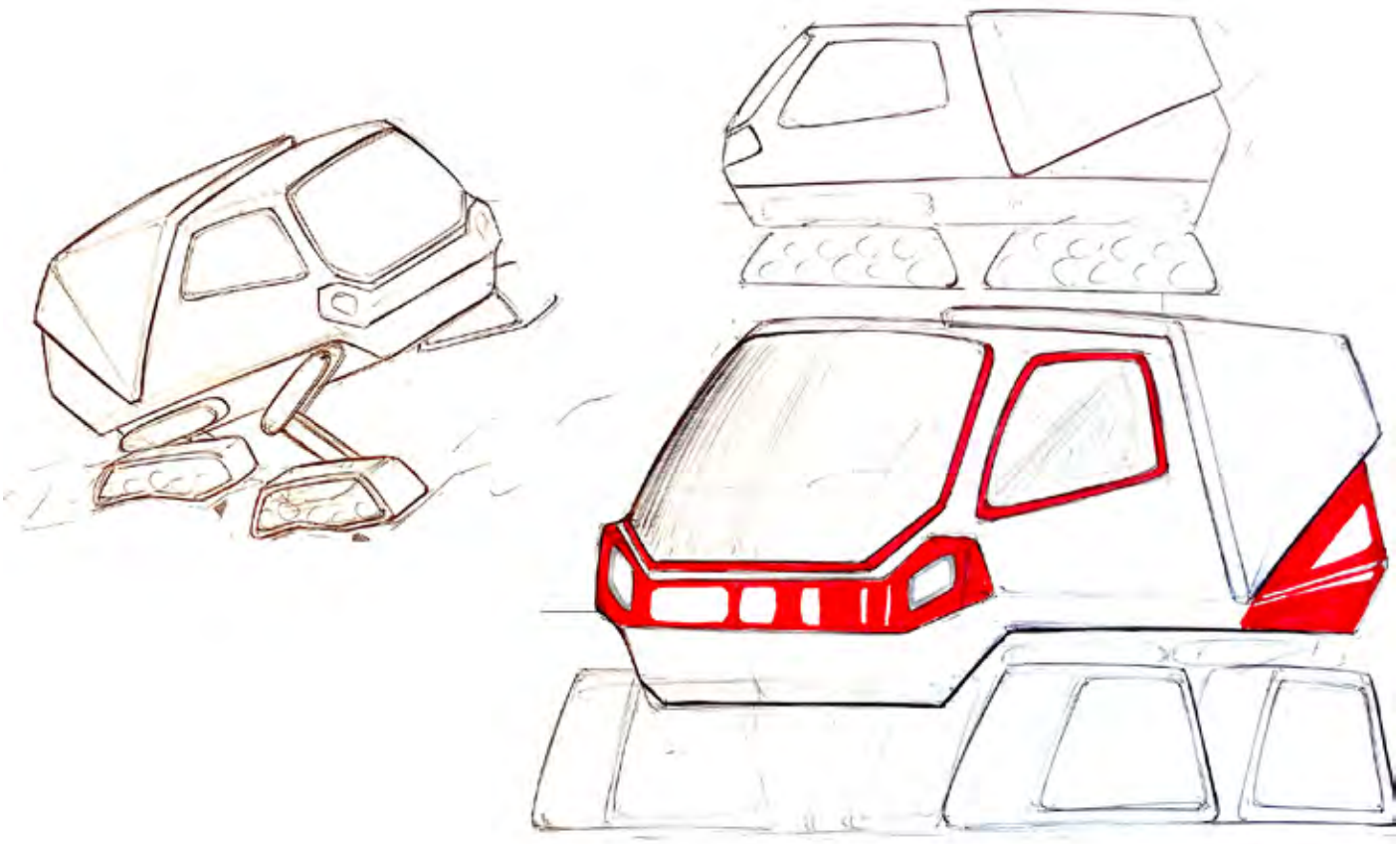
4.2 Concepts Exploration

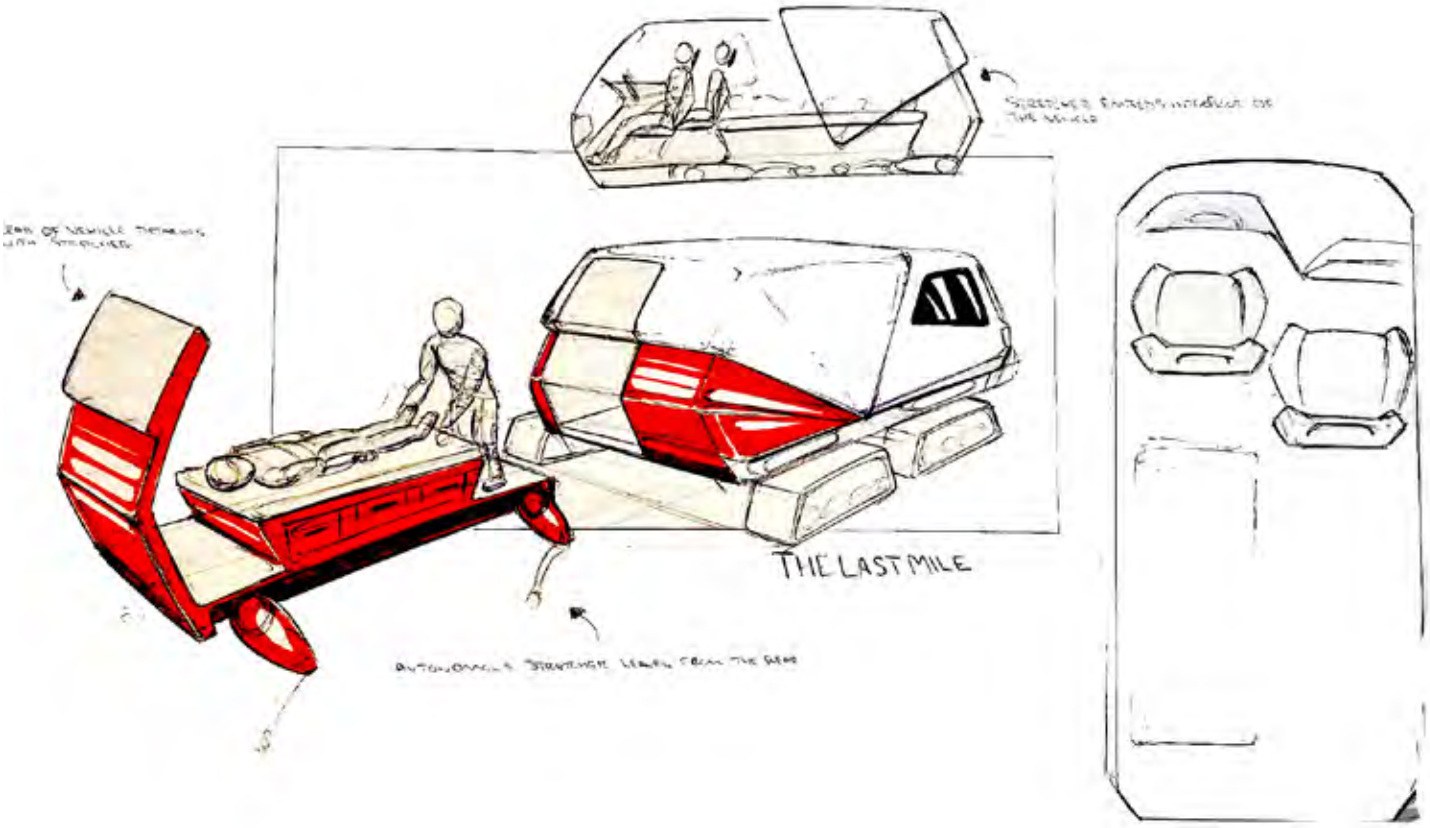
Various vehicles were conceptualized, each with unique traversal styles and mechanics to suit different environments. One concept featured a full vehicle equipped with all necessary equipment, designed with a tandem layout for enhanced maneuverability in rugged terrain. Another concept focused on the "last mile," where a walking stretcher would attach to a small drive train, allowing it to autonomously transport the patient over longer distances to a medical facility. These explorations underscored the commitment to finding a comprehensive solution that prioritizes efficiency, safety, and patient care in emergency scenarios.

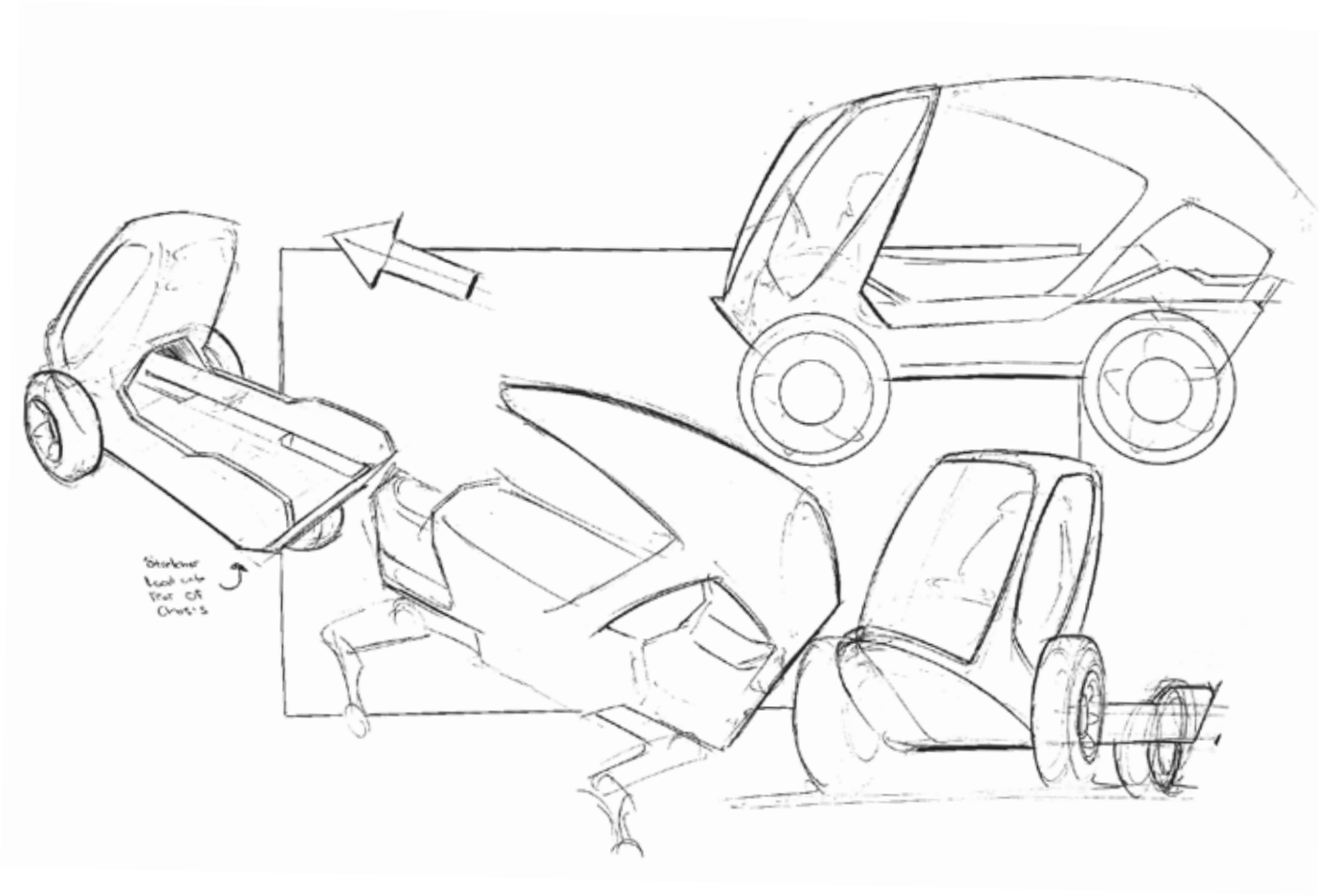
4.2.1 Concept One

Various vehicles were conceptualized, each with unique traversal styles and mechanics to suit different environments. One concept featured a full vehicle equipped with all necessary equipment, designed with a tandem layout for enhanced maneuverability in rugged terrain. Another concept focused on the "last mile," where a walking stretcher would attach to a small drive train, allowing it to autonomously transport the patient over longer distances to a medical facility. These explorations underscored the commitment to finding a comprehensive solution that prioritizes efficiency, safety, and patient care in emergency scenarios.



