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Exterior Design of an Urban Air Mobility Vehicle

Optimizing for Medical Emergencies and Public Acceptance

Master's thesis in Industrial Design Engineering

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Abstract

Technological advancements have enabled the development of previously unfeasible transportation solutions, with Urban Air Mobility (UAM) vehicles emerging as a promising approach to addressing growing urban congestion challenges. This project focuses on designing an emergency UAM vehicle, developing its exterior to support critical rescue missions comparable to those performed by ambulance helicopters, while aiming to design it to be accepted and trusted by the public and society.

An iterative design methodology guided the project, beginning with comprehensive research, including literature reviews, market analysis, stakeholder interviews, and field observations, to establish key design requirements. Subsequent phases used various methods and tools, progressing from conceptual sketches to 3D-printed prototypes, physical mockups, and final Class-A surface modeling.

The project resulted in a proposal for a concept vehicle: the exterior design of a medical emergency UAM, demonstrated through CAD models and realistic renderings, with requirements and dimensions tailored to emergency medical missions. While the initial focus was on designing a UAM, prioritizing both medical emergencies and public acceptance, the project later shifted towards medical operations, with public acceptance becoming a secondary consideration. This adjustment was due to the project's scope; findings suggest that emergency UAM design must first fulfill mission-critical needs before addressing semiotic and aesthetic considerations.

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1. Introduction

The initial chapter deals with the prerequisite and purpose of the thesis. It describes the background of UAM, and how the current situation is creating opportunities to further explore how UAM can be integrated into the emergency sector. Lastly, the aim and research questions of the thesis will be covered, as well as the limitations and deliverables.

1.1 Background

The rapid advancement of technology and improvements in battery efficiency have created new opportunities in urban air mobility (UAM). UAM focuses on integrating advanced air transportation into urban environments to address challenges such as traffic congestion, environmental impact, and efficient handling of emergency situations. More and more research in recent times see significant potential in exploring these innovative solutions, particularly for socially beneficial applications such as search-and-rescue missions, medical evacuations, and disaster relief (Wu et al., 2024).

In 2023, a research project, Air Mobility Emergency System, was initiated to design, build, and demonstrate Air Mobility Emergency systems. The goals of this research are to:

- Build competence and spread knowledge about AMES.
- Integrate UAM vehicles into today's complex traffic environments while focusing on safety.
- Advance technology, particularly focusing on effective communication.

For UAM vehicles to gain widespread acceptance, they must not only be technologically advanced but also socially accepted. Exterior design plays a role in shaping public perception and ensuring that these vehicles integrate seamlessly into urban environments.

The design of the UAM has been divided into two separate projects: one focusing on exterior design and the other on the interior. Although this project was dedicated to exterior design, a close relationship with the interior team was held throughout the project to make sure that the operational needs were met.

1.2 Framing the area of use

As the integration of UAMs into the emergency sector is still in the early stages, there are no exact or real use-cases to display. However, it was still considered necessary to put the UAM in this project into a context, to connect the design work with potential real-life uses. An important clarification is the relationship between an ambulance helicopter and the UAM. For instance, VGR (Västra Götalandsregionen, collaborator and part of the research project), currently has one ambulance helicopter that is responsible for the whole region. The manned UAM should not be seen to replace the helicopter, but rather to complement and support the workload of an ambulance helicopter. The following scenario should therefore be seen to put the particular UAM in this project into a more graspable context, despite it being made up;

Early in the morning, emergency services are alerted to a serious highway accident involving multiple vehicles and critically injured patients. A helicopter ambulance is immediately dispatched to the scene to provide quick medical support and transport for the most severe cases.

While the helicopter is on the way to the accident scene, another call comes in from a remote island on the Swedish west coast where a man has suffered a cardiac arrest. With the area difficult to reach by road, a manned medical emergency UAM (Urban Air Mobility) equipped with two paramedics and medical equipment is deployed. The UAM quickly reaches the location, and the paramedics deliver life-saving care on-site before providing further transport to the nearest hospital to stabilize the patient.

In this scenario, the manned UAM acts as a complement to the ambulance helicopter, taking care of accidents that the helicopter may not be able to handle.

1.3 Aim and Purpose

This study aims to establish design principles for the exterior of a medical emergency Urban Air Mobility (UAM) vehicle, ensuring seamless integration into urban environments through aesthetic design elements. To achieve this, the study will address the following research questions:

1. Functional Requirements

- *What are the key design requirements for a medical emergency UAM (e.g., needs for operation, dimensions, safety)?*

2. Public acceptance and perception of safety

- *Which visual characteristics (e.g., shape, color, surface treatment) help urban populations trust and welcome a UAM as an emergency vehicle?*

The study will employ a mixed-methods approach, including the development and evaluation of both low- and high-fidelity visual concepts (e.g., mockups, renderings) to assess public perception and functional viability.

1.4 Project limitations

To make the project feasible considering the timeframe a few limitations were introduced before the start of the work;

- Elements such as the rotors and skids are to be considered in a holistic perspective, however not in technical nor detailed manner. The main focus is the exterior shell/body; the design, functionality and integration with the interior.
- Flyability and aerodynamics of the cabin will not be calculated as it is outside of the scope of the project, however it will still be considered and evaluated from an aesthetic perspective.
- The overall dimensions of the cabin has to fit in a standard container (2,44 m x 2.59m x length (m)) in order for it to be transported, especially constraining the height and width of the exterior design.

1.5 Deliverables

The deliveries of the project should include the following;

- **3D model** (*Class-A surfacing standard*).
- **Photorealistic renders** of the final exterior design.
- **A 3D-printed scale prototype** of the exterior design.

1.6 Terminology

UAM (Urban Air Mobility):

In the context of this report, *Urban Air Mobility (UAM)* refers specifically to the design and operation of a medical emergency ambulance aircraft capable of rapid, low-altitude medical transport within urban and suburban environments. The term *UAM* will be used throughout this paper to describe the system under development.

From an operational perspective the term UAM in this project also refers to the aircraft not having a pilot directly inside the aircraft. Instead, the term includes the idea of being remotely controlled from the ground.

eVTOL (Electric Vertical Take-Off and Landing):

An aircraft type that enables vertical take-off, hover, and landing, powered entirely by electric propulsion. eVTOL technology is suitable for UAM systems due to its quiet operation, low emissions, and compact footprint.

2. Theoretical Background

This chapter will introduce the concept of UAM and why it has the potential to be feasible within the emergency sector. Furthermore, it will describe the relation to public acceptance and how semiotics will influence the project.

2.1 Urban Air Mobility (UAM)

According to the European safety agency urban air mobility is “....a new safe, secure and more sustainable air transportation system for passengers and cargo in urban environments, enabled by new technologies and integrated into multimodal transportation systems. The transportation is performed by electric aircraft taking off and landing vertically, remotely piloted or with a pilot on board” (EASA, n.d).

The broad definition of UAM in regard to transporting people and goods can be further specified in line with the aim of this project, more specifically with the purpose of facilitating medical emergency situations and transportation of people involved in accidents.

2.2 The octocopter

An octocopter is a type of aircraft that takes advantage of rotors in order to fly and hover in the air, and the type of aircraft used as the UAM in this project. The eight rotors (divided in pairs) on an octocopter eliminates the need for a tail rotor, which is a common trait on regular helicopters. The arrangement of the rotors is often in a plus or X formation, creating the desired symmetry. By having two pairs spinning clockwise and the other two pairs spinning counter clockwise, a net zero torque can be achieved which creates the possibility for the aircraft to hover, similar to a regular helicopter.

2.3 Integrating UAM into the emergency rescue sector

A crucial factor during emergency situations is efficiency and the duration between calling for help until medical support has arrived. Traffic congestion is one aspect that is becoming a bigger problem in urban areas which could hinder road ambulances and lead to less successful operation rates (Sheirbeck et. al. 2023). In the same study, Sheirbeck et. al is testing and evaluating the idea of transporting heart defibrillators out to patients in need with the help of

drones. It showed great potential in arriving earlier compared to road ambulances, potentially saving more lives in the long run.

When the roads and infrastructure around it get busier, taking advantage of other ways of transportation becomes interesting or even necessary. Using the airspace above us is therefore an important step and already used by the ambulance helicopter. The ambulance helicopter has great maneuvering ability, possibilities to land and operate in uneven and difficult locations, and great efficiency in regard to transporting patients from A to B.

The integration of a UAM into the emergency sector would also mean that it would be a new addition to the current selection of ambulance vehicles. Even though a road ambulance and an ambulance helicopter for instance are two very different types of vehicles, they share the same attributes that catch the eye of their surroundings. These attributes are mentioned by Socialstyrelsen, and specifically concerns the colour, symbols and reflex patterns of the ambulance vehicle (Socialstyrelsen, 2025). These aspects are described as follows:

- Yellow main body paint (Colourcode RAL 1016)
- Reflex check pattern on the sides of the vehicle in green (Colourcode RAL 6026)
- The Star of Life symbol clearly visible on the exterior
- The word “AMBULANCE” clearly visible on the exterior

2.4 Public acceptance

A broad and general definition of public acceptance is to which level people feel okay with something becoming or to some extent affecting their life or society in which they are part of. It can for instance be new technology, new policies or societal changes.

This area is particularly interesting considering the aim of this project. UAM, in this case as a concept, will encounter and be visible for the public eye. It is therefore fair to assume that it will create emotions, different opinions and questions, when they will be a part of urban societies. What is even more interesting is when UAM is integrated into the emergency sector, which has its established norms and already existing vehicles, some which have been around and accepted for a long period of time.

