



**EMBRAER
HUMANITARIAN
AIR
SERVICE**

**DESIGNING A PRODUCT-
SERVICE ECOSYSTEM IN
HUMANITARIAN AID.**

Master Thesis - Integrated Product Design
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DESIGNING A PRODUCT-SERVICE ECOSYSTEM IN HUMANITARIAN AID.

Utilizing eVTOL vehicles in Immunization Programs for
East Africa.

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PREFACE

Urban Air Mobility (UAM) has been on my radar ever since I started my Master: it incorporate my aerospace background; the market is still in its initial state which gives space for latent opportunities; and I will be able to apply my design skills to create original vehicles. Now, I do want to contribute to society by bringing necessary solutions to problems that are yet to be explored. The medical field is broad and has identified issues that can be solved using an update of support vehicles, especially in regions where resources and infrastructures are scarce.

With knowledge and methods acquired from my previous projects, which were specifically concerning UAM solutions, my goal is to create a beneficial and desirable system that focuses on the less fortunate. It would allow me to become a more responsible and supporting designer, while still fulfilling profitable ambitions. Working in cooperation with Embraer enables me to reach a certain professional standard that supports the feasibility of my idea, and would allow me to understand the inner working of a company with such a significant reputation.

It is not everyday that you find the will of creating a solution for issues that have been omnipresent since the beginning of the modern era of humanitarian aid. But, envisioning the potential benefits and the evolution of such idea allows us to look further than the obvious context, and dive us into the unknown. Technological innovations are essential to improve the effectivity of helping those in needs, especially in a world that tends to ameliorate the contentment of those already in comfort.

Ever since the start of the project, I have been gradually submerged in the humanitarian community, noticing the baffling amount of issues that occur everyday without our knowledge. The role of humanitarian organizations seemed rather vague, and not observing first-hand the amount of work that is carried out in the areas of operation leaves us in the dark. Although, by reading, listening and being involved, I finally understood the importance of their impact. I might not currently have much influence on the matter, but it might spark an ambition for the future.

“The destiny of world civilization depends upon providing a decent standard of living for all mankind.”

Norman Borlaug

EXECUTIVE SUMMARY

Research has taught us that a colossal amount of people do not have access to basic health care. In order to reach the unreachable, humanitarian organizations assemble medical units that provide health service to the most outreach communities. Although, these units experience numerous challenges and drawbacks when it comes to traveling, questioning the effectivity and efficient of such operations. With advancement in new air mobility solutions, it is investigated whether it is time to push forward technological improvements in the humanitarian sector and allow the penetration of major aerospace companies in its market.

Using a linear design approach, further research is carried out to gain knowledge on the potential gaps in the humanitarian market and narrow down the project's mission.

The project focuses on designing a product-service that permits the immunization of remote communities by avoiding the obstacles of the current methods of transportation, and setting a new path in humanitarian aid. In collaboration with Embraer S.A., the product is based on the latest EVE eVTOL vehicle and has been adapted to fulfill the needs on the field. Equipped with supportive equipment and an integrated auxiliary station system, the vehicle provides a resource for the structuring of a service that puts immunization programs

at its core. The service, known as Embraer Humanitarian Air Service (EHAS), is initiated in Kenya where its implementation is projected and planned to reach new heights. With well defined operation planning, business logistics and financial projection, the project demonstrates the potential of using eVTOL solutions in humanitarian aid, and defines a possible course to achieve profitability.

Recommendations are mapped to give a possible procedure for the client to follow in order to fulfill the vision settled. The product-service is established in a conceptual level and to reach a viable market-potential solution, additional stages are required to dive into the details, and specifically fit the legal and societal requirements. With the idea projected to be implemented around 2026, it highly desired to have improvements in the performance of the current eVTOL vehicles and it is envisioned that by then, humanitarian initiatives will attract the attention of the next generation traffic system.

EHAS is just the beginning of a brave new world, where luxury is not reserved for the fortunate.

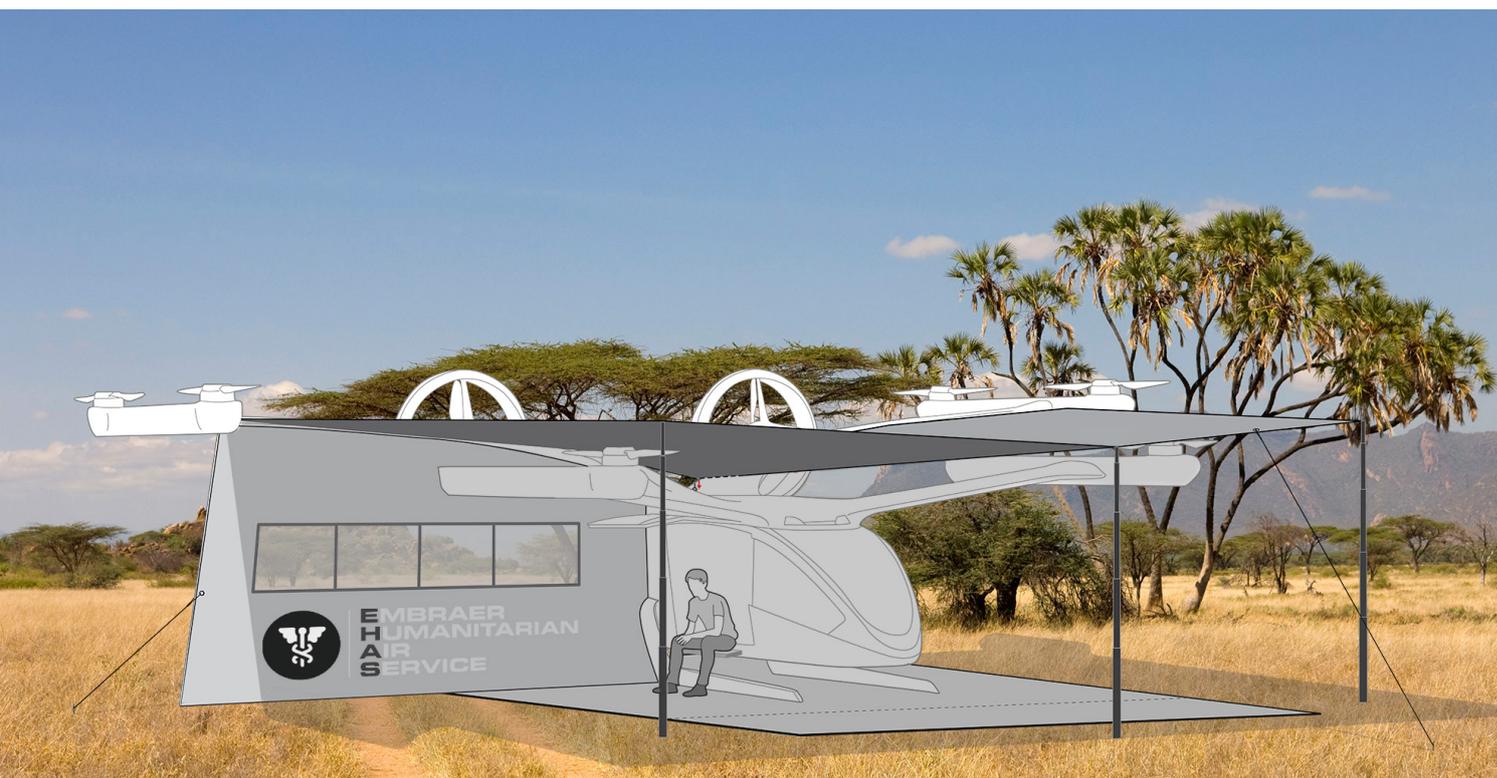


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INTRODUCING THE PROJECT

Throughout this section, the essence of the project brief is laid out, providing a concise description of the context and design direction. Then, a design approach will follow, characterizing the process used throughout the project.

A MASSAI'S WELCOME

The helicopter crew is getting greeted by Maasais, an ethnic group inhabiting Northern, Central and Southern Kenya, and Northern Tanzania.

Photographed by: Mohammed Hersi [1]



DESIGN BRIEF

The demand for humanitarian aid is constantly growing, originating from the increasing number of natural and man-made disasters. Triggering suffering into people's lives around the world, humanitarian aid organizations are at a stand point where the need of innovative solutions for complex crises becomes crucial. These organizations, such as Medecins Sans Frontières or Red Cross, have operations in third world countries that assure the health of people in need. Two main operations are in the scope of the graduation project: mobile treatment, designating teams to move around, raising awareness of diseases, and providing free testing and treatment for people in need; and emergency response, supporting the local medical staff with immediate help of victims of disasters and conflicts.

One of the biggest challenges MSF faces is getting medical care to those that need it the most: those living in remote, insecure areas with little or no health care access; whether it is because of seasonal rains that flood roads or active armed conflict that forces people to leave their homes. Due to these limitations, the numbers of missions are still low and the number of people in need for treatment is rising. With the lack of roads and limitations of the terrain vehicles, organizing mobile treatment missions without the spending of a high amount of resources (e.g. people, money and time) becomes a challenge.

Technologically speaking, an opportunity presents itself by replacing the current vehicles (cars & trucks) with air mobility solutions (eVTOL vehicles). With the fast advancing propulsion and power train technologies, the range and lift power of the air mobility solutions increases. This allows for a more efficient, effective and determined method of transportation that does not take into account the limitations of the current approach.

Nevertheless, replacing terrain vehicles with air mobility solutions defines a big switch. Understanding the user as well as the local cultures, the governmental bodies and airspace organizations is needed to simplify the integration of the new solutions, bringing a sense of safety and ease to the patients. Acceptability is a big issue to cover in order to improve the success of the implementation of the new technology.

In terms of potential profitability, Medecins Sans Frontières spends an annual budget of its emergency and medical programs of approximately \$360 million (including transportation - which defines the operation, maintenance and update of current vehicles). The longer the operations last, the more resources are spent, and using eVTOL vehicles to replace the current methods of transportation would not only be cost-effective but would also shorten the duration required for a mission and improve its effectivity. Although, as MSF is an NGOs, showing the benefits of replacing (or at least supporting) their current vehicles with an eVTOL product-service system becomes an important matter.

EmbraerX's EVE concept vehicle offers a benchmark that would allow us to determine the feasibility, desirability, and viability of such usage of eVTOL solutions in the humanitarian sector. It grants us the possibility of focusing on the adaptation of the vehicle, and structuring of the service in a conceptual level, without the need of designing a product from scratch. It is important to note though that due to EVE's design being focused on urban use, some of its subsystems are potentially not fit for the harsh environments that may occur in Africa (e.g. dust impact on the rotors, or gravel damage on the structure). Nevertheless, this is out of the project's scope and we assume that the vehicle can operate anyway. The eVTOL solution allows to disregard the lack of roads and infrastructure, the inaccessibility of regions due to flooding, and can be in location much faster than terrain vehicles.

DESIGN APPROACH

Throughout the project brief, the general topic to be covered was chosen, taking into account the ambitions of both the client - Embraer S.A., and the author. Throughout the project, we aim on solving a latent issue with EVE's concept vehicle as foundation. Due to the novelty of the technology, and its current demonstration phase, the thesis provides a solution that is developed to a conceptual level. To simplify the theme choice, it is decided to limit ourselves to the humanitarian sector, fulfilling both the sustainable and personal goals.

The thesis follows the 'candy' approach, an iterated version of the traditional 'double diamond' method which is shown below. It follows the Discover-Define-Develop-Deliver model nonetheless, but is modified to take into account the unknown starting point and the potential continuation after delivering the solution. It allows us to take a step back from designing the details, and solving the problematic on a meta-level. It is important to know that this process is not necessarily linear, and new insights provided through decision making or interviews could potentially lead to design iterations.

RESEARCH

The research phase includes two stages: discover and define. The discover is a converging stage that aims at narrowing down the potential topic for the project. It is distinctive from the traditional 'double diamond' method as in our case, the topic has not been settled. From the client's perspective, any issue that would relate to a sustainable solution founded on the available

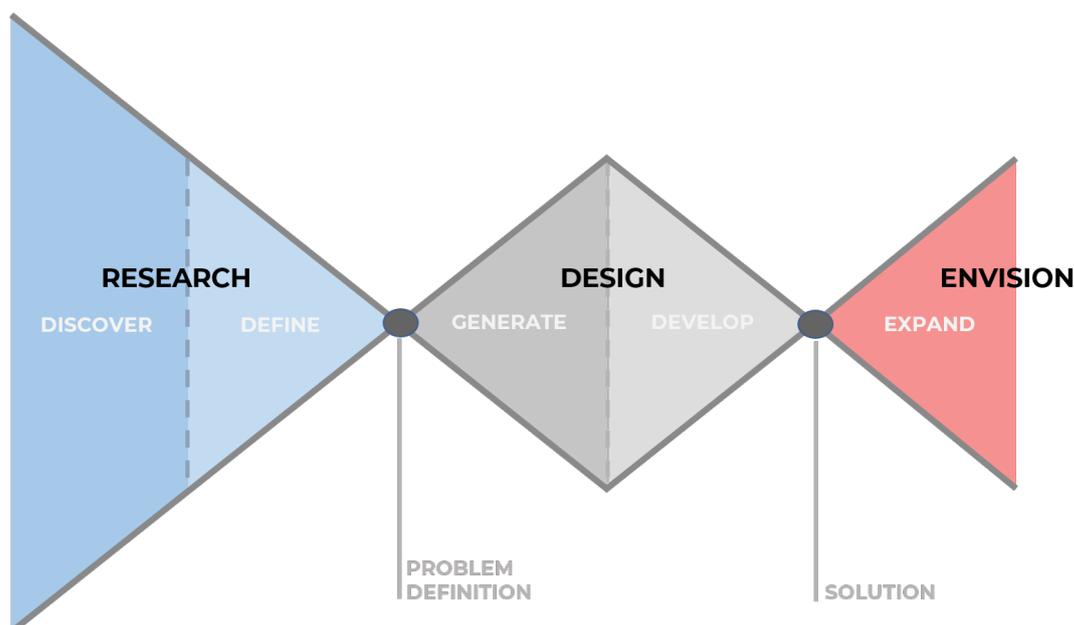
technology provided by the company is desired. Now, the latter can be applied for a colossal amount of topics, differing in industries, sectors and context. For this reason, the discovery of potential issues within the medical field will be carried out, supporting the accomplishment of the define stage, giving the desired problem to solve and the design direction. This phase include both the Research and Definition sections of the thesis.

DESIGN

With the problematic defined, a solution can then be thought of. By first generating ideas, we diverge into a list of potential solutions that would fit the settled topic and the created list of requirements. At this point, a decision is made on the fitting design to continue with, which will be further worked on in the develop stage. By the end of this diamond, a solution in the conceptual level will be provided. This phase includes both the Technological Support and Business Proposal sections of the thesis.

ENVISION

This phase has been added due to the 'open' ending of the project. As we are limited with the amount of detailing we can perform due to the conceptual nature of the solution, and the fact that our technological foundation is aimed at being released in 2026, envisioning the implementation of our solution in a future context is desired. This phase includes both the Business Proposal and Future Recommendations sections.



SU



ON THE ROAD

Assessment visit due to the increase in the number of snakebites around Baring, Kenya.

Photographed by: Paul Odongo [2]

REPORTING WITH RESEARCH

In this section, the research carried out to understand the current state and needs of humanitarian aid will be discussed. It gives an overview of the topic, defining key information for the continuation of the report. An internal & external analysis will first be performed, providing with general information on the client, today's humanitarian aid's workings and current transportation methods. Then, a stakeholder analysis and cost comparison will follow, giving supportive data for the completion of a SWOT analysis that will define the direction of the project. A summary of this section can be found on page 30.



INTERNAL & EXTERNAL ANALYSIS

EMBRAERX

EmbraerX, a division within its parent company - Embraer S.A., defines the client of the project. It specializes in creating a future consisting of Urban Air Mobility solutions. EmbraerX has shown interest related to sustainability and social value, potentially solving challenges provided by the 17 sustainable development goals defined by the United Nations (UN). Leaning towards the less fortunate and thus third world countries, Embraer's desire is to create jobs and opportunities. The goal is to apply their aerospace knowledge and expertise into useful and practical solutions, to solve salient needs.

Eve Urban Air Mobility Solutions is a newly independent company, first to graduate from its parent company - EmbraerX, and is dedicated to developing the Urban Air Mobility (UAM) ecosystem. The company is currently in the demonstration of its latest concept – EVE, a fully electrical vertical take-off and landing (eVTOL) vehicle, presented below.

The project will be based around EVE, providing a new business proposal for EmbraerX that detaches from the current popular wave of air mobility solutions development in urban context, and into the humanitarian sector.



EVE CONCEPT VEHICLE

Currently demonstrated, the vehicle's delivery is expected to start in 2026. Over 200 orders have been set already, assuring the future of EVE in urban air mobility. [3]

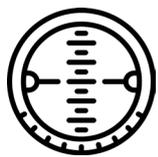
SPECIFICATIONS



SPEED
> 240 km/h



PROPULSION
Fully electric



ALTITUDE
800 - 1000 meters



PASSENGER
4 pax + 1 pilot



RANGE
> 96 km



RELEASE DATE
2026



INTERNAL & EXTERNAL ANALYSIS

HUMANITARIAN ORGANIZATIONS

Humanitarian aid organizations, commonly referred as humanitarian NGOs, are indispensable players in the provision of material and logistic assistance to people around the world. With needs originating from natural and man-made disasters, humanitarian aid's primary goals are to "save lives and alleviate suffering during and in the immediate aftermath of emergencies" (Humanitarian coalition, 2021), while maintaining human dignity throughout its operations. Although, its support doesn't stop at the immediate needs, and can expand towards development aid at the region of operation. Historically speaking, the idea of involving humanitarian aid in our society

sprung in the early 18th century in Europe and North America. Initially taking roots as private branches taking action in their acting countries, the internationalization of these organizations has been a recent development, supported by large development around the world such as the enlargement of the European Union (Ryfman, 2007).

In today's society, we account an estimated 10 million non-governmental organizations worldwide, serving a social or political goal (IBSO, 2015). These civil societies provide a wide range of operations, with the recurring ones being (among others) (MSF, 2018) (ICRC, 2019):



Food provision



Water sanitation



Shelter provision



Access to education



Access to medicine



Diseases prevention & treatment



Raising awareness



Natural disasters response



Protection



Refugees, IDPs

Even though the number of organizations is colossal, six organizations also known as the "Big 6", account for nearly a quarter of the total humanitarian spend, with Medecins Sans Frontières being the leader.

Throughout the project, both Medecins Sans Frontières (MSF) and the International Committee of the Red Cross (ICRC) will be used as target customers.

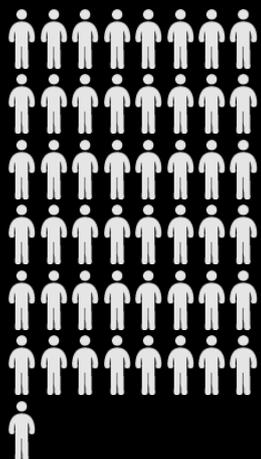




PROTECTING THE YOUTH

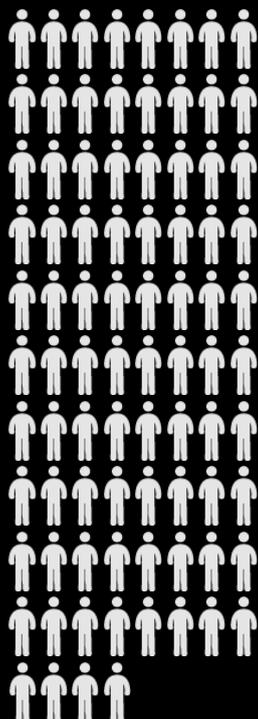
Mother & child in the measles ward of Bossangoa hospital, in Central African Republic.

Photographed by: James Oatway [4]



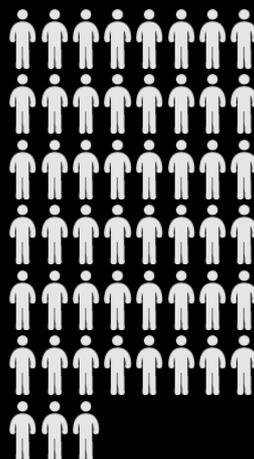
168 million

Total people in need



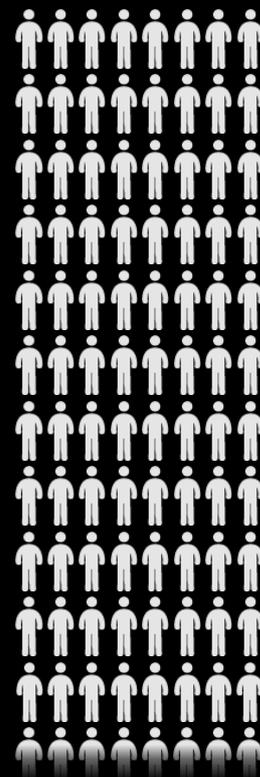
98 million

Total people reached



100 million

People with no access to basic health services



+3 billion

Forced to choose between food and health care

Facts taken from (OCHA, 2020)

The need for Mobile Health Units (MHU)

Obviously, humanitarian organizations need to cope with various drawbacks that require innovative solutions. Nevertheless, an important issue that arises around the world, and especially in third world countries, is the access of health care for the people in need. Defined by the 3rd Sustainable Development Goal - “Good Health and Well-being” (UN, 2021), the importance of essential health services coverage is a key topic in humanitarian aid, suggesting that health care is a basic human need. The lack of access of health care can originate from numerous factors, including seasonal environmental influences, armed conflict, or badly planned infrastructure system. Fixing a local health care system requires an immeasurable amount of resources, planning and time, which can only be done from a national stand-point. Thus, humanitarian aid organizations have searched ways to provide support in the meantime, interlocking their efforts to the needs of today.

Taking the example of MSF and ICRC, the

organizations have provided an interim solution – Mobile Health Units, which have as a mindset (Du Mortier et al., 2007): ‘if the patients cannot come to us, we will go to them’. These units consist of a designated team of medical professionals on the move, providing care to the underserved populations. Even though “mobile clinics are expensive (relative to other delivery strategies), logistically burdensome, time-inefficient (a large portion of productive time is spent traveling), and rarely demonstrate a lasting impact”, they are still endorsed by the community as they provide a bigger health coverage in region where access is highly limited (McGowan et al., 2020). They allow the provision of health care to patients that are affected by long waiting times, unaffordable services, long traveling and low health literacy (Khanna et al., 2016).