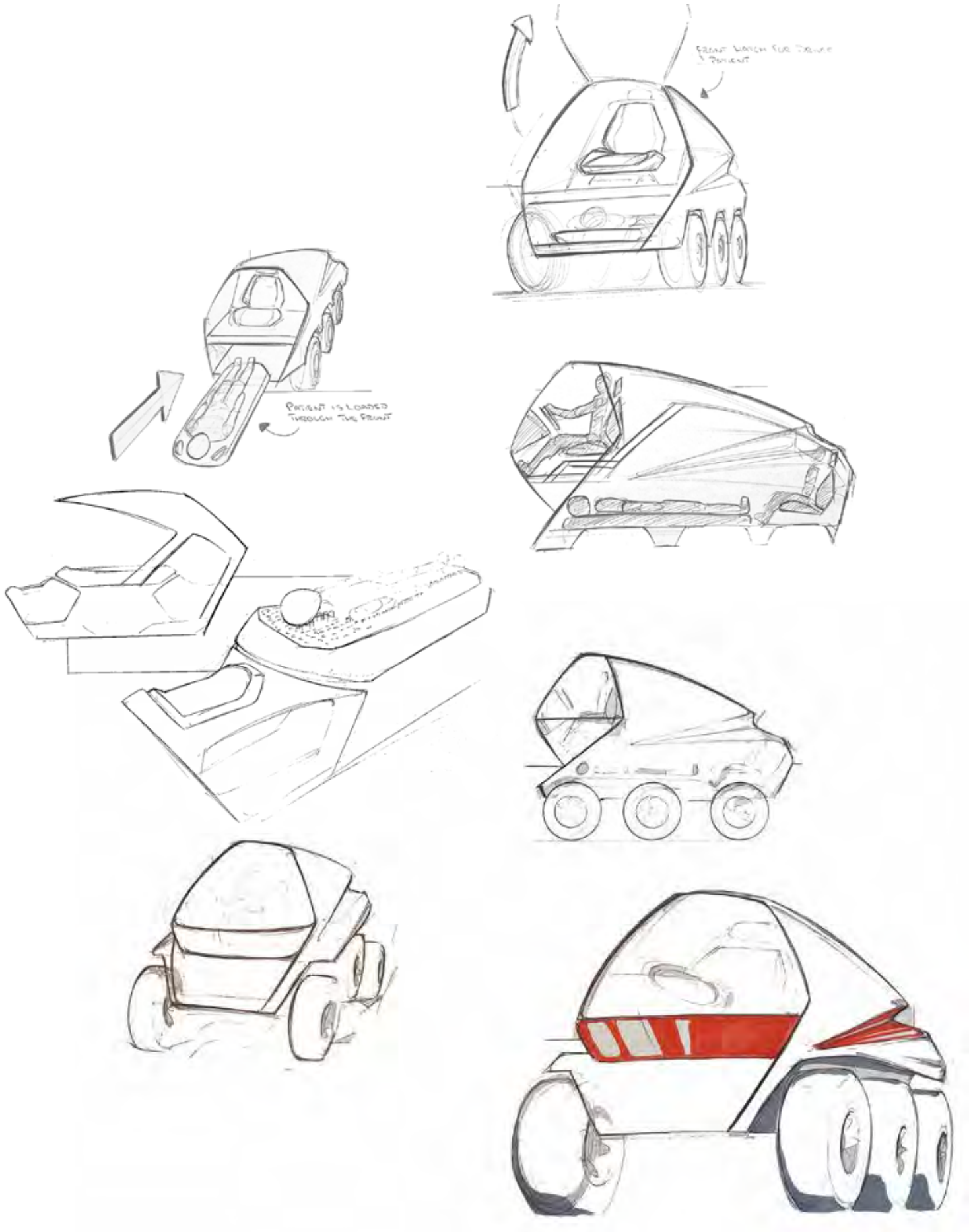



THE LAST MILE



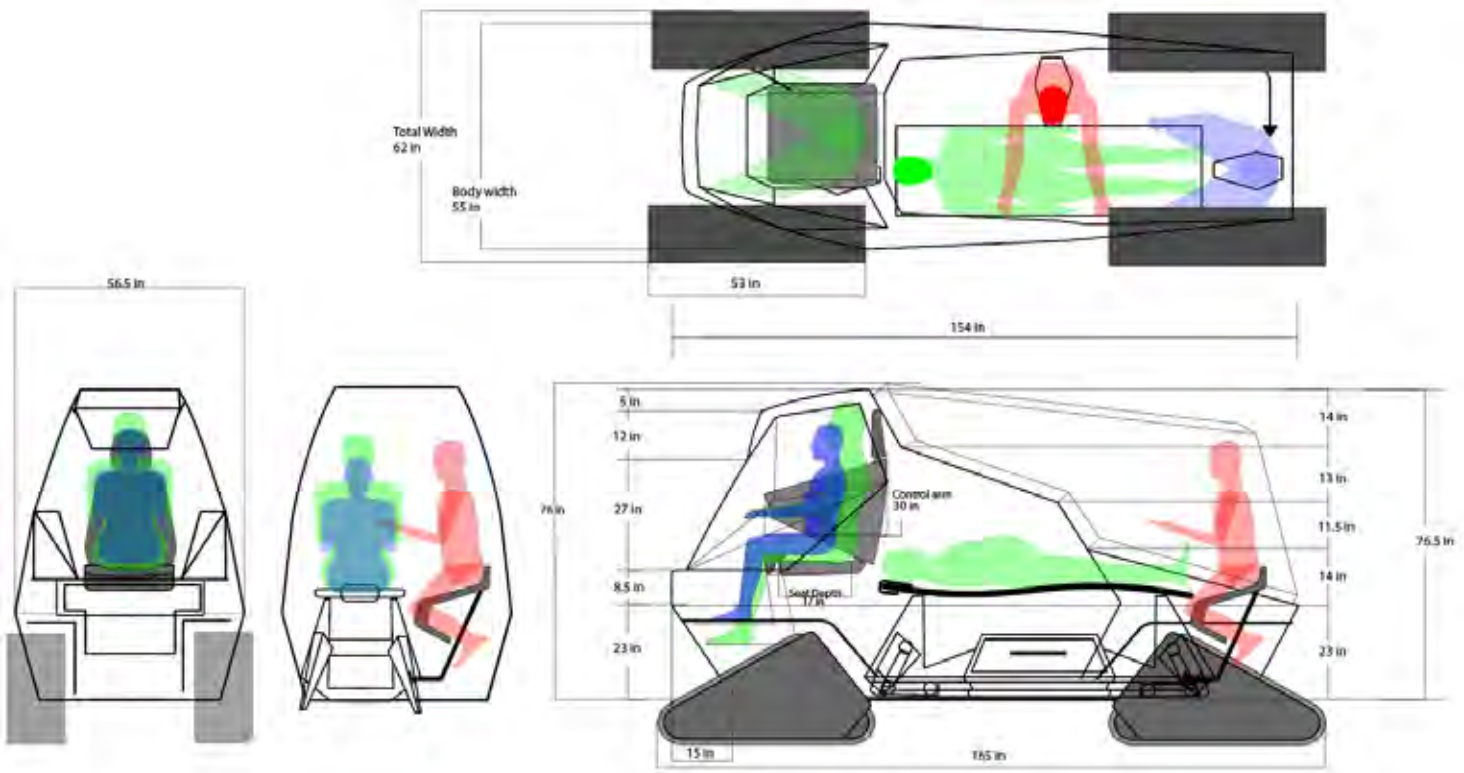
4.2.2 Concept Two

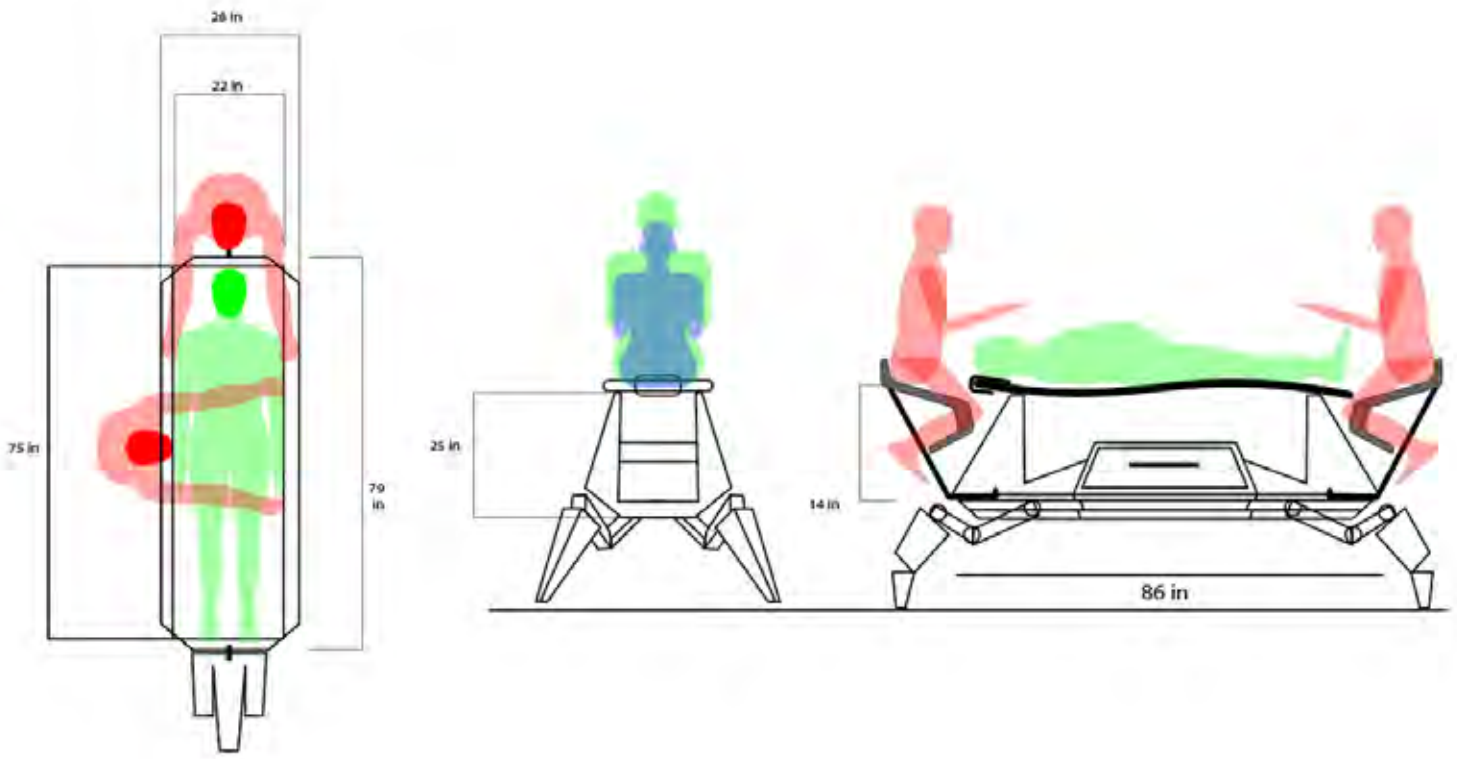
Concept two introduces a revolutionary approach to addressing the last-mile challenge in emergency response. By designing a vehicle or autonomous stretcher specifically for traversing challenging terrain, paramedics can efficiently reach patients in remote locations. This concept emphasizes the importance of quick and effective medical intervention in critical situations, where traditional ambulances may be unable to navigate. The focus on efficiency and adaptability ensures that paramedics can provide timely care to patients, potentially improving outcomes in emergency situations. This concept represents a significant advancement in emergency response capabilities, particularly in challenging terrains where access is limited.


PATIENT IS LOADED
THROUGH THE FRONT

4.3 Concept Strategy

Through extensive research and user observations, it became evident that there was a critical need for a solution that could bridge the "last mile" between the main vehicle and the patient. This realization drove the development of a concept that focused on providing a safe, efficient, and reliable method for paramedics to reach the patient and transport them back to the main vehicle for further care. The autonomous stretcher emerged as a solution, allowing paramedics to navigate difficult terrain with ease and speed, ultimately improving response times and patient outcomes. This concept addresses the immediate need for effective emergency response while also prioritizing the safety and well-being of all users.





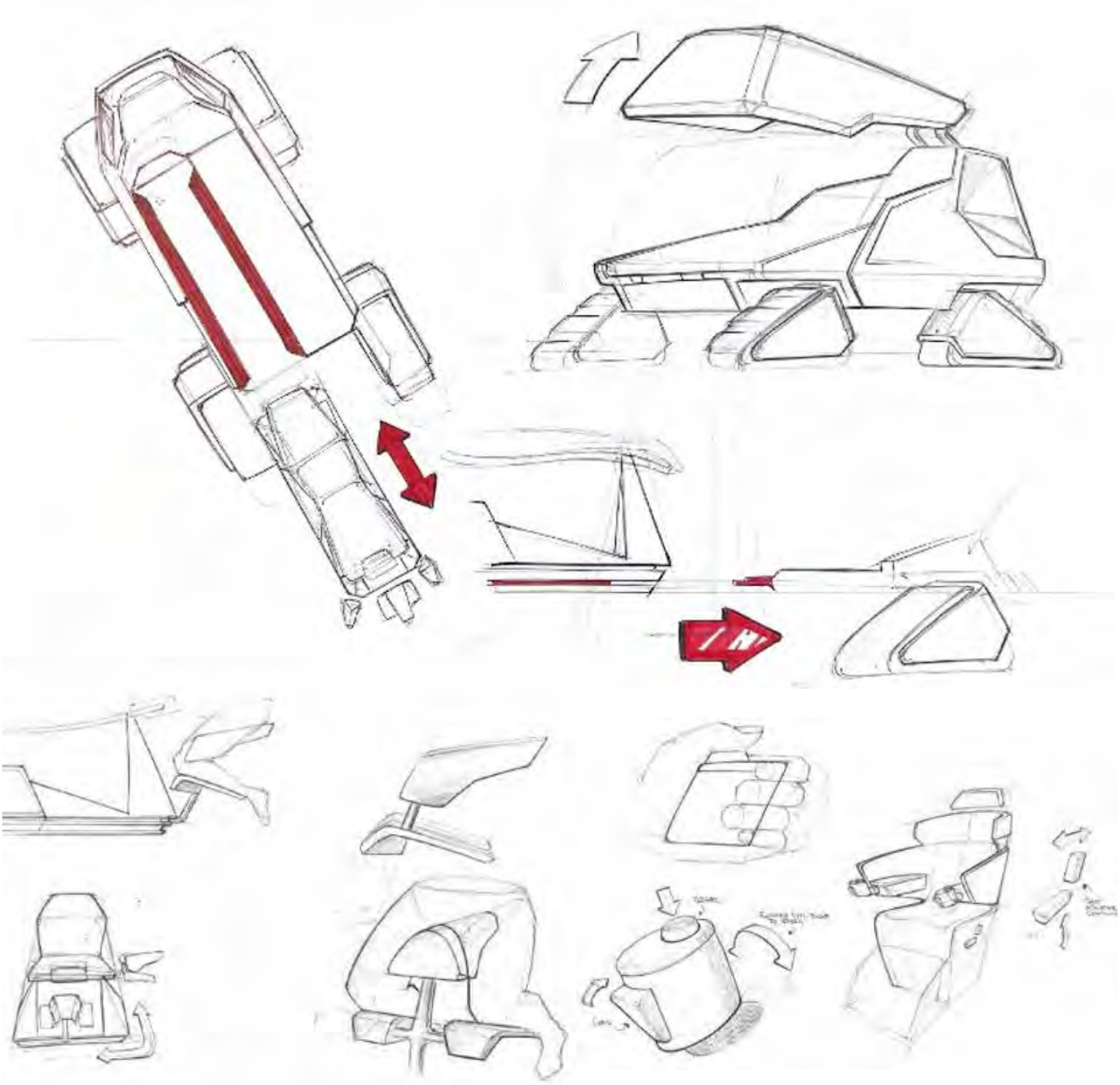
4.3.1 Concept Direction and Product Schematic