There are already organizations working with the potential integration of UAM. For instance, the EASA (European Union Safety Aviation Agency), working under the European Commission (part of the European Union), dealing with questions regarding civil aviation safety in Europe. They are constantly working with current frameworks and aviation systems but also keeping an eye on the future and preparing for new potential areas, one such area being UAM. In 2021 EASA released a comprehensive report regarding the topic of public acceptance of UAM, collecting a variety of different studies (EASA, 2021). In the report, one of the included studies concluded that noise and type of noise emitted by the UAM, the altitude of flight, the time during the day in which the UAM flies, and the overall safety of people on the ground were highly ranked and important for people to accept UAMs (Yedavalli & Mooberry, 2019).

Aspects such as these are, inevitably, factors that people consider and think are important before even knowing how the UAM is designed. A similar, and in this case, relevant parallel is the public acceptance of autonomously driven cars. It is not about the shape or color of the car that affects the decisions from the public to use or accept it in the city. Rather, it comes down to the advancement of technology and the statistics such as number of accidents, reliability, user control etc. This is also true, or even more so, when discussing the UAM.

With that being said, the prerequisite is that the exterior design of the UAM does matter from a public acceptance perspective. Not necessarily on the same level or the same way as the technology and the concept behind it, but rather as a way to close the gap between visionary aircraft and the current emergency sector, facilitating the challenging integration.

2.5 Design and how it affects human psychology

Semiotics

Semiotics, as described in Rune Monö's book *Design for Product Understanding, The Aesthetics of Design from a Semiotic Approach*, is "the study of things and sign systems and their structure, properties, and roles in socio-cultural behaviour." (Design for Product Understanding, 1997)

Everything around us that we can see, hear, or touch can be assigned names, signs, or symbols. Although a word is, in its most basic form, merely a combination of characters, it carries meaning beyond its structure. Words are examples of what are called signifiers, they represent or signify certain meanings. These signifiers often carry different meanings depending on the context, situation, culture, individual interpretation, or point in time.

In product design, physical attributes, such as shape, color, and materials, as well as perceived functionality and practicality, play an important role in how a product is interpreted. These elements communicate meaning to the observer, and by consciously shaping them, a designer can evoke specific associations and emotional responses.

An emergency Urban Air Mobility (UAM) vehicle, for example, can signify safety and trustworthiness through design elements that align with culturally shared associations tied to rescue and emergency response. For instance, its shape should communicate robustness. This can be achieved through a compact, visually sturdy form that appears structurally strong, rather than thin or fragile. Another key aspect is functional clarity: each design element should clearly indicate its purpose. Avoiding excessive or decorative components helps ensure the vehicle appears practical and dependable, rather than superficial or fragile (Design for Product Understanding, 1997).

Every design decision conveys a message. Therefore, all elements should signify a meaning that matches what the designer wants users to intuitively associate the product with (Design for Product Understanding, 1997).

Symmetry

Symmetry is a trait that humans commonly perceive as aesthetic, a characteristic that is both pleasant and easy to recognize and process. This is due to a region of the brain that is particularly sensitive to symmetry and is involved in the brain's reward system, making symmetrical objects more visually appealing (Tyler et al., 2004; Karakashevska et al., 2021)

Curved vs. Angular Forms in Design Perception

Research has consistently shown that humans tend to prefer curved shapes, which are generally perceived as aesthetically pleasing. However, the emotional response to jagged or angular shapes is less clear. Some studies suggest that angular forms may evoke negative emotional responses, such as fear or discomfort. This is possibly due to an evolutionary association between sharp angles and potential threats, linking them to emotions such as excitement, aggression, or danger. Conversely, other research finds no significant correlation between angular shapes and negative affect. Despite this uncertainty, one consistent finding across studies is that curved shapes are more often associated with calmness, softness, and peaceful emotions, contributing positively to perceptions of safety and trustworthiness in design (Bar & Neta, 2007; Bertamini et al. (2015)).

Familiarity and How It Affects User Perception of Design

Familiarity plays a significant role in shaping how users perceive and evaluate design. One key psychological principle relevant here is the mere exposure effect, which suggests that repeated exposure to certain stimuli, such as shapes or forms, can lead to a preference for them (Pohl, 2022). The theory holds that frequently encountered stimuli become easier to process, making them feel more familiar and perceptually fluent (Bornstein & D'Agostino, 1994).

In the context of car interior design, Leder (2007) observed that users showed a clear preference for curved shapes over straight lines, an innovative design element in that field at the time. This preference was attributed, in part, to the mere exposure effect, as users tended to favor forms they had encountered frequently.

Moreover, Leder noted that the appreciation for curvature in design was also culturally and historically influenced. For example, curved exteriors were more favorably received when they aligned with the design trends of specific decades, such as the era when rounded car chassis was popular. This suggests that users' aesthetic judgments are shaped not only by perceptual tendencies but also by temporal and cultural contexts, reinforcing the importance of considering both psychological and sociocultural familiarity in the design process (Leder & Carbon, 2005).

Processing Fluency and Aesthetic Experience

In the article *Processing Fluency and Aesthetic Pleasure: Is Beauty in the Perceiver's Processing Experience?*, Reber et al. (2004) propose that the ease with which a stimulus is mentally processed, known as processing fluency, is strongly correlated with aesthetic appreciation. They argue that "the more fluently perceivers can process an object, the more positive their aesthetic response." In other words, our perception of beauty or aesthetic appeal is closely tied to how effortlessly we can mentally interpret what we see.

The article identifies several visual characteristics that can enhance processing fluency, including symmetry, repetition, prototypicality, figure-ground contrast, and priming. These features help make a visual stimulus easier to decode, increasing the likelihood of a positive aesthetic judgment.

Reber and colleagues conclude that aesthetic experience is not purely objective nor entirely inherent in the object itself. Instead, it is shaped by the interaction between the properties of the object and the cognitive processes of the perceiver. Perceived beauty arises from both the design's visual attributes and the individual's ability to process it fluently, highlighting the subjective nature of aesthetic pleasure (Reber et al., 2004).

Supporting this idea, another study found that aesthetic appeal and visual simplicity significantly influence users' perceived quality of a product. Simpler visual design was associated with higher user satisfaction, suggesting that clarity and minimalism in design can positively impact how quality is judged (MousaSabti, 2021).

The Role of Color in Perception and Emotion

Color plays a vital role in shaping how a perceiver responds to an object or environment. In the article *Impact of Color on Marketing*, Singh (2006) highlights the powerful influence of color on decision-making, stating that "people make up their minds within 90 seconds of their initial interactions with either people or products. About 62–90 percent of the assessment is based on colors alone." This underscores the importance of color as a key factor in how objects are perceived, particularly in design contexts.

Beyond visual appeal, color can also affect the perceiver emotionally. Research has shown that color influences both mood and performance. Cool colors, such as blue and green, tend to evoke feelings of calmness and relaxation, while warmer colors, like red and yellow, are more likely to stimulate excitement and arousal (Barbato et al., 2019).

It is also important to understand that color perception is shaped by three fundamental components: hue, saturation, and brightness. While hue is often the most immediately recognizable aspect, saturation and brightness significantly influence emotional and perceptual responses. Brighter, more saturated colors are typically associated with higher arousal levels. Similarly, vivid colors, those that are both saturated and bright, have been linked to positive emotional responses such as pleasure and energy (Wilms & Oberfeld, 2017).

Summary: The Psychological Impact of Design on Perception

The design of an object, its shape, form, and color, plays a critical role in how it is perceived by the viewer. Research in design psychology demonstrates that visual characteristics such as symmetry, curvature, simplicity, and color evoke instinctive emotional and cognitive responses (Bar & Neta, 2007; Reber et al., 2004). However, while these principles provide a foundational framework for aesthetic appeal, their interpretation is not universal.

Contextual and Cultural Variability

- Design perception is deeply influenced by cultural background, historical trends, and individual experiences (Leder & Carbon, 2005). What one group finds aesthetically pleasing, another may not.
- Familiarity and the mere exposure effect (Bornstein & D'Agostino, 1994) suggest that repeated exposure to certain design elements can shape preferences, but these preferences evolve over time.
- Processing fluency (Reber et al., 2004) indicates that ease of comprehension enhances aesthetic response, yet what is "fluent" varies across demographics.

There is no clear recipe for design

While guidelines exist (e.g., symmetry = pleasing, angularity = aggressive), rigid adherence to design "rules" does not guarantee universal acceptance. Instead, successful design requires a holistic approach, considering:

- Functional clarity (Monö, 1997) – Does the design communicate its purpose?
- Cultural resonance – Do the forms/colors align with the target audience's associations?
- Temporal relevance – Does the design fit contemporary expectations or future-oriented innovation?

For emergency UAM vehicles, this means balancing intuitive safety cues (e.g., robustness, high-contrast colors) with cultural and contextual adaptability to ensure broad public acceptance.

3. Methods

This chapter outlines and explains the primary methods used throughout the project to achieve the final results. It will cover both the methods used during the initial research phase, as well as the methods used during the design process, from ideation to final concept.

3.1 Literature Review

“A literature review can broadly be described as a more or less systematic way of collecting and synthesizing previous research. An effective and well-conducted review as a research method creates a firm foundation for advancing knowledge and facilitating theory development. By integrating findings and perspectives from many empirical findings, a literature review can address research questions with a power that no single study has.” (Snyder, 2019).

3.2 Semi-structured Interview

A semi-structured interview is a method of gathering qualitative data by using a predefined interview guide in combination with open-ended questions (Knox & Burkard, 2009). The method allows for, as stated by Knox and Burkard (2009), “creativity and flexibility to ensure that each participant’s story is fully uncovered”.

3.3 Data collection: Observation

The observation technique is a method of first-hand data collection that involves direct engagement with the setting. Information is obtained through observation, providing a direct understanding of the concept. This method is particularly useful when the concept is unexplored or not well-known (Taherdoost, 2021).