So, what exactly are they doing? Mobile Health Units (MHU) also known as mobile clinics, carry out missions that can be categorized in three main classes, shown on the right side (Du Mortier et al., 2007).



RED CRESCENT'S MOBILE HEALTH UNIT
Providing medical assistance to remote communities that do not have access to health service.

Photographed by: IFRC [5]

PREVENTATIVE

1. Health promotion activities
2. Vaccinations
3. Screening
4. Hygiene education

MISSIONS CARRIED OUT BY MHUs

CURATIVE

1. Surgery
2. Mental health services
3. First aid services
4. Medication treatment

OTHER

1. Referring to fixed health stations
2. Palliative care
3. Resources/patient transportation
4. Local health workers education

“

“In only one day we reached 400 people who hadn’t seen a doctor for three years. We are here to provide primary health assistance regardless of who controls the territory.”

VIKKI STIENEN
Head of Mission

“

A “mobile clinic” is just what it sounds like: instead of waiting for people to come to us, we get in the car and go to the people!

SEINN SEINN MIN
Health Promoter

“

We were going through the bush in an attempt to go where others don’t, we had been driving for hours without stopping.

DALE KONINCKX
Anthropologist



Further description of MHU

Due to their dependence on the local infrastructures (e.g. roads, local buildings for operation center set-up) and technical limitations (e.g. payload weight), Mobile Health Units are constrained to carry out operations with limited effectivity as they are less equip compared to fixed health centers, and rely on a precise prioritization of activities that concern patient that can be immediately supported. For this reason, MHUs define a strategy that should be used as a 'last resort', depending on the assessment of needs performed before the provision of the missions (Du Mortier et al., 2007). The benefits and constraints of MHUs are summarized below (Roodenbeke et al., 2011).

MHUs' effectivity is highly dependent on their frequency of visit, allowing the increase of patient consultation visits (and thus treatment effectivity). Additionally, follow-ups and referrals to local health centers are crucial for better health care, which encompasses the need of relating MHUs to a proper logistical system (Khanna et al., 2016). Currently, these units travel using terrain vehicles, but also through air support for the most unreachable places. With the need of MHUs increasing, their limitations still affecting and technological advancement becoming highly desirable, the transportation sector defines an important opportunity in the improvement of this strategy, helping more people around the world.

BENEFITS

- **Surveillance of the population's needs**
- **Specialist visits to underserved regions**
- **Creating confidence in the supply of care**
- **Time and cost-effective for the patients**
- **Time effective for medical care due to more relevant referrals**
- **Strengthen health workers' capacities**

CONSTRAINTS

- **Relying on private funding and charities - not sustainable and hard to implement for long-term problems**
- **Highly influenced by regulations and government cooperation**
- **Logistical nightmare due to:**
 - **Bad infrastructures**
 - **Professionals' availability**
 - **Seasonal obstacles**
 - **Uncertainty about population movements**
- **Current methods of transportation are highly affected by infrastructure quality and environmental factors**

INTERNAL & EXTERNAL ANALYSIS

TRANSPORTATION

Now as previously discussed, EmbraerX's new innovative solution in air mobility, and the one we will focus on throughout the project, is its EVE concept vehicle. When researching crucial data concerning the workings of humanitarian aid organizations, special attention has been put on the transportation part of the operations. Fleet management and operations defines one of the most significant overhead cost within the humanitarian aid sector, estimated to be around 1 billion USD back in 2011, followed by high projected growth (Gu et al., 2021). Many improvements have been carried out in order to reduce the everlasting cost, such as fleet management transformation (e.g. switch from a decentralized to centralized vehicle asset management) or fleet optimization (e.g. fleet size

and age reduction) (Kunz et al., 2015). Although, notable cost saving can be found from the product stand-point. With rapid technological advancements in the transportation industry, the current vehicles are bound to get replaced by next-generation solutions.

Now-a-days, the main methods of transportation that are used to reach remote regions with no health care access are: the symbolic Land Cruisers (the main vehicle used for MHUs), helicopters, and aircrafts. Other methods, such as motorcycles, animals, bicycles and boats are neglected from the analysis as they are used in very rare cases but will be taken into account when defining requirements for the technological solution.

LAND CRUISER

The Land Cruisers are the most noteworthy vehicles in humanitarian work. Present in most of the major organizations, they have been a strong addition since the 70's. By quoting Robin Vincent-Smith, a logistics training officer at MSF: the Land Cruiser define a "strong, simple, [and] almost indestructible" vehicle. They have been the primary preference for many staff members and partners of humanitarian organizations (Arsenault et al., 2018), due to their reliability, plug-and-play option and easy maintenance, even on-the-go if required. Land Cruisers are simply an all-round suitable method of transportation for humanitarian operations, adaptable to any mission requirements and easily modifiable on the field in case the MHU needs to "drop everything and carry crucial patients to hospitals, even if it means not performing the planned mission" (from an interview with Stéphane Du Mortier, Health Learning & Development Manager at ICRC). Due to their well-known usage, local communities

recognize the organization whenever they see a fleet approaching, specifically designated through highly visible logos on the livery.

Although, even the best can have drawbacks. Since it is a terrain vehicle, it is highly dependent on the road conditions. Affected by seasonal environmental changes, such as high rain that can flood the paths and sink the vehicle in mud, the Land Cruiser can be obstructed in bush regions that delays the mission's success. With narrow and bumpy paths, treating patients on the way to the hospital presents a serious challenge. Additionally in conflict areas, terrain fleets are suspected to pass through zones that put the security of the staff and patients at risk. In the best-case scenario, we are just talking about a road blockade. But in the worst case, humanitarian organizations have had a history of attacks against their national and international staff (OCHA, 2020).

“

There is nothing to fix [the vehicle] with, no one has come by because of the rain, there's no phone network, no phone to call.

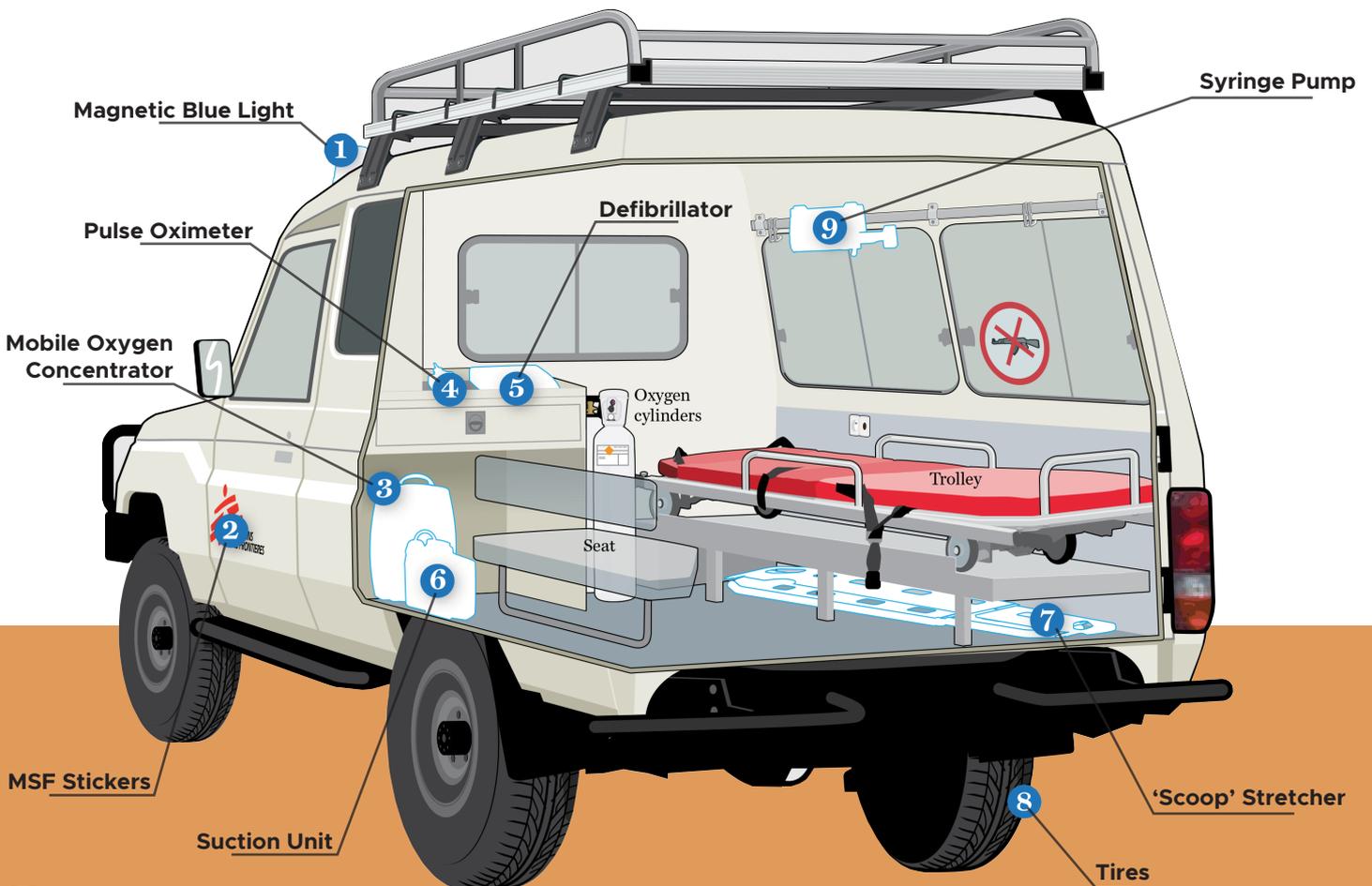
DALE KONINCKX
Anthropologist



LAND CRUISER'S NIGHTMARE

Seasonal factors can affect the roads, creating delays in areas with badly maintained infrastructures.

Photographed by: MSF [6]



[7]

An exemplary set-up of the Land Cruiser used by MSF can be found on the left. The vehicles carry the medical staff, the specified kits, enough food for the mission timeline and extra gasoline in order to offer agility if required.

In terms of fleet logistics and management, the terrain vehicles in most humanitarian organizations are owned (in contrary to leased or contracted). This means that the provision of these vehicles relies on the transparent donations or earmarked funding. The management policies are set centrally by the headquarter (HQ), but the fleet is managed in a decentralized fashion: strategic decisions are made by HQ, but tactical & operational decisions are sub-delegate to regional, national and field levels. Most international humanitarian organizations (e.g.

WFP and IFRC) create logistics hubs in regions with social and political stability, which then provides the vehicle to the staff on-demand. In terms of maintenance, there's no consensus between the organizations on the best solution. Some players rely on their own centers and may be pushed to build workshops due to the lack of facilities, which defines faster and more reliable repairs; others rely on outsourced maintenance and local suppliers. All-in-all, the terrain vehicles are usually owned by the humanitarian organizations as, due to their excessive usage, the more easily obtainable certifications, the cheap procurement cost and the thoroughly evaluated strategies, it defines a more cost-effective solution than if it was provided by a third-party (Pedraza-Martinez et al., 2012) (Kunz et al., 2015) (Eftekhari et al., 2016).

“

The newest vehicles go to the vehicles go to the most challenging places - to nurses doing mobile clinics deep in the bush - that's where they're most needed.

ROBIN VINCENT-SMITH
Logistician

HELICOPTER & AIRPLANE

Air vehicles often define the only solution to reach an area that has unreliable infrastructures (e.g. roads, ports, air strips). As previously discussed, environmental obstacles can leave a community stranded if reached on the ground, which sometimes is not an option in emergency situations (ECHO, 2020).

Helicopters provide a short-range service, accessing difficult terrains with their vertical landing capabilities and independence to specific infrastructures, the perfect instrument for 'last mile' traveling (Airbus Helicopters, 2017). They

are a key component in the fast evacuation of medical staff and patients in times of threat, as well as cargo transportation to support humanitarian aid operations. Due to their aptitude to reach location without the terrain vehicles' hassles, except for security risks; and their more efficient traveling in terms of speed, helicopters have a wider range of mission destinations. Although, this has the risk of vehicle unavailability which adds to the logistical challenges that a humanitarian organization faces throughout its operations.

“

Our task is to provide urgent goods such as medical equipment to the camps, which are difficult to reach by road, and to get specialist staff there and back.

DOMINIK GOLDFUSS
CEO of Global
Helicopter Services

Airplanes, in comparison, are not subjected to the same operation needs. Due to their longer-range capabilities and higher payload weight possibilities, they define a relevant solution for medical staff, cargo and patient transportation. With their inclusion in an international network, they allow inter-regional operations that avoids the need of local hubs, supplying the operations with the necessary goods. Although, airplanes require well-defined infrastructures, such as air strips and traffic control, which makes them unsuitable for 'last mile' missions. They might avoid conflict-ridden areas but they still require the support of helicopters or terrain vehicles to supply the goods to the inaccessible areas in scope of the operations.

Humanitarian organizations mostly charter air services from third parties, which combines both global and local sources. It defines a more cost-effective solutions as the operation of air vehicles in complex operational environments usually includes additional specific requirements. In term of regulations, air services need to be commercially licensed by the civil aviation authorities, the vehicles need to be certified under the EASA guidelines and the flying crew requires

eVOL VEHICLE

Owing to major advances in electric propulsion, eVTOL vehicles are a strong point of discussion in our current society. With the growing need of mobility in urban areas, we observe a peak of interest in mobility solutions of the future, with a great deal of companies emerging into the fast-developing market. Although, the design of eVTOL vehicles does not stop at the product level. Since these mobility solutions define a new perspective to today's transportation, a new structure needs to be created and implemented in order to bring the current traffic set-up into a 3-dimensional system. This means that developments in traffic management, regulations, certifications and infrastructure organization are necessary, which are found to be challenging and are scoped to be implemented by 2030 (Reichmann, 2021).

The current craze of eVTOL vehicles has been highly focusing on civil use, specifically in urban areas, bringing new solutions to the taxi services, medical assistance and recreational aviation. Companies tend to form their product in developed regions due to the projected profit it could provide. Innovative solutions are found in the medical field, such as Ambular which adapts the eHANG vehicle into an emergency response aircraft (Ambular, 2021). But it is designed in the safety of an urban environment, where the regulations & certifications have a better chance

to clear certain demands set by UN regulations (e.g. captains require 1500 hours of flight on the same type of vehicle). In terms of maintenance, helicopters and airplanes define more complex vehicles compared to the previously discussed Land Cruiser, which set the needs for a far more specialized maintenance drill, staff and profound checks before use. Humanitarian organizations simply do not have the resources to spend on the development of an owned air division, especially as it wouldn't provide additional value to their current strategies (Reinhold, 2019) (Airbus Helicopters, 2017) (ECHO, 2020).

Nevertheless, a major set-back that humanitarian organization experience is finding "the right helicopter operator with the right asset at the right time, and who is willing to engage in complex emergencies" (Airbus Helicopters, 2017). Air service operators do not specifically provide support for humanitarian operations and can become unavailable in times of need due to their personal goals of achieving profit. Although, as preparedness measures, humanitarian organizations such as World Food Program (WFP) have identified qualified air operators with standby contracts in case a new emergency strikes (WFP, 2019).

to be settled, the required infrastructures could be promptly arranged and technology acceptance could be facilitated. Thus, we observe an enormous opportunity in other unfocused markets, as for example: the potential niche in the humanitarian aid sector. Companies are less likely to enter the latter, especially if the usage of eVTOL vehicles has not been settled yet in urban settings, and are more likely to appease their profit goals instead of their social responsibility.

So, what is the benefit of using eVTOL vehicles in humanitarian aid operations? Firstly, similarly to helicopters, eVTOL vehicles avoid obstacles experienced by terrain vehicles and are not limited to the roads' conditions. Secondly, they define a sustainable alternative to their fuel-based counterparts due to their zero-emission propulsion, their opportunity of creating new jobs and the need for infrastructure development leading to regional advancements. Lastly, compared to helicopters, they define a quieter solution with improved reliability, reduced manufacturing & maintenance costs due to reduction in parts' complexity, reduced operational cost due to the substitution of fuel and with a potential upgrade possibility of autonomous system architecture (TransportUP.com, 2019).

Obviously, implementing eVTOL solutions in air support for humanitarian aid faces the same challenges found in urban usage: public acceptance, availability of necessary infrastructures (e.g. charging stations, landing zones), interaction with air traffic control, flight density achievable in uncontrolled airspace, flight paths, regulations and appropriate certifications (Vascik et al., 2017). Although, in under-developed regions, these challenges are found to be more acute, which explains the missing desire of eVTOL development in humanitarian aid. Firstly, public acceptance is critical for the success of new air solutions (Altran, 2019). Since current air vehicles are usually associated with military usage and governmental control, and communities might feel subjected to privacy unsettling, familiarizing the public with the new technology is required. This encompasses both the passengers, and the citizens inhabiting surrounding areas of the vehicle's operation and under its flight path (Ito et al., 2019). People need to feel safe and trustworthy for the evolving methods of support. Then, due to the recurring lack of stable grid systems in regions of operations, charging is a critical feature that needs to be thought of.

eVTOL solutions define a sustainable alternative to their fuel-based counterparts due to their zero-emission propulsion, their opportunity of creating new jobs, and the need for infrastructure development leading to regional advancements.

With EVE eVTOL vehicle being electrically propelled, specific requirements concerning energy generation, such as system self-sufficiency, might be necessary. Sequentially, due to the shorter-range capabilities, a new operation strategy and logistics need to be planned to fit the system's performance. Additionally, due to the nature of humanitarian operations, the organizations are highly crucial towards the necessity of proof of concepts for new innovations, especially when the safety of the people is at play. Nevertheless, some constraints such as certifications and interaction with air traffic control will not be looked at as they are out-of-the-scope of the project. As previously shared, EVE eVTOL vehicle is at the center of the project. Currently being demonstrated by EmbraerX, it defines a good starting point for the projection of eVTOL opportunities in humanitarian aid.



EVE & HALO PARTNERSHIP
Development of UAM products and services in the United States and the United Kingdom. [8]

“

New eVTOL concepts need to work for the most difficult scenarios. If it cannot operate in the least resourced environments, it is not going to work.

MICHAEL CHAPMAN
Board member of Airserv
International, Inc.

STAKEHOLDERS ANALYSIS

When designing a new system, mapping out the different stakeholders is a crucial step that allows to evaluate their influence and potential impact on the project.

To facilitate the analysis, we will assume that EVE will have the same system structure as the current air support services that are available in humanitarian aid. The relevant stakeholders are mapped in figure 1 below.

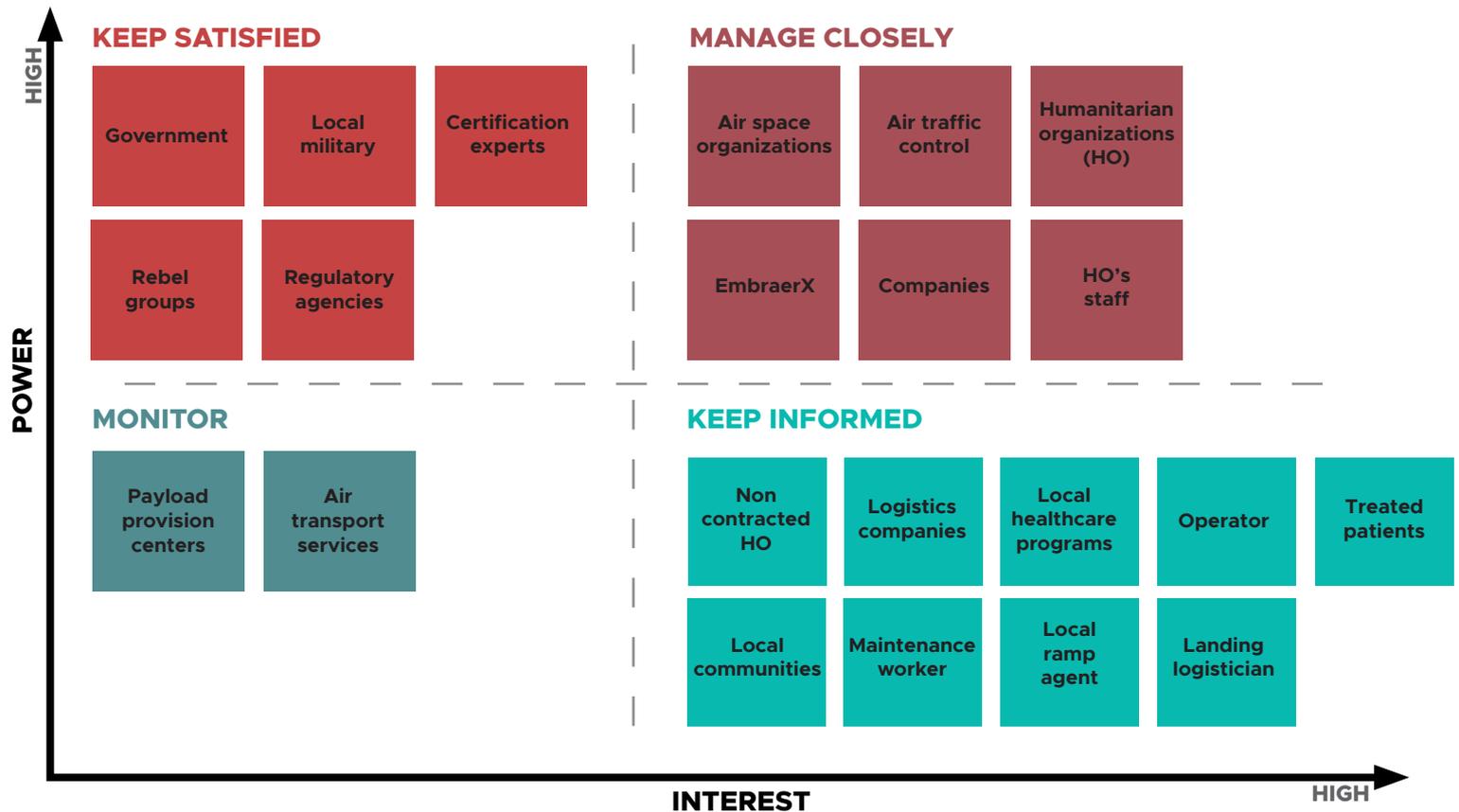


Figure 1: Stakeholders map for an air support in humanitarian aid.