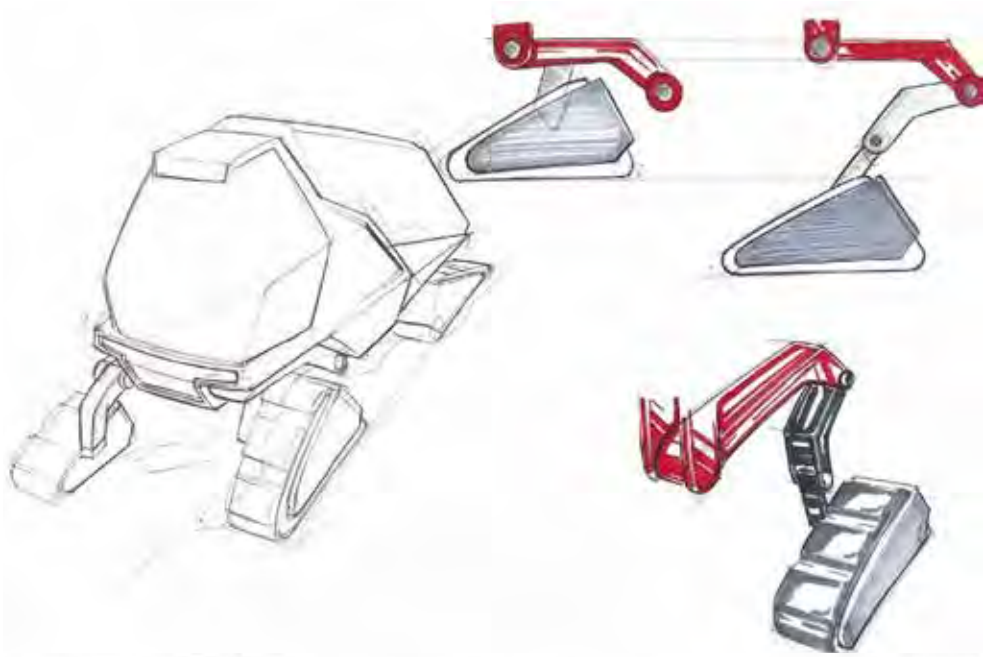
The concept direction focuses on creating an all-terrain ambulance that can navigate challenging landscapes with ease, ensuring timely and efficient medical assistance. This direction emphasizes the importance of user experience, incorporating features that prioritize patient comfort and paramedic efficiency. The Product Schematic delves into the specifics of the design, detailing the layout, dimensions, and key components of the project. This stage lays the foundation for the physical manifestation of the concept, guiding the development process towards a tangible and impactful solution.

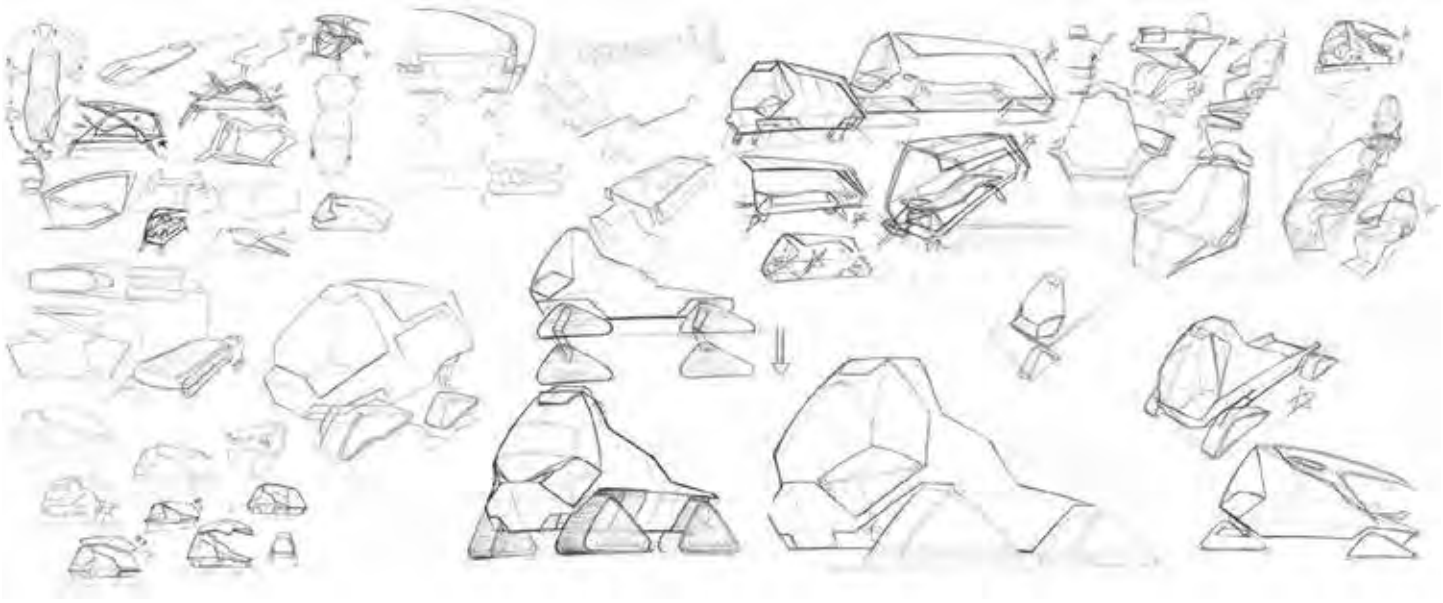
4.4 Concept Refinement and Validation

During concept refinement, design ideas are iteratively improved based on feedback and further research. This stage involves refining the vehicle's form, function, and features to optimize its performance in challenging terrain.

Validation is the process of testing the refined concepts to ensure they meet the project's goals and requirements. This may involve simulations, prototypes, or user testing to evaluate the concept's effectiveness in real-world scenarios. Validation helps ensure that the final design will effectively address the needs of paramedics and patients in challenging terrain, ultimately leading to a more successful and impactful solution.







4.5.1 Design Finalization

The final concept is a specialized emergency response vehicle designed for efficient and effective operations in challenging terrains. The vehicle features a compact design for enhanced maneuverability, making it suitable for navigating narrow trails and rough terrain often encountered in outdoor activities and extreme sports events.

One of the key features of COL is its autonomous stretcher, which deploys from the rear of the vehicle and uses spider-like legs to travel the "last mile" to reach patients in remote or inaccessible locations. This innovative design allows paramedics to reach patients faster and provide immediate care without the need for manual transport over difficult terrain.

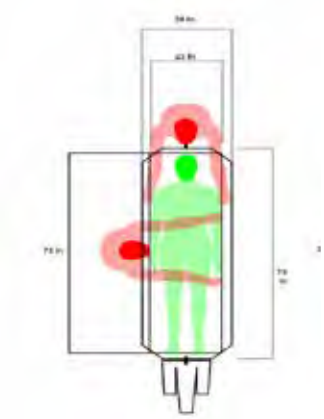
COL also includes a tandem layout, with saddle-like seats for two paramedics on each side of the stretcher. These seats are adjustable in location allowing the paramedic to treat every part of the patient effectively. This layout allows paramedics to provide continuous care to the patient during transport, ensuring their comfort and safety.

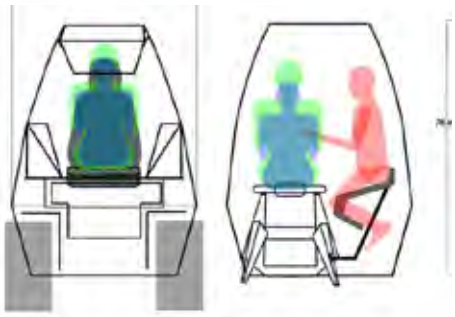
4.5.2 Physical Study Models

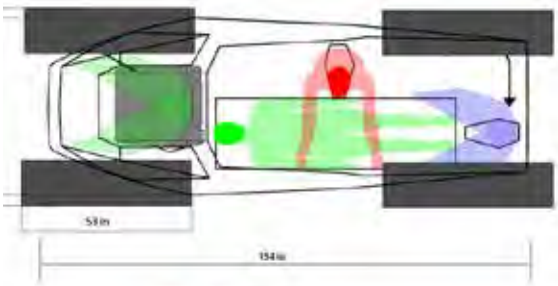
The physical study model of COL was constructed using pink foam, foam core, and 3D printed parts. It served as a tangible representation of the vehicle design, aiding in visualizing the scale and details of the concept. This approach helped in gaining a better understanding of the vehicle's shape and form in a three-dimensional context, which informed the development of the digital 3D model. The physical study model played a crucial role in refining the design, ensuring it met the project's requirements for functionality and aesthetics.

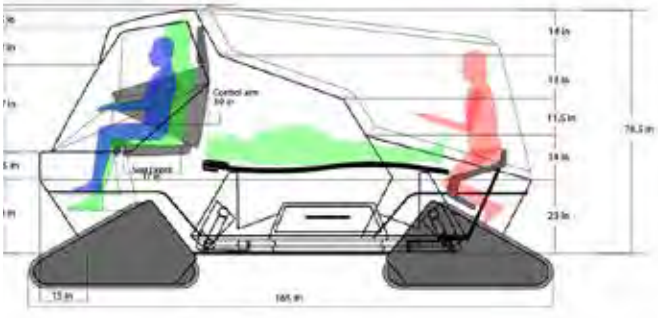
4.6 Design Resolution

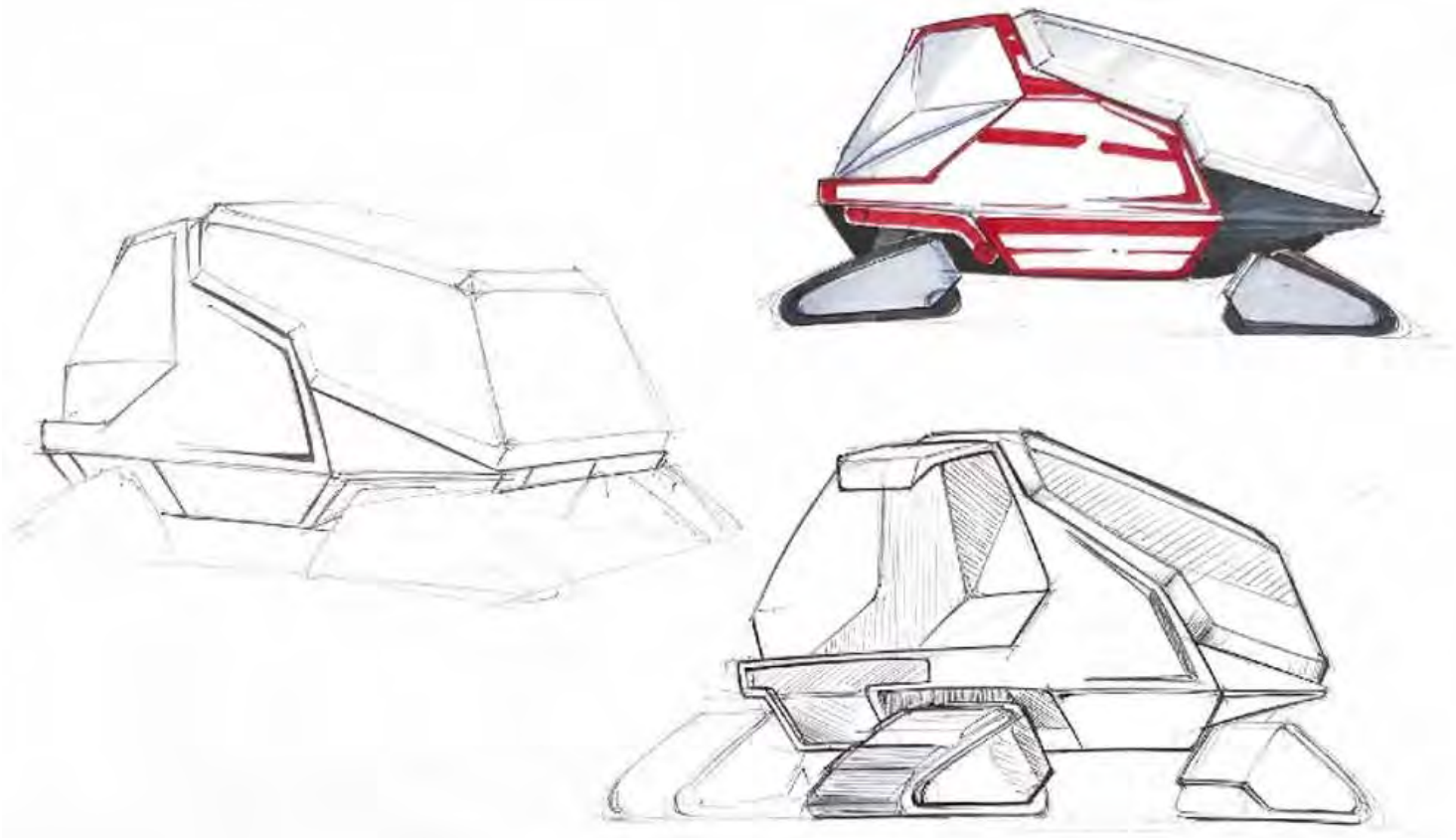
The final resolved design of COL is a groundbreaking emergency response vehicle specifically engineered for navigating challenging terrains with unparalleled efficiency and safety. The vehicle features a compact yet robust silhouette, incorporating adaptable suspension systems to tackle uneven surfaces with ease. One of the key innovations is the autonomous stretcher, equipped with spider-like legs that can traverse the last mile to reach patients in remote or difficult-to-access locations. This stretcher ensures that paramedics can provide timely and critical care, even in the most challenging environments. The main vehicle is designed with an intuitive joystick control system, offering paramedics precise control and maneuverability. The interior layout includes saddle-like seats for two paramedics, allowing them to move around the patient for optimal care. The overall design is inspired by minimalist aesthetics, with modern lighting elements and part lines that not only enhance its visual appeal but also contribute to its rugged yet sophisticated look. The final design of COL represents a significant leap forward in emergency response technology, prioritizing efficiency, safety, and sustainability in challenging terrains.