3.4 List of requirements

A list of requirements is a tool used to organize and clarify what a product needs to fulfill (Johannesson, Persson, & Pettersson, 2018). Requirement lists can be structured in various ways, such as categorizing items into "needs" versus "wishes," grouping them by themes like emotional or functional aspects, or prioritizing them from most to least important.

3.5 Mood board

A mood board is a tool that designers use to inspire creativity with the aim of developing end products (Munk et al., 2020). It is a creative process that helps solve design problems by gathering visual data aligned with the intended outcome.

3.6 Brainstorming

"Brainstorming is a method aimed at generating ideas. The focus lies on quantity rather than quality. It is a creative and flexible approach that encourages the exploration of potential solutions and ideas (Johannesson, Persson, & Pettersson, 2018)."

3.7 Physical Mock-ups

A physical mockup is a tool that allows testing and experimenting with design decisions (Strobl, 2012). The fidelity of a mockup can vary, ranging from quick and simple versions made with easily obtained materials, allowing for fast and efficient testing and adjustments, to high-fidelity models that closely represent the final product.

3.8 Rapid Prototyping

Rapid prototyping is a method where CAD models are rapidly turned into physical prototypes, reducing the time spent in physically creating them, which makes it possible to experiment and evaluate concepts faster (Kamrani & Abouel Nasr, 2010).

3.9 Traditional prototyping

A traditional prototype is a method that uses a physical or digital model to explore, test, and communicate ideas (Bäumer, Stolterman, & Croon Fors, 2018). Prototypes help convey concepts, sparking conversations and discussions that can inform design decisions. These models can vary in fidelity, allowing for both quick and detailed prototypes that represent specific characteristics or illustrate the final outcome.

3.10 Explorative models

Explorative models are quickly produced with three-dimensional sketches. This tool helps explore ideas to varying extents and is typically used in the early stages of design development, when ideas are at their most novel (Gürsoy, 2010)

3.11 Concept selection

Concept selection can occur at various stages of the product development process, making it iterative, furthermore there are multiple ways to make decisions (Ulrich & Eppinger, 2015). At its core, concept selection involves eliminating less desirable options to identify the most promising ones. The decision-making process can vary, some approaches follow a formal structure, while others are more flexible. Methods for making these decisions include external voting, pros and cons analysis, multivoting, and intuition. It's also possible to combine different methods to suit the context and team needs.

4. Process

This chapter describes the process followed throughout the project and presents the different activities and decisions that led to the final result. While the presentation follows a generally chronological structure, it is important to note that many of the activities occur in parallel. The chapter goes through the key phases, tools, and approaches used.

4.1 The Design process

To fulfill the project's aim and objectives, a structured yet flexible workflow was established. The approach followed a design process that allowed freedom for iterative exploration and refinement. The iterative design process (Define, Explore, Develop, Evaluate) was adapted to changing insights from stakeholder feedback and prototyping, ensuring alignment with user needs.

The design procedure was organized into the following interactive stages:

1. Definition – Clarifying the problem statement and project requirements.
2. Exploration – Investigating ideas, inspirations, and potential solutions.
3. Development – Refining selected concepts through prototyping and testing.
4. Evaluation – Assessing outcomes against objectives and iterating as needed.

As illustrated in figure 1, the process was non-linear, with frequent loops between stages, particularly among the first three (Define, Explore, and Develop). Significant effort was dedicated to these early phases to ensure a strong conceptual foundation before advancing.

This iterative approach allowed for adaptive decision-making, ensuring that insights gained in later stages could inform earlier steps, ultimately leading to a more robust and well-considered final outcome.

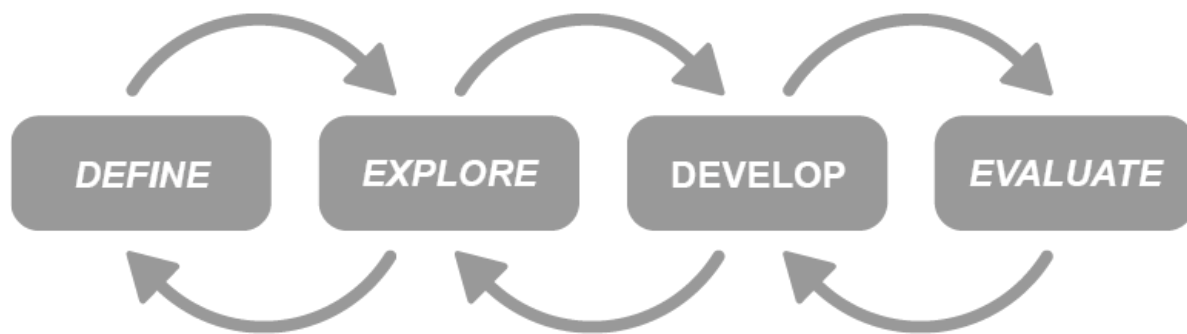


Figure. 1 The process

4.2 Literature Review

The primary objective of the literature review was to develop a broad understanding and comprehensive knowledge base to address the aim of the project. This involved two main components. The first focused on researching the emerging technology of emergency rescue Urban Air Mobility (UAM), including its historical development, current state, and the evolution of public acceptance over time. The second component examined how shape, form, and color influence the perception of the observer.

4.3 Research and preparations

A crucial part of the project was to understand the current situation in the emergency sector, gather insights and shape the solution space for the exterior of the UAM. This was done through a variety of different field trips, establishing a requirement list, and scenario creation which was presented in the introduction chapter; 1.2 Setting the scene.

Field trips and requirement list

At present, the closest relative to the UAM being designed in terms of usage, purpose, and shape, is an emergency rescue helicopter. The UAM is expected to share many similar requirements and operational needs, making it relevant to conduct field research visits to the operational emergency rescue helicopter in VGR.

The two field trips to the ambulance helicopter included interviews and discussions with personnel involved in helicopter operations during missions, with a focus on how the exterior design impacts their performance during operations. Additionally, observations and measurements of the helicopter itself were conducted. Prior to the first visit, some general

questions regarding helicopter operations were prepared. These were formed by initial scenarios and requirement specifications. The focus during the first visit was to understand the relation between the helicopter and the emergency sector and listen to the experiences from the ambulance personnel. During the second visit, a greater focus was on measuring and understanding specific exterior features, such as the dimensions of windows, doors, and footstep heights.

Apart from visiting the ambulance helicopter, a visit to the road ambulance station in Göteborg was also conducted. The same procedure was done here, preparing some general questions to begin with, but keeping the majority of the visit open for discussions and spontaneous questions while being walked- and talked through the elements of the ambulance vehicle by ambulance personnel.

These field trips lead to important insights and created a strong foundation for the design decisions made in this project. Without them, the requirements list would not have been as detailed or as aligned with the project's specific context. By interviewing professionals with firsthand experience in emergency rescue with similar vehicles, it was possible to make informed and context-specific design choices. Moreover, the ability to ask clarifying questions and engage in discussion during the interviews helped ensure the relevance and accuracy of the gathered information. The final requirement list is shown in table 1, but it should be noted that this was a constantly updated document until the final stages of the project.

Table 1. Final requirement list

Requirements	Measurement	Comments	Importance	Source	
Technical					
Lenght	4.7 m	Standard container	D	C	Source
Widht	2.2 m	Standard container	N	C	C - Client
Height	2 m	Standard container	N	C	L - legislation
Clearence from bottom	0.5 m	Clearence to protect battery	N	R	U - User (EMS)
Side door	widht: 1.2 m, H: 1.45 m	Heli dimensions	N	U	R - Research
Back door	widht 1.6 m, height: 1.45 m	Heli dimensions	N	U	
Rotors (Emrax)	2.5 m ø, min .4 m H		U	C	Importance
Battery at the bottom	Volume 1.44 m3, (H 0.3 m)		U	C	N - Necessary
Maximum Take Off Weight (MTOW)	~1.2 Ton		U	C	D - Desirable
fit into a standard 40 foot container			N	C	U - Undesired
ABC-pillar			U	C	
Skids (with wheels)			U	C	
Slanted roof			N	C	
Windows lead to greenhouse effect			U	U	

4.4 Initial ideation and concept creation

This chapter deals with the initial work during the project, including gathering inspiration, setting a moodboard and starting with sketching and digital prototyping.

4.4.1 Brainstorming

To begin the work and get ideas flowing a multitude of different brainstorming sessions were held during the early phases of the project. The project deals with a new, complex and visionary subject that requires creative ways of thinking and building on each other's thoughts and ideas.

Different types of brainstorming sessions were held to cover different challenges and areas of the project. Brainstorming sessions in the shape of sketching were common and further described later on. Brainstorming sessions on more specific elements of the UAM was also held, such as for instance the type of doors to use, in order to include functional aspects early in the design process.

4.4.2 Moodboard and inspirationboard

To facilitate the creative process and give direction to the work a variety of different mood- and inspirationboards were made, see figure 2. The distinguishing between the two are primarily the purpose; Moodboard to examine the expression, theme and colors of the design, based on images that in one way or another helps to communicate those thoughts. An inspirationboard on the other hand focuses more on actual ideas or concrete solutions, based on for instance similar projects, other vehicles, shapes and general design decisions.

The moodboards were the first focuspoint to find themes that matched the objectives and aim of the project. The abstraction level is high on individual pictures and elements, but together it forms a direction. Keywords used were *safety, modernity, trust*.



Figure 2. Developed moodboards

The goal with the inspirationboards was to take advantage and inspiration from other vehicles and shapes to understand and determine how the UAM could be shaped, see figure 3. This was especially important in relation to this project, due to the fact that this type of vehicle is still new and undefined on the market. Therefore, taking ideas from helicopters, cars and bikes to name a few was decided. Keywords used for the inspirationboards were futuristic, modern and visionary.