Numerous key players are shown which play a decisive role in the project:

- EmbraerX:** Being the client of the project and main responsible for the functioning of its vehicle, the potential new business plan will fall under its management which defines a new expansion opportunity for the company.
- Humanitarian organizations:** These entities represent the main customers of the prospective air service. They define the needs and requirements for the newly designed system, as well as the main income source for the company. They will play a vital role in determining the desirability and success of the project.
- Field workers:** Encompassing both the vehicle's operator and the humanitarian staff, they are the front-line that will be subjected to the usage of EVE. The usability of the vehicle needs to be optimized to their needs, taking into account issues that might occur on the field.
- Government bodies:** ranging from the concerning bodies that set the regulations and provide certifications, to air traffic control, they are crucial stakeholders to keep satisfied as they will define the feasibility of the project. Although, they will not be looked at in detail as it is out-of-the-scope of the project, but will be included in the structuring of the new business.

Stakeholders relationships map

Now, a great addition to the characterization of the stakeholders is to determine their relationships, giving space to potential opportunities to arise. For that, a stakeholders relations map is provided in figure 2.

Clearly, some stakeholders are not present in the map due to their negligible impact within the scope of the project. Additionally, some players

have been grouped together (e.g. government agencies include regulatory agencies, certification experts and local military) for the facilitation of the analysis. Here, Embraer's Humanitarian Air Service (EHAS) - the prospective new business, is assumed to take the same structure as the current air support services for now and will be readdressed later on. The map will support the creation of the SWOT analysis, advising with potential opportunities to focus on.

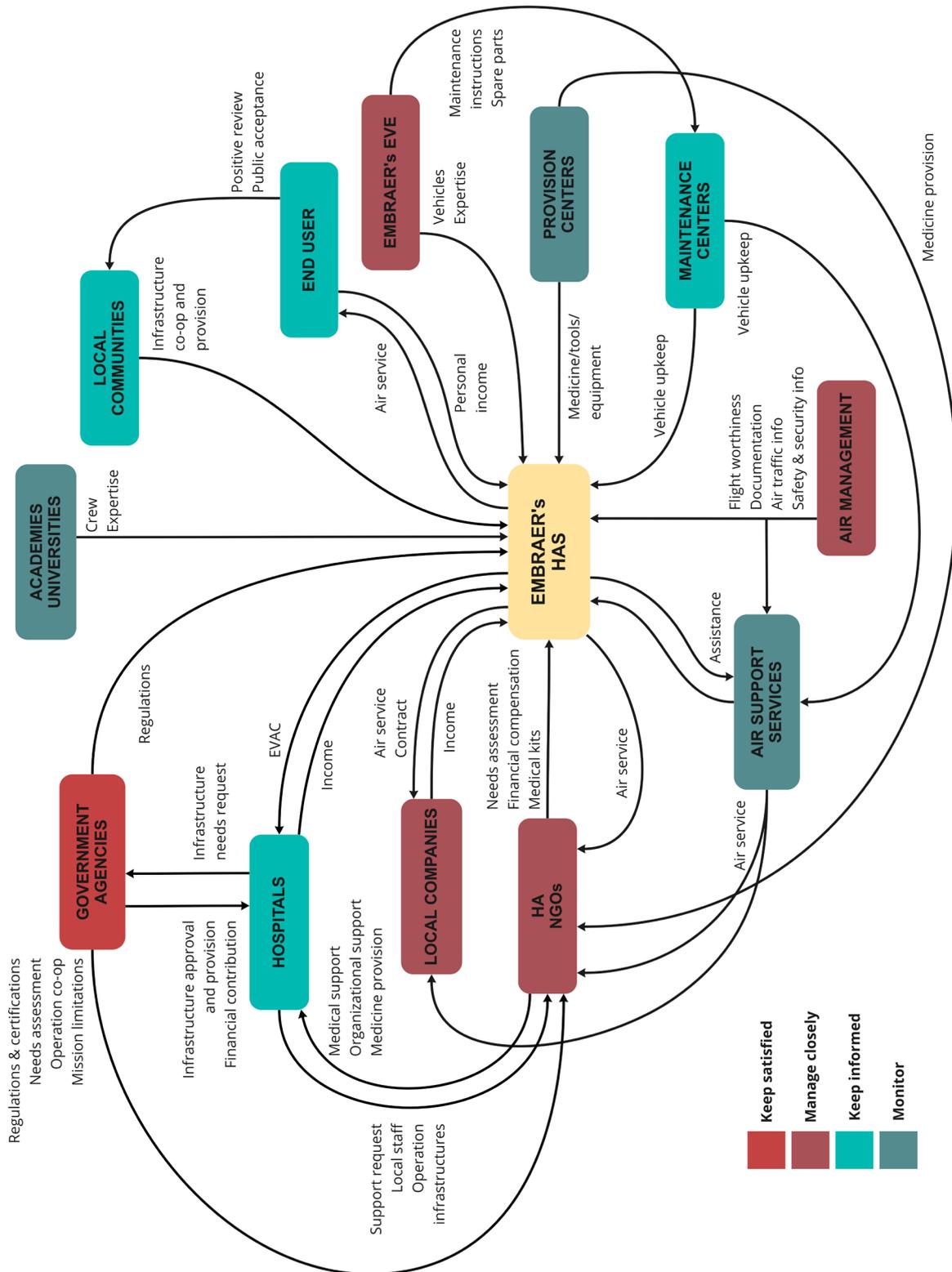


Figure 2: Stakeholders relations map

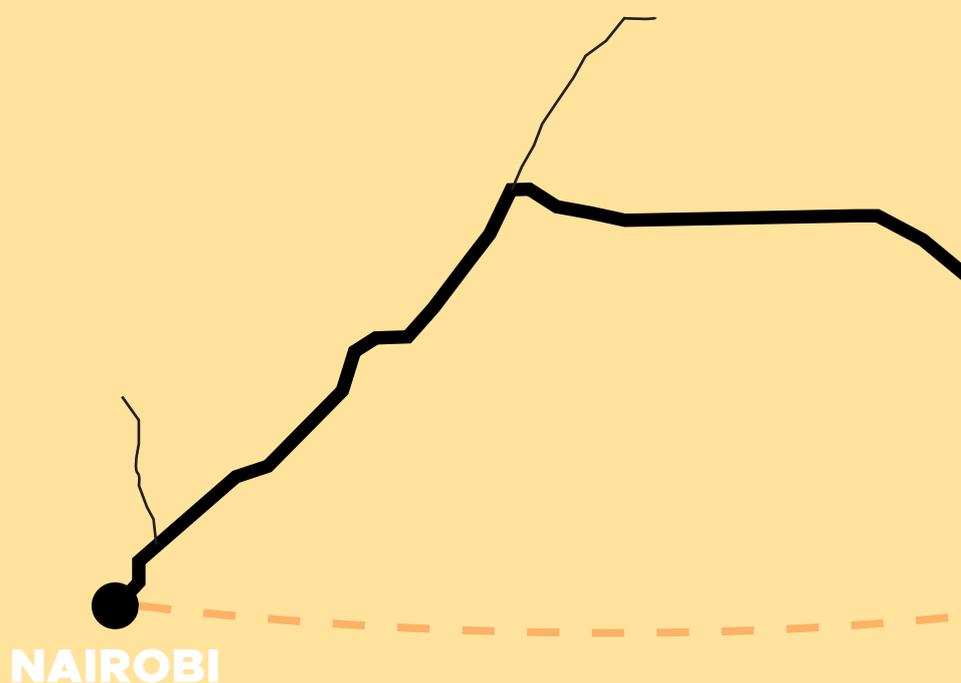
COST COMPARISON

Opportunities can be vague until concrete information is put at their foundation. Money talks, especially for conglomerate such as Embraer S.A., describing if a new idea could be viable for the company and the customers. For this reason, a brief cost comparison between the current methods of transportation is constructed.

It gives a quick overview on the potential of the project's scope, defining if value can be found in this new business direction.

Wet operational cost comparison is presented below, which includes fuel, insurance, hangar fees, maintenance and landing fees:

<p>LAND CRUISER Quoting from (Hermann, 2006), “a 36-month lease arrangement for an appropriately equipped Hardtop (HZJ78) is about \$36,540”, which is about \$48,000 if we take into account the increase of purchasing power of the dollar from 2006 to 2021 (CPI inflation calc., 2021).</p>	<p>1.5 €/hour</p>
<p>HELICOPTER Taking the Eurocopter AS350 B3 as reference, the lightest vehicle used by Global Helicopter Services (GHS) which provides air support for humanitarian organizations, the operational hourly cost for 2021 is calculated (Aircraft cost calculator, 2021a).</p>	<p>932 €/hour</p>
<p>AIRPLANE Taking the Cessna 208 Caravan as reference, which is the model used by AirServ for its humanitarian air services, the operational hourly cost for 2021 is calculated (Aircraft cost calculator, 2021b).</p>	<p>476 €/hour</p>
<p>eVTOL From (Duffy et al., 2017), the author has concluded that the seat-mile cost of an electric 5-seater eVTOL vehicle is 26% cheaper than a Robinson R44. Taking the operational hourly cost of a R44 and assuming the seat-mile cost is proportional to the operational hourly cost, we can calculate the operational hourly cost of an eVTOL vehicle.</p>	<p>116 €/hour</p>



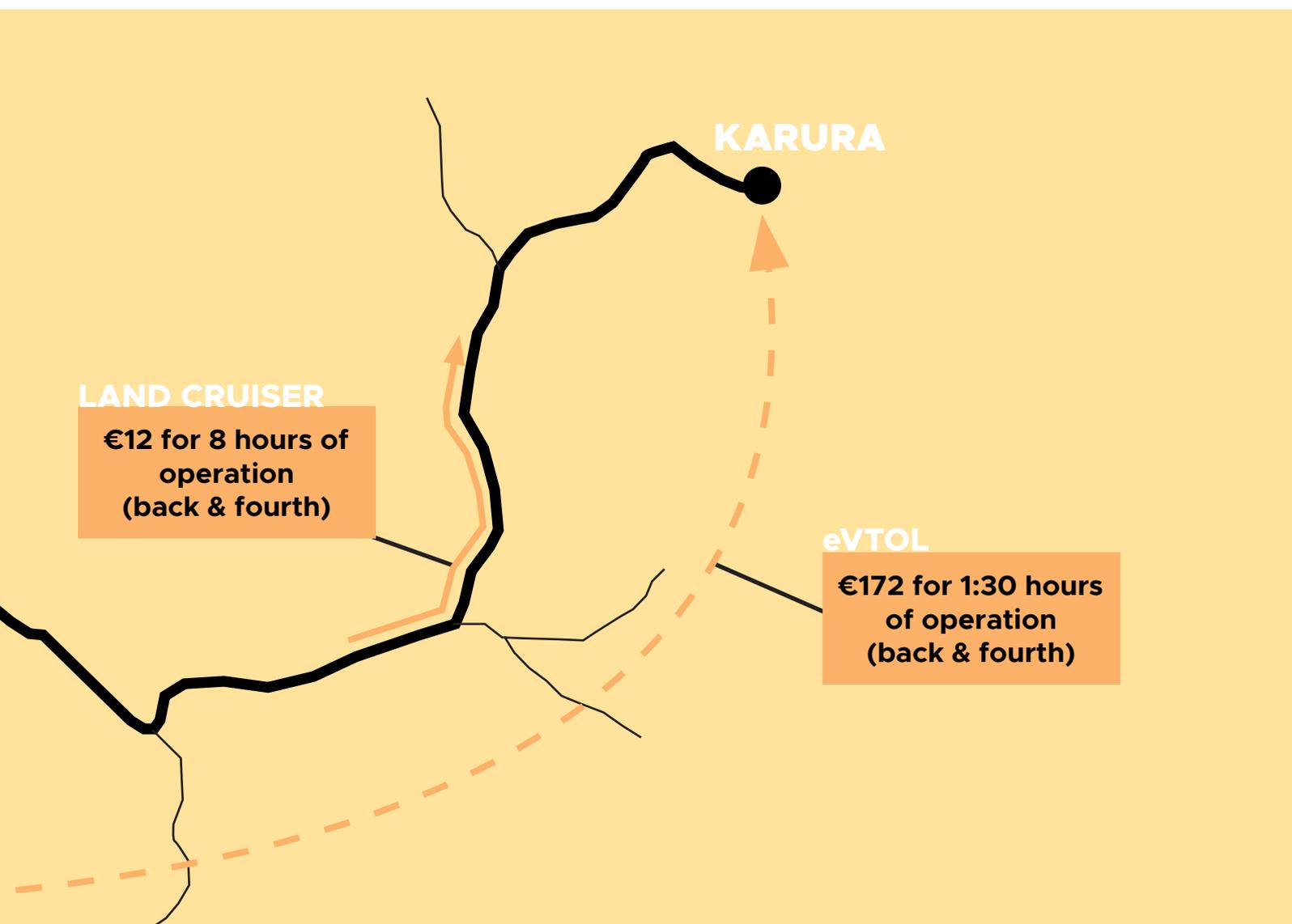
These cost values show that humanitarian organizations would benefit from the replacement of their current contracted air services with an eVTOL vehicle alternative, in monetary sense. Obviously, the Land Cruiser is costing a grain compared to an air vehicle but they both provide different values and advantages. Here, EmbraerX has the opportunity of offering a cheaper air service prevision with minimized vehicle upkeep, which lowers the budget required for market entry. Although, the costs of personnel training, new infrastructures needs and certification are excluded from the comparison, which influences the viability of the new business opportunity.

Mission comparison between terrain & air vehicles

To put it into the mission perspective, we compare exclusively the cost and duration of traveling between a Land Cruiser and an eVTOL vehicle. It allows us to relate cost to value, and analyze if it plays a valid role of convincing humanitarian organizations of eVTOL benefits. Using the

specifications of EVE and the operational hourly cost previously provided, and assuming that the eVTOL vehicle follows the road taken by the Land Cruiser (and not traveling in a straight line), an exemplary vehicle path is shown below.

We observe a cost increase of 640% for one mission but at 5.3 times higher rate. Thus, even though it defines a more expensive option, it provides considerably more mission effectivity in term of duration. In other words, the air vehicle can potentially replace 5 Land Cruisers for one mission if it goes back and forth, which further reduces overall cost due to less required vehicles (thus reducing upkeep cost), personnel, and logistics. If we additionally account that the eVTOL vehicle travels in a straight line, the duration is further reduced by 26% and it would replace an additional 2 Land Cruisers. This is excluding the fact that the terrain vehicles might not drive through well-kept roads, and that the eVTOL vehicle needs charging.



SWOT ANALYSIS

Grouping all the data gathered from research, a SWOT analysis can be constructed and found below. Two players have been at the scope of the analysis: EmbraerX, which defines the client and the new business provider, and humanitarian organizations, which are the main customers and requirements setters. By combining the strength and opportunities of both parties, potential

project topics are found on the right side. Additionally, mixture of their weaknesses and threats will define crucial obstacles that will have to be looked at in the continuation of the project.



EMBRAERX



HUMANITARIAN ORGANIZATIONS

STRENGTH

Proven aerospace technology experience, applied to UAM	Well funded eVTOL department - subsidiary	Sustainable management with socio-environmental goals
EVE concept vehicle, currently developed for demonstration	Framework in South Africa - expansion of opportunities	Decreases travel duration for operation
Less noise than helicopters	Quick movement of the staff	Zero-emission vehicle
Brand recognition & respect in place of operation	Use of local volunteers and workforce	Worldwide coverage for operations

WEAKNESSES

eVTOL concept vehicle still in development, no proof of concept	Low market control in regions of operations (e.g. Africa)	Lower range than helicopters
Not recognized technology	Legal permission for eVTOL usage	No control center of the company available in the region
Limited usage of air vehicle due to local issues	Financially supported through donations & funds	No usage of escort for staff security
Slow process of implementation of crucial changes	Transportation influenced by local infrastructures	Every operation needs to be negotiated with local parties

OPPORTUNITIES

Usage of eVTOL technology for humanitarian aid (better image)	Distancing from the UAM market and towards sustainable usage	Charter service for important personnel
Implementation of eVTOL technology in less regulated regions	Implementation of eVTOL technology in less crowded air space	Collaboration with South Africa framework
Development of more reliable system due to harsher environments	Service provision to local companies	Usage of eVTOL technology for cargo transportation
Usage of eVTOL technology for patient transportation	Usage of eVTOL technology to set-up an agile station of operation	eVTOL for support of stuck terrain vehicles
Aerial coverage	Replacement of current MHUs transportation	

THREATS

No electrical grids in places of operations	Electrical subsystems - new maintenance expertise req.	New requirement of specialist for operation
EVE designed for UAM usage (less harsh environments)	Local controlled air space and regulations	Slow public acceptance
Public safety in case of failure	Vehicle hijacking	Local rebel & gang groups
Local governments (e.g. airspace control, op. logistics)	No coverage of bush areas	Lack of well preserved infrastructures
Humanitarian organizations seen as an armed threat	Extra staff required for operating the eVTOL vehicle	

POSSIBLE PROJECT TOPICS

Implementation strategy of eVTOL vehicles in humanitarian organizations	Servitization of eVTOL vehicles for humanitarian aid	Adaptation of EVE concept vehicle for the needs of MHUs
New business of eVTOL aerial coverage	Improve public acceptance of eVTOL usage for humanitarian aid	Demonstration of eVTOL feasibility for humanitarian aid
Set-up of new EmbraerX hubs		

POTENTIAL OBSTACLES FOR THE PROJECT

Public acceptance	Local legality, regulations & safety certifications	Staff safety
Logistical complexity	Humanitarian organizations skepticism	Climate & environment
Energy requirements	Political situation	Finding stable income source

The chosen topics have been highlighted:

- **Servitization of eVTOL vehicles for humanitarian aid**
- **Adaptation of EVE concept vehicle for the needs of MHUs**

Both these topics will be combined into one opportunity, looking at the use of EVE concept vehicle in the product and business level.

They define a product-service opportunity for the expansion of EmbraerX's business, leeching on the niche market of humanitarian aid and on its potential of pushing the use of eVTOL outside of urban settings. Since EVE still defines a mode of transportation, we will focus on MHUs as their main goal is to be on the move. This is both based on current needs and personal preference, and is supported through interview with professionals in the humanitarian aid sector.

Section summary

The first section has provided critical data towards the construction of the project's focus. Information concerning key players have been shared, showing that there is still a good deal of needs in humanitarian aid, especially in the access of health care in underserved regions. Currently, humanitarian organizations have been providing support through their Mobile Health Units (MHUs) which maneuver designated teams of medical professionals to communities in need using terrain transportation, or air services in the rare cases. Although, these current methods of transportation face many drawbacks, for instance in terms of mission effectivity (e.g. long

traveling duration, or environmental obstacles) or monetary sense (e.g. current air services are expensive and used as last case scenario). Thus, with the new advances in air mobility, eVTOL vehicles offer an alternative for humanitarian organizations to provide more effective mobile health operations without the need of investing high amount of resources, as summarized in table 1 below.

EmbraerX has the opportunity of entering a niche market that has not experience the potential of eVTOL technologies, possibly becoming the pioneer in next-generation air mobility solutions in the humanitarian aid sector.

Table 1: Comparison between different modes of transportation in humanitarian aid operations.

TYPE	Land Cruiser	Helicopter	Airplane	eVTOL
VALUE	<ul style="list-style-type: none"> • Payload transportation • Patient transportation • Modular vehicle that can change use during the mission • Medical staff transportation 	<ul style="list-style-type: none"> • Payload transportation • Patient transportation • Aerial coverage • Medical staff transportation • Fast emergency response 	<ul style="list-style-type: none"> • Payload transportation • Patient transportation • Aerial coverage • Medical staff transportation • Fast emergency response 	<ul style="list-style-type: none"> • Payload transportation • Patient transportation • Aerial coverage • Medical staff transportation • Operation station set-up • Fast emergency response
BENEFITS	<ul style="list-style-type: none"> • Known method of transportation • More subtle in conflicts areas • Less technologically complex for easier maintenance • Defined system & logistics • Easier staff training • More cost-effective • Already available maintenance infrastructures • High availability of vehicles 	<ul style="list-style-type: none"> • Fast method of transportation • More payload weight availability • Not dependent on roads/seasonal threats • Provides passive aerial coverage • Can provide air drop options • Reduced response time • Settled regulations & certifications system 	<ul style="list-style-type: none"> • Highest payload weight availability • Long range • Fast method of transportation • Higher altitude thus reduced risk of rebel threat • Settled regulations & certifications system 	<ul style="list-style-type: none"> • Fast method of transportation • More payload weight availability • Not dependent on roads/seasonal threats • Provides passive aerial coverage • Can provide air drop options • Reduced response time • Potentially self-sufficient • Quiet • Easier maintenance due to less complex parts • More cost-effective than helicopters • Sustainable (zero-emissions)
OBSTACLES	<ul style="list-style-type: none"> • Slow method of transportation • Limited with the payload weight • Fuel based (polluting) • Dependent on local infrastructures • Obstructed by road blocks and environmental influences 	<ul style="list-style-type: none"> • Loud • Bad reputation due to possible military relations • Utilizes a lot of fuel (polluting) • Expensive to operate • More complex technology and moving parts, affecting maintenance • Requires specialized crew training • Requires additional stakeholders (e.g. air traffic control) 	<ul style="list-style-type: none"> • Requires a landing strip • Utilizes a lot of fuel (polluting) • Requires a specialized crew • Expensive to operate • Loud • Requires additional stakeholders (e.g. air traffic control) • Not an agile transportation solution • Require thorough planning 	<ul style="list-style-type: none"> • Aerial vehicle that can be seen as military property • Requires new training for operators and mechanics • Spare parts are not widely available • Dependent on charging infrastructures • Requires additional stakeholders (e.g. air traffic control) • Shorter range

VACCINATIONS IN THE VAST LAND

MSF vaccination teams searched for semi-nomadic families in Chad for the provision of measles vaccines.

Photographed by: Juan Haro [9]





PROTECTION AGAINST MEASLES

MSF teams carrying out immunization operations against Measles in the village of Mina, Chad.

Photographed by: Juan Haro [10]

DEFINING THE FOCUS

The insights found throughout the research phase on the concerned topic of transportation solutions in humanitarian aid has given us an identification of opportunities based on the client and customer's needs. To narrow down the problem to be solve in the project, a mission and vision will be settled that will characterize the goal of the design phase, followed by an establishment of the region of implementation to simplify the upcoming decisions to be made. Then, an overview of the mission life cycle is defined, providing additional insights that will be projected into the constructed list of requirements.