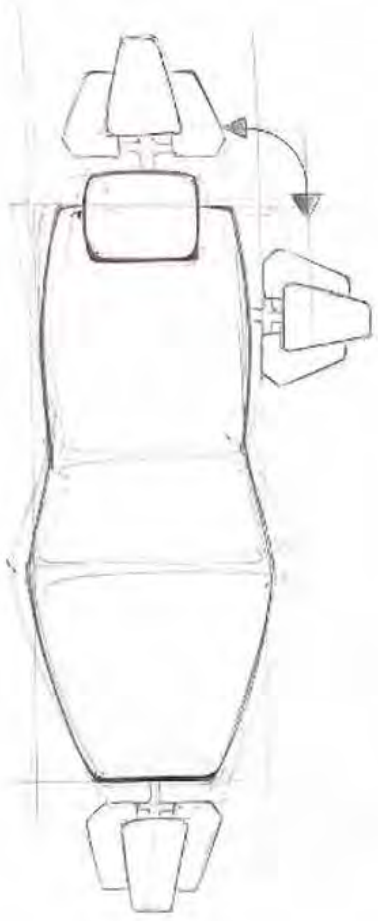


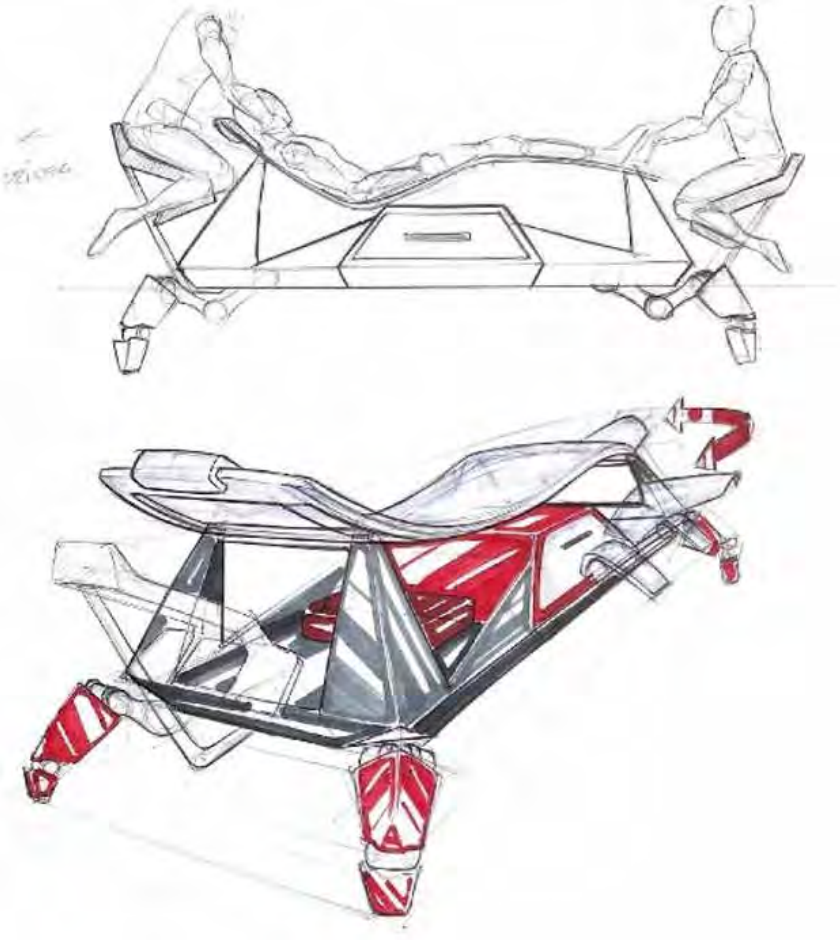


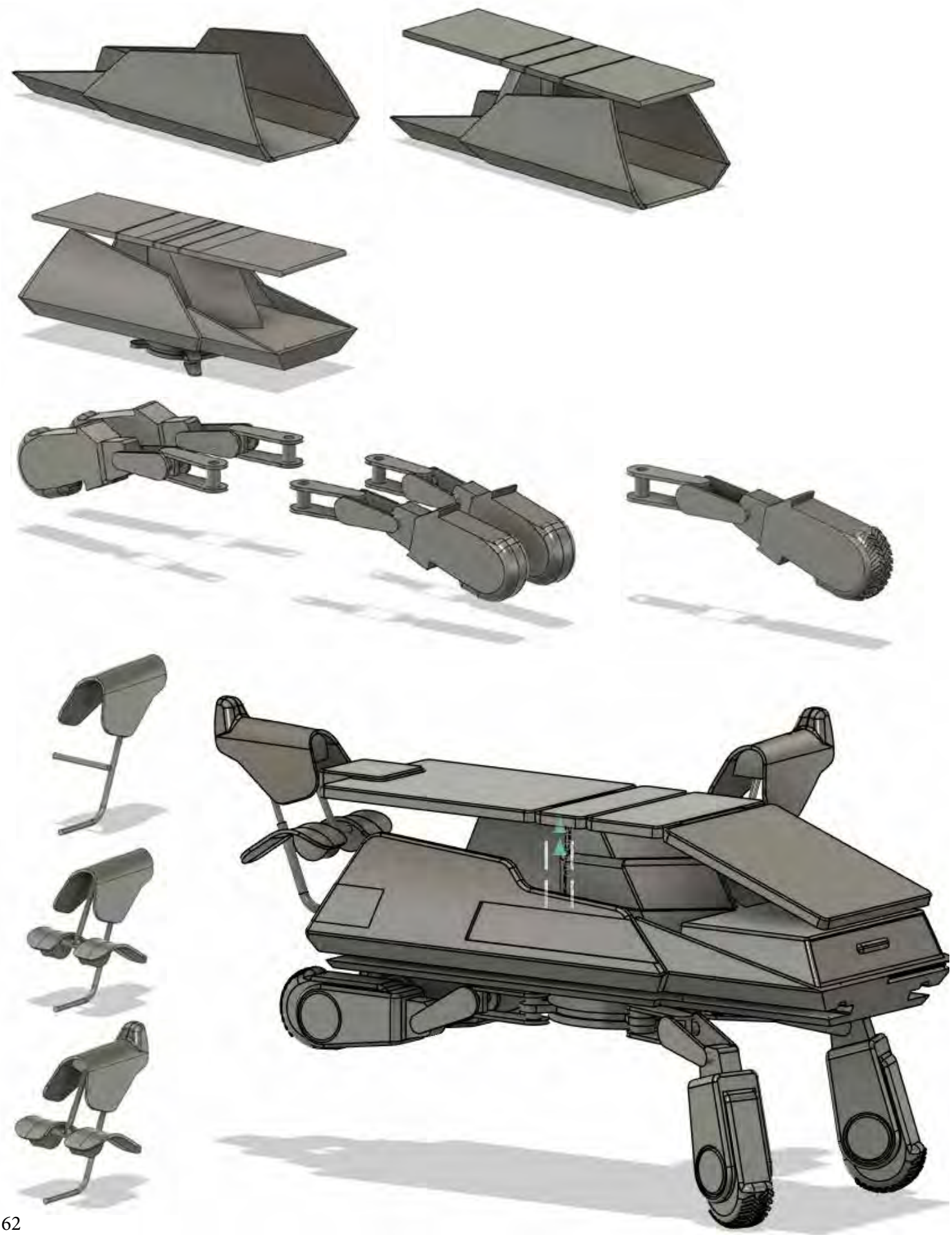






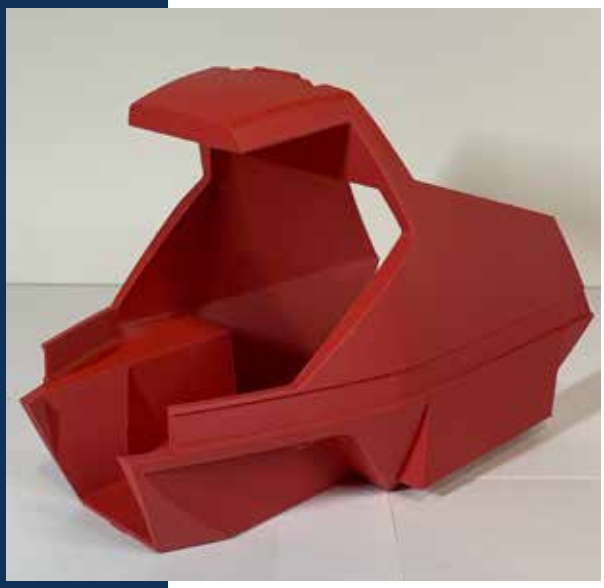


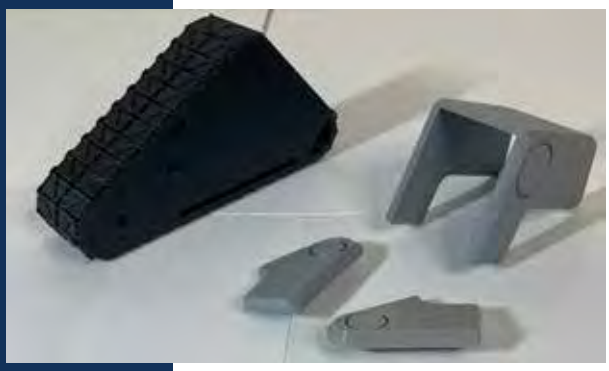




4.7 CAD Development

For the CAD development of COL, Fusion 360 was employed, leveraging its capabilities in surface modeling to create a detailed and functional design. The process involved modeling the main vehicle and the stretcher as separate components to ensure precision and clarity in their individual functions. The design was then integrated, ensuring seamless compatibility and functionality between the two. Joints were strategically utilized in the CAD to simulate the mechanics of the legs, allowing for a realistic representation of their movement and interaction with the terrain. This approach not only facilitated the visualization of the final product but also aided in the analysis of its mechanical aspects, ensuring that the design was both practical and efficient in its intended operation.





4.8 Physical Model Fabrication

For the physical model of COL, a combination of 3D printing and traditional model-making techniques was employed. The majority of parts were 3D printed using a high-resolution printer to ensure accuracy and detail. After printing, the parts were meticulously sanded to achieve smooth surfaces and remove any imperfections. They were then primed to prepare them for painting. The painting process involved applying multiple layers of paint to achieve the desired finish, which included a combination of glossy and matte surfaces to mimic the look of different materials such as metal and plastic. Finally, a base was added to the model to demonstrate the adaptable suspension, showcasing how the vehicle could traverse challenging terrain. This physical model served as a tangible representation of the design, allowing for a more comprehensive and detailed evaluation of its aesthetics and functionality.

Chapter 5

Final Design

This chapter will discuss the final design solution and product result for the thesis problem of improving Emergency Response in Challenging Terrain.

5.1 Design Summary

Extreme outdoor recreational activities, such as rock climbing, mountain biking, and hiking, have surged in popularity, often unfolding in challenging terrains. Conventional emergency response systems and vehicles find themselves inadequately equipped to navigate these environments efficiently, resulting in prolonged wait times and diminished chances of successful rescue. This thesis aims to confront this issue by investigating ways to enhance emergency response capabilities in challenging terrain, with a primary focus on refining user interaction design and ensuring physical comfort for both patients and paramedics. The overarching goal is to elevate the overall outdoor adventure experience while prioritizing sustainability and social responsibility to minimize environmental impact. The COL concept emerged from the realization that there is a critical need for improved last-mile transportation between the main vehicle and the patient, providing a safe and efficient method for paramedics to reach the patient and return. The COL consists of an all-terrain ambulance with a smaller silhouette and adaptable suspension for navigating difficult terrains. It features an autonomous stretcher with spider-like legs that dispatches from the rear of the vehicle to reach patients in remote locations efficiently. The stretcher includes saddle-like seats for two paramedics, allowing optimal care while transporting the patient. The main vehicle is equipped with intuitive joystick controls for easy maneuverability. By addressing these challenges, the COL concept not only improves the efficiency of emergency response but also enhances the safety and well-being of both paramedics and patients, ensuring a better outcome in challenging terrain situations.

5.2 Design Criteria Met

In this section, we detail how the COL project meets specific design criteria, focusing on full-bodied interaction design, the selection of materials, processes, and technology, as well as the implementation of the overall design. These elements are crucial in ensuring that the final concept not only addresses the challenges of emergency response in challenging terrains but also delivers a sustainable, user-centric solution.

5.2.1 Full-Bodied Interaction Design

The COL project is a full-bodied interaction design by incorporating intuitive and engaging interfaces that facilitate seamless communication between the user and the vehicle. The joystick controls on the main vehicle allow for precise maneuvering, mimicking the experience of driving a car. This design choice enhances the user's sense of control and agency, crucial in high-stress situations. The autonomous stretcher further exemplifies full-bodied interaction, as it autonomously navigates challenging terrain, adapting its movements to ensure patient comfort and safety. The saddle-like seats on the stretcher provide ergonomic support for paramedics, allowing them to interact with the patient effectively. Overall, COL's design prioritizes user experience, ensuring that both paramedics and patients can interact with the vehicle in a natural and intuitive manner.

5.2.2 Materials, Processes, and Technology

Materials

The emergency response vehicle will feature a range of sustainable materials carefully chosen to enhance durability, reduce weight, and minimize environmental impact. The main body of the vehicle will be constructed from a combination of high-strength, lightweight aluminum alloys and advanced composite materials, ensuring structural integrity while keeping weight to a minimum. The exterior surfaces will be coated with an environmentally friendly, low VOC paint to protect against corrosion and provide a sleek finish. The interior components, including the stretcher bed, will be made from a lightweight and strong carbon fiber composite, providing durability and support for patient transport.