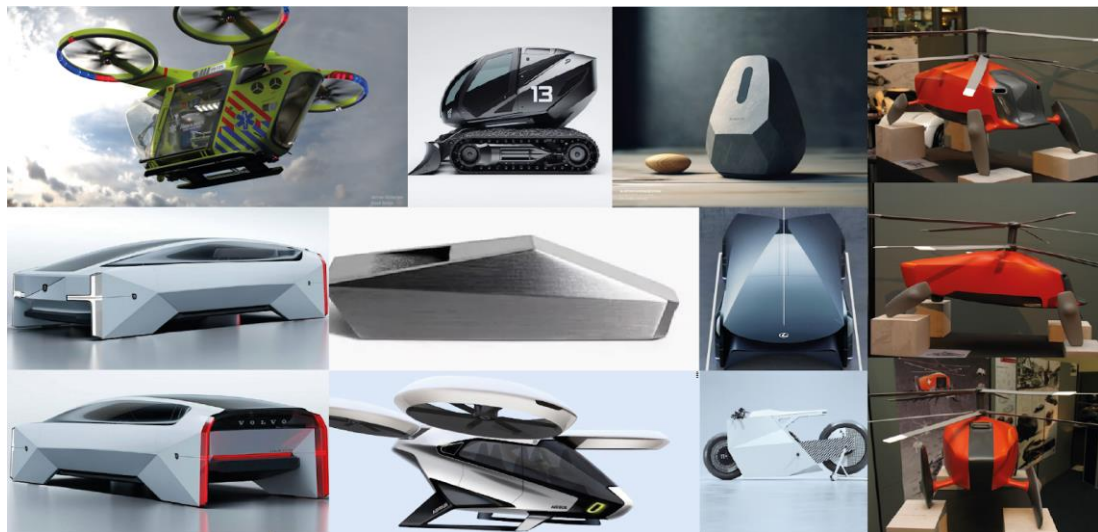


Figure 3. Inspirationboard

4.4.3 Sketching

During the initial stages, the focus was on quantity over quality and exploring variations, with a focus on producing a large number of simple silhouettes to capture potential shapes and forms. These early sketches were intentionally kept minimalistic, focusing on broad outlines and overall proportions rather than detailed features.

As the design process progressed, the sketches became more complex. In the later stages, different silhouettes were combined, such as integrating front and side views, to create more accurate and cohesive representations of the design. This approach allowed for a more comprehensive exploration of the design space, enabling the improvement of concepts and the identification of the most promising directions.

The most highlighted silhouettes sketches of various shapes from the initial sketch phase can be seen in figure 4. The whole selection of early sketches is presented in appendix A.

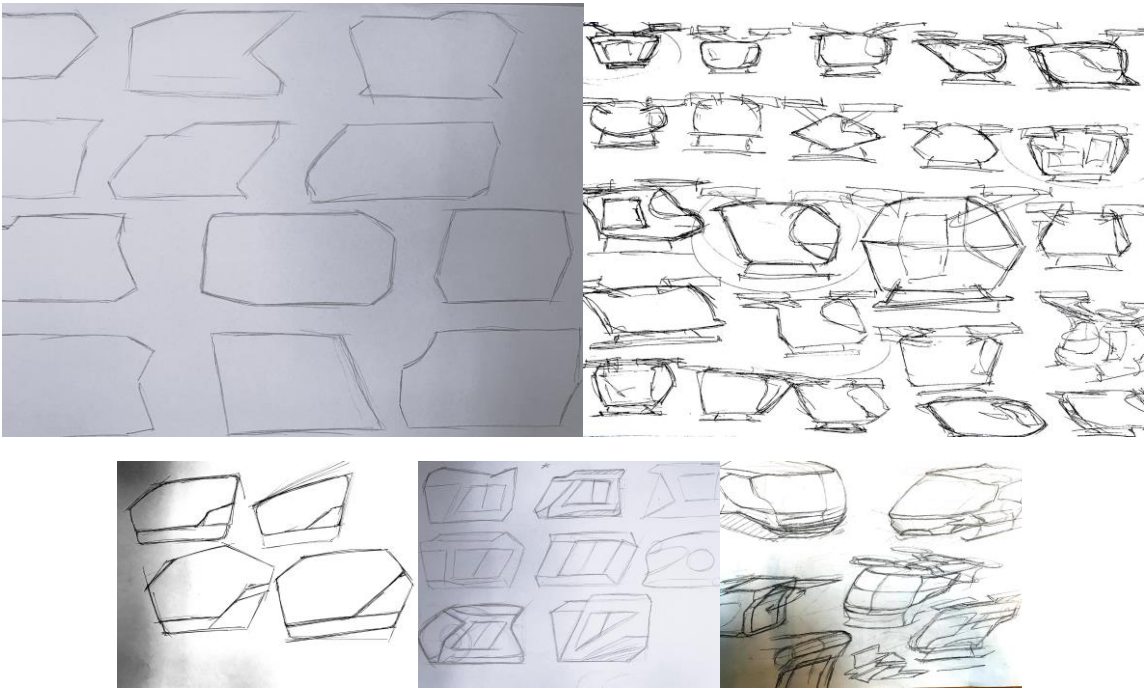


Figure 4. A selection of the initial sketching phase

Throughout the project, particularly in the early stages involving rough sketches, AI tools were used to enhance the quality of the visual concepts. This was achieved by prompting the AI to create more realistic renditions of the sketches using inputs such as “make this sketch into a real vehicle” or “improve this sketch; make it realistic.” To further improve the results, additional AI tools were used to generate more refined prompts, leading to higher-quality output. These more realistic visualizations made the concepts feel more tangible, enabling direct comparisons between them as if they were real vehicles. This not only improved the design evaluation process but also sparked new ideas and facilitated deeper discussions

A selection of the sketches that were turned into life early in the process with the help of AI refinement, see figure 5. This made the process more efficient as it gave the ideas more definition and by that also more elements to discuss.



Figure 5. Some sketches developed through AI

Concept generation 1 - sketching

The result of the primary concept generation is shown in figure 6. Three concepts with different approaches were made to keep the possibility to merge and mix different ideas. Windows and doors on these concepts are placed without any real considerations during this phase, only included to serve a proportional purpose and create the feeling of an actual exterior.

Concept 1 was created to challenge the idea of creating direction in the shape. The shape is symmetrical, with a negative angle that narrows down to the floor. The positive aspect of concept 1 is that it would provide the opportunity for great visibility out from the vehicle, with the possibility to look down. On the negative, this type of angle creates more space in the ceiling, which is not as desirable as the area and volume close to floor, which will serve as the operational space inside, decreases.

Moving on to concept 2, it focuses on creating visual illusions while keeping the actual exterior rectangular. The idea was based around volume optimization, while still creating a

unique exterior with a distinct direction supported by the “overhang” on the sides of the body.

Lastly, concept 3 is made working more with sharp edges, taking inspiration from futuristic vehicle concepts. The idea was to make extrusions in the exterior body and angles on the side to create depth and potentially also more space for storage if needed.

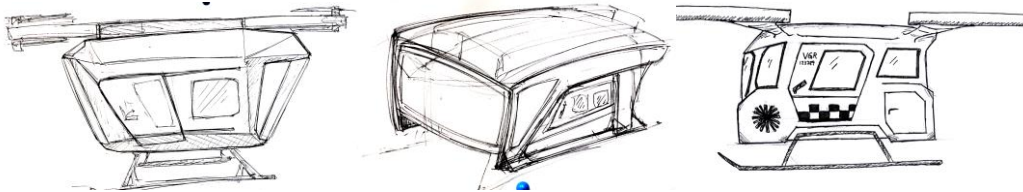


Figure 6. The 3 primary concepts (1-3 reading from the left) based on the created sketches

What was considered similar with all three concepts was how the design was fixed, and to some extent also limited to the idea that the shape needs to be closely related to a rectangular box in order to fulfil functional requirements, such as providing enough space for the interior.

4.4.4 Digital prototyping concepts 1

Once the initial rough sketches were completed, the design process continued to digital prototyping and modeling using different CAD softwares. sculpting tools with less focus on measurements but form and shape, making the process quick, but also later with the help of more precise class-A modelling tools. These tools were used to create more accurate visual representations of the design, enabling a better understanding of the shape, form, and overall aesthetics. 3D modeling provided several advantages:

1. **Multi-Angle Visualization:** The ability to view the design from various perspectives helped in assessing proportions, ergonomics, and overall coherence.
2. **Material and Texture Application:** Different materials and textures could be applied to the model, offering a closer approximation of the final product's appearance and feel.
3. **Rapid Iteration:** Changes could be made quickly, allowing for efficient exploration of design alternatives and refinements.

3D modeling was used in parallel with sketching throughout the design process, creating an iterative cycle that enabled the rapid generation and adjustment of ideas and concepts. This approach allowed for the seamless transition between conceptual exploration (through sketching) and more comprehensive visualization (through 3D modeling). By integrating these two methods, it was possible to adjust designs quickly and effectively, ensuring accurate representations of the intended form, function, and aesthetics. The iterative cycle resulted in continuous improvement, as feedback from 3D models could affect further sketches, and vice versa, ultimately leading to an improved and well-considered final design.

Using the three sketch concepts as a basis, three early design concepts were created from the digital prototyping as shown in figure 7. In this stage some simple skids and rotors were added in order to examine how the exterior would fit with the other elements of the aircraft. During this period the work began to look closer into the aspect of how to shape an exterior that leans more towards the aircraft sector, and how the rotors affect the expression of the cabin.