PROBLEM DEFINITION

We discovered that access to health care in humanitarian aid is an on-going sustainable development goal that requires improvements. The current methods of transportation are highly influenced by their region of operation, depending on current infrastructures that potentially delays response time and logistics for an efficient and effective patient support. The previously proven eVTOL air solution showed that time and cost savings can be made throughout the traveling, ultimately changing the process in which Mobile Health Units (MHUs) would function. With omnipresent local uncertainties, it is desired to use eVTOL vehicle technology to improve access of health care to underserved areas without the dependence of local players and factors. Since the project envisions an opportunity for EmbraerX, the solution is based on the adaptation of its currently demonstrated

EVE concept vehicle and is evolved into a self-sufficient tool that can be expanded to other fields. For this reason, the design of an integrated auxiliary station system will also be performed, making EVE the new mobile hospital. It will go hand-in-hand with the development of a service structure, taking the product to a profitable level.

Now, even though MHUs have as goal to improve the access to basic health care, they still carry out numerous missions, ranging from preventive to curative support. Accounting all these operations possibilities into one design is found to be complex and thus a single operation will be focused on. Once the solution has been worked out, the process of expansion to other operations is permitted and looked at. The mission and vision are given below.

MISSION

Create a shared air support service used for the vaccination of remote communities in East Africa.

VISION

Improving the access of health care and emergency response through the creation of an international network of eVTOL air support in humanitarian aid.

Immunization is chosen as the basis since:

- Does not required high complexity medical equipment (IAC, 2021).
- Good combination of cargo and medical staff transportation which can show the potential of an eVTOL solution.
- The need for an auxiliary system becomes more relevant to the organization of the operation.
- It is one of the main operation carried by MHUs.
- Some vaccinations require multiple sessions such as Measles (MSF, 2021), thus providing continuity of the service.
- Initially avoiding patient transportation, easing the implementation of the concept.
- A lot of knowledge can be found due to the current COVID-19 pandemic.

The mission is divided into two levels, referring to the previously created SWOT table:

MISSION

PRODUCT LEVEL

Design of an auxiliary station system to be integrated in EVE concept vehicle

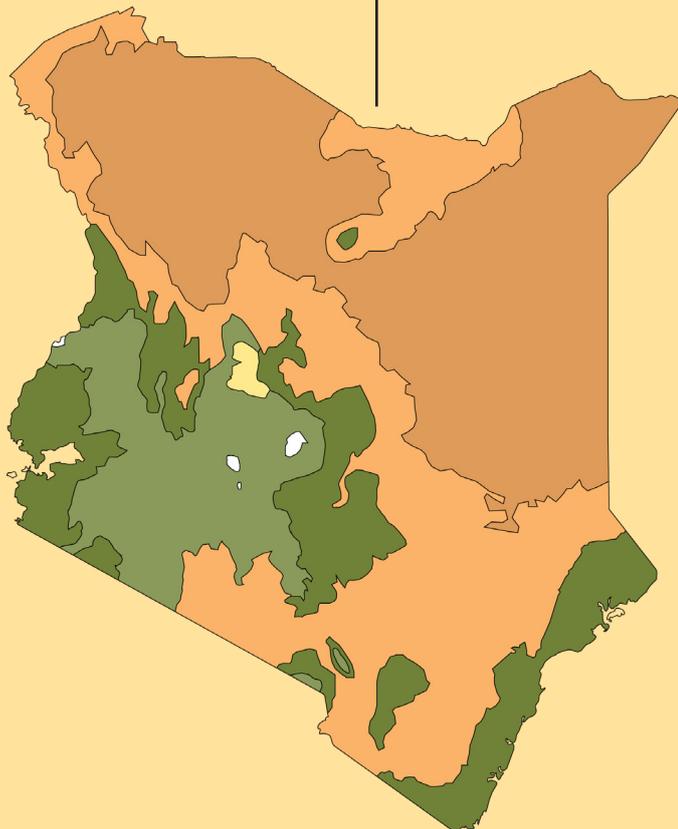
SERVICE LEVEL

Servization of EVE for immunization operations

REGION OF IMPLEMENTATION

It was previously hinted that the adaptation of EVE concept vehicle is done for humanitarian aid in East Africa. The continent defines the biggest area of operations of humanitarian organizations, with more than 76.1 million people targeted (OCHA, 2020). With the lack of adequate infrastructures and stable electrical grids, the region defines a low resource zone that will provide numerous challenges for the solution. Primarily, Kenya is chosen as it is the largest MSF program outside a conflict zone, with manageable landscape, scattered cities,

a presence of mobile health operations and a need for immunization operations (MSF, 2018). For the simplification of the project, we want to assume that the concept vehicle is utilized outside of conflict zones as it neglects the threats of local rebel groups and military. Staff and patient securities are an omnipresent need in humanitarian organization but define a whole project by themselves. Since EVE defines a new opportunity, we want to start in a safe and stable region, and potentially expand to lower developed areas that have added threats.



CLIMATE MAP LEGEND
(Beck et al., 2018)

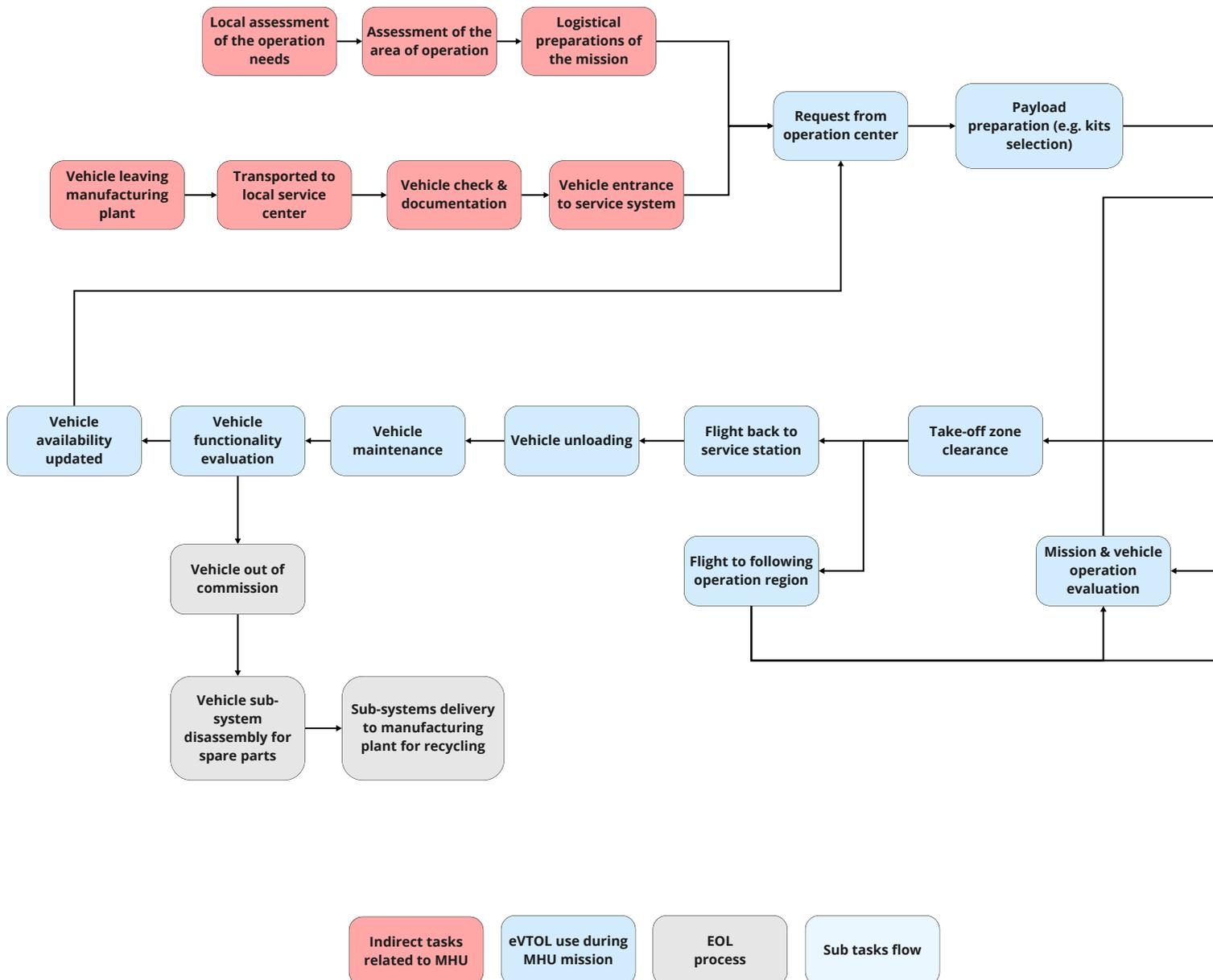
- Polar, tundra
- Arid, steppe, cold
- Arid, steppe, hot
- Arid, desert, hot
- Temperate
- Tropical, savannah & rainforest

MISSION PROCEDURE

Due to the Mobile Health Units' limited effectiveness, their planning, organization and procedure define crucial elements in their implementation that decide if the mission is worthwhile. Initially, since MHUs are considered as a 'last resort' solution, numerous tasks are done beforehand in order to confirm their potential and necessity. MHUs are logistically laborious that require precise planning to avoid any issues and delays. Their consideration is based on a list of questions that are asked throughout their journey, shown in appendix A.

The queries supply requirements to be fulfilled by the solution, prescribing design constraints that lead to a more specialized product and

service. At this moment, key stakeholders such as the assessment teams (currently part of the humanitarian organizations) and local communities play a vital role in supporting EVE with the mission requirements. They do not only help plan the vehicle's mission, but also support it on the field through practical matters (e.g. providing landing space clearance). The consideration chart is furthermore useful if Embraer Humanitarian Air Service (EHAS) decides to take a more decisive role in the creation of missions. By taking the concerned players' tasks and combining them with vehicle operation necessities, a mission journey map is given in figure 3 below, highlighting the main tasks that are carried out in a chronological order.

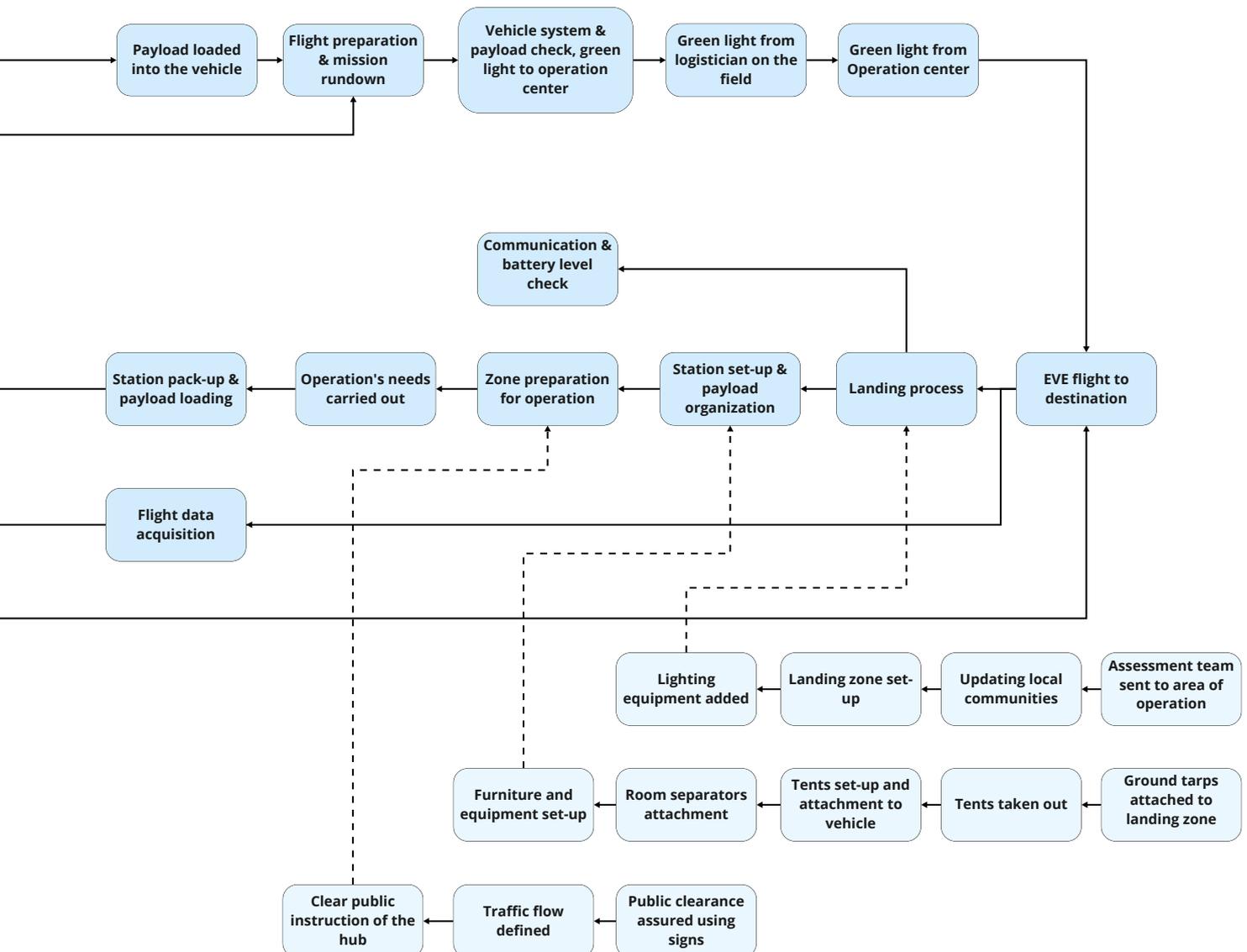


Take-away from product journey map

One main take-away from the defined journey map is that the assessment teams are a crucial element of the mission, providing with the what (type of vaccination), who (the amount required) and where (the vehicle's destination). Therefore, even though EVE is solely used to carry out the immunization operation, the assessment teams will have to travel to the specified locations regardless. Until eVTOL vehicles are widely implemented into our current transportation structure, EVE will not fully 'replace' the terrain vehicles and will require their support at the beginning of the new system transition.

Since these ground traveling assessment teams are not usually rushed, do not carry critical tasks (e.g. patient saving), and arrive on location before the operation is carried out, they allow to find advantages and opportunities for the product & service design, providing a smoother mission procedure and relieving EVE from being overly equipped. Provisionally, we assume that these assessment teams are present through the mission's timeline (providing helping hands for pre-landing tasks) and carry the necessary payload for the livelihood of the staff (e.g. food, sleeping gear).

Figure 3: Product journey map



LIST OF REQUIREMENTS

The identified design requirements are based on the wants and needs of the intended users and clients, literature research and market analysis. They define objectives that shall be fulfilled in order to comply with the stated problem. Key requirements are identified in table 2 below. Obviously, the list is continuously iterated, additionally encompassing yet to be found requirements.

When finalizing the design of the concept, it is crucial to validate the requirements initially defined. Due to limitation in the time span of the project and availability of resources, numerous requirements are yet to be verified and validated, which shall be included as future recommendations.

The complete list and the verification & validation of the project's requirements are presented in appendix B.

Table 2: List of essential requirements

TOPIC	IDENTIFIER	REQUIREMENT	VALUE	UNIT	TYPE
Power	SS-B-003	The vehicle shall be equipped with a charging system	-	-	Demand
Payload	SS-PL-002	Medical equipment included shall be considered "essential" in order to limit weight	-	-	Demand
Logistics	O-LO-003	The auxiliary system shall be set and packed up in less than X	1	hour	Demand
Auxiliary system	SS-AS-001	The auxiliary system shall not cost more than	6000	€	Demand
	SS-AS-005	The auxiliary system not be heavier than	100	kg	Demand
	SS-AS-011	The auxiliary system shall be easily stored	-	-	Wish
	SS-AS-014	The auxiliary system shall have the required humanitarian organization representation (e.g. stickers)	-	-	Demand
	SS-AS-020	The auxiliary system shall be suitable for any kind of environment condition	-	-	Demand
	SS-AS-021	The auxiliary system shall be easily maintained	-	-	Wish
Vaccination	O-VA-001	Vaccines shall be transported within the temperature range recommended by the manufacturers	-	-	Demand
Vehicle	R-VE-001	The vehicle shall not have military affiliation and equipment	-	-	Demand/regulation
	R-VE-005	The vehicle shall transport a minimum of X passengers.	2	pax	Demand

IMMUNIZATION IN THE AMAZON
MSF team & health staff returning to their
boats, used to reach remote communities
on the shores of Lake Mirini, Brazil.

Photographed by: Diego Baravelli [11]





CAMPAIGN AGAINST MEASLES

Vaccination of a child during a campaign carried out by MSF and the Ministry of Health in Timbuktu region, Mali.

Photographed by: Mohamed Dayfour [12]

FINDING A SOLUTION



With the project's scope defined, and an initial list of requirements constructed, the solution on a product level can be looked at. As previously shared, the product is based on EmbraerX's EVE concept vehicle, adapting it to the need that arise from the mission requirements. First, an arrangement of the station set-up is given, characterizing the different elements of the auxiliary station system. Then, we examine its integration into the vehicle, followed by a glance on the product's livery. A Bill of Material will then be created, giving preliminary cost and weight estimations. Finally, user feedback will be carried out in order to create an optimized design iteration.

MOBILE CLINIC LAY-OUT

An advantage from carrying out the project during a pandemic is the available knowledge concerning optimized vaccination clinic lay-outs. Since mobile vaccination center solutions were also needed throughout these hard times, they can easily be implemented into our scenario as they represent the same goal.

The first step is to acquire the different clinic lay-outs that are used, with exemplary one found in figure 4 below, and define their similarities.

From quick observation, we notice a recurring trajectory:

Entry > Reception & registration > Waiting area > Vaccination area > Observation area > Exit

Note that reception & registration needs to have a clear view of the traffic, with separate entry & exit. Even though it is the first checkpoint, traffic control outside of the clinic should also be thought of. The waiting area is just an intermediate space. Although, due to COVID-19, distance between the patients is mandatory and is not necessary for standard immunization operations. The people shall be organized with the first registered close to the vaccination area and the recent patients at the back.

With that in mind, an initial set-up can be constructed for the vehicle. For now, only a single vehicle lay-out will be looked at, shown in figure 6. Nevertheless, the clinic could potentially be enlargement in the future into a double vehicle lay-out, presented in figure 7, increasing the number of vaccinations within a day of operation. For this reason, we want the auxiliary station system to be design with a certain freedom of play, enabling a modular characteristic to the product.



Figure 4: Exemplary vaccination clinic lay-outs used in Beau Sejour for COVID-19

Landing zone organization

Now, similarly to helicopters, a crucial component in air services is the dedicated landing zone. It is bound by regulations that dictates the necessary lay-out and components. The landing zone needs to meet specific clearances during landing and take-off procedures, which shall be well identified. This also includes maximum terrain slope angles, which shows the importance of choosing a fitting landing area. Taking into account recommendations for hospital helipad development (MOAAMS, 2008), the landing zone is illustrated in figure 5 below. Since the vehicle shall also be able to operate during night time, adequate lighting needs to be provided to increase pilot visibility and thus vehicle safety. For this reason, the ground traveling assessment team carries Avlite's EMS Temporary Helipad Kit, consisting of four steady burning green visible/infrared lights and one flashing white visible/infrared light (Avlite, 2015).

The landing zone is fully set-up by the ground unit before the arrival of the eVTOL vehicle and is bounded through the use of stripes & poles, keeping the communities at a safe distance. As we do not want to overlap the carried equipment and add unnecessary weight, the designated landing zone will consist of a groundsheet that is additionally dedicated for the auxiliary station system. It is important to note that the groundsheet shall be well secured in order to avoid any debris collision with the vehicle while landing. Additionally, since the groundsheet is flexible, it will fit for harsh & uneven terrains.