Processes

For the emergency response vehicle, the manufacturing process will adhere to sustainable practices seen in the automotive industry. The production line will prioritize energy efficiency, using renewable energy sources where possible and implementing energy-saving measures throughout the manufacturing facility. Waste reduction strategies will be employed, such as recycling scrap materials and using environmentally friendly coatings. The assembly process will focus on modularity and standardization, allowing for easier repair and maintenance. Lean manufacturing principles will guide the production, minimizing waste and optimizing resource utilization. Additionally, the facility will aim for a closed-loop system, where materials

Technology

The emergency response vehicle will integrate cutting-edge technology to enhance its functionality and sustainability. The vehicle will be equipped with an electric drivetrain, reducing emissions and reliance on fossil fuels. Advanced battery technology will provide sufficient power for extended operations. The vehicle will feature adaptive tracks and articulating legs, enabling it to navigate challenging terrains without causing damage to the environment. Additionally, the vehicle will incorporate smart sensors and communication systems to optimize route planning and enhance safety. These technological advancements not only improve the vehicle's performance but also contribute to its overall sustainability by

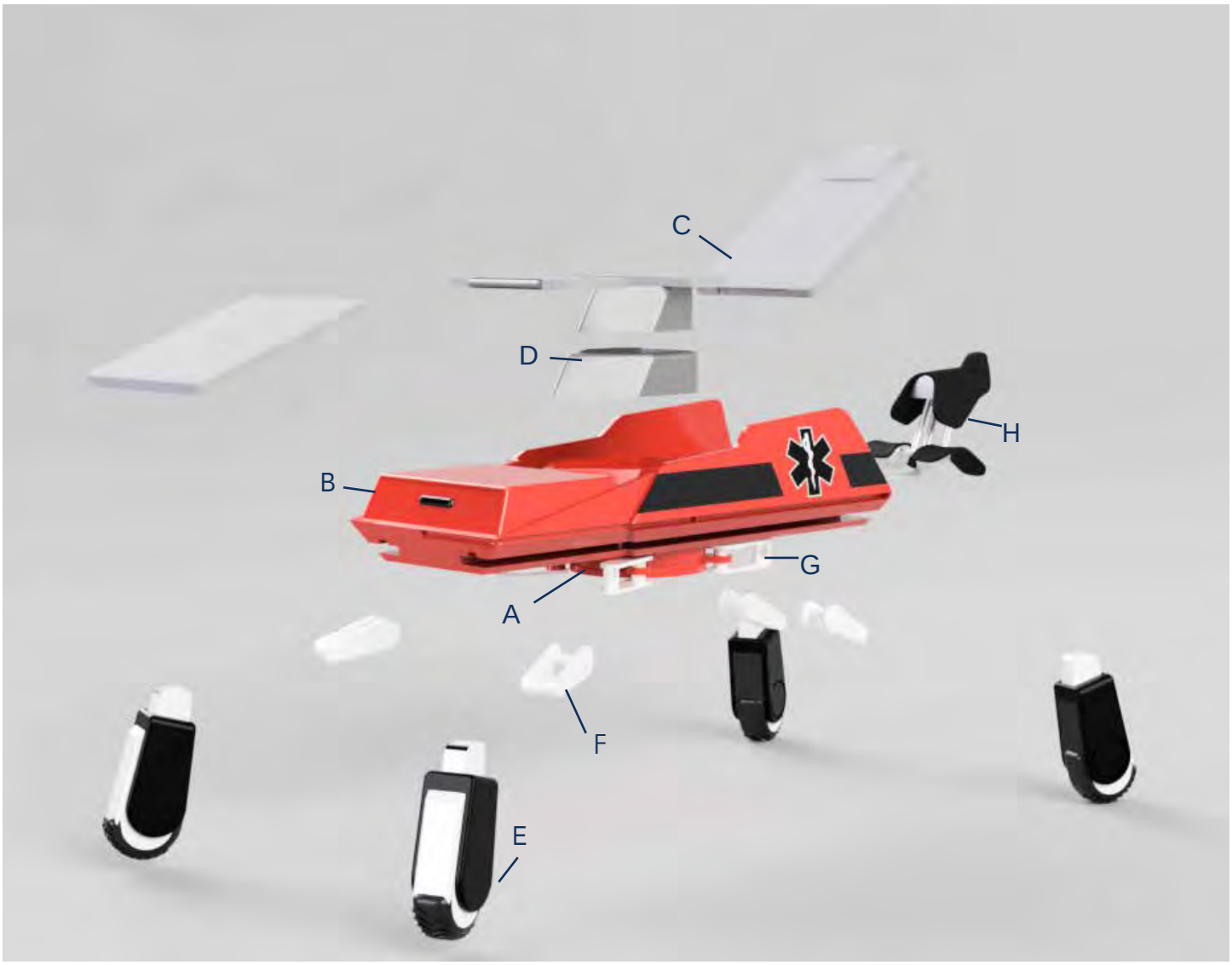
5.2.3 Design Implementation

The following tables show the components of COL and the predicted material, manufacturing process, and quantity.

COL - Bill Of Materials

Main Vehicle

Letter	Name	Material	Quantity
A	Chassis	Steel	1
B	Body	Aluminum. Plastic	1
C	Rear Canopy	Aluminum	1
D	Tracks	Steel and rubber	4
E	Track Housing	Steel	3 x 4
F	Adaptable Suspension	Steel, Aluminum	4
G	Emergency Lights	Polycarbonate housing	3
H	Windsheild	Glass	1
I	Rear Windsheild	Glass	1
J	External Cabinets	Steel	4
K	Headlights	Polycarbonate housing	1
L	Tail light	Polycarbonate housing	1



5.2.3 Design Implementation

The following tables show the components of COL and the predicted material, manufacturing process, and quantity.

COL - Bill Of Materials

Autonomous Stretcher

Letter	Name	Material	Quantity
A	Chassis	Steel	1
B	Body	Aluminum. Plastic	1
C	Stretcher bed	Aluminum	1
D	Hydraulic base	Aluminum	1
E	Feet	Steel and rubber	4
F	Leg Mid arm	Steel	4
G	Leg Top Arm	Steel	4
H	Saddle seat	Leather	3

COL

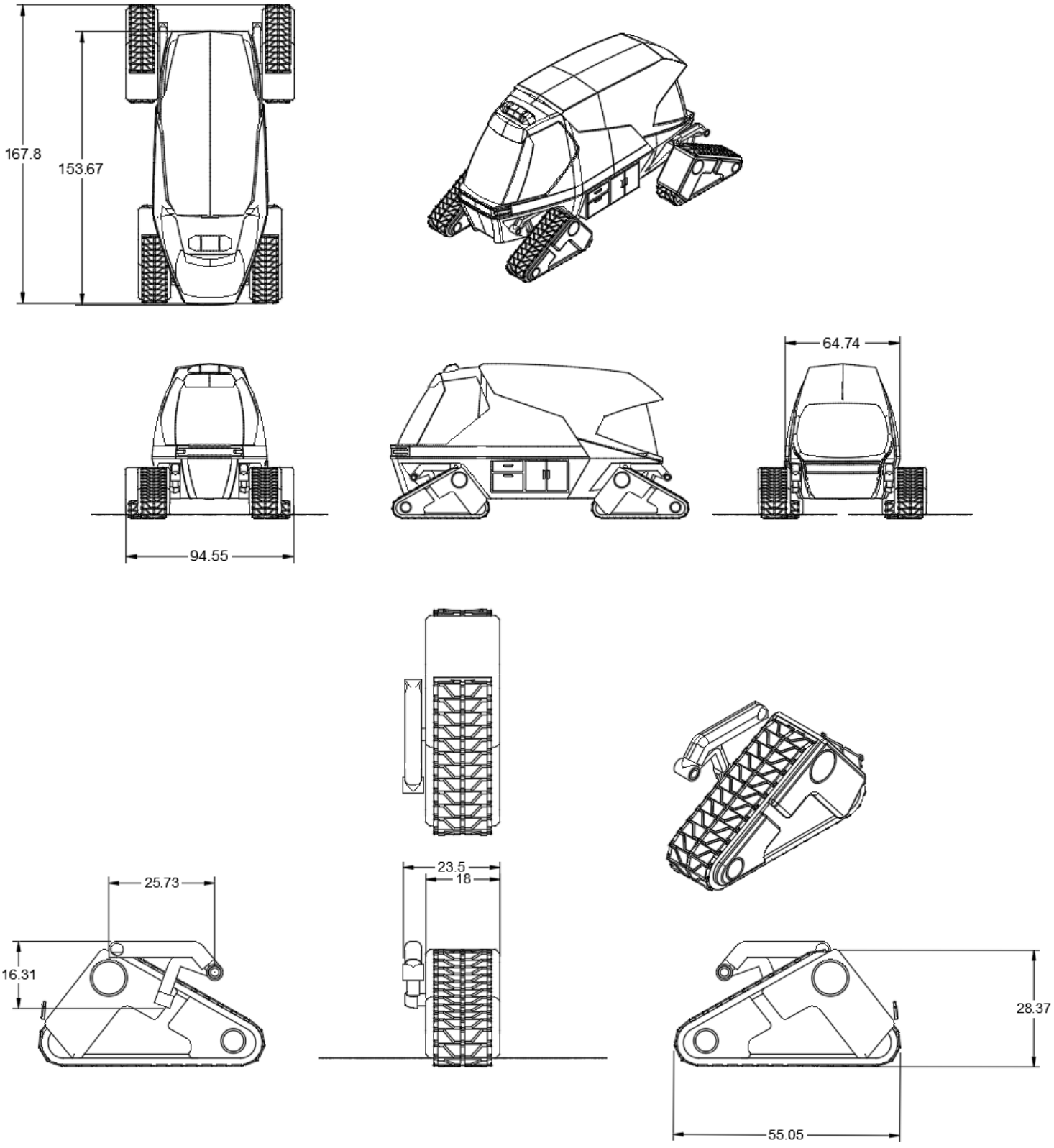
ALL-TERRAIN RESCUE VEHICLE

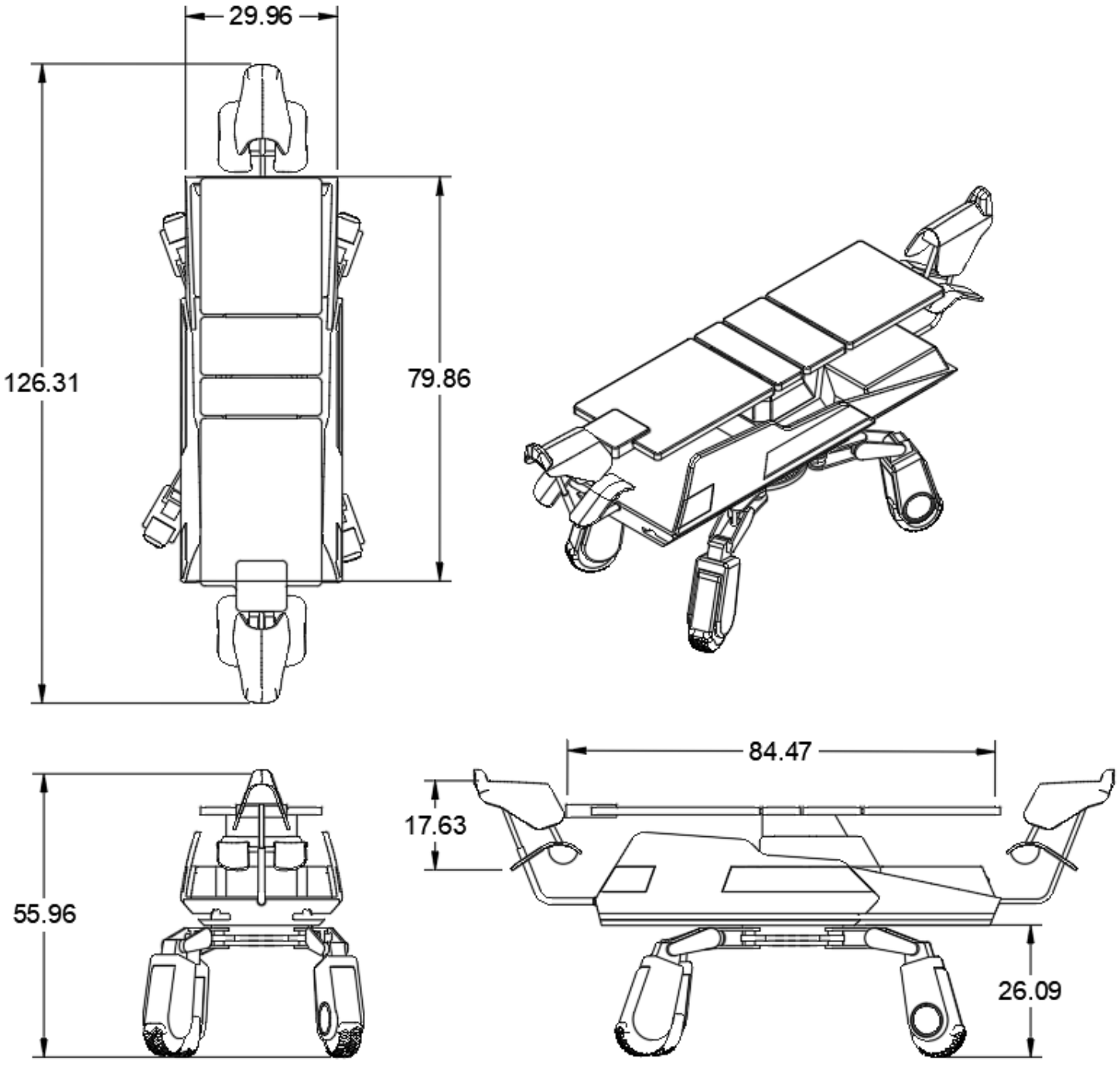
5.3 Final CAD Rendering

5.4 Physical Model

The final model of COL features a dynamic presentation, showcasing the vehicle in an open configuration with the stretcher extending from the rear. The model is positioned on an uneven base, simulating challenging terrain, to demonstrate the adaptable suspension system. This configuration allows viewers to visualize how the vehicle would navigate and operate in real-world scenarios, highlighting its innovative design and functionality. The open layout provides a clear view of the vehicle's interior and the positioning of the stretcher, emphasizing the user-centric approach of the design. Overall, the final model effectively communicates the key features and capabilities of COL, making it an impactful tool for presentation and evaluation.

5.5 Technical Drawings




29.96
126.31
79.86
84.47
17.63
55.96
26.09

5.6 Sustainability

Processes

Health:

The project's focus on sustainability directly benefits health, particularly through the reduction of emissions. By opting for an electric drivetrain, the vehicle minimizes its carbon footprint, contributing to cleaner air and a healthier environment for both responders and the communities they serve. This choice aligns with global efforts to combat air pollution and its associated health risks. Additionally, the emphasis on ergonomic design ensures that paramedics can perform their duties safely and efficiently, reducing the risk of musculoskeletal injuries and other health issues related to repetitive tasks.

Safety:

In terms of safety, the project incorporates several innovative features that enhance the vehicle's performance in challenging terrains. The adaptive tracks and articulating legs improve stability and maneuverability, reducing the risk of accidents during emergency response operations. These features also minimize the vehicle's impact on the environment, as they help prevent damage to sensitive ecosystems. Moreover, the use of durable and reliable materials ensures that the vehicle can withstand the rigors of emergency situations, enhancing overall safety for both responders and patients.