Figure 7. Early design concept from generation 1

These concepts were discussed and evaluated, which resulted in the following adjustments that needed to be made;

- Increase the length to create better proportions and more space inside for the interior
- Put more effort into the front, shaping it more into a nose similar a helicopter
- Start considering the actual placement of doors and windows as it has great influence on the design

Finally, common for all three concepts was the impression that these concepts are not very adapted according to basic aerodynamics. The project does not go into any details on aerodynamics, however common sense and inspiration from other aircraft were taken more into consideration from this point forward to create a more convincing concept.

4.5 The prototyping stage - working hands on

This chapter describes the hands-on work during the process, including the creation of small scale 3D-printed models, but most importantly showcasing the work connected to the creation of the full scaled mock-up of the medical emergency UAM in cardboard.

4.5.1 Small scale prototyping with 3D printing

The 3D printing stage began by making another iteration of digital prototyping, this time by taking the insights from the previous concepts in consideration and focusing on the main body shape. It resulted in two new concepts, see figure 8, this time relatively similar in the overall shape with slightly different angles and fidelity.

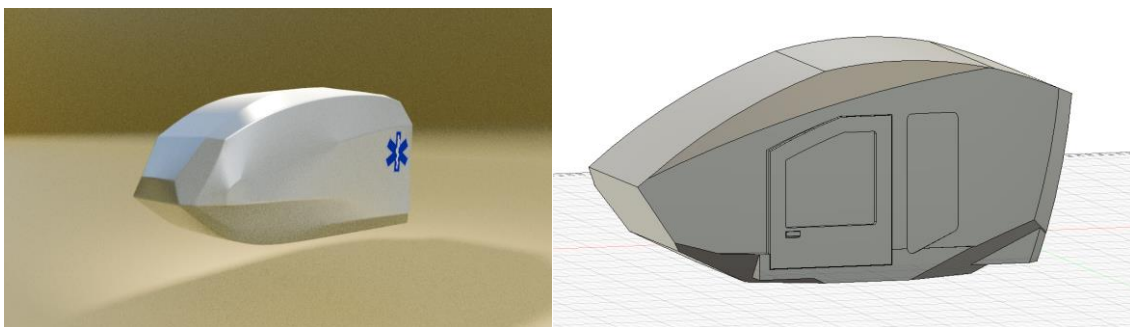


Figure 8. The two 3D-printed concepts

There were two main takeaways from the earlier iterations that shaped these two concepts; Focus on creating a more defined nose, examining how the angle from both the roof and floor of the exterior could connect at the front. Furthermore, these concepts were kept in a more natural state, avoiding adding any unnecessary details such as backgrounds and decals. Those aspects are important and serve a purpose from a holistic perspective but were considered important to avoid during this iteration to understand the main shapes and surface meetings without any distraction.

3D printing and creating a miniature landscape

The concepts shown above were then decided to be 3D-printed in order to get a sense of the volume and expression in real life. Prototypes were created using the 3D CAD models developed in earlier stages, produced on a smaller scale with the help of Fused Deposition Modeling (FDM) printing. These physical prototypes provided a tangible representation of the design, giving a more comprehensive assessment of its proportions, scale, and overall aesthetics. Unlike sketches or digital 3D models, the physical prototypes offered a realistic sense of how the design would look and feel in real life.

To further set the scene and take advantage of the 3D printed models, a simple miniature landscape was built. This approach helped in visualizing the design within its intended environment, providing insights into its functionality and user interaction.

A human on the same scale as the UAM, rotors and skids were also 3D-printed to understand the relation and proportions, see figure 9.

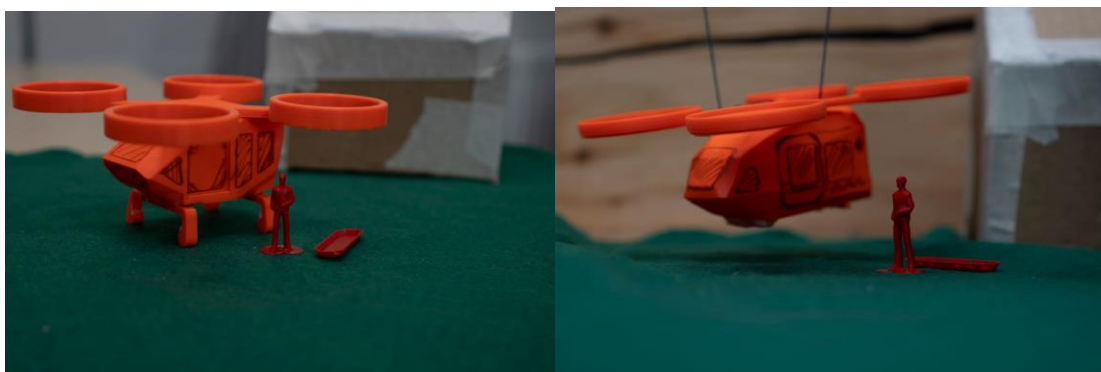


Figure 9. The 3D printed models in a simple miniature landscape

The physical models led to iterative improvements to the shape and form. By combining digital modeling with physical prototyping, the design process became more robust, ensuring that the final product was both aesthetically pleasing and functionally effective.

4.5.2 Building a full scale mock-up of the UAM

A large part of the project was the creation of a 1:1 scaled mock-up of the UAM to understand, evaluate and confirm design decisions. This was a big but valuable activity during the project and done parallel to the other steps of the project, and began during the same period as the 3D-printing.

Preparing and building the platform

Parallel with the explorative design work the 1:1 scale mock-up was built, mainly for two purposes; to guide the design process and create a feeling for size and proportions, but also to create a realistic feeling inside the UAM while conducting user evaluations of the interior and back/side entrances.

The 1:1 mockup was constructed using aluminium structures (flexlink), a modular system that allowed for flexibility and precision in assembly. To design the structure, a detailed blueprint was created using Autodesk Inventor, a CAD software equipped with specialized extensions. These extensions enabled the conversion of a simple 3D sketch into a fully detailed CAD model, complete with accurately sized beams, see figure 10.

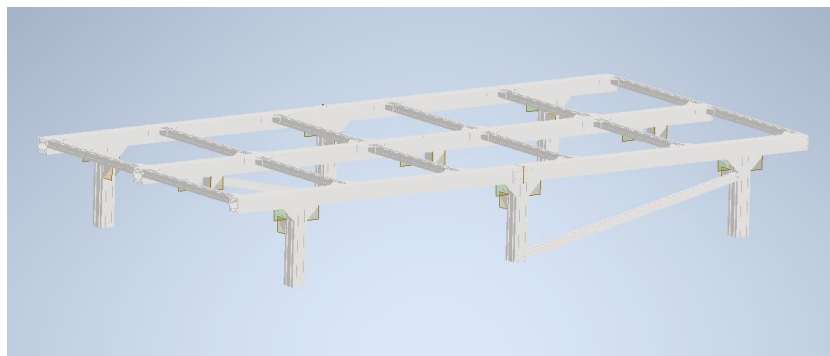


Figure 10. The platform for the 1:1 scale mockup

The finished and built platform can be seen in figure 11. This includes the platform made by flexlinks, and a wooden floor screwed on top of the platform which made it possible to walk and stand on the platform, resembling the actual floor of the UAM. a



Figure 11. The finished platform

Working on the mock-up in parallel with the concept iterations made it possible to try different versions in real-time. The nose was especially important to understand in full size, as there were different opinions regarding the overall shape and specific angles, see figure 12 for different nose variants.

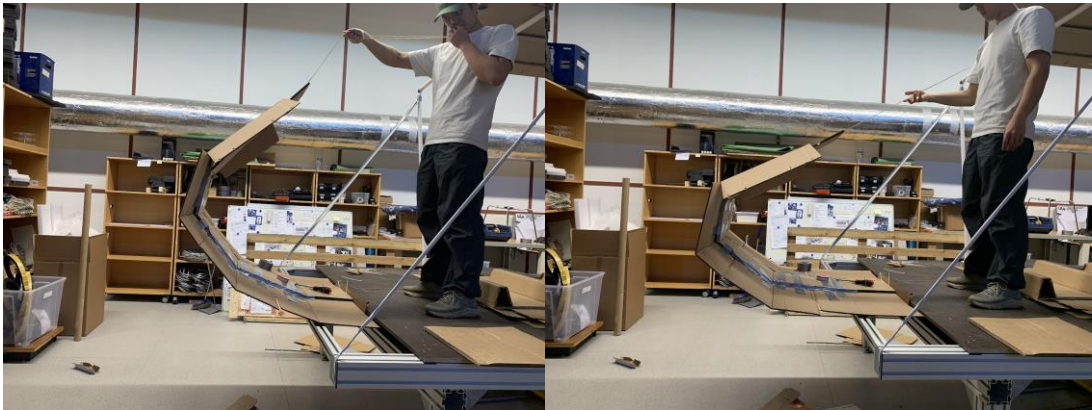


Figure 12. Testing the angle of the nose

The final mock-up can be seen in figure 13 and 14, showcasing the full volume of the UAM, with cut-outs for entrances on the sides, in the back and also for the large window in the front to examine the visibility from the inside.



Figure 13. Cut out of entrance at the back



Figure 14. Front view of the finished mock-up

4.6 Concept development and decision making

With new insights from the 1:1 mock-up creation, the 3D-printing and a more defined requirement list with a closer collaboration with the interior design team, the concept development started to get closer to a potential final exterior concept.

4.4.1 3D modelled concepts V2

Parallel to the creation of the 1:1 scaled mock-up the exterior design continued to develop with more accurate digital prototyping. It resulted in two slightly different concepts as seen in figure 15, with the main difference being the angle of the nose and window design and placement. These concepts were considered suitable to start collaborating closer with the interior team and looking closer on functional elements.