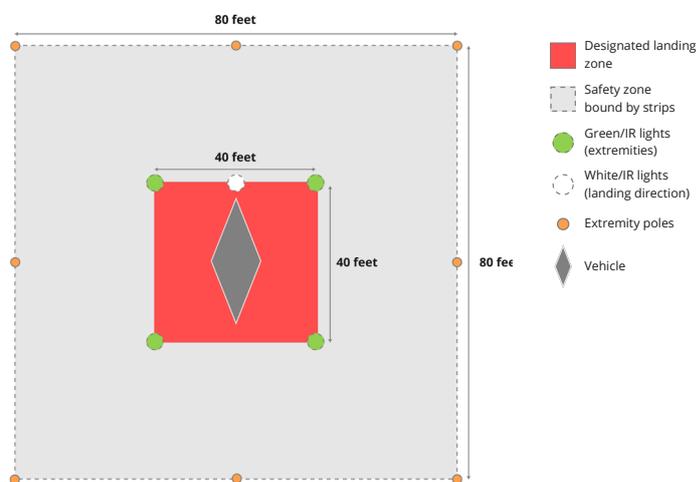


Figure 5: Landing zone lay-out

SINGLE VEHICLE LAY-OUT

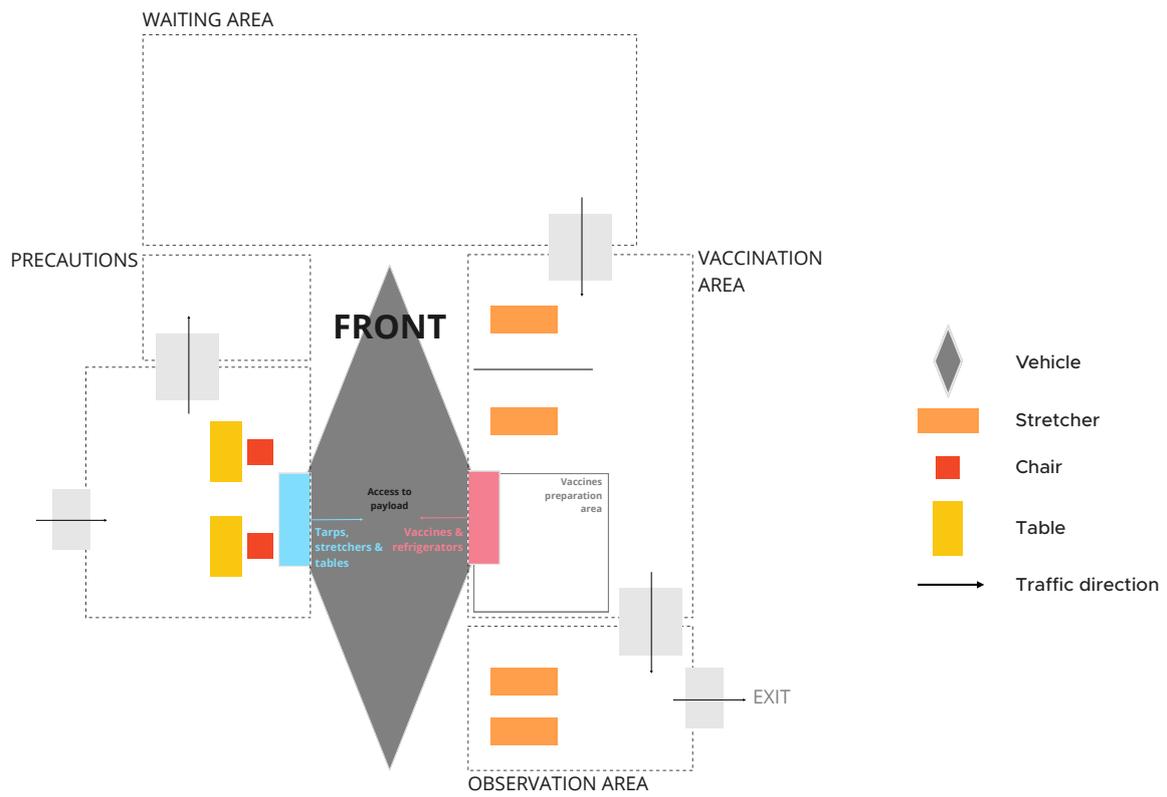


Figure 6: Preliminary single vehicle lay-out of the system

DOUBLE VEHICLES LAY-OUT

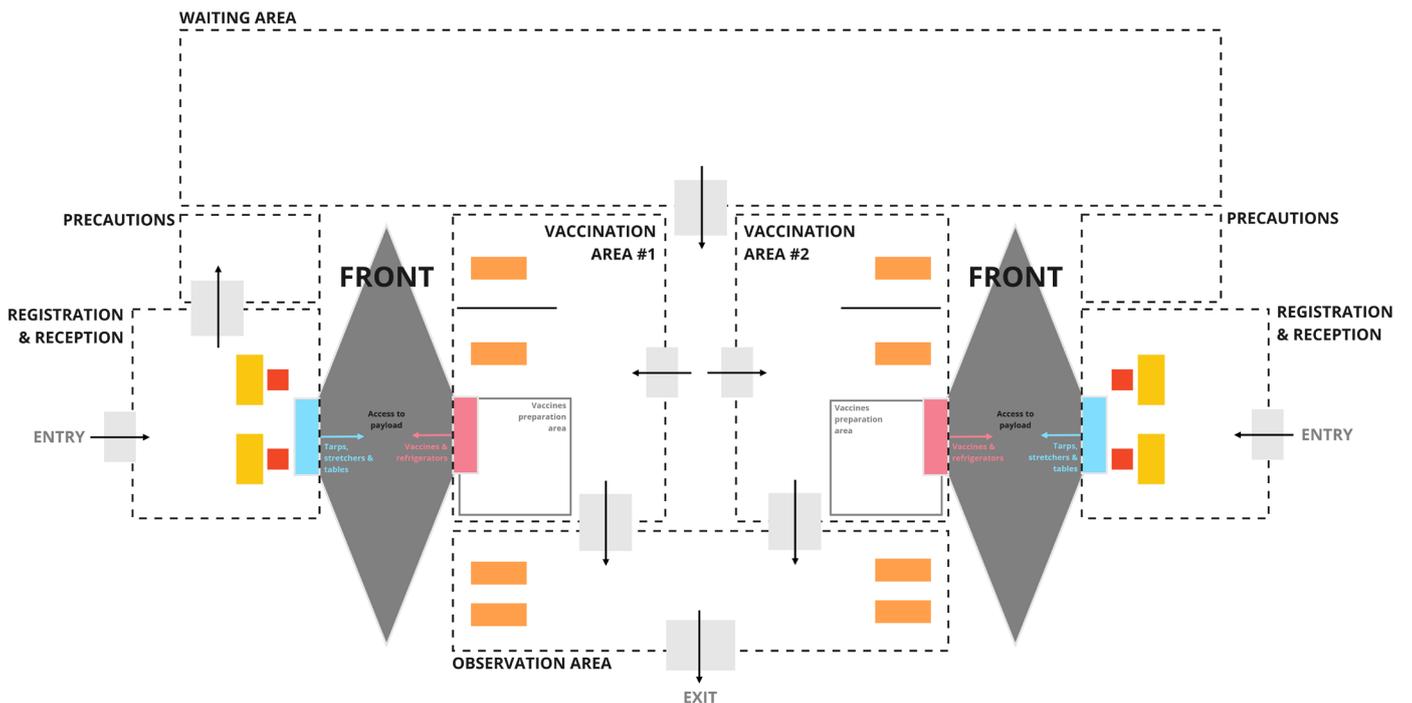


Figure 7: Preliminary double vehicles lay-out of the system

AUXILIARY STATION SYSTEM DESIGN

With the general lay-out briefly known, we can dive into the technical perspective of the auxiliary station system. For that, a Design Option Tree is created to provide an overview of the possible technology options that could be used, shown in figure 8 below. The elements are based on a technology research, inspired from simple leisure tents to military grade versions.

The red-marked elements are options that are excluded from the decision and allow to narrow down the possible combinations:

- **Full framed tent system** defines a heavier solution compared to a pole tent, and will be

avoided in order to conform to the weight requirement set beforehand.

- **Local infrastructure adaptation** is skipped as the scope of the project only focuses on the vehicle as a self-sufficient product.
- **Nylon** is not be used as a tent material as it is less resistant to the harsh environment that the station could experience.
- **Steel poles** are avoided as they are heavy, and their sturdiness can be replaced by aluminum alternatives.

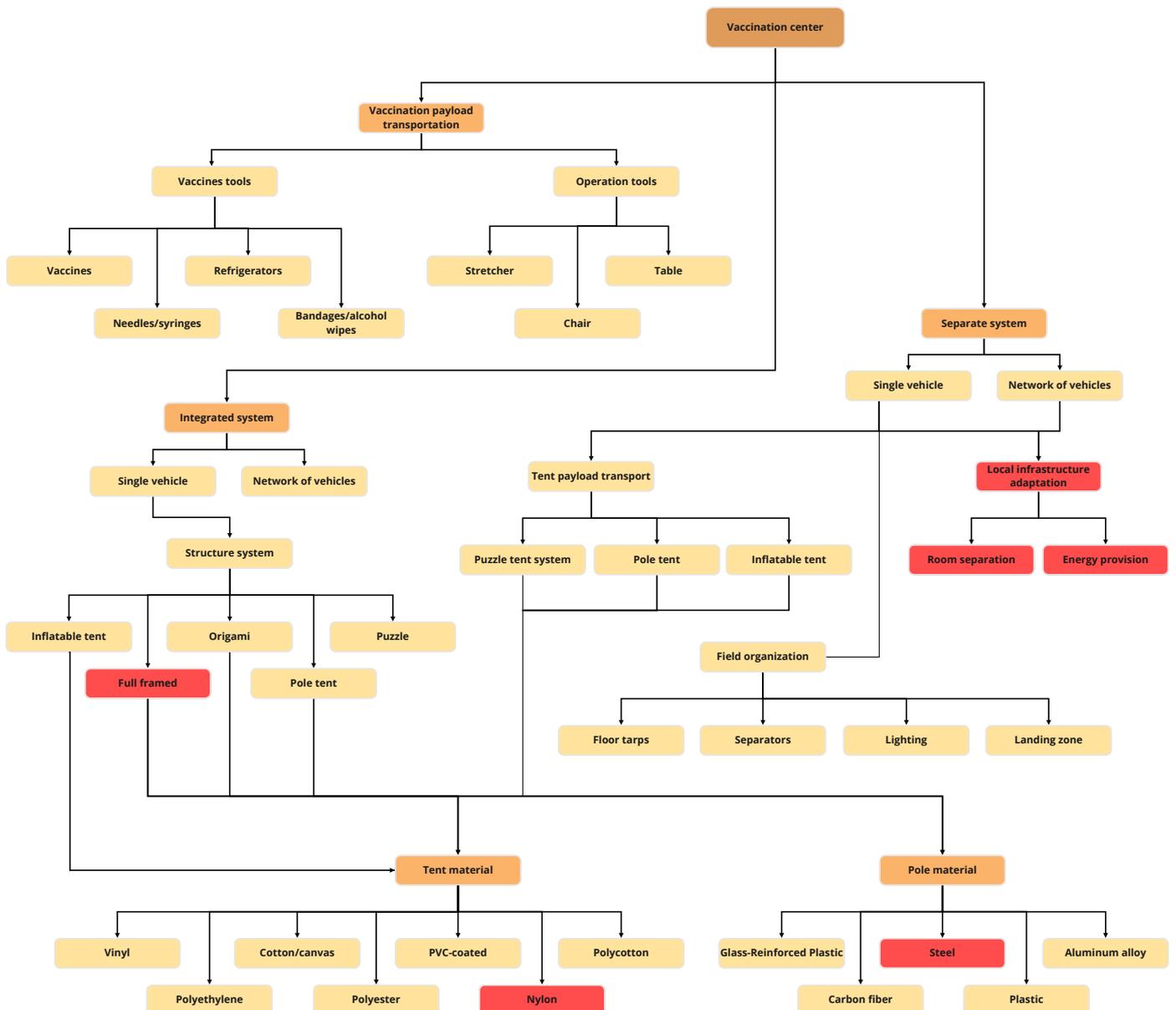
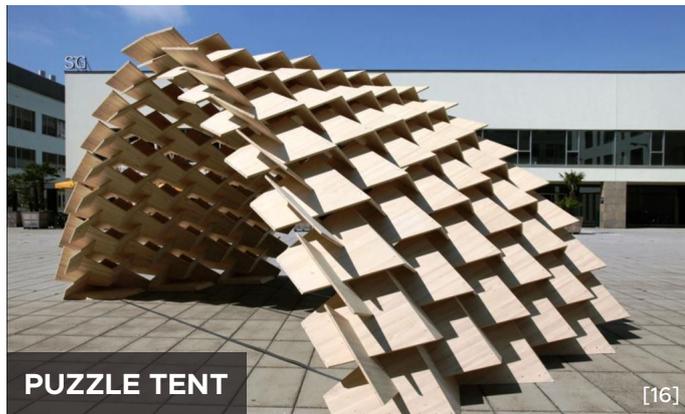


Figure 8: Design Options Tree for the auxiliary station system

The main component of the auxiliary station system is its structure. Four relevant options are offered, presented below.



In order to find the most suitable option in our scenario, a Weighted Criteria Method is utilized (table 3). The decision making uses six criteria that were taken from the list of requirements, and gives a score of 1 (bad) to 5 (excellent) for each characteristic. After adding the respective criteria's weights, a winning option is defined and is found to be the standard **'pole'** tent structure.

Table 3: Auxiliary station system structure type trade-off

			TENT TYPE			
REQUIREMENT	CRITERIA IDENTIFIER	WEIGHT [%]	Inflatable	Origami	Pole	Puzzle
The auxiliary system shall be set and packed up in less than 1 hour.	Set-up duration	25	4	5	4	1
The auxiliary system shall be suitable for any kind of environment condition.	Adaptability	25	3	2	5	2
The auxiliary system shall not be heavier than 100 kg.	Lightweight	20	3	2	4	2
The auxiliary system shall be easily stored.	Space efficiency	15	3	2	4	5
The auxiliary system shall be easily maintained.	Maintenance	10	3	3	4	5
The auxiliary system shall not cost more than 6000 euros.	Cost-effectivity	5	4	3	5	3
			330	290	430	255

Vehicle operation set-up

Now, by combining the preliminary clinic lay-out, the landing zone lay-out, a representation of the vehicle's simplified structure and the decided auxiliary station system structure, a vehicle operation set-up can be settled and shown in figure 9. A 3D sketch of the system is shown in figure 10.

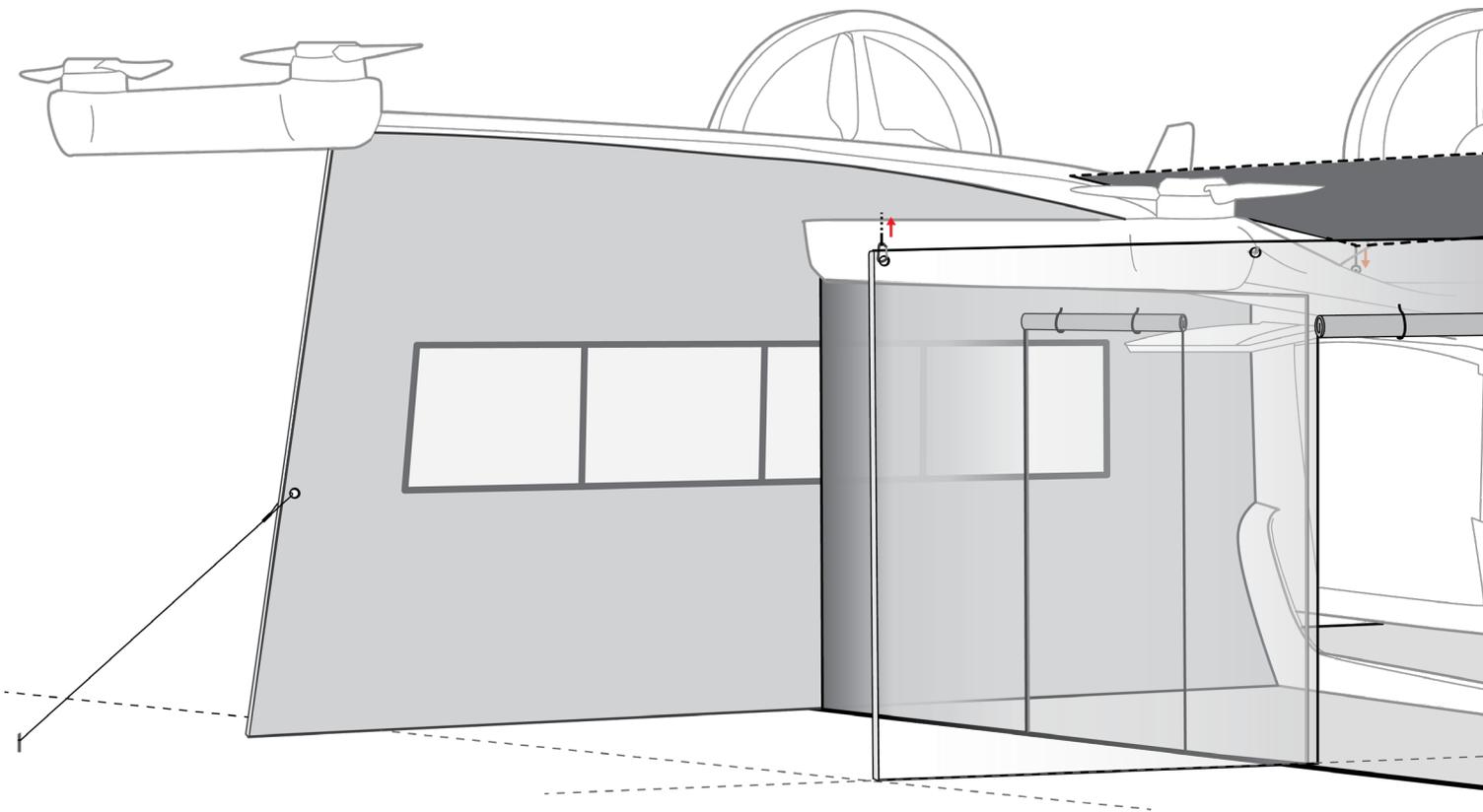
Few comments can be made in order to support the vehicle operation set-up:

- **Tarps are widely available on the market in rectangle shapes**, defining a cheaper, promptly available and easier solution compared to custom made versions. By analyzing the vehicle's structure, the tarp could fit perfectly between the rear rotor arms system, which in turn could be used as attachment points for the auxiliary system. This will not only reduce payload weight due to replacing the poles with integrated attachment in the vehicle, but also set-up time.

- **Four designated rooms are required:** reception > waiting area > vaccination area > observation area, in that order. Taking into account possible connection points on the vehicle to avoid the need of poles, the areas were separated.

- Currently, **the main overhead tarp is covering the four front rotors**. Since we desire to use a one-piece tarp for easy storing and set-up, and the fact that the front rotors are at a lower height compared the rear ones, it is possible to extend the overhead tarp to provide a wider area coverage. Due to the tarp's connection to the rear rotor arms, it allows for sufficient head room for the staff and patients. The tarp is also connected in the center line of the fuselage, offering a slight angle to push the water away when raining.

- **Extra space can be added** with the use of one extra pole, if the quantity of patients has increased or other needs have emerged.



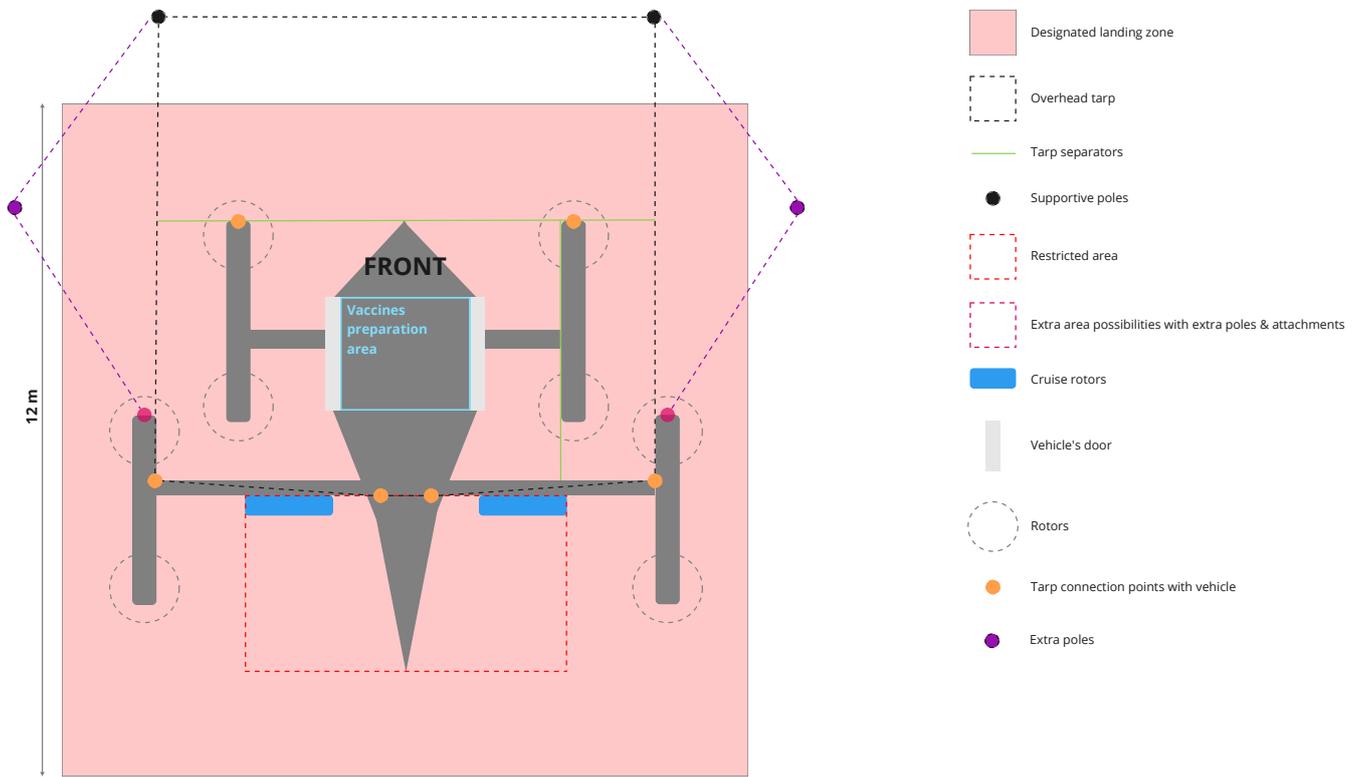


Figure 9: Vehicle operation lay-out

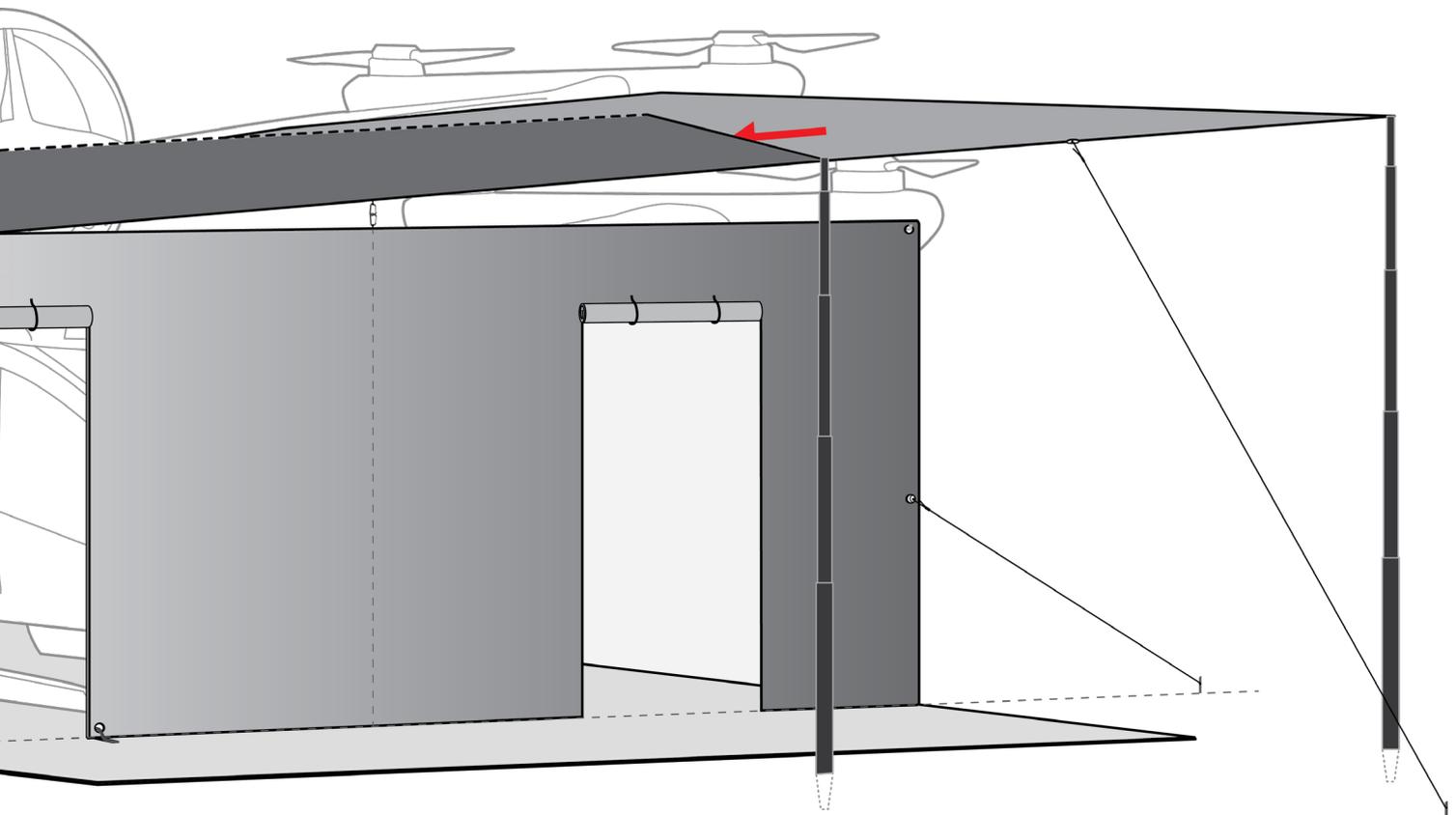


Figure 10: Auxiliary station system design

Drawback due to vehicle charging

An important drawback that surrounds eVTOL technology and will influence the logistics of the service later on is the charging of the vehicle. With eVTOL vehicles currently being developed and improved, their range still pose an issue on their effectivity when drifting away from inter-city transportation. The specific flight range of EVE is yet to be known. Although, since EmbraerX is an Uber partner and is taking part in Uber's Urban Air Mobility (UAM) initiative, the vehicle is required to have a range of at least 96 km (Uber, 2016). Obviously, it is not much and finding a solution to skip the charging issue becomes relevant.