Sustainability Statement:

The project's sustainability initiatives encompass a holistic approach that addresses various aspects of environmental impact. The decision to use an electric drivetrain significantly reduces emissions, aligning with global efforts to reduce carbon footprints in the transportation sector. Additionally, the emphasis on repairability and durability promotes a circular economy model, where components can be reused or recycled at the end of their life cycle. This approach reduces waste and conserves resources, contributing to a more sustainable future for emergency response vehicles. Furthermore, the use of sustainable materials, such as recyclable components and environmentally friendly coatings, further reduces the project's environmental footprint. Overall, the project sets a new standard for sustainability in the emergency response service industry, showcasing innovative solutions that prioritize both environmental stewardship and operational excellence.

Chapter 6

Conclusion


COL
ALL-TERRAIN RESCUE VEHICLE

Conclusion

In conclusion, the COL project has been a comprehensive exploration of enhancing emergency response capabilities in challenging terrains. Beginning with an in-depth analysis of user needs and existing products, the project progressed through concept ideation, refinement, and validation, culminating in the development of a final design that addresses key challenges faced by paramedics in such environments. The final design of COL features an innovative vehicle with adaptable suspension and an autonomous stretcher, providing a safe and efficient solution for navigating and accessing patients in remote or difficult-to-reach locations.

Throughout the project, sustainability, usability, and user experience have been paramount considerations, ensuring that the design not only meets the functional requirements but also enhances the overall emergency response process. The use of advanced technologies, such as CAD development and physical modeling, has enabled the visualization and refinement of the design, resulting in a well-rounded and practical solution.

Looking ahead, the COL project has the potential to significantly impact the field of emergency response, offering a new standard for vehicles and equipment tailored to challenging terrains. Further development and testing will be necessary to refine the design and ensure its effectiveness in real-world scenarios. Overall, the COL project represents a significant step forward in improving emergency response capabilities and enhancing the safety and well-being of both paramedics and patients in challenging environments.

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Imageby<ahref="https://pixabay.com/users/jean52photosstock-14428522/?utm_source=link-attribution&utm_medium=referral&utm_campaign=image&utm_content=6219889">Jean photosstock from Pixabay

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Photo by Mikhail Nilov: https://www.pexels.com/photo/man-and-woman-standing-beside-the-ambulance-8943255/

Image by Enzo J from Pixabay

Image by Pexels from Pixabay

Appendix A - Discovery

1	2	3	4	5
Terrastorm	John Deere rescue Gator	Mercedes Unimog Ambulance	The Medital Off-road ambulance	Medical Helicopter

3.1 User Needs

Two Products: ***Ambulance- Large vs Small***

Type III Ambulance: MX 152
https://www.demers-ambulances.com/ambulance/mx-152-ems/

John Deere Gator with MEDLITE attachment
https://www.kendrasprotech.com/john-deere-gator/

Benefits and Features- from Promotional Literature

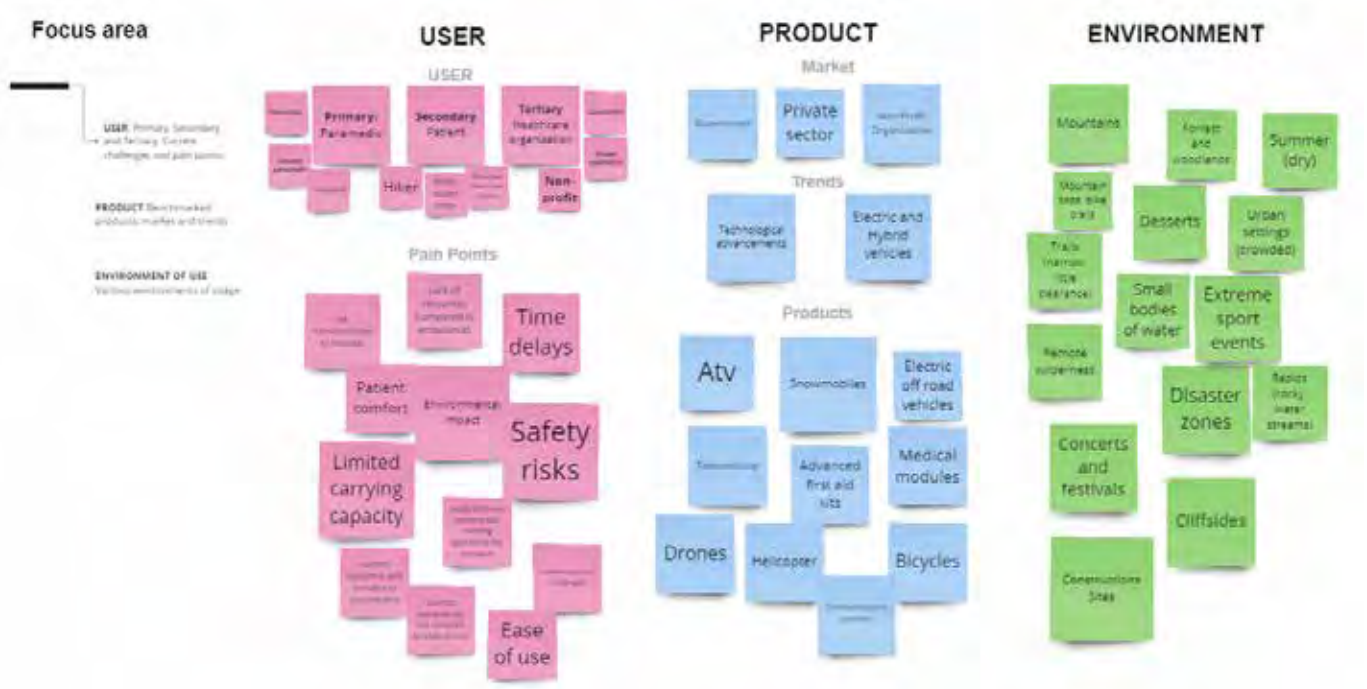
Benefits	Features
Reassurance for patient and paramedic safety	Safety features
Functional work environment	Spacious interior
Comprehensive medical care	Medical Equipment
Timely patient transport	Road-oriented design

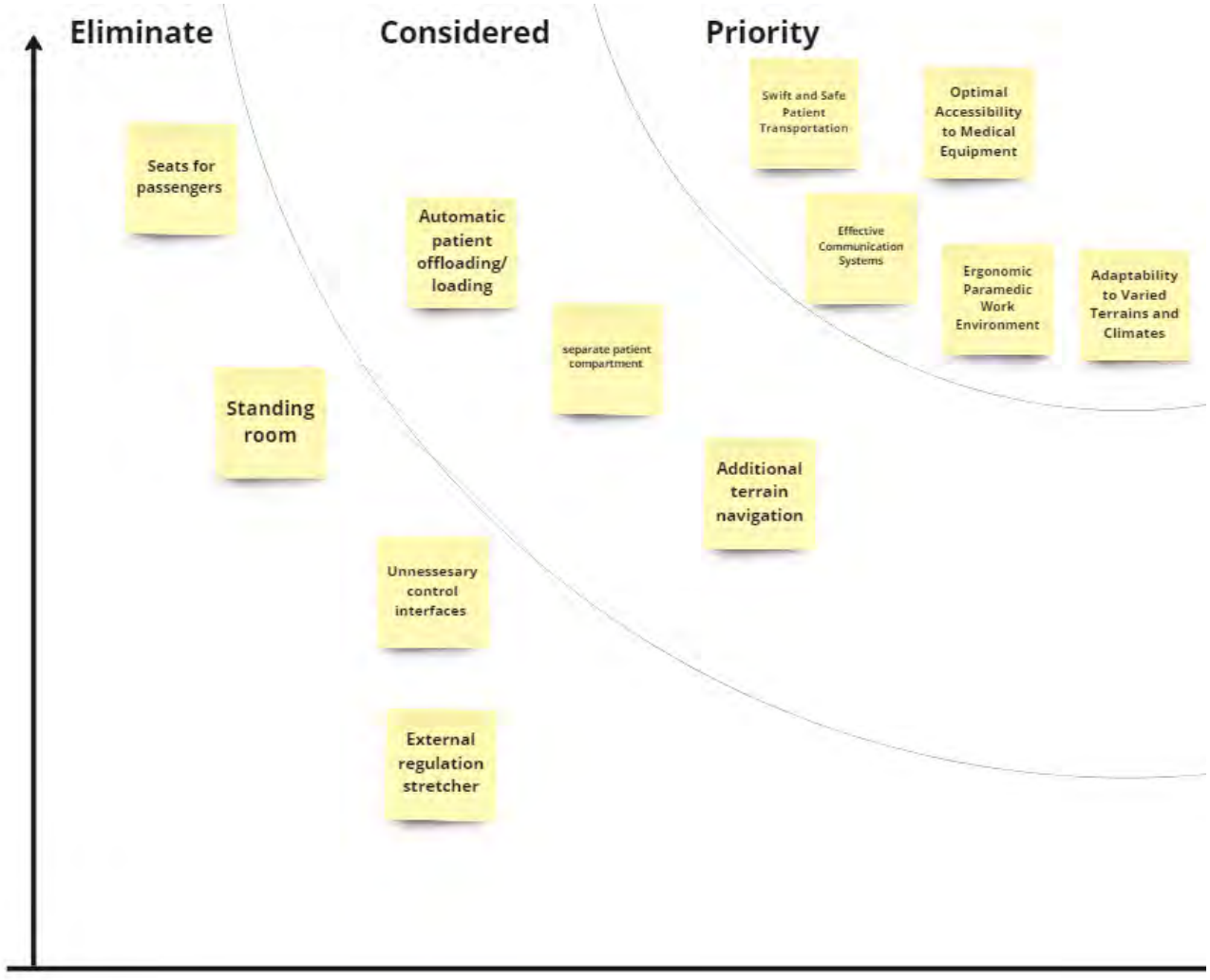
Benefits	Features
Remote access	Off-road capability
Quick response	Compact design
Maneuverability	High accessibility
Versatility	Specialized suspension

Need Type	Product Benefits (marketing)	Human Needs (psychology)
Immediate Needs		
	Short term need: • Immediate response, transport and, care of patients • Quick access no required equipment	Psychology- Unfulfilled Human Needs Pain point alleviation: • Patient safety during transport • Ease of patient physical pain during process • Keeping the patient alive and healthy during process
Latent Needs	Latent needs are **unknown**, the user being unaware of them	
	Examples of latent product benefits Breakthrough Products • Off road ambulance • Inner city ambulance Unanticipated Experience • Smooth transport • Reduced silhouette increases vehicle accessibility	***Examples of latent needs*** Fundamental human needs (Maslow) • No added discomfort • Safety of patient during comfort *'Hidden Persuaders'* N.A>
Wants / Wishes		
	Marketing- a.k.a. Incipient Needs • Integration of cutting edge medical technologies • Symbol of health and safety	Psychology- Unfulfilled Human Needs *Increasing the confidence in paramedics and the confidence of the public when it comes to putting their lives in the hands of these paramedics*

Needs Statement

Paramedics need to decrease response times in challenging terrain while providing safe and effective care in order to improve patient outcomes.


Focus area
USER
PRODUCT
ENVIRONMENT
USER
Primary: Paramedic
Secondary Patient
Tertiary Healthcare organization
Hiker
Non-profit
Pain Points
Time delays
Patient comfort
Environmental impact
Safety risks
Limited carrying capacity
Ease of use
Market
Private sector
Trends
Technological advancements
Electric and Hybrid vehicles
Products
Atv
Snowmobiles
Electric off road vehicles
Advanced first aid kits
Medical modules
Drones
Helicopter
Bicycles
Mountains
Summer (dry)
Deserts
Urban settings (crowded)
Small bodies of water
Extreme sport events
Disaster zones
Concerts and festivals
Cliffsides


Eliminate
Considered
Priority
Seats for passengers
Automatic patient offloading/ loading
separate patient compartment
Standing room
Additional terrain navigation
Unnessesary control interfaces
External regulation stretcher
Swift and Safe Patient Transportation
Optimal Accessibility to Medical Equipment
Effective Communication Systems
Ergonomic Paramedic Work Environment
Adaptability to Varied Terrains and Climates

Appendix B - Contextual Research (User)

Organizing the Data

Assembling activity data, or grouping of similar observations.

The injury and the reaction

- Crashing bike
- Aiding the patient doing what they can
- Calling the medical services

Emergency Response

- 30 minutes for medic response
- Medics were ill equipped when arriving
- Helicopter was required
- Lifting and transporting patient was difficult with the supplies they had
- Patient was left with a less than 50% chance of survival due to all of the complications and wait times.

Priority User Need

- Swift and Safe Patient Transportation
- Ergonomic Paramedic Work Environment
- Effective Communication Systems
- Adaptability to Varied Terrains and Climates
- Optimal Accessibility to Medical Equipment

Needs Statement

Paramedics need to decrease response times in challenging terrain while providing safe and effective care in order to improve patient outcomes.