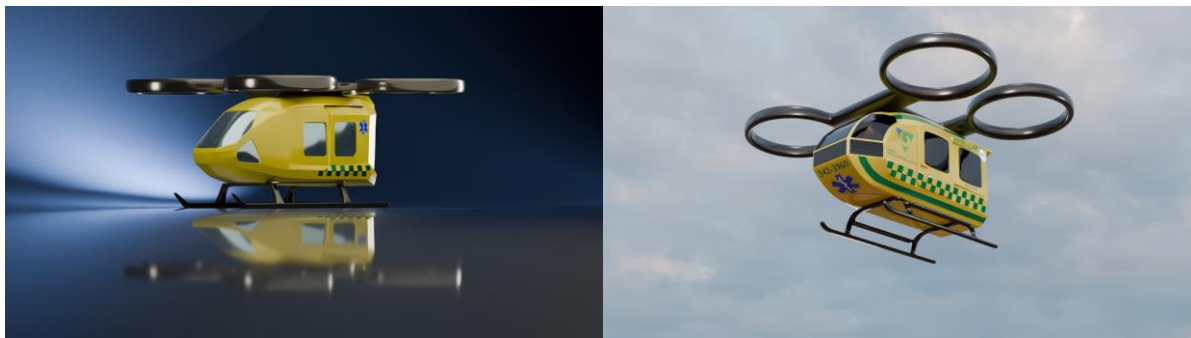


Figure 15. The two concepts close to the design freeze

4.4.2 Integration with the results from the interior design team

During the work on the exterior of the UAM, a close collaboration with the interior design team was held throughout the project, and the importance of it became even more evident when starting to define the final solutions. While arriving closer to the design freeze deadline it was considered necessary to merge and test the work from both teams in order to align ideas, dimensions and requirements. This would also facilitate the final design for both teams, having a better idea in which direction the teams are heading towards.

A first merge of the work between exterior and interior is shown in figure 16. The overall impression by both teams was that it was looking feasible. The width and height was determined before-hand and worked well, with the interior fitting inside the exterior. The

main concerns however was the placement of the side doors and windows, as it influenced how and where the interior team could place storage and equipment for the actual workspace.



Figure 16. First iteration of merging the work between exterior and interior

4.4.3 Functional decisions

During this stage of the project it was also decided a necessity to determine what type of functional solutions to go for. This specifically concerns the entrances with corresponding door types, and the windows of UAM as these elements are crucial both for the exterior and the interior.

Selecting the door solutions for the entrances

The selection of doors for the UAM design was conducted using a systematic comparison approach. A decision matrix was created to evaluate and compare different door types based on their mechanical properties. The door alternatives included swing doors, trunk doors, and other potential mechanisms. Each door type was listed in a row, with its corresponding advantages (pros) and disadvantages (cons) detailed underneath, see figure 17. Two separate matrices were used, for side and back door, as the requirements and use-cases for the entrances differed.

This structured approach allowed for a clear comparison of the mechanical properties, functionality, and potential trade-offs of each door type. By analyzing the pros and cons of

each alternative, it was possible to identify the most suitable door design for the UAM, considering factors such as ergonomics, safety, and aesthetic integration.

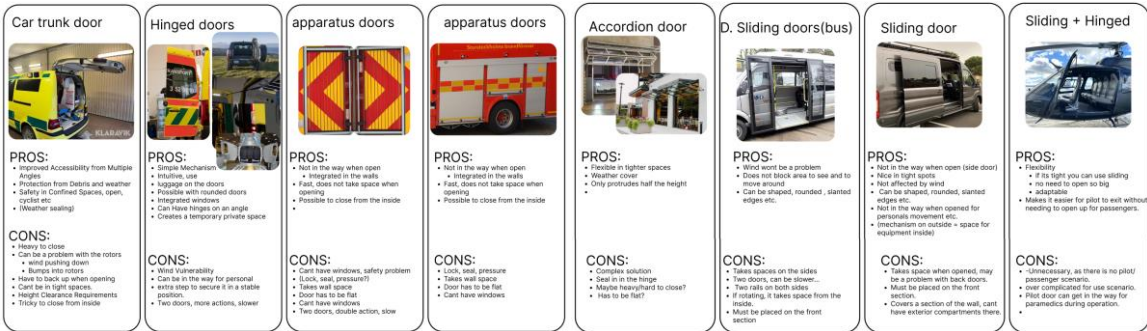


Figure 17. Structure of the comparison matrix

On the side entrances of the UAM, traditional sliding doors were selected to provide fast and smooth access to the interior, important in the work of the ambulance personnel. The sliding door will be guided by two rails attached on the sides of the exterior.

On the back of the UAM, where the stretcher is supposed to be inserted/taken out, it was decided to take inspiration from the car industry and create a solution similar to a trunk door. This is supported by primarily these arguments; already existing technology can be used to open/close the trunk door automatically from a distance. While open, it provides protection during unstable weather conditions, and lastly it does not affect the working space around the UAM vehicle which facilitates the work for the ambulance personnel. Final dimensions and design of the doors will be presented with the final exterior concept.

4.4.4 Concept refinement (AI)

AI tools and software were used to further define and add a sense of realism to the newly updated concepts, see figure 18. More iterations of the AI refinement are located in Appendix B. The tool has the ability to refine and adjust already rendered pictures by inserting prompts, suitable in this case. The prompts used in this phase were simple and clear, not affecting overall design or shape, but rather defining and adding a sense of realism to surfaces, the rotors and background.



Figure 18. The concepts refined through AI

The AI refined rendering at the bottom were then decided as the preliminary final concept, to be used as a guideline when moving on to the final and detailed concept creation, as it was the most in line with desired nose design.

4.4.5 Surface modeling

With the preliminary final concept developed and the requirements gathered in earlier stages, the next step was to integrate the conceptual design with specific hard requirements, such as dimensions for doors, windows, steps, and more. This process was carried out using a CAD program that offered higher precision compared to earlier 3D modeling tools, which had been more similar to modeling clay without the ability to define exact measurements. At this stage, key components were assigned strict dimensions to ensure accuracy and alignment with design specifications.

For design elements and decisions that did not have specific or strict requirements, and which had no significant impact on functionality or operational use, the main references were the AI renderings, the mood board, and the overall goal of conveying safety and trust. These elements included, for example, the detailing on the front, back, and sides of the vehicle, the angularity of the front, and the general shape of the rear bumper. Evaluating, discussing, and reflecting on every individual design decision, to find the optimal shape, etc, would have been extremely time-consuming and, therefore, was not feasible.

With the final CAD model, featuring realistic and accurate dimensions, completed, it became possible to apply materials, colors, and graphics in accordance with Swedish ambulance regulations. This enabled the creation of realistic and representative renderings using rendering software, reflecting the intended outcome. The model was placed in various environments, such as urban and rural settings, to create contextually accurate visual representations. Additionally, renders from different angles were produced to highlight important design features.

6. The result of the final exterior concept

In the following chapter the final design of the exterior design concept will be presented, including the final CAD-model and renditions of how a potential integration into the Swedish emergency sector could look like in different settings. Important to note is that the skids and rotors have been designed and added for visualization and proportional purposes.

6.1 Finished CAD model of the cabin exterior

The final stage of the projects was to move on to more detailed CAD-modeling in order to create realistic surfaces, surface meetings and fillets. As reference throughout the CAD-modelling the preliminary concept was used to. This was done to achieve one of the main deliverables of the project; to create detailed and realistic renderings of the final exterior concept of the UAM.

The exterior

The front of the UAM has less restrictions to be volume optimized as space for the medical operations will take place in the back of the UAM. Additionally, there will not be a traditional cockpit with pilots, but rather a dashboard with emergency controls. This allows for a nose, similar to a helicopter that expresses the direction of the vehicle, see figure 19. An important integration was the front windshield and complementary side windows. This allows for light intake, as well as great vision for the ambulance personnel.

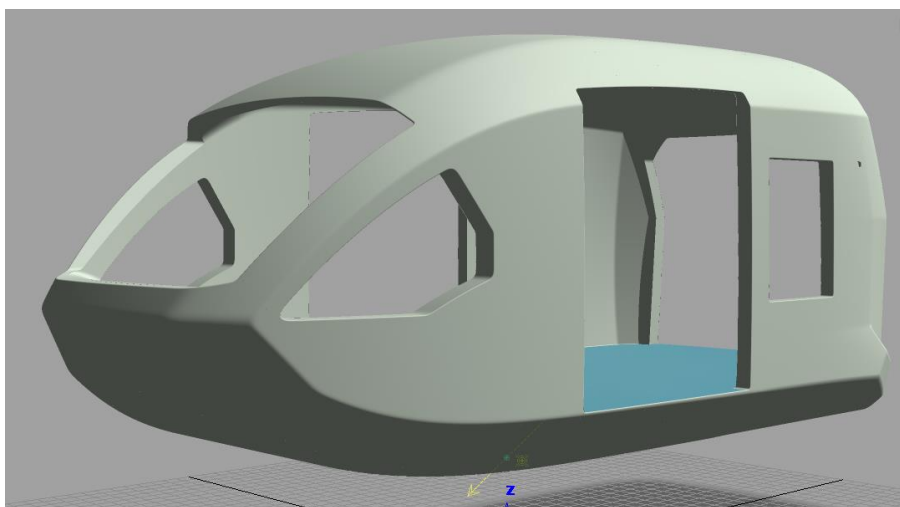


Figure 19. The front

The back is designed largely around the back entrance as it is important for the usage of the UAM and the interior group. To highlight this, the back of the body narrows with the help of a chamfer. The spoiler and the rear bumper are design elements with inspiration from the car industry, creating familiarity and serving a functional and aesthetic purpose to avoid the feeling of a “cut-off” helicopter, as there is no tail on the UAM, see figure 20.