Now, a remarkable advantage of having a large overhead tarp is that it offers a large area that could be used for power generation through sunlight. Numerous solar powered tarps are available on the market, making the idea a feasible option. A decisive factor of its success would be to find if a solar powered tarp could charge the vehicle without overwhelming it with extra weight (which will be looked at later on). Having a power generation method fitted in the vehicle transforms it into a self-sufficient system, allowing to power sub-systems required by the operation and have more opportunities in term of service logistics.



Charging duration calculation

By estimating the rear wing span of EVE through image scaling, finding the daily energy output of a comparable solar powered tarp system and applying them to the assumed battery capacity of the vehicle, we get that by using an overhead tarp equipped with PowerMod solar panels (FTL Solar, 2020), the vehicle can be fully charged in 1 days and 5 hours. A more profound explanation of the calculation steps can be found in appendix C. Note that this is excluding the power usage of other sub-systems such as refrigeration, increasing the charging time slightly if included. As Mobile Health Units' operation usually last few days at each destination, using a solar powered overhead tarp is found to be a potential solution

to avoid the charging issue and thus the short flight range. This means that the vehicle could potentially travel to additional locations where vaccinations are required without the need of going back to base for charging purposes.

Tent exterior design

As for the tent exterior design shown below, it was desired to blend it with its surrounding with the use of similar earthy shades to avoid strong contrast with the vehicle and the environment, and gives a feeling of comfort for the patients. Potentially, it will drift the attention away from the futuristic looking vehicle, avoiding the attraction of cluster of curious people that could influence the efficiency of the operation.



PRODUCT IN CONTEXT

The solution is integrated well into the environment through the use of suitable colors and adequate recognition of the humanitarian organization.

INTERIOR & EXTERIOR DESIGN

So far, two relevant items have been settled: immunization purposes of the operation, which asks for specific tools & equipment; and the auxiliary station system design, which provides with the necessary sub-systems to carry out the mission. These elements describe the payload to be transported by the vehicle in addition to the crew. A diagram that clarifies the list of items is given in figure 11 below. As previously discussed, some payload is also carried by the

ground traveling assessment team beforehand, such as the ground sheet and food supplies, which lightens the cargo to be carried by EVE. The list defines the essential items that are needed to carry out the operation even in case the assessment team has not arrived to the destination, and includes equipment that is currently transported by the Land Cruisers run by MSF.

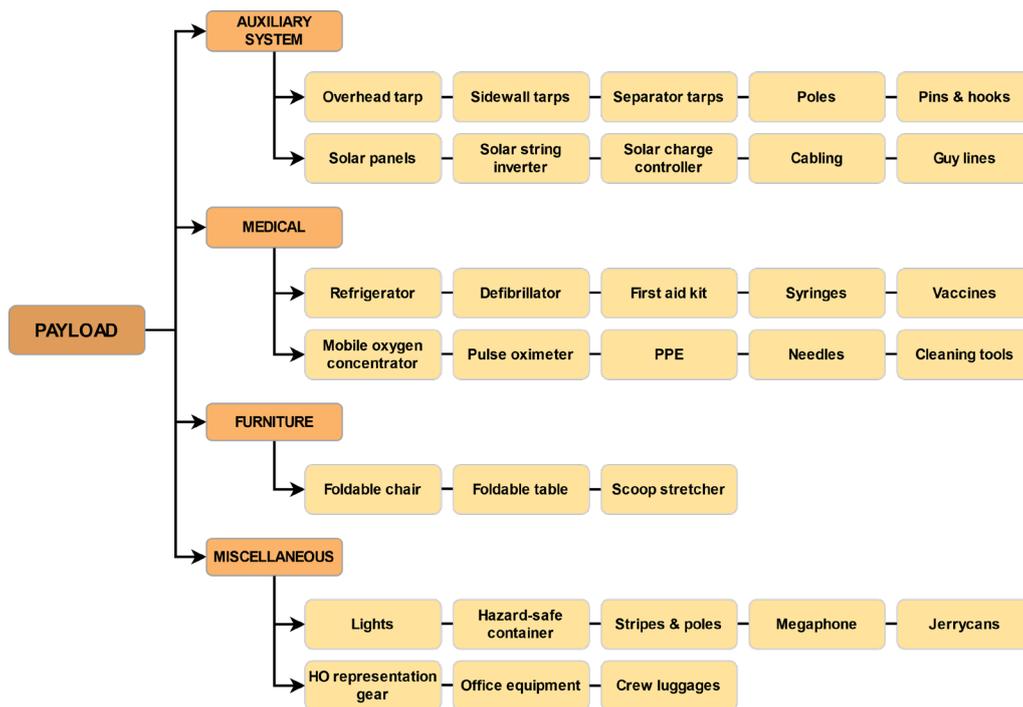


Figure 11: Payload of the vehicle for the immunization operation

Vehicle interior lay-out

The interior lay-out is organized with space efficiency and staff ergonomic as foundations. Initially, transporting a minimum of 2 crew members excluding the pilot is set as a requirement. It defines the minimum staff amount in order to carry the operation without additional support: one crew member is at the reception & registration, the other one is providing the vaccines, and the pilot controls the traffic and has a supportive role. Another crucial item that takes an important percentage of the payload's weight is the refrigeration system. It is imperative for the vaccines to stay in the recommended temperature range by placing them in proper storage throughout the mission's time frame. This also implies that the solar powered overhead tarp shall potentially provide the refrigerator with continuous power for the remaining of the mission (which leads to an increase of vehicle charging

time). Additionally, as previously indicated in the mobile clinic lay-out, the vehicle's cabin is used as a vaccination preparation area as it defines a sterilized workspace. Thus, an integrated foldable table will be added which can be raveled to offer cargo space. By estimating EVE's cargo space through image scaling, a quick lay-out is presented from a top view perspective in figure 12 and a more defined illustration is provided in figure 13.

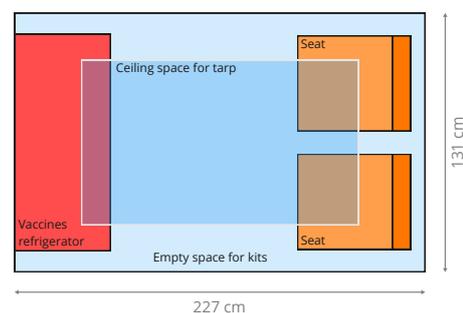
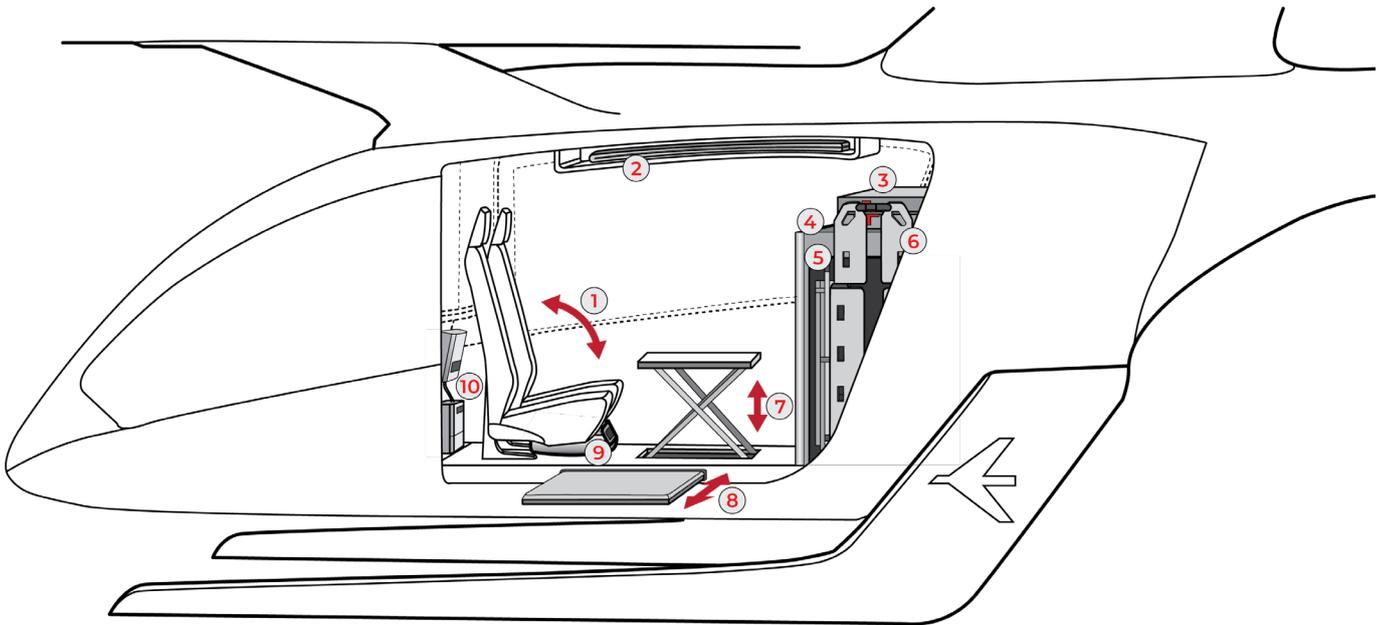


Figure 12: Top view of the payload organization



- ① The vehicle is equipped with two passenger seats, for medical staff, flight crew, or other personnel. The seat can fold, allowing for additional space for patient or cargo transportation.
- ② The vehicle has a compartment attached to the ceiling which allows for the storage of the overhead tarps, sidewalls, and separators.
- ③ The vehicle is equipped with a first aid kit, which contains standard tools, a pulse oximeter, and a defibrillator.
- ④ A refrigerator is added to the vehicle in order to keep certain vaccines at the specified temperature range provided by the distributor.
- ⑤ A foldable table and chair are provided, offering supportive furniture to the staff and a place to seat for the patients. The tent poles are also stored on the other side of the refrigerator.
- ⑥ The vehicle is equipped with a scoop stretcher, allowing to transport an injured patient to the vehicle, or to the supportive terrain traveling crew.
- ⑦ Within the floor of the vehicle, a foldable table can be raised in order to offer a space to prepare the vaccines.
- ⑧ A sliding chair can be pulled to offer a seating option for the staff. It is in addition to the foldable chair and is stored in an efficient matter.
- ⑨ The vehicle is equipped with a mobile oxygen concentrator, replacing the need for an oxygen cylinder.
- ⑩ In order to use the generated power by the solar panels, the solar powered tarp is connected to a string inverter and charge controller.

Figure 13: Interior organization of the payload

The livery of the vehicle (found in figure 14) is devised to adequately give the local communities a sense of professionalism, safety and dedication. The colors are chosen to reflect the environment through earthy shades, and

the humanitarian organizations through their specified red. Proper labeling is added with the use of the humanitarian organization's logo to show the purpose of the vehicle and drift it away from any military representation.

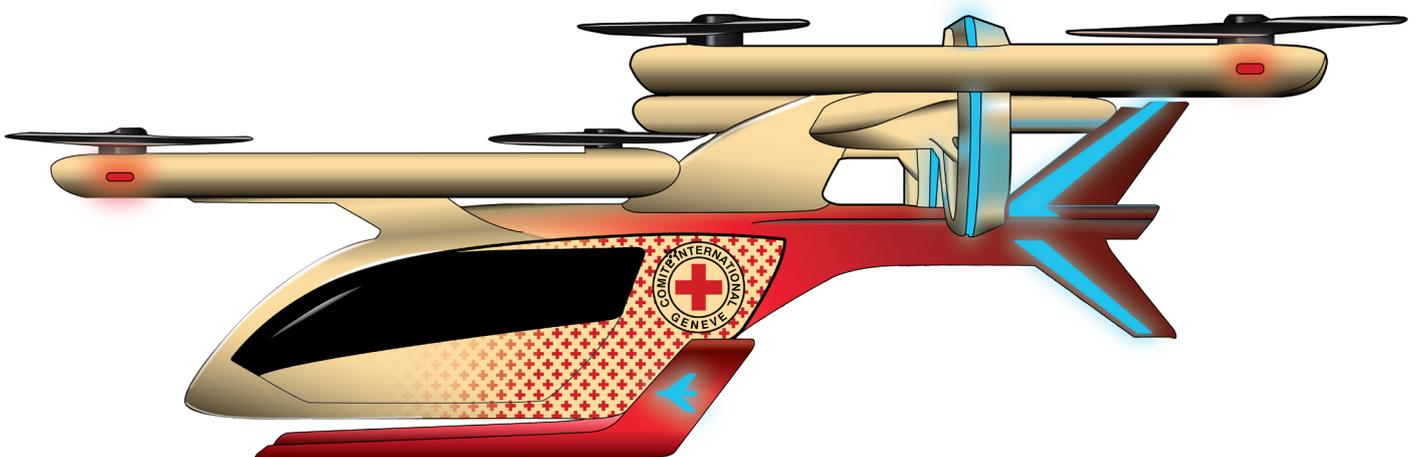


Figure 14: Livery of the vehicle

BILL OF MATERIALS

The bill of materials, which lists all the required components for the mission, allows to estimate the cost and weight of the end product. It provides more concrete information concerning the feasibility and viability of the idea, bringing us closer to a desirable solution. The complete bill of materials can be found in appendix D.

Assuming that EVE's has a total payload weight of 450 ($\pm 10\%$) kg (taking similar specifications to Vertical Aerospace VA-X4 model (eVTOL news, 2021)), and knowing that 3 passengers are present throughout the flight (1 pilot and 2 passengers at an average mass of 70 kg), we have that the total mass left for the rest of the payload amounts to 240 kg. By analyzing the bill of materials, we notice that the vehicle is overweight by 36%, with the heaviest elements being the tarps, refrigerator and solar generation system. Thus, prioritization and sacrifices need to be made in order to stay within the weight limits.

- **The refrigerator is crucial for the operation** and its mass depends on the required vaccines quantity. The version selected is a 45L refrigerator which is the smallest one available and has a storing capacity of around 18,000 doses. Since the refrigerator needs continuous power for stable temperature control, it is connected to the vehicle's power storage system.
- **The mass of solar panels depends on their effectivity & efficiency.** The solar panels that are used for the mission are lighter than the solar panels tarp system available on the market (135 kg vs 770 kg), have around half the performance but can still be folded. Although, by adding the string inverter and charge controller, the solar generation system takes 26.8% of the total weight, resulting in 164 kg.
- **The tarps have been chosen to be made from Knitted Polyester Scrims**, a military grade material that is resistant to the potential harsh environment and is moderately lightweight. Characteristics of the auxiliary station system tarp materials are given in appendix E.
- **All medical equipment**, including the refrigerator, **is provided by the humanitarian organization's kits.** These kits include the vaccines and needed equipment for the operation, and thus are essential. Nevertheless, their costs are excluded from the total sum as they are not included in EmbraerX's budget.

All in all, by regrouping the necessary components for the mission, we get a cost estimation shown in table 4 below. It is observed that the solar panels represent 93% of the total cost of the payload. Nonetheless, assuming that solar panels will gradually become cheaper in the future, special partnerships can be founded with EHAS and the flight range of the vehicle will increase (potentially avoiding the need of fully charging the vehicle mid-mission), the total payload cost is projected to decrease substantially. The solar generation system is thus playing a decisive role in the payload organization of the vehicle, taking the majority of the weight and cost. It is crucial to identify whether the solar generation system shall be scratched and replaced with more essential payload (e.g. medical kits), or whether it shall be decreased in size. This issue will be reinspected after the user feedback and will likely affect the operation logistics of the service.

Table 4: Summarized cost & mass estimations

SUBSYSTEM	COST [€]	MASS [kg]
Tarp	2,602	145.4
Poles	50	7.3
Extras	63	0.7
Auxiliary station total	2,715	153.4
Solar panels	56,700	134.6
Solar string inverter	595	12.5
Solar charge controller	822	16.6
Solar generation system total	58,117	163.7
Refrigerator	-	70
Miscellaneous (e.g. vaccines, chairs)	-	13.7
Passengers	-	210
TOTAL	60,832	610.8

By removing the solar generation system from the cost calculation, the total amount for the rest of the payload is manageable for the adaptation of the vehicle, especially that it defines a fixed cost that stretches over the system's lifecycle.

USER FEEDBACK & ITERATION

The main concern when designing a solution from afar is the missing realization that theoretical expectations are distinct from the real scenarios on the field. For this reason, user feedback is essential for optimizing the solution to the problem, additionally providing with insights that have been overlooked.

The first interviewee, Stéphane du Mortier - Health Learning & Development Manager at the International Committee of the Red Cross (ICRC), has been working in the humanitarian sector since 1993. Carrying out operation on the field in numerous countries, he has experienced firsthand the needs and actual procedure of communities' immunization. Three pivotal comments have been given and used to iterate the design:

1. Basing the clinic lay-out on the current pandemic set-up is irrelevant as the immunization operation on the field are much less private and luxurious than initially thought. As presented by the figure below (courtesy of

ICRC), we see that humanitarian operation are highly based on practicality and function with the available resources.

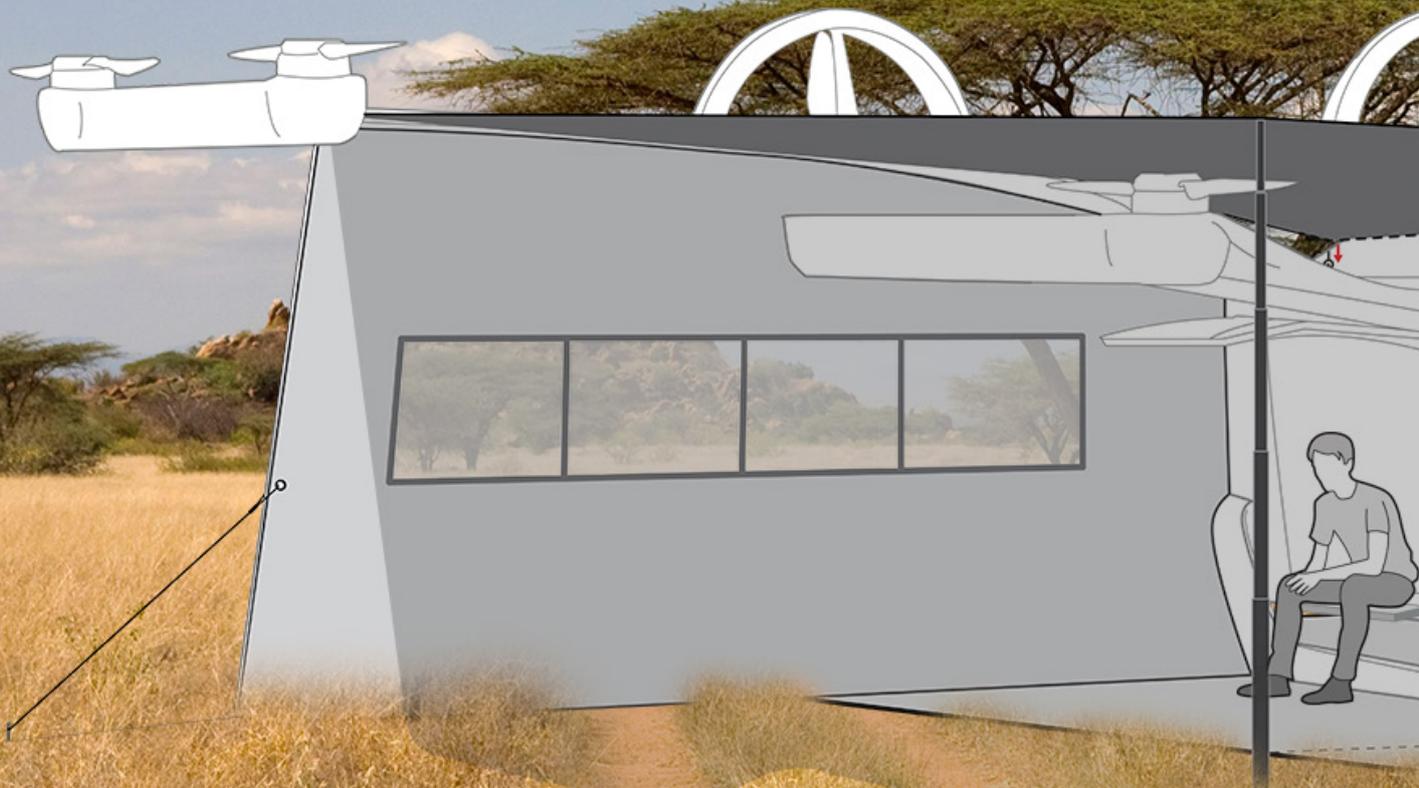
2. After receiving a certain benchmark on the procedure currently used on the field and knowing that the vehicle is currently overweight, **it was decided to remove the sidewall and separator tarps completely**, besides one unit that is left to avoid traffic congestion. The iterated set-up is shown in the realistic visualization on the next page.