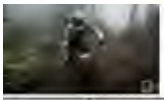
Other benefits to consider:

- Maneuverability Easy control and navigating to the patient in and out of different terrain
- Storage for Medical supplies
- Shelter for both paramedic and patient health and comfort

Objectives

The 10 objectives that will guide the design of a solution challenging terrain emergency response:

	Objective	Rationale	*Evidence
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			



Observations – Video #1

Time	Environment	Say	Action (Paramedic)	Action (Patient)	Attitude
0:00	Biking trail, 4 miles from the nearest town			Crash occurs	Shock
0:10-0:20	"	"Voice Over" "I fell a rock on the ground, I'm seeing on the ground. It (handlebars) went straight into my bone."		Patients friends come to assess and help the patient get back	Shock
0:30	"	"Push on it with all your strength"		Friends are applying pressure to the wound to stop the bleeding best	Panic Trying to stay calm and do what they can
0:45-0:55	"	Voiceover "I try to explain we need a helicopter" Voiceover (What the operator said) "try not to don't worry it is not a problem we will send the fireman"	Starting first aid/try to reach the patient	They were calling emergency services. Requesting a helicopter but being told fireman will come and it will be ok"	Frustrated Reassured
0:54		Narrator: "It still take the ambulance team at least 30 minutes to reach him. The drive to the hospital is another hour."	Continuing first aid to the patient	Friends continuing to provide aid to the patient	Stressed Worried
2:15	"	"	The medics arrive and begin to take over aid of the patient	Telling the medics to hurry as patient expresses they are in deep pain	Relief Desperation
3:25		Narrator: "Cedric's only chance of survival is a blood transfusion but the medics don't carry any blood."	Keeping the patient awake and providing whatever care they can	Helping the paramedics apply pressure to the wound	Stressed
3:45		Voice Over of friend - "They take the phone and call on it's a big problem it's not for us you must call a helicopter"	Helicopter is called	Continue to help	Annoyed Observer
5:50		Narrator - "It is now 40 minutes since the crash"	Helicopter arrives		
6:30- 10:50		Medic voice over - "4 people have to push Cedric up and carry him to the helicopter, and one has to push down through the motion to stop the bleeding and it's very difficult."	The patient is loaded onto a stretcher and brought to the helicopter	Helping to carry the patient	
7:30-end	Helicopter to hospital		Medics bring patients to the hospital and perform blood transfusion and operation Patient survives with less than 50% chance	Ditch the cart for their items	

Questions	Answers
Can you describe any experiences you've had as a paramedic where you have encountered challenging terrain or unique situations that required you to adjust your response?	[redacted]
What kind of emergencies or injuries have you treated during your work as a paramedic?	[redacted]
What resources or equipment are the most important for responding to emergencies?	[redacted]
Based on your experience as an onsite medic at a mountain biking competition, are there any insights or protocols that you think might be valuable for improving emergency response in challenging terrain?	[redacted]

What do think are key considerations for providing emergency care in challenging terrain in comparison to urban settings?	[redacted]
Have you ever had to alter your response procedures when responding to emergencies in less accessible areas, and if so how?	[redacted]
Are there any challenges related to communication or coordination that you think are relevant when responding to emergencies?	[redacted]
Are you aware of any specialized training or guidelines for paramedics who might work in challenging terrain? If so what are your thoughts on their effectiveness?	[redacted]
What are your ideas or suggestions for improving emergency response outcomes in challenging or inaccessible terrain?	[redacted]
What are the main things you would like to see improved when it comes to emergency response in the future?	[redacted]

Identifying Key Activities Based on this User Observation

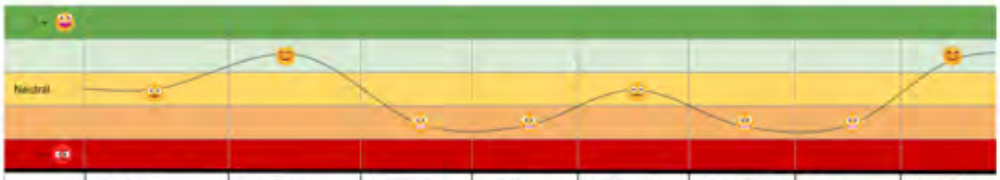
A User Journey Map was created, based mostly on Observations (preliminary and focused).

Description of Activity

Activities involved in an average paramedic's journey following a call from dispatch

User Journey Map

	Call alert	Preparation	Transportation	On site assessment	Patient care	Coordination	Patient transport	Handoff to Hospital
User goals	Quickly assess the nature of the emergency and plan for a rapid response.	Ensure they have the right equipment for the specific terrain and weather conditions.	Reach the incident location swiftly while maintaining team communication.	Quickly assess the situation and provide critical care.	Administer comprehensive medical care, prioritize patient well-being.	Collaborate effectively with the emergency response team.	Safely evacuate the patient from the challenging terrain.	Ensure a smooth handoff to a medical facility.
Actions	Receive and assess the emergency call, gather necessary information.	Check equipment, weather reports, and specialized gear.	Drive, hike, or bike to the site, maintain radio contact.	Assess the patient's condition, perform initial treatments.	Administer treatments, ensure patient comfort and safety.	Communicate with the team, request additional resources.	Prepare the patient for transport, navigate the terrain.	Provide detailed patient information and treatment history.
Thoughts	Understanding the urgency, preparing mentally for the response.	Focusing on equipment readiness and potential challenges.	Monitoring the route and ensuring efficient navigation.	Prioritizing patient needs and potential challenges of the terrain.	Concentrating on effective treatment and monitoring.	Team dynamics, resource allocation, and ensuring efficient coordination.	Assessing evacuation options, patient safety, and potential obstacles.	Effective communication with the medical facility and ensuring a seamless transition.
Feelings	A mix of anticipation and readiness to provide assistance.	Determination to be well-prepared and confident.	A sense of urgency and commitment to arriving on time.	Focused, concerned about the patient's condition.	Determination to provide the best care under challenging conditions.	Team spirit, responsibility for the patient's well-being.	Concern for the patient's comfort and safety during transport.	Relief and the hope for the patient's recovery.



	Call alert	Preparation	Transportation	On site assessment	Patient care	Coordination	Patient transport	Handoff to Hospital
User Goals	Quickly assess the nature of the emergency and plan for a rapid response.	Ensure they have the right equipment for the specific terrain and weather conditions.	Reach the incident location swiftly while maintaining team communication.	Quickly assess the situation and provide critical care.	Administer comprehensive medical care, prioritize patient well-being.	Collaborate effectively with the emergency response team.	Safely evacuate the patient from the challenging terrain.	Ensure a smooth handoff to a medical facility.
Problem, Challenges	Limited information and communication delays in remote areas.	Bulky and heavy equipment that's challenging to transport.	Navigation difficulties and terrain-specific obstacles.	Limited visibility and accessibility in remote areas.	Limited access to advanced medical equipment.	Communication gaps in remote and rugged environments.	Terrain-specific obstacles and patient transport difficulties.	Handoff coordination and information sharing with medical facilities.
Ideas/Take aways	Develop improved communication devices with long-range capabilities.	Design lightweight, compact, and easy-to-carry equipment.	Develop navigation aids and adaptive vehicles for challenging terrains.	Design specialized diagnostic tools for challenging environments.	Develop portable and ruggedized medical equipment.	Create advanced communication devices for remote teamwork.	Design adaptable patient transport solutions for rugged environments.	Develop standardized handoff protocols and information-sharing tools.

Coding

Time	Location	Do	Say			
Day	Mountain biking trails	Crashed bike	The handlebars went right into my bone	[redacted]		[redacted]
		Helping patient	Its bleeding everywhere	[redacted]		[redacted]
		Calling emergency services	Voiceover: "I try to explain we need a helicopter" Voiceover (what the operator said) 'No no no don't worry it is not a problem we will send the fireman'	[redacted]		[redacted]
		Paramedics take over care	Narrator- 'Cedric's only chance of survival is a blood transfusion but the medics don't carry any blood.'	[redacted]	[redacted]	
		Helicopter is called	Voice Over of friend - 'They take the phone and call on it's a big problem it's not for us you must call a helicopter'	[redacted]		[redacted]
	Helicopter	Patient is loaded to stretcher and brought to helicopter for transport to hospital	Narrator - "It is now 40 minutes since the crash" Medic voice over - "4 people have to push Cedric up and carry him to the helicopter, and one has to push down through the motion to stop the bleeding and it's very difficult."	[redacted]	[redacted]	

Appendix C: Field Research (Product)

Features

					
	1	2	3	4	5
	Torsus Terrastorm	John Deere rescue Gator	Mercedes Unimog Ambulanza	The Med stat Off-road ambulance	**Medical Helicopter**
Length	6 meters	3 meters	6 meters	**3 meters**	90 meters
Weight (Tons)	3.5 tons	1.158 tons	10.3 tons	**Approx. 1.2 tons**	7.3 tons
Horsepower	176	20	231	**Approx. 20**	240km/h cruise speed
Patient Loading	**Manual**	Manual	Assisted	**Manual**	Manual
Medical Supplies	Standard ambulance required supplies	Paramedics medical bags	43 dB	IV holder. Paramedic med bags and other supplies. Not machines or advanced equipment	Adrenalin, propofol Beta-blockers Anticoagulants (blood thinners), such as heparin Other emergency medications Defibrillator Pacemaker Breathing apparatus and monitoring systems Blood transfusion equipment Ventilators And others

					
	1	2	3	4	5
	Torsus Terrastorm	John Deere rescue Gator	Mercedes Unimog Ambulanza	The Med stat Off-road ambulance	**Medical Helicopter**

Interface

Patient loading system	X Secondary stretcher helps with loading		X Ramp for secondary auto stretcher		
Communications system	Radio	Radio	radio	Radio	Radio
Navigation system	Integrated GPS and screen		Integrated GPS and screen		Integrated GPS and screen
Operation	Common steering and cameras for visibility	Regular steering	Regular steering	Regular steering	Common Helicopter controls

Benefits

				
1	2	3	4	5
Torsus Terrastorm	John Deere rescue Gator	Mercedes Unimog Ambulanza	The Medstat Off-road ambulance	**Medical Helicopter**
Fast Highly manuverable Road and rural Remote areas to hospital 3.5 tons 6 meter length spacious	All terrain Reliable Small size High torque	Large Reliable Auto loading stretcher 10.3 tons Self recovery wench	features a fully enclosed, all aluminum patient compartment that secures a full-size cot and seating for up to two attendants and a driver.	High speed No traffic or terrain limitations during transport

Appendix D: Result Analysis

PANEL ON RESEARCH ETHICS

Navigating the ethics of human research

TCPS 2: CORE 2022

Certificate of Completion

This document certifies that

Ethan Medeiros

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

Certificate # 0000953078 **8 September, 2023**

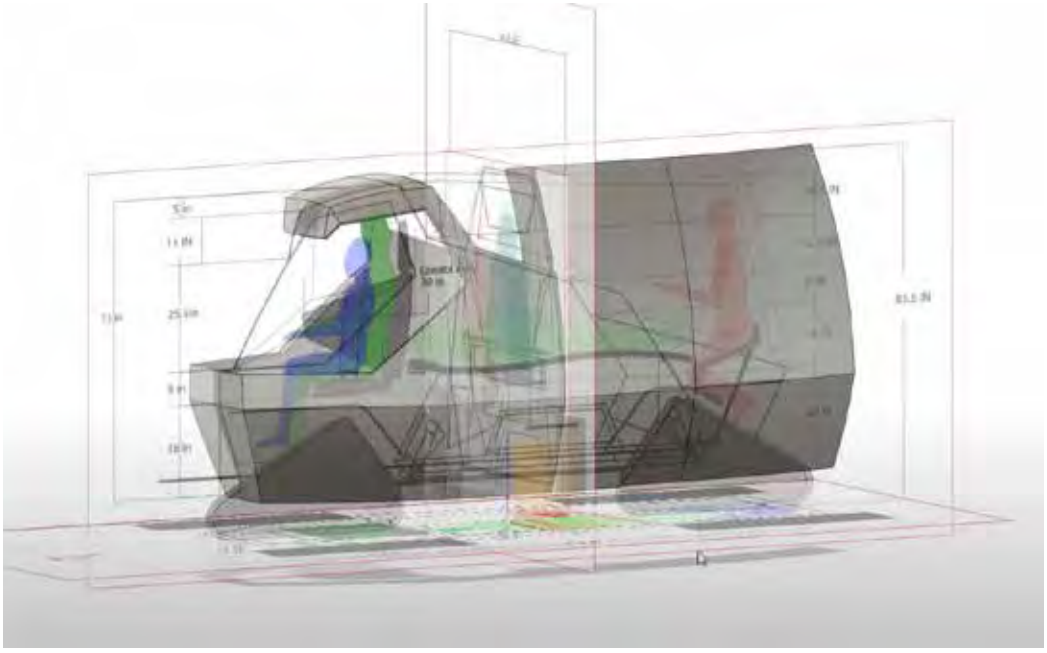
Student Name:	Ethan Medeiros
Topic Title:	How Might We Improve Emergency Response In Challenging Terrain?

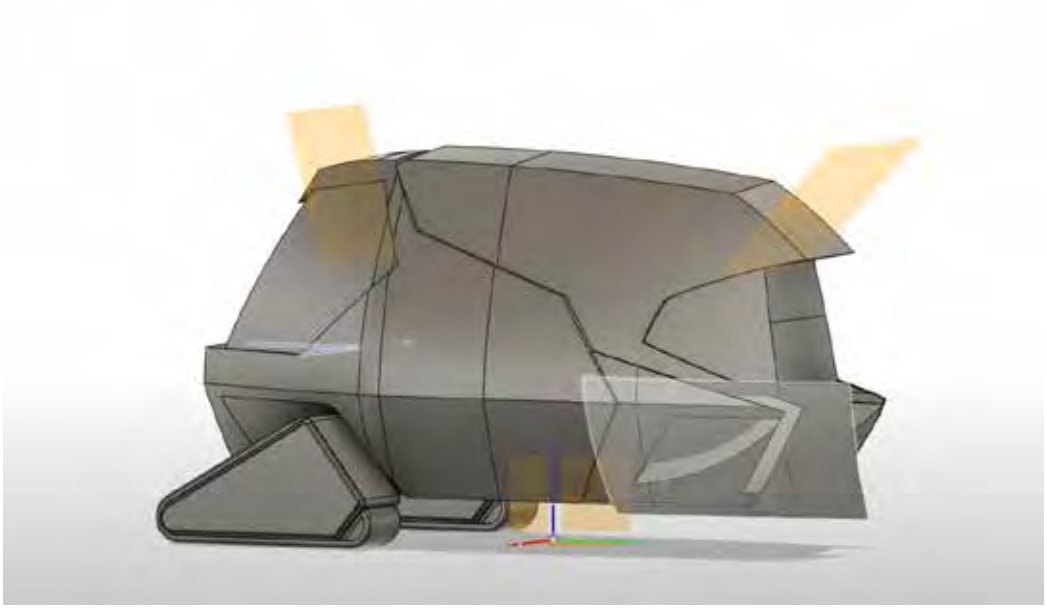
TOPIC DESCRIPTIVE SUMMARY (PRELIMINARY ABSTRACT)