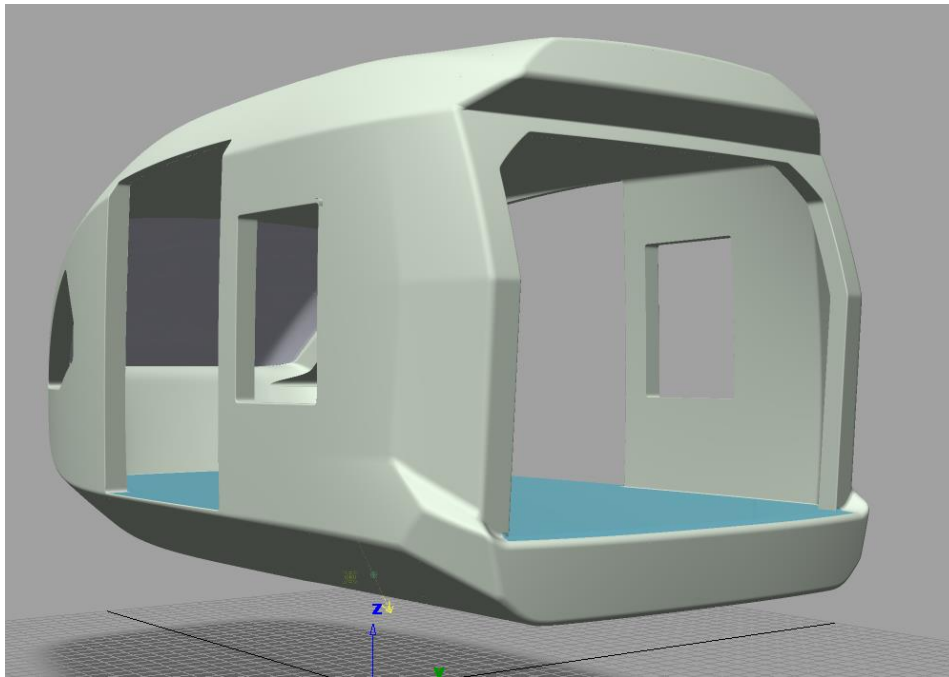


Figure 20. The back

6.2 Insights from ambulance personnel

The interior team coordinated an evaluation and user-test meeting with ambulance personnel during the closing stages of the project. The structure of the occasion was divided into two main parts. Firstly, an open discussion was held in a meeting room where the design concepts from exterior and interior could be evaluated. The other half of the evaluation took place in the lab where the 1:1 cardboard mock-up was located. Here, some exterior elements such as entrances, footsteps and windows could be discussed, but the focus was on the interior design as it is the main focus of the ambulance personnel. During the presentation of the exterior design the following pictures were shown, see figure 21. It included, apart from the exterior of the cabin, the skids, the rotors and a model of a human placed beside the vehicle. The skids and rotors were added to give the participants a better idea of the completed UAM, and how

the different elements would merge. The human, which in these pictures is 180 cm tall, was added as a reference to understand the real-life size of the UAM better.

The insights were considered positive overall. They could all see themselves working inside this type of exterior, as long as the technical aspects of the vehicle were working correctly. The slide door was considered as the optimal solution for the side entrances as it is a quick and reliable way to get in and out of a vehicle, like already existing solutions on road ambulances and ambulance helicopters.



Figure 21. One of the pictures of the UAM shown during open discussion

6.3 Final renderings in potential real-life settings

With the finished exterior of the UAM in place, the work with creating realistic and detailed renderings of the designed UAM began. Details were added to the exterior body in order to turn the shell into a convincing and realistic concept. The rendering software is designed for the vehicle industry and connected to the surface modelling software which was used, suitable for the application of this project.

The final livery of the medical emergency UAM was lastly defined as shown in figure 22. This is crucial in order for the UAM to fit into the current Ambulance vehicle family and alert the public what kind of purpose the UAM serves. The livery is primarily based on the

regulations from Socialstyrelsen as mentioned earlier concerning the yellow paint, the green rectangular pattern and the ambulance-related symbols. The placement and size of the elements is chosen to enhance familiarity and create a visual balance that fits the overall expression of the UAM.



Figure 22. Final livery on the exterior of the UAM

The Silhouette

The side view of the UAM can be seen in figure 23, showcasing how the silhouette of the cabin connects with the other elements of the vehicle.



Figure 23. Side View of the UAM in a remote environment

The entrances and door solutions

The final design of the UAM incorporates two types of doors based on functional and operational requirements. On each side of the UAM, traditional sliding doors were selected to provide rapid and unobstructed access for ambulance personnel. Dimensions for the side doors being 120 cm in width and 145 cm in height. These doors will be guided by two external rails and have dimensions as detailed below.

At the rear of the UAM, a single trunk-style door was chosen to accommodate stretcher loading and unloading. This configuration allows for automated opening and closing and provides overhead shelter during inclement weather. The trunk door also ensures that the working area behind the vehicle remains unobstructed. Dimensions for the trunk door being and entrance being 160 cm in width and 145 cm in height. The back door and side door will be presented in the following figures 24 and 25.



Figure 24. Entrance at the back with trunk door solution.



Figure 25. Entrance on the sides with sliding door solution

Windows and Footsteps

Integrated in the exterior and the doors a total of 8 windows were determined necessary and appropriate for the usage of the emergency UAM. The 8 windows are allocated as follows;

1 large windshield in the front

3 windows on each side of the UAM (6 in total), 1 connected to the front windshield, one located on the side door and 1 located directly behind the side door.

1 window integrated into the trunk door at the back.

Some of the windows serve as more than just providing vision out from the UAM and providing the interior with sunlight. The side windows on the side door and the window located directly behind it also serve as emergency windows, crucial to ensure the safety of ambulance personnel in case something goes wrong.

Connected to the entrances it was regarded as a necessity to integrate a footstep. This is already an existing solution on the ambulance helicopter used today, important in order for the ambulance personnel to quickly and safely enter and exit the aircraft. The distance between the ground and the floor of the UAM is 80cm, which is why the footsteps are placed 40 cm above the ground to create equal distance between the steps.

The emergency UAM flying in remote and urban environment

To emphasize the idea of the UAM being able to operate both in remote and urban environments, the UAM was put into the respective locations, see figure 26 and 27.



Figure 26. Landing in Urban environment



Figure 27. Landing in remote environment

Adding context

Lastly, a few mannequins were added to further put the UAM into a context, see figure 28 and 29.



Figure 28. UAM in an active scenario 1



Figure 29. UAM in an active scenario 2

7. Discussion

This chapter looks into the outcomes of the project, assessing its successes, limitations, and areas for future improvement. The discussion begins with a summary of key findings, followed by an interpretation of results, focusing on how well the design meets the aim of the project. Finally, it reflects on the project's scope, process, key learnings, and finally insights for future development.

Summary of Key Findings

This project has resulted in the initial exterior design of a medical emergency UAM (Urban Air Mobility vehicle), forming a solid basis for further development and refinement. The work bridges the gap between a conceptual idea and a future operational UAM.

The design process was informed by a combination of preliminary research, operational and technical requirements, scenario development, user studies, and field observations, providing a comprehensive understanding of the challenges involved in designing a medical emergency UAM. Based on this groundwork, the first concept was 3D modeled using Class-A surfacing software, offering a realistic visual representation of the intended final product.

Although the project aimed to place equal importance on aesthetic design, aiming to encourage public trust and acceptance for smoother societal integration, this objective could not be fully realized within the project's time constraints. It was determined that operational needs should come first at this stage. While aesthetic considerations remained an underlying factor, they were assigned lower priority. As a result, functional and practical requirements played a dominant role in shaping the final design.

Interpretation of Results

Since the design was primarily guided by operational requirements, it effectively meets those needs, as confirmed by paramedics through interviews, concept showcases, and user studies involving interaction with a full-scale 1:1 mockup, taking into consideration at what stage this concept is. However, when it comes to evaluating the aesthetic design, particularly whether it conveys a sense of safety and trustworthiness, the project lacks supporting evidence. This is partly because aesthetics were given lower priority during the design phase, and partly due to the absence of dedicated evaluations such as targeted user studies.

Nonetheless, it is still possible to discuss and reflect on this aspect. The following section will explore how the current concept might be perceived by the public and identify design elements that could be important in encouraging public trust in future iterations.

The current concept shares several visual elements with existing medical emergency vehicles, such as color schemes, patterns, and decals. These design choices are intended to align with the public's mental model of a medical vehicle, helping the UAM feel more familiar and naturally integrated into the urban environment.

However, the overall shape of the UAM presents a greater challenge. Currently, there are no widely recognized aerial vehicles operating in urban airspace, making this concept unfamiliar and potentially prompting public skepticism. To address this, the UAM's form draws inspiration from familiar flying vehicles, such as helicopters and airplanes, as well as general vehicle design. These influences are evident in the pointed, rounded front section and the rear with its angular shape. The goal is that by incorporating recognizable aerodynamic features, the design will subconsciously convey a sense of capability and safety. Familiarity with these established forms, already well-integrated into society, may help reassure the public that the UAM is equally trustworthy and not something to be feared.

The exterior design of the UAM can be broken down into several distinct elements, each with deliberate decisions made throughout the design process. These decisions were consistently guided by core values such as safety and trust. While individually discussing each design element may not yield significant insight at this stage, the concept's strongest asset lies in its visual familiarity with existing emergency vehicles—as previously discussed. This familiarity is likely what would support smoother societal integration today.

For future iterations, where there is greater opportunity to refine the aesthetic aspects, several key visual attributes should be explored and optimized. The UAM's form, color, and detailing will all play crucial roles in shaping public perception. Visual qualities such as symmetry, curvature, simplicity, color, and prototypicality, (just to name a few), are known to evoke instinctive emotional and cognitive responses (Bar & Neta, 2007; Reber et al., 2004). These elements can be studied individually, but they are all part of a broader framework: semiotics, the study of how visual forms communicate meaning.