3. The time difference between the assessment team and medical team is minimal, and triage is done during the operation. **It is highly preferred to carry an additional staff member and/or medical equipment** than having a more protected operation center, thus pushing the need for the vehicle to be independent from other players. Thus, there is potentially an occasion for a two-EVE vehicle logistics in order to fulfill the mission's needs which will be looked at later on.



A NEW METHOD OF OPERATING

The iterated auxiliary station system is improved in terms of cost & weight usage. Due to the decreased amount of parts, the system is suitable for numerous terrains and defines easier maintenance, creating a more optimized solution.



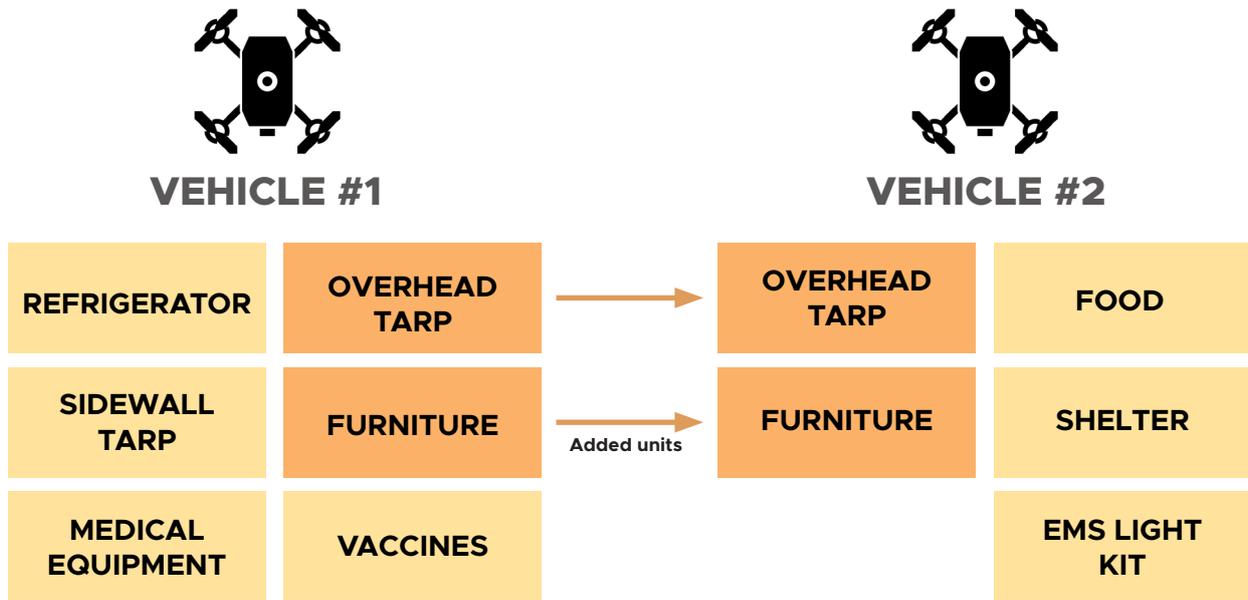


Average daily vaccination rate estimation

Now, even though we have rigged the vehicle with necessary equipment, it is crucial to estimate the effectivity of the solution in terms of how many vaccinations can be carried out within the mission time frame, which in turn affects the service logistics. Using quick back-of-the-envelope calculations, we assume that it takes 2 minutes to vaccinate a person (registration & vaccination process overlap as it is done through chain method). Estimating a daily average work schedule of 10 hours, we are able to vaccinate 300 patients within a day for a team of three staff members. It seems rather low since MSF was able to vaccinate a total of 1700 children

and women within two days (MSF, 2019).

Thus, it is fundamental to have more helping hands in order to accelerate the vaccination process. With three more members, the daily vaccination jumps to an estimate of 700 patients and can deliver the 18,000 vaccines within a month of operation. For this reason, it is decided to add another vehicle in the equation. Not only it provides more passenger transportation and necessities for the livelihood of the staff, but it replaces completely and does not rely on the ground traveling assessment unit. This means that vehicle #2 has to fly during the day as adequate lighting for landing are not available.



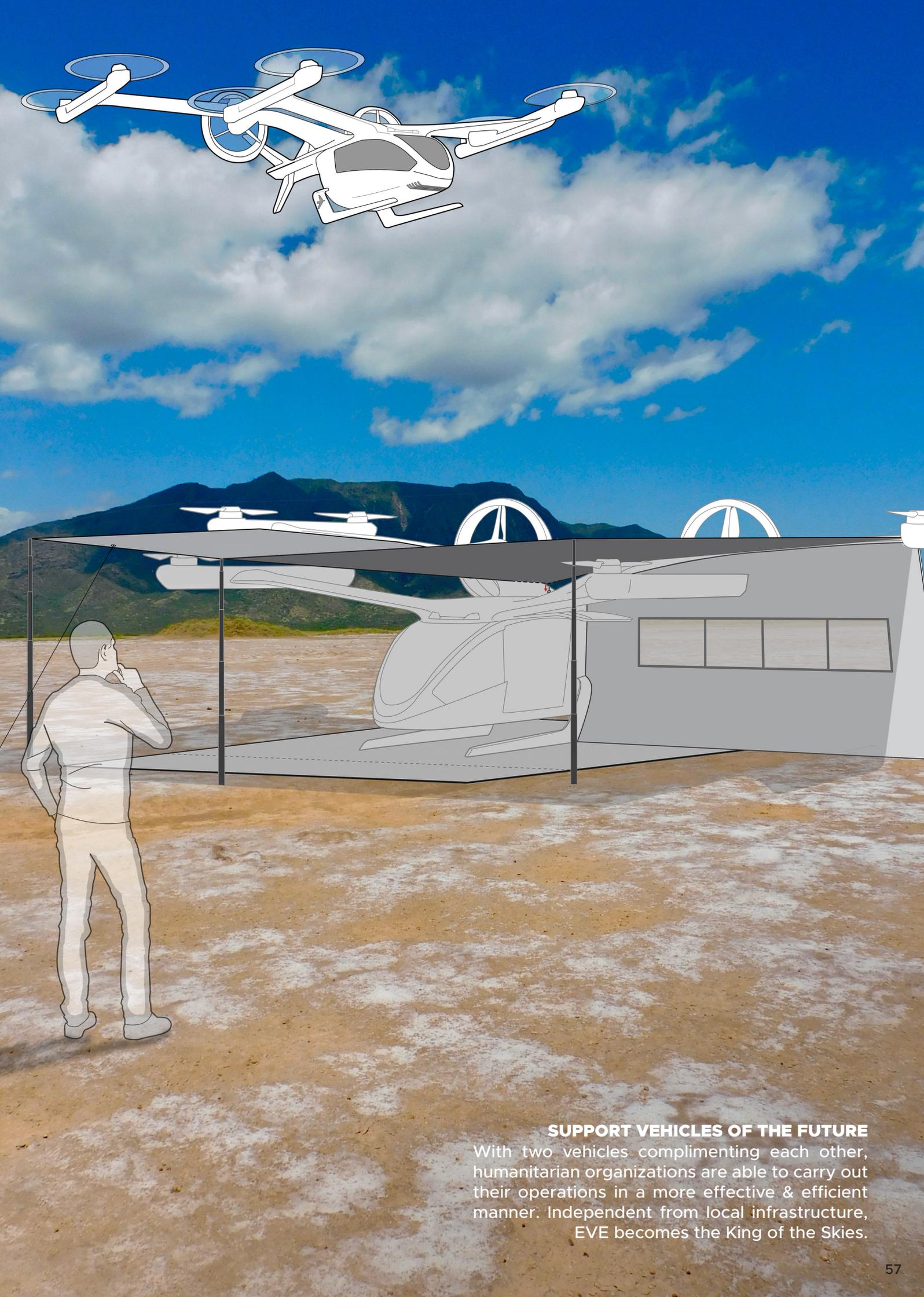
Iterated vehicle set

After performing calculation for the projected number of vaccinations, we can settle the issue with the solar generation system. By halving the amount of the solar panels (and thus resolving the vehicle's overweight problem), we are able to fully charge the vehicle within a week which

results in 4900 vaccinations delivered. This then define the required stay duration when looking at the service logistics later on. The iterate cost & weight estimations are given in table 5 below. Note that vehicle #1 surpasses the 450 kg payload weight specification but is still within the safety margin ($\pm 10\%$).

Table 5: Iterated cost & mass estimations with an additional vehicle

	VEHICLE #1		VEHICLE #2	
	Cost [€]	Mass [kg]	Cost [€]	Mass [kg]
Station system	1765	97	1215	77
Medical	0	76	0	4
Solar generation	29060	82	29060	82
Staff livelihood (e.g. food, shelter)	0	0	N/A	63
Passengers	0	210	0	210
Miscellaneous	44	7	2671	13
TOTAL	30869	472	32947	450



SUPPORT VEHICLES OF THE FUTURE

With two vehicles complimenting each other, humanitarian organizations are able to carry out their operations in a more effective & efficient manner. Independent from local infrastructure, EVE becomes the King of the Skies.

PROPOSING A BUSINESS

With the solution settled in the product level, it is crucial to define its integration into the market in order to show its evolution into a viable and profitable business for the client. Initially, the operation logistics are settled, putting the product into its use context and defining a preliminary list of capital needs. Finally, with the support of a competitor analysis, the business is structured, both in terms of organization and finance.

A KENYAN LANDSCAPE
Aerial view of remote communities
in Turkana, Kenya.
Photographed by: Imani Manyara [18]



OPERATION LOGISTICS

Referring back to the mission of the project, the solution is focusing on the immunization of remote communities. It is thus useful to define geographically the region of operation, leading to construct the service respectively.

Two maps were superimposed to create figure 15: the national electrical grid plan and the partition of the population density per district. By combining these maps, it allows us to identify the regions that would suggest the presence of 'remote communities' due to the small ratio of population vs. region area, and the unavailability of electrical infrastructures. In turn, it would advise that these communities are independent, and rely on the support of external players to provide them with the necessary health services due to the difficulty of reaching nearby medical centers (e.g. long distances, unavailability of transportation methods), if there are any. Now, it is important to note that some density value ranges are grouped for simplification purposes.

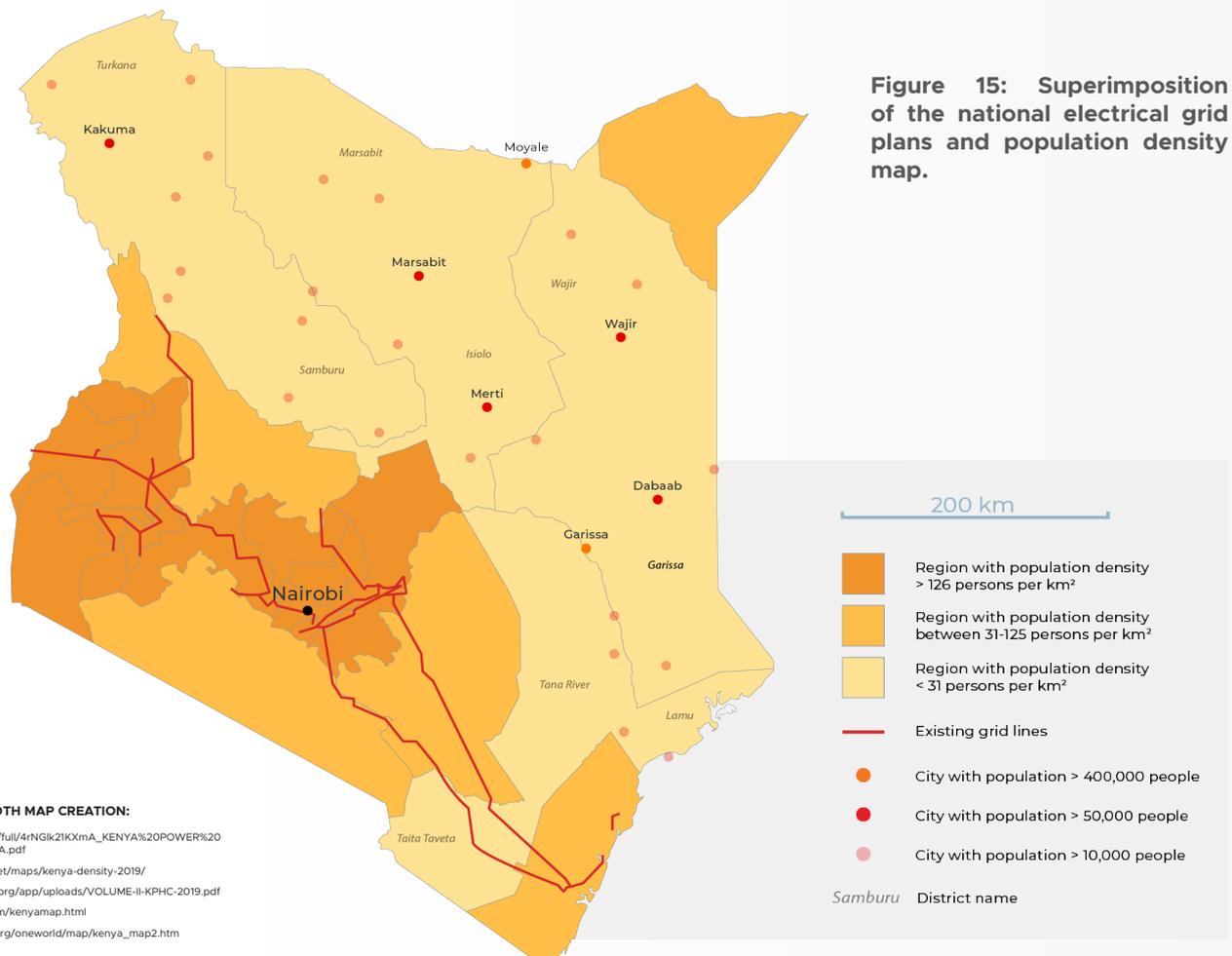
Numerous observations can be retracted from the map:

1. Districts in the South-West region of the country and the periphery of Nairobi are equipped with a functional grid that allows us to assume the presence of adequate infrastructure, and would thus suggest the availability of health care center. In this case, **these districts will not be initially included in the service's region of implementation.**

2. By superimposing the climate map previously found on page 35, we realize that **the least population dense regions are vast lands with aride or even desertic climates.** This defines an advantage for the usage of the vehicle as it present less environmental threat for the landing of EVE, and better clearance for the power generation of the auxiliary system.

3. The least dense regions (<31 persons per km²) are the largest in the country and have communities that are situated far apart. **This increases the benefits of using eVTOL vehicles** due to their independence to local infrastructure and their faster traveling.

4. Fortunately, **small villages are scattered around the vast desertic environment** which defines intermediate location throughout the operation's duration.



REFERENCES FOR BOTH MAP CREATION:

- https://www.kplc.co.ke/img/full/4rNGlk21KXmA_KENYA%20POWER%20ANNUAL%20REPORT%20FA.pdf
- <https://en.populationdata.net/maps/kenya-density-2019/>
- <http://housingfinanceafrica.org/app/uploads/VOLUME-II-KPHC-2019.pdf>
- <https://www.shoortravel.com/kenyamap.html>
- https://www.nationsonline.org/oneworld/map/kenya_map2.htm

Operation & logistical hubs locations

Thus, by analyzing Kenya's population density partition, national electrical grid and its climate, we are able to choose the regions that will be focused upon throughout the business structuring, presented in figure 16. These districts define vast environments with population densities of less than 31 persons per km², with hot climates and scattered villages.

Now, multiple things can be said about the shared map:

1. Wajir is chosen as the location of the service's operation base due to its strategic placement in the middle of the concerned regions and its well maintained airport that has asphalt runways. This allows for the landing of large cargo airplanes and thus the shipping of EVE vehicles through air.

2. The secondary hubs locations, which act as resupply and maintenance centers, are chosen by placing them in moderately populated cities (>50,000 people) for the availability of local work force, airports for resources provision and the presence of infrastructures. Four secondary hubs are settled in order for the vehicle to be able to reach the majority of the concerned areas of operation and stay within the reach of intermediate hubs.

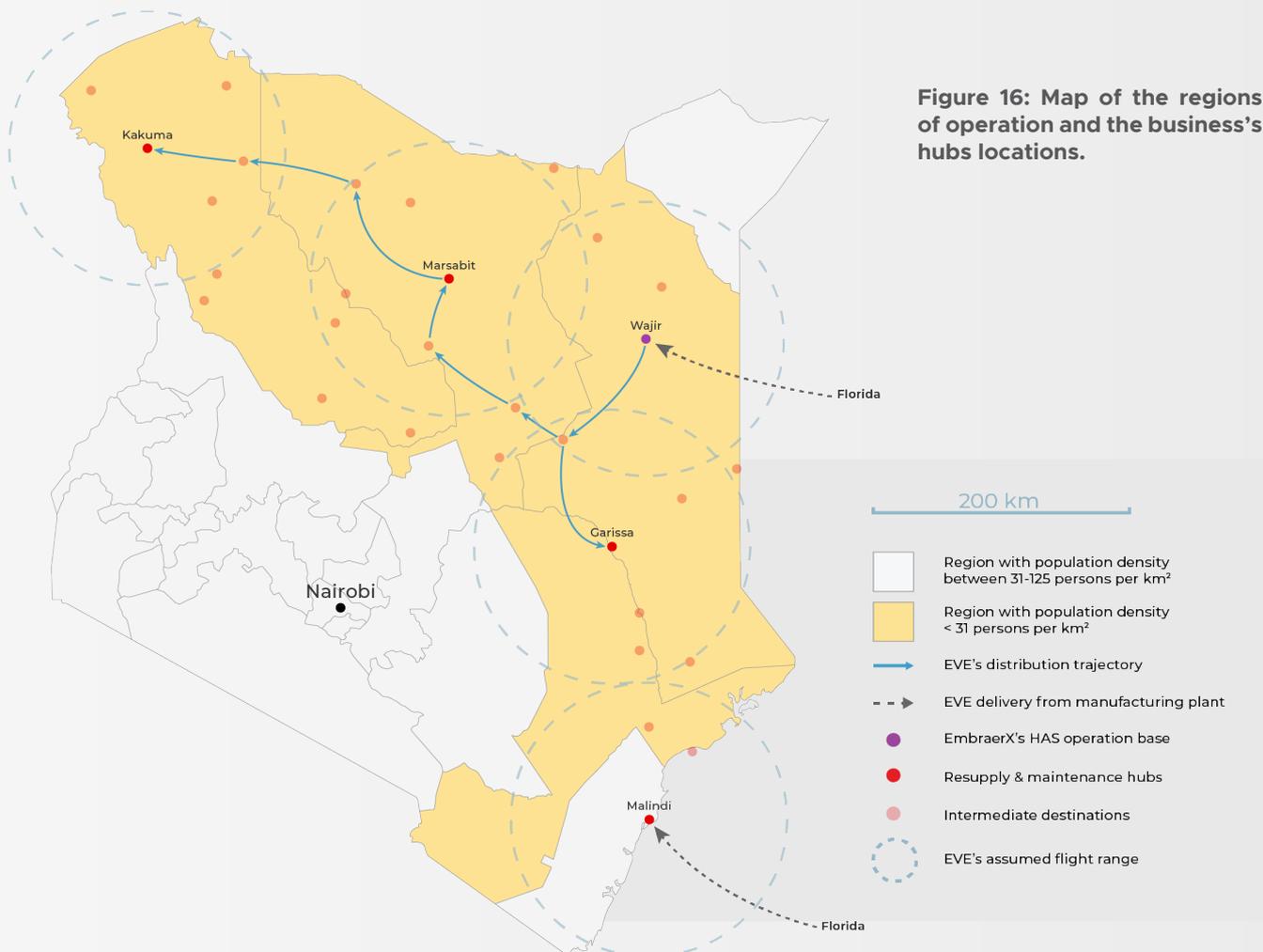
3. The travel plans of EVE delivery to the secondary hubs define the most efficient routes. They take into account the vehicle's maximum range, stopping at populated village for vehicle charging and offer safe stay for the staff.

4. Vehicles will be directly delivered to Malindi due to its well maintained airport, allowing for a faster and safer shipping. Additionally, since the city is situated on the coast, delivery through water presents a viable option, potentially reducing cost of delivery.

5. The vehicles are shipped from Florida, USA, where the manufacturing plant of EVE Urban Air Mobility Solutions is located.

6. It is important to note that, throughout the immunization operations, the vehicle will not be flown until its range limit. This is due to safety requirements, leaving reserve energy in case unforeseen factors come into play.

7. Since the vehicle's charging using the solar generation system is done within a week, this defines the required duration of stay at each destination. Thus, strategic location of operation need to be decided upon, additionally allowing for the reach of nearby communities.



Measles immunization operation estimations

To estimate the effectivity of the service, it is beneficial to project its usage for an exemplary scenario, in this case the vaccination of Measles. This exemplary vaccination operation is set-up through five steps:

1. First, we estimate the number of the concerned patients by summing up the population number of the focused districts.
2. Then, we assume the percentage of children aging from 0 to 12 years old (as they define the target group for Measles immunization).
3. We relate the estimated daily average of 700 vaccines that can be carried out by the mission's personnel, calculated on page 56.
4. Four days of resupplying, maintenance, assessment and travel to other destinations after each 18,000 vaccines are then added.
5. Measles immunization includes the requirement of 2 doses, meaning each destination needs to be visited twice for a complete vaccination process.

With these steps, we can finally estimate the duration it will take to vaccinate all the concerned patients in the focused regions, found in table 6. It is important to note that here, we assume that none of these patients have been vaccinated against Measles which is not close to the realistic situation.

Additionally, the amount of vehicles in operation is arbitrary and can be modified in order to shorten the duration of the immunization goal. With every added vehicle set, the duration is reduced by approximately 127 days. A vehicle set defines one vaccines carrier (vehicle #1) and one payload carrier (vehicle #2). The choice of the required fleet is done through deciding that the immunization program shall be successful within a maximum of 2 years. This requires to also add the newly born patients to the calculations for each passing year. The complete version is found in appendix F.