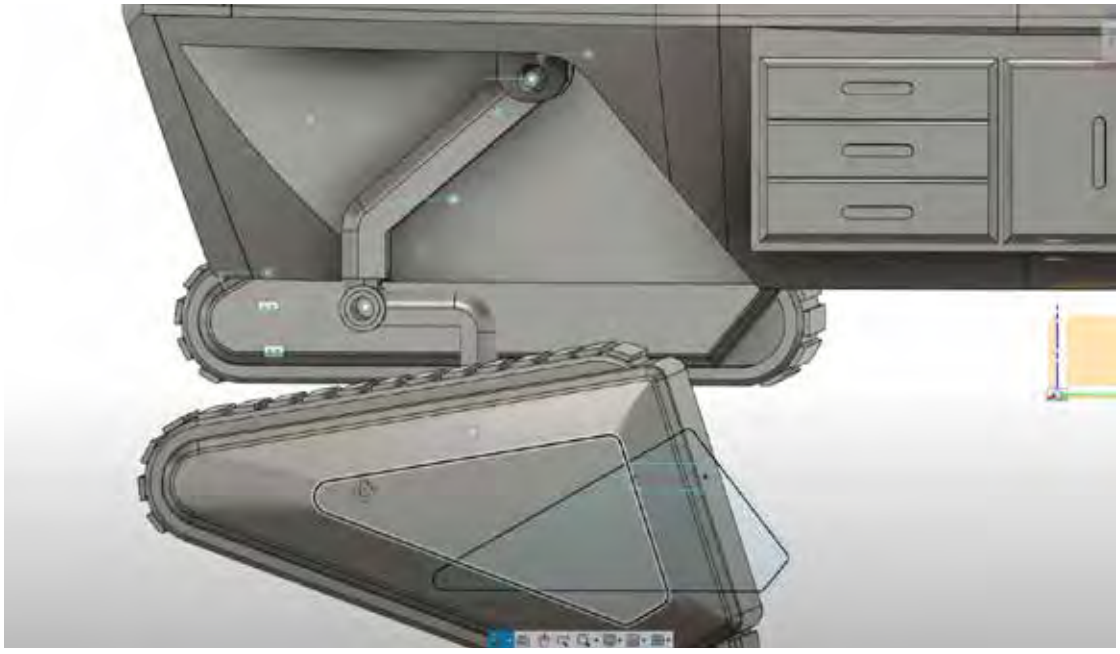
Extreme outdoor recreational activities like rock climbing, mountain biking, and hiking have gained significant popularity, often taking place in challenging terrains. However, traditional emergency response systems and vehicles are ill-equipped to effectively navigate these environments, resulting in increased wait times and reduced chances for rescue. This thesis aims to address this issue by exploring how to improve emergency response in challenging terrain and enhance the overall outdoor adventure experience, emphasizing user interaction design and physical comfort for both patients and paramedics. It also seeks to promote sustainability and social responsibility by reducing environmental impact. This research, focusing on challenging terrain emergency responses, is unique and novel, combining human-centered design, technology optimization, and environmental sustainability. Through literature review, data collection, and interviews with experts in the field, it strives to provide a solution that ensures the safety and well-being of outdoor enthusiasts while protecting the environment in which these activities are practiced.

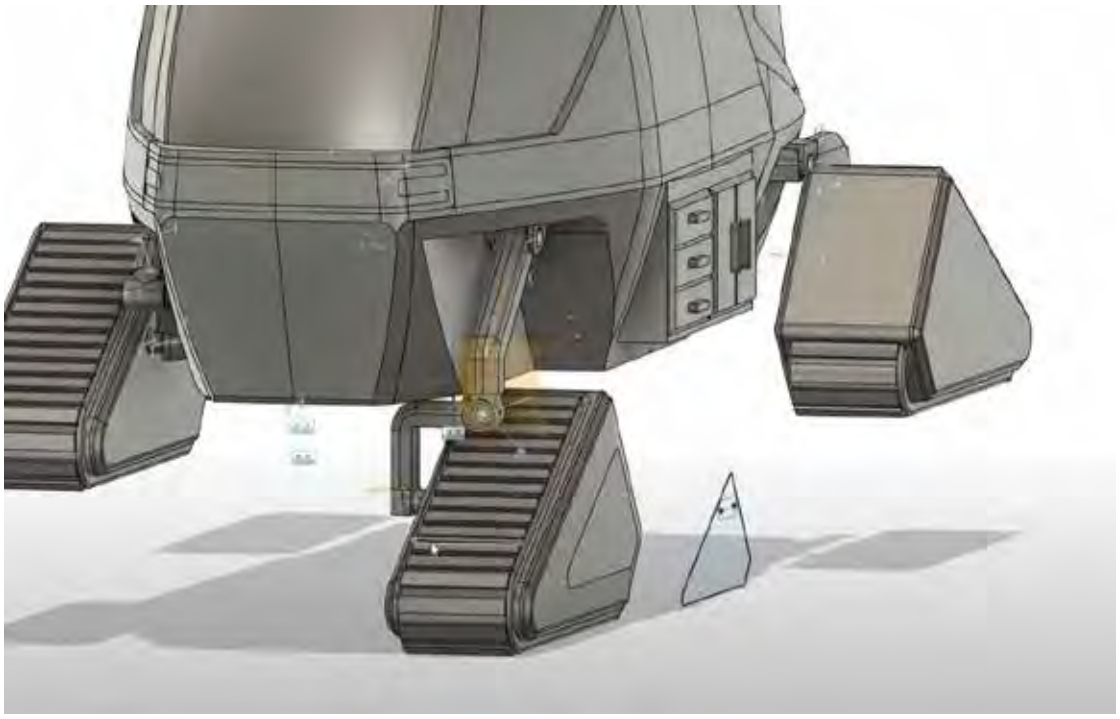
Student Signature(s):	**Instructor Signature(s):**
Date: 06 / 10 / 2023	**Date:** 10 October 2023

Appendix E: CAD Development









Appendix F: Physical Model Photos

Appendix J: Approvals & Plans

PANEL ON RESEARCH ETHICS
Navigating the ethics of human research

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Certificate # 0000953078 **8 September, 2023**

THESIS TOPIC APPROVAL

Bachelor of Industrial Design / FALL 2023

Student Name:	Ethan Medeiros
Topic Title:	How Might We Improve Emergency Response In Challenging Terrain?

TOPIC DESCRIPTIVE SUMMARY (PRELIMINARY ABSTRACT)

Extreme outdoor recreational activities like rock climbing, mountain biking, and hiking have gained significant popularity, often taking place in challenging terrains. However, traditional emergency response systems and vehicles are ill-equipped to effectively navigate these environments, resulting in increased wait times and reduced chances for rescue. This thesis aims to address this issue by exploring how to improve emergency response in challenging terrain and enhance the overall outdoor adventure experience, emphasizing user interaction design and physical comfort for both patients and paramedics. It also seeks to promote sustainability and social responsibility by reducing environmental impact. This research, focusing on challenging terrain emergency responses, is unique and novel, combining human-centered design, technology optimization, and environmental sustainability. Through literature review, data collection, and interviews with experts in the field, it strives to provide a solution that ensures the safety and well-being of outdoor enthusiasts while protecting the environment in which these activities are practiced.

Student Signature(s):	**Instructor Signature(s):**
Date: 06 / 10 / 2023	**Date:** 10 October 2023

Appendix K: Advisor Meetings & Agreement Forms

Consent Forms

IDSN 4002 / 4502
SENIOR LEVEL THESIS ONE & THESIS TWO

HUMBER
Bachelor of Industrial Design / [illegible]

PARTICIPANT INFORMED CONSENT FORM

Research Study Topic: Emergency response in challenging terrain
Investigator: Ethan Medeiros / (289) – 221 - 1276 / ethanmedeiros.design@gmail.com
Courses: IDSN 4002 & IDSN 4502 Senior Level Thesis One & Two

I, « insert participant's Name » Adam Medeiros (First Name-Last Name), have carefully read the Information Letter for the project Emergency response in challenging terrain, led by Ethan Medeiros. 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 Ethan Medeiros 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 principal investigator /researcher, Ethan Medeiros and Prof. Catherine Chong may access and analyze the data. All published data will be coded, so that visual data is not identifiable. Pseudonyms will be used to quote a participant (subject) and data would be aggregated.

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

I understand that I can verify the ethical approval of this study, or raise any concerns I may have by contacting the Humber Research Ethics Board, Dr. Lydia Boyko, REB Chair, 416-675-6622 ext. 79322, **Lydia.Boyko@humber.ca** or « Ethan Medeiros / (289) – 221 - 1276 / ethanmedeiros.design@gmail.com

Verification of having read the Informed Consent Form:

☑ I have read the Informed Consent Form.

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

Adam Medeiros	Adam Medeiros	December 5, 2023
Participant's Name	Participant's Signature	Date

Survey Questions

When the objective is to narrow down the inquiry from a topic to a specific focus, the survey emphasis is on those tasks or jobs central to the activity, and to determine the main pain points for the user or rate limiting tasks. Below are possible questions for such a survey.

Core Questions:

What is your age group?

What is your gender?

What is your level of education?

In which Ontario region do you primarily work in?

How often do you respond to calls for injuries related to extreme sports or outdoor activities in challenging terrain?

Are you a professional Paramedic or medical responder?

Do you have any specific medical training or certifications related to challenging terrains, such as wilderness first aid or rescue training?

Refinement Questions:

When you think about emergency response in challenging terrain, what aspect do you believe requires the most improvement?

In your experience, what technology has the most significant impact on improving emergency response in challenging terrains?

Which addition to a paramedic's toolkit would be most valuable in challenging terrain?

Do you believe the public should receive more education on how to assist paramedics and first responders during emergencies in challenging terrains?

In your opinion, what factors contribute most to patient outcomes in emergency response in challenging terrains?

What is a major obstacle for paramedics when responding to emergencies in challenging terrains?

Can you describe a particularly challenging or unique emergency response experience you've encountered during your career, and how you handled it?

Can you describe the most significant change or improvement in emergency medical services that you've witnessed during your career?

How can technology be used to improve training and education for paramedics?

Setting-up an Observation Session

Date for observation session (tentative):	Saturday, November 18, 2023
Location:	Aurora, Ontario, Canada
Activity to be undertaken	Patient transport in challenging terrain
Equipment Required: (Real / scaled mock-up)	None

Prep for Session
Type of Observation: Expert critique of video
Recording equip for session etc. (note paper / camera, video, sound recording etc) Sound Recording/Note paper
Test recording equipment prior
Consent waiver
Script: preparing the user for the activity to be observed
Researcher: I'm Ethan Medeiros, a student from Humber college's Bachelor of Industrial design program. Today we are conducting an expert critique session as a part of my thesis project, which focuses on improving emergency response in challenging terrain situations. The main goal of this is to leverage your expertise in critically analyzing video footage of emergency response activities in challenging terrain. Your insights will help in identifying success, challenges, and opportunities for improvement
Key Activity 1
To determine the viewer's insights and observations regarding the challenges related to extended wait times and accessibility in emergency response scenarios, focusing on the video depicting hikers in the Grand Canyon
Sequence of steps Introduce the video context and scenario. Ask the participant to pay attention to specific elements: wait times, accessibility challenges, and any notable details. Encourage the participant to think out loud, sharing reactions, pain points, and potential areas for improvement. Conclude with a prompt for any additional comments or suggestions.
Script "As we watch the first video, please pay close attention to the challenges depicted, particularly regarding wait times and accessibility in the context of emergency response. Feel free to express your thoughts out loud as you watch. Note any pain points, areas of concern, or opportunities for improvement. After the video, I'll be eager to hear your insights and any suggestions you might have."
Key Activity 2
To gather the participant's perspectives on challenges related to patient transportation in emergency response scenarios, with a focus on the video portraying a mountain biking incident
Sequence of steps Introduce the second video and its context, emphasizing patient transportation challenges. Instruct the participant to observe and think aloud about the difficulties encountered during patient transport, considering factors like equipment, terrain, and the overall process. Encourage the participant to share observations, potential improvements, or any questions that arise Conclude with a prompt for additional comments.
Script: "Moving on to the second video, we're concentrating on patient transportation challenges in emergency scenarios, particularly during the mountain biking incident. As you watch, consider the difficulties faced in transporting the patient, such as equipment issues, terrain challenges, and the overall process. Express your thoughts out loud, noting any pain points or areas where enhancements could be made."

Questions:	Answers
Can you describe any experiences you've had as a paramedic where you have encountered challenging terrain or unique situations that required you to adjust your response?	Weather emergencies can affect response times and impede terrain. During the winter storm Elliot in December 2022, multiple trucks on the south side of the Niagara peninsula were trapped in snow and unable to respond to emergencies.
What kind of emergencies or injuries have you treated during your work as a paramedic?	All kinds of injuries and medical emergencies, from car accidents to heart attacks.
What resources or equipment are the most important for responding to emergencies?	The cardiac monitor would be the most important piece of equipment we carry. It allows for quick diagnosis of medical problems and allows for electric cardioversion.
Based on your experience as an onsite medic at a mountain biking competition, are there any insights or protocols that you think might be valuable for improving emergency response in challenging terrain?	preparedness for predictably unpredictable terrain and situations would be prudent for successful responses. During the Canada Games mountain biking tournament it was anticipated that accidents could occur in the forests with no roads or egress routes. The gator, which is a specialized tractor with medical equipment on it was utilized so that
	we could be prepared for retrieval and treatment of bikers in emergencies
What do think are key considerations for providing emergency care in challenging terrain in comparison to Urban Settings?	lack of roads, lack of access by allied resources such as fire. Planning an egress route
Have you ever had to alter your response procedures when responding to emergencies in less accessible areas, and if so how?	During winter storm extreme caution was used while responding to emergencies. Lack of visibility and high probability of being stuck in snowbank meant even highest priority calls were cautiously and slowly responded to
Are there any challenges related to communication or coordination that you think are relevant when responding to emergencies?	Constant radio telecommunications with dispatch is essential for call details and safety in case of emergencies. Radio grey zones where communication is poor such as in NOTL or Fort Erie can prove hazardous
Are you aware of any specialized training or guidelines for paramedics who might work in challenging terrain? If so what are your thoughts on their effectiveness?	specialized medics are trained to repel down the Niagara gorge in case of emergencies. They are effective when they reach the patient however extrication of the patient remains as an issue
What are your ideas or suggestions for improving emergency response outcomes in challenging or inaccessible terrain?	More training and specialized units such as gator to overcome challenging terrain. Maybe even a snowmobile that can be fitted with equipment to respond in snow emergencies
What are the main things you would like to see improved when it comes to emergency response in the future?	Better funding for EMS services to be able to obtain the resources required to respond to all kinds of emergencies.

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ALL-TERRAIN RESCUE VEHICLE

2024

HOW MIGHT WE IMPROVE EMERGENCY RESPONSE IN CHALLENGING TERRAINS?

Ethan Medeiros

Bachelor of Industrial Design