In simple terms, the question becomes: Does the UAM visually signify its intended purpose? As Monö (1997) describes it, this is about “functional clarity”, whether the design clearly

communicates its function. A medical emergency UAM must signify that it is safe to fly, capable of navigating urban airspace without causing harm, and able to transport patients swiftly and reliably. These messages should be embedded not only in the overall shape but also in finer details—such as sturdy landing skids, rotor protection, and structural components that suggest strength and control.

For future development, it is essential to ensure that the UAM communicates and reinforces messages of safety and trust through every aspect of its design, from its silhouette down to the smallest bolts and fittings.

Project Scope & Process Reflection

From the outset, this project's scope proved extensive, as evidenced by the diverse range of outcomes achieved throughout its duration. The process involved substantial research, including interviews, field observations, and user studies, each requiring careful preparation, execution, and analysis. The ideation phase employed multiple approaches: Traditional pen-and-paper sketching, physical mockups, to digital tools for 3D modeling. Design decisions continuously balanced technical constraints with stakeholder needs, both internal and external. Many project stages contained enough depth to be standalone projects, though here they remained in early-phase development.

Key Learnings:

- **Process Structure:** A project of this scale could benefit from a more rigid framework with clear milestones, creating a better trail of decisions and outcomes.
- **Focused Exploration:** Targeted research in specific areas could have increased efficiency and direction.
- **Flexibility vs. Creativity:** While the open-ended approach likely led to creativity, it came at the cost of prioritization, some phases (like constructing the 1:1 mockup platform) received disproportionate effort. Future iterations should emphasize rapid prototyping ("quick and dirty") within a more defined plan.

The project's ambiguous end goals required flexibility, making structured planning challenging in practice. While a more structured process might have yielded different results, the exploratory nature did facilitate creative solutions across multiple mediums.

Conclusion

In conclusion, this project has established a comprehensive exterior design foundation for a new class of medical emergency vehicles, serving as a basis for future development. The proposed concept has been visualized through detailed 3D renderings, providing a practical starting point for further exploration. While the 3D model presents a near-finalized design, significant testing, evaluation, and refinement remain necessary before a deployable vehicle can be realized. Future research should focus on constructing a physical prototype based on this concept, enabling real-world testing and performance assessment to advance toward a functional emergency medical vehicle.

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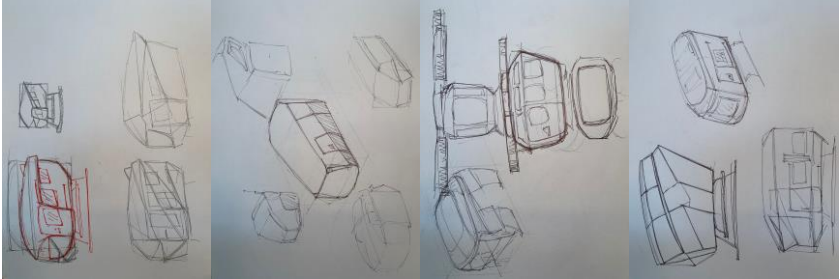
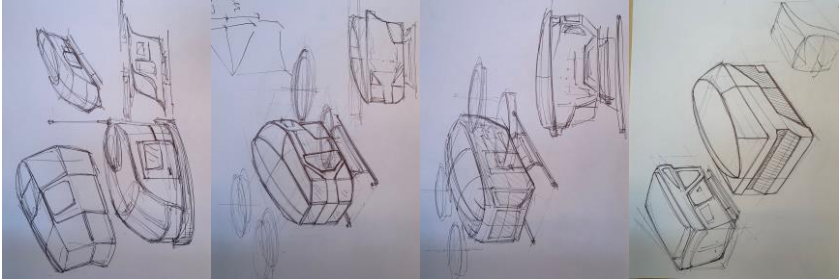
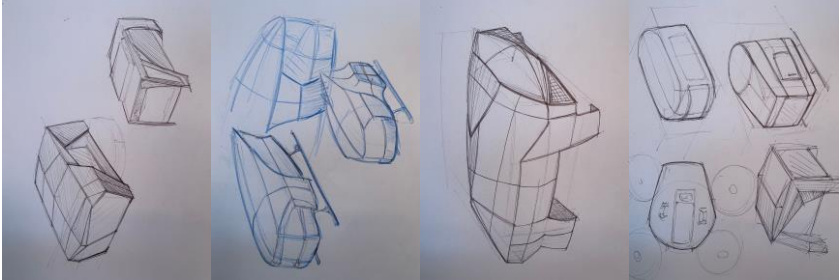
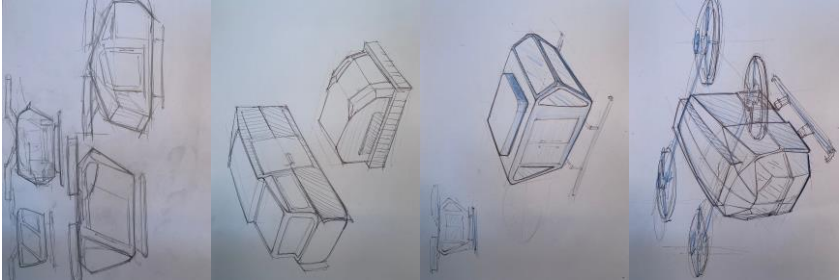
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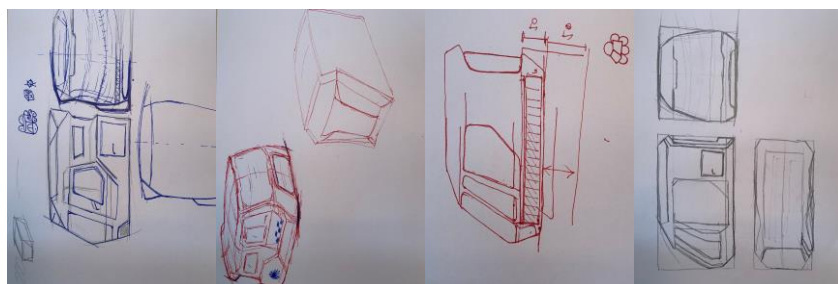
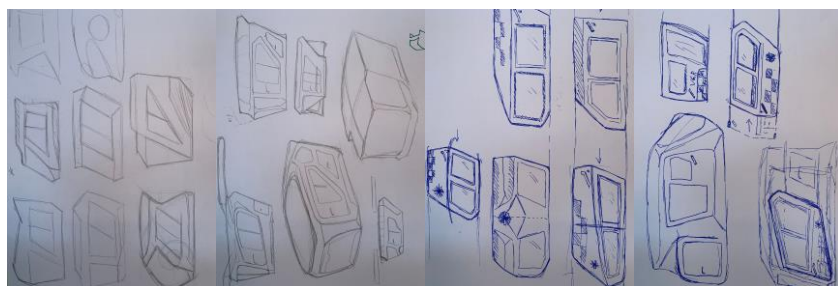
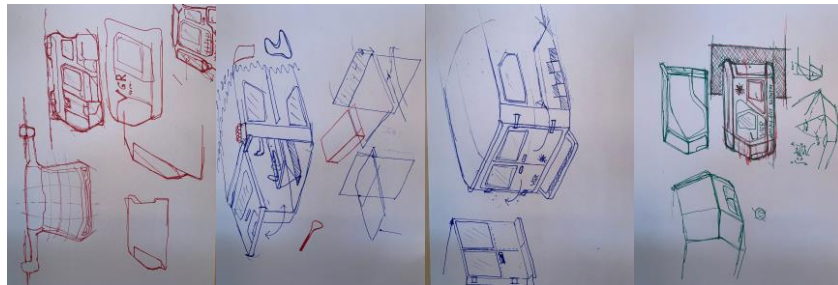
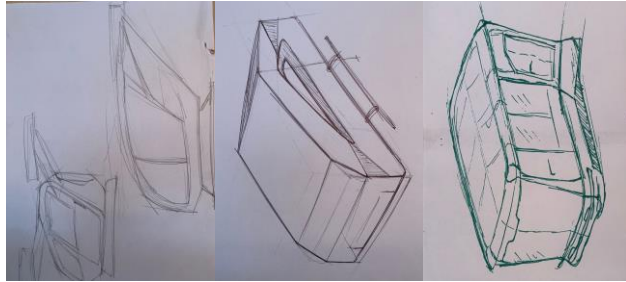
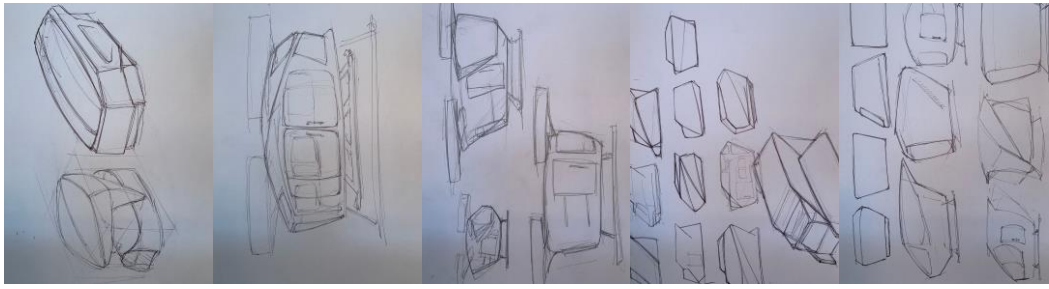
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Appendix

Appendix A - a selection of the sketches throughout the project.





Appendix B - A selection of renditions that has been refined with the help of AI.



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