To further prove the effectiveness of this newly built service, comparing it to previously carried out immunization operations is beneficial. Back in 2016, a vaccination campaign in Central African Republic (CAR) has been performed by Medecins Sans Frontières (MSF), reaching more than 14,000 children in 5 days through the mobilization of 16 mobile teams, consisting of 370 medical staff and health promotion workers (MSF, 2016).

Now, comparing it to a 16 EVE vehicle set operation - with a total staff of 48, 14,000 children could be vaccinated within a day and a half. This includes even the most inaccessible of rural areas and the fact that these vehicle would just work 10 hours a day - and not around the clock. Indeed, the service defines a more efficient system, using less personnel, a more sustainable method of transportation and shorter traveling duration. Even if it is financially higher, vaccination efficiency defines a more crucial value.

Table 6: Immunization operation duration estimation against Measles

Concerned population partition per district		Operation duration	Nb. of vehicle set
Coast region	267,639	498 days	2 vehicle set
Tana River	105,628		
Taita/Taveta	113,895		
Lamu	48,116		
Eastern region	243,317	453 days	2 vehicle set
Marsabit	153,717		
Isiolo	89,600		
Northern Eastern region	542,479	755 days	3 vehicle set
Garissa	281,284		
Wajir	261,195		
Rift Valley region	413,660	576 days	3 vehicle set
Turkana	309,910		
Samburu	103,750		

COMPETITOR ANALYSIS

A fruitful method of finding the most suitable business structure is by looking at the competitors that have already penetrated the market of air service in humanitarian aid. By characterizing their operations, income and clientele; and relating them to their success through their revenue statement, one can identify market gaps that could be found to be profitable. Three competitors are described below.

It is important to note that WFP/UNHAS is an NGO and invest its profit into expenditure. Now, by comparing Amref's and Airserv's revenues, we notice that relying solely on humanitarian organizations and governmental agencies as customer does not result in a profitable business, even though both companies have a similar fleet (Amref with 6 aircrafts and Airserv with 5 aircrafts). It does allow to be fit to receive income from contributions & grants, but it does

not cover for the potential revenue it could make by opening its door to other customers. For this reason, Amref's income also originates from private contracts and from its secondary business - the insurance cover.

Now, an assumption of why Airserv's revenue is low compared to other air services is due to its goal of offering 'last mile' air transportation, which results in single-operation contracts. This is where the new business structure could shine: providing a long-term contract to humanitarian organizations, closely similar to a partner-type relationship. This is even more prevalent since the new business is not simply used for transportation but also for the carrying out of the immunization operation. By adding this additional level of service provision, EHAS is playing a bigger role in the success of the operations.

	AMREF FLYING DOCTORS (Amref, 2019)	AIRSERV (Airserv, 2019)	WFP/UNHAS (WFP, 2019)
OPERATIONS	<ol style="list-style-type: none"> 1. Medical assistance 2. Night evacuations 3. Transport incubator 4. First aid courses 5. Medical standby 6. Commercial standby 7. Air ambu cover 8. Client Insurance cover 9. Ground ambulance support 	<ol style="list-style-type: none"> 1. Payload transport 2. Charter 3. Base management 4. Mission preparation logistics 5. Air escort 6. Evacuations 7. Aerial surveys 8. Maintenance 	<ol style="list-style-type: none"> 1. Passenger transport 2. Cargo transport
INCOME	<p>In order from higher to lower:</p> <ol style="list-style-type: none"> 1. Air ambulance 2. Medical & assistance service 3. Insurance cover 4. Contract business 5. Government grants 	<p>In order from higher to lower:</p> <ol style="list-style-type: none"> 1. Program service revenue 2. Contributions & grants 3. Investments 	<p>In order from higher to lower:</p> <ol style="list-style-type: none"> 1. Funds 2. Donations 3. Contributions
CLIENTELE	<p>In order from higher to lower:</p> <ol style="list-style-type: none"> 1. Service provider agreement 2. Personal 3. Insurance covered members 4. United Nations Support Office for AMISOM 5. British Army Training 6. Tourists 7. Charities 8. National Hospital Insurance Fund 	<p>In order from higher to lower:</p> <ol style="list-style-type: none"> 1. Humanitarian aid NGOs 2. Government agencies 	<p>In order from higher to lower:</p> <ol style="list-style-type: none"> 1. DG-ECHO partners 2. Other humanitarian aid NGOs 3. Government agencies
REVENUE	<p>Revenue (2018): €107 million</p>	<p>Revenue (2019): €1.6 million</p>	<p>Revenue (2019): €166.1 million</p>

BUSINESS STRUCTURING

The competitor analysis shows that the definition of the service provision affects the methods in which the business could be profitable. Being a subsidiary of Embraer S.A., EHAS (Embraer Humanitarian Air Service) needs to prove that the niche market of humanitarian air services is worthwhile and can be grasped before the competition's influence becomes too significant. On one side, we do want to improve the image of its parent company but only if the newly structured business can sustain itself and show promise of expansion.

In this section, we discuss the business structuring for the ground up, further concretizing an idea into a functional service. Initially, we create a business model canvas that provides with an overview of the business main characteristics. Then, a financial plan is devised, showing the capital needs to start off the service and the potential success it could bring to the table in terms of numbers. A network of key partners is then identified, which will be regrouped into a business road map that plans the creation and set-up of the new service

BUSINESS MODEL CANVAS

The business model canvas is a tool used to shape the business in a structured way, giving an overview of its different elements. It allows us to describe the methods in which the organization creates, delivers and captures value, in a straightforward visualization. The canvas is presented in figure 17 on the right side.

Now, it is important to note that this strategic tool does not capture the potential evolution of the business model in the future. Although, as a starting pack, it fits the needs that were previously settled and offer a way of utilizing the product in its relevant context. As stated in the competitor analysis, simply providing a service to humanitarian organizations, which defines the core value of the business, should not be the only provided service element. Profit can be found in opportunities that would not hinder the provision of the main immunization activities.

For this reason, even though the product has been specifically adapted to carry out immunization operations requested by humanitarian organizations, opening its doors to many more customers could support the fast expansion and demand of the service. Governmental agencies could become a key customer, expanding the range of possible operations and immensely increasing the available budget for the immunization of its population. This means that the business model needs to be flexible in order to fit the needs of the market and capitalize on profitable gaps that would contrary be left in the dark.

EHAS's additional values provision

In general, Embraer Humanitarian Air Service (EHAS) defines a highly beneficial actor in the improvement of local communities, which

increases its convincing power for the finding of customers. Not only it generates jobs which provides financial and educational solutions for the local communities, but it also improves the region's development image, bringing prospective investors to the area. Due to Embraer's known reputation and its possibly proven profit in this newly uncovered market, companies would be more keen on starting a business in the less developed region.

EHAS's revenue stream

Since the business provides both the vehicle and its operation throughout the settled mission, and the operation success is dependent on the amount of vaccines delivered, the service is sold in an hourly rate. Similar to the estimations previously made for the Measles vaccination, the price of the service is settled through defining the required hours from the company and providing a total budget to the customer. This would allow to offer a series of bundles, including addition of vehicles, staff, payload or even mission objectives that allow for the optimization of the service depending on the customer's needs.

Now, why would humanitarian organizations use EHAS for their immunization operations? Obviously, the ratio of delivered vaccines per operation duration would be improved, but the main advantage is the fact that EHAS support the organizations with the operation of the vehicle and logistics management. It is not a simple lease service and it provides more value than the simple product provision. The management, maintenance, adaptation and usage of the vehicles is taken out of the humanitarian organizations' hands, saving them time and money.

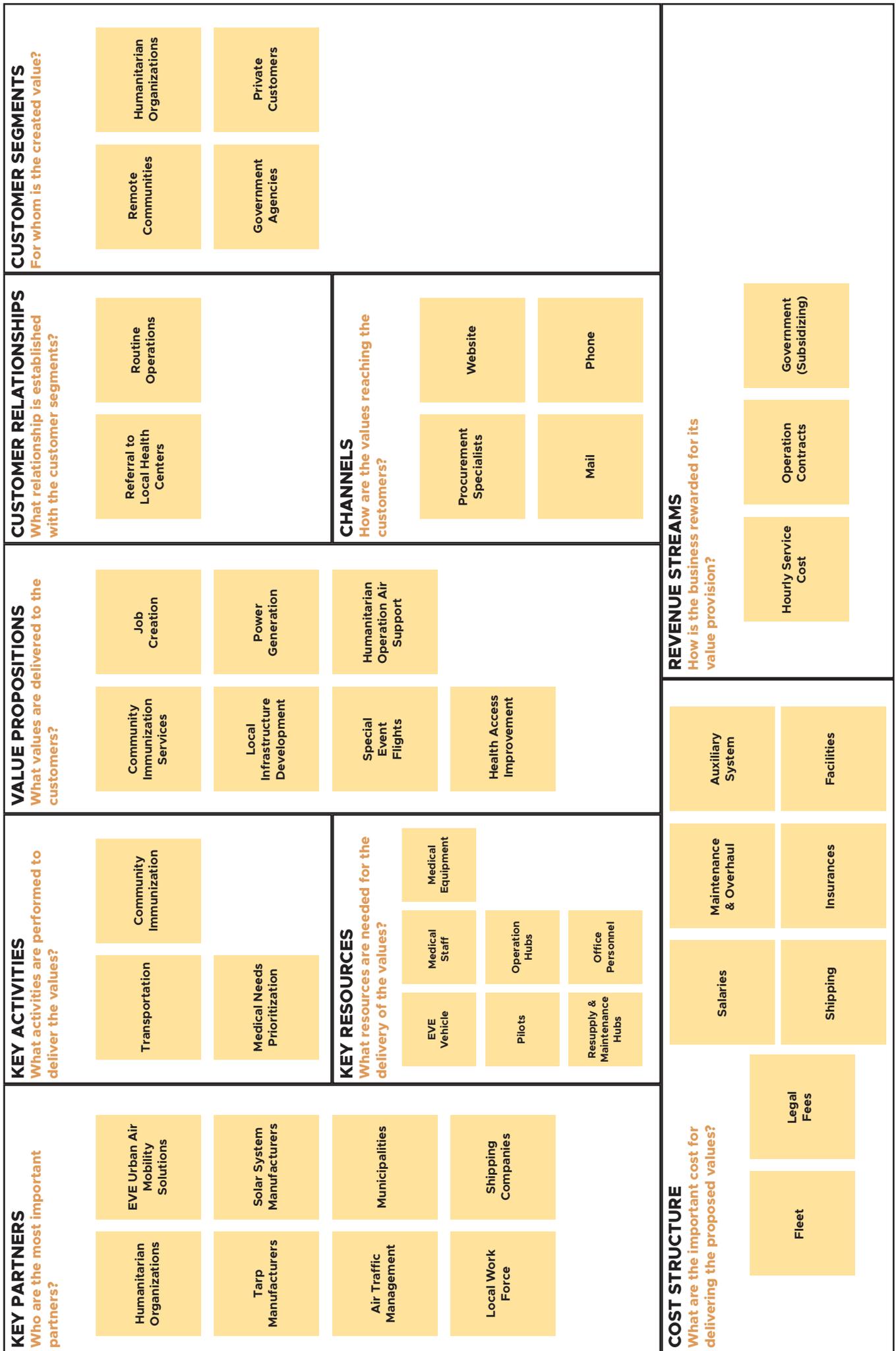


Figure 17: Business model canvas of EHAS

Method of reaching customers

This brings us to discussing the method of reaching customers. Contrary to Airserv where humanitarian organizations directly request their assistance, EHAS does its own customer procurement. This different approach is required as the organizations already have a functional method of communities' immunization, and would doubt about the need of changing their ways. This is the reason for releasing the

humanitarian organizations' role in the operation and management of the fleet, and simply requesting them for the provision of medical equipment and professionals.

The more EHAS provides services to the humanitarian organizations, the more they will trust the company for further operations, which ultimately would allow the complete replacement of their fleet with third party eVTOL solution provision.

FINANCIAL PLAN

Constructing a financial plan yields more concrete information on the business's financial needs and prospective developments, and builds a foundation to describe the viability of the service. The plan is divided into three components: a capital needs planning, a service revenue planning and an income statement; and are all discussed respectively. The complete financial plan is found in appendices G, H, and I.

Capital needs planning

This component is used to budget resources for the creation of EHAS and projects the different cost that shall be covered with initial investments. A summarized version is found in table 7.

The cost groups are essential for the launch of the business and are closely evaluated:

- The product, which encompasses both the vehicle and the auxiliary station system, defines the biggest cost. With eVTOL technology being rather recent, its initially price is significant but is projected to gradually decrease with the passing years. EVE Urban Mobility Solutions which will sell the vehicles at a transfer price is owned under the same parent company, and will offer the product at a better price than the one determined by the market.

- The infrastructures cost includes both the company's office (initially thought to be in Florida, close to EVE Urban Air Mobility Solutions' office) and the planned construction of the operation & secondary facilities in Kenya. Since the hubs needs to be built from ground up and are equipped with a fully functional solar generation system, their cost is quite significant but the investment could potentially be payed back through the selling of excess power generated. The defined number includes both labor and material cost, related to the market standards of today.

Table 7: Summarized capital needs planning

COST GROUPS	COST EXCL. VAT
PRODUCT	€10,576,560
INFRASTRUCTURES	€653,800
ASSISTANCE	€20,208
PRE-LAUNCH	€998,822
CAPITAL NEEDED TOTAL	€12,249,389
FUNDING	
EQUITY CAPITAL	€12,500,000

- The pre-launch cost group is mostly determined by the necessary salaries for the creation of the company. A significant amount of administrative, planning and procurement tasks need to be carried out in order to bring the company to its functional state. As previously said, the company's headquarter is planned to be situated in Florida, easing the registration of the new service due to already available knowledge from its sister company and the adaptation of the vehicle due to its close proximity to the manufacturing plant.

The funding is mostly originating from the parent company - Embraer S.A., which additionally supports the creation of the business through knowledge sharing. Although, separate investors, such as partners and possibly other subsidiaries, could potentially help the initiation of the newly founded service.

Service revenue planning

Service revenue planning, as its name suggest, allows to forecast the revenue of the company through the sales of its product/service. A summarized version is presented in table 8.

The planning's component are described as follows:

- The hourly cost of the service has been initially found through using the previously estimated cost on page 26, and adding a price margin to account for service uniqueness and significant launch costs. Obviously, with vehicle and operation costs decreasing over time, the service price will follow while still fulfilling revenue needs to reimburse the investment and make profit.

- A nominal quantity of 20 vehicles is used. It is expected to double the amount the year after, and have a faster increase of the fleet over the years due to decreasing production cost. Nonetheless, an increase of vehicles means increase in infrastructure investment needs and expansion of the business. The increase of vehicles is not exponential as the priority of EmbraerX would still be urban transportation, reserving the manufacturing of a certain amount of vehicles. A peak vehicle buying is carried out in year 4, potentially suggesting the expansion of the service into neighbor countries.

- The defined hours are based on the estimated vaccination effectivity. As it takes 25 days to vaccinate 18,000 patients, the defined operation hours are found through averaging a best and worst case scenarios. The best case scenario (3,000 hours per year) is for a non-stop vehicle operation within the month, with the rest of the days used for maintenance/resupply/traveling. The worst case scenario (1,800 hours per year) describes the operation if carried out only during half a month.

- Finally, by multiplying the hourly cost, the number of vehicles and the averaged total operation hours per year, the yearly revenues are given. After 5 years, the revenue is growing almost ten fold and is projected to grow even further once the service is expanding to other operations and regions. On the first year, EHAS already surpasses the revenue statement of Airserv and is envisioned to match AMREF Flying Doctors' revenue after 9 years (assuming AMREF's revenue will not increase exponentially, and new vehicles are bought after the 5th year).

Table 8: Summarized service revenue planning

YEAR	SERVICE PRICE (per hour, incl. 14% VAT)	NUMBER OF VEHICLES	AVERAGE OPERATION HOURS PER YEAR	AVERAGE SALES REVENUE
1	€161	20	2,400	€7,739,520
2	€154	40	2,400	€14,782,483
3	€147	80	2,400	€28,234,542
4	€140	120	2,400	€40,445,983
5	€134	200	2,400	€64,376,523

Income statement

The income statement allows to determine the amount of profit that is made by subtracting the business' expenses and losses to the service's revenue. A summarized income statement is given in table 9 below.

Numerous observations can be made from the statement's components:

- The variable cost is mostly defined by the staff's salaries and the product cost. Additional service costs are added, such as utilities bills, insurances, and shipping, but they define a small percentage of the total number. It is important to note that the added product cost is defined as an investment for the following year and is thus subjected to be covered by the revenue made in the current year. The first 20 vehicles that are bought in the first year for the launch of the company are included in the capital needs, and are covered by the initial investments.

- The fixed cost, which even though increases over time, still stays the same amount per capital (or vehicle in this case) and is mostly accounting for legal fees such as: permits, licenses, certifications and lawyers.

- The depreciation on investment is the salvage price that can be used at the end of life of the initially invested 20 vehicles. The newly bought vehicles after Year 1 could also be sold at a salvage price but they are included directly in the profit calculations at the year of their sale.

- By subtracting the variable, fixed and depreciation costs to the yearly service revenue, the profit made can then be calculated. As expected, the beginning of the business' lifetime is described with losses due to the high initial investments. But, it recovers as the variable cost slowly stagnate and the service revenue keeps on increasing. The low profit described in Year 4 is due to the buying of 80 additional vehicles (including the auxiliary station system and thus the expensive solar generation system) for the following year, which also explain the significant jump in profit made on Year 5 (which does not currently possess any new vehicle investments).

The statement shows that, even though initial investments are high and the work load could be even more significant, air services in humanitarian aid would ultimately be found to be a very profitable business, especially if it is expanded towards other missions and regions of operation.

Table 9: Summarized income statement

SPECIFICS	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
Service revenue	€7,739,520	€14,782,483	€28,234,542	€40,445,983	€64,376,523
Variable cost	€11,501,272	€21,459,499	€21,870,197	€39,668,651	€5,562,121
Fixed cost	€20,208	€38,498	€75,078	€111,658	€184,818
TOTAL	€11,521,479	€21,497,996	€21,945,274	€39,780,309	€5,746,939
Depreciation on investment	€572,894	€572,894	€572,894	€572,894	€572,894
PROFIT	- €4,354,853	- €7,288,407	€5,716,375	€92,780	€58,056,690
	LOSS	LOSS	GAIN	GAIN	GAIN

KEY PARTNERSHIPS

A network of suppliers and partners is crucial to support the functioning of the new service into the unaccustomed humanitarian sector for new air mobility solutions. Due to the uniqueness of the required subsystems and the recent development of eVTOL solutions, partners assist with the implementation of the product into the market by easing up the acquirement of resources (e.g. materials, staff) at an optimal cost, and the settlement of legal entities (e.g. permits, certification). They reduce risks in uncertain environments through knowledge and connections sharing, and allow for the delegation of tasks to more specialized players.

The partnerships are mainly classified into three types:

1. Strategic alliances (e.g. operation partners, governmental bodies) - allowing for the functioning of the service that is beneficial for all parties in terms of profit, people helped and/or

air infrastructure development.

2. Joint ventures (e.g. EVE UAMS) - by joining companies, EVE UAMS can create a more optimized product for its usage in the humanitarian sector and EHAS can help its sister company enter the newly founded market before its competitors.

3. Buyer-supplier relationships (e.g. distributors, manufacturers, shipping company) - by building trust and showing commitment, the partners can assure the quality of the products delivered at an optimal price range. It simplifies communication and reduces risks due to the will of success from both sides.

DISTRIBUTORS

- 1. HUMANITARIAN ORGANIZATION MEDICAL STOCK**
Provision of the refrigerator & medical equipment
- 2. FURNITURE**
Provision of the chairs, stretchers & tables
- 3. SHELTER**
Provision of staff's tents
- 4. SOLAR SUBSYSTEMS**
Provision of solar generation hardware (e.g. solar string inverter)

LEGALITY

- 9. AIR WORTHINESS CERTIFICATION AGENCIES**
Validity provision for the operation of the vehicles
- 10. REGULATORY AGENCIES**
Support used to shape the air mobility system
- 11. BUSINESS PERMITS PROVIDERS**
For the new company, offices and facilities
- 12. INSURANCE COMPANY**
For the staff of the company

MANUFACTURERS

- 21. EVE UAMS**
Provision & adaptation of the vehicle
- 22. SOLAR GENERATION SYSTEM**
Provision of the solar panels for the tarp system
- 23. TARPS**
Fabrication of the customized tarps for the auxiliary system
- 24. ALUMINUM POLES**
Manufacturing of customized extendable poles
- 25. VACCINES**
Provision of the vaccines for the immunization operations

EHAS PROSPECTIVE PARTNERS

- 5. PILOT TRAINING SCHOOLS**
Including the provision of pilot licenses
- 6. HUMANITARIAN ORGANIZATION STAFF PROCUREMENT**
Recruitment of supportive medical staff for the operation
- 7. LOCAL WORK FORCE RECRUITERS**
For the construction of facilities and functioning of hubs
- 8. HEAD HUNTERS**
Search of a specialized core team members of the company

- 13. AIR TRAFFIC CONTROL**
For the operation of the vehicle in the air space
- 14. FACILITY CONSTRUCTION COMPANY**
Supervision for the construction of the new facilities
- 15. HUMANITARIAN ORGANIZATIONS LOGISTICIANS**
Optimization of the operation plan
- 16. LOCAL COMMUNITIES**
Organization of the prioritized end-users
- 17. GOVERNMENTAL ASSESSMENT TEAMS**
Definition of the required operation to be carried out
- 18. SHIPPING COMPANY**
For the delivery of the vehicle
- 19. AIRPORT MANAGEMENT**
Arrival of vehicle through air cargo transportation & departure hubs
- 20. PORT MANAGEMENT**
Arrival of vehicle through water cargo transportation & departure to hubs

STAFF

OPERATION

BUSINESS ROAD MAP

The business road map provides a long-term strategic planning of the tasks required to bring the company into a functioning state, and thus into the official operation of the service.

Looking at the road map provided in figure 18 below, it is important to note that the timeline has been divided into two time frames:

1. The initial year that define the duration in which the company is registered and structured.
2. A full two years overview, divided into semesters, that defines tasks that are more specifically related to the settlement of the service and the implementation of the product into the system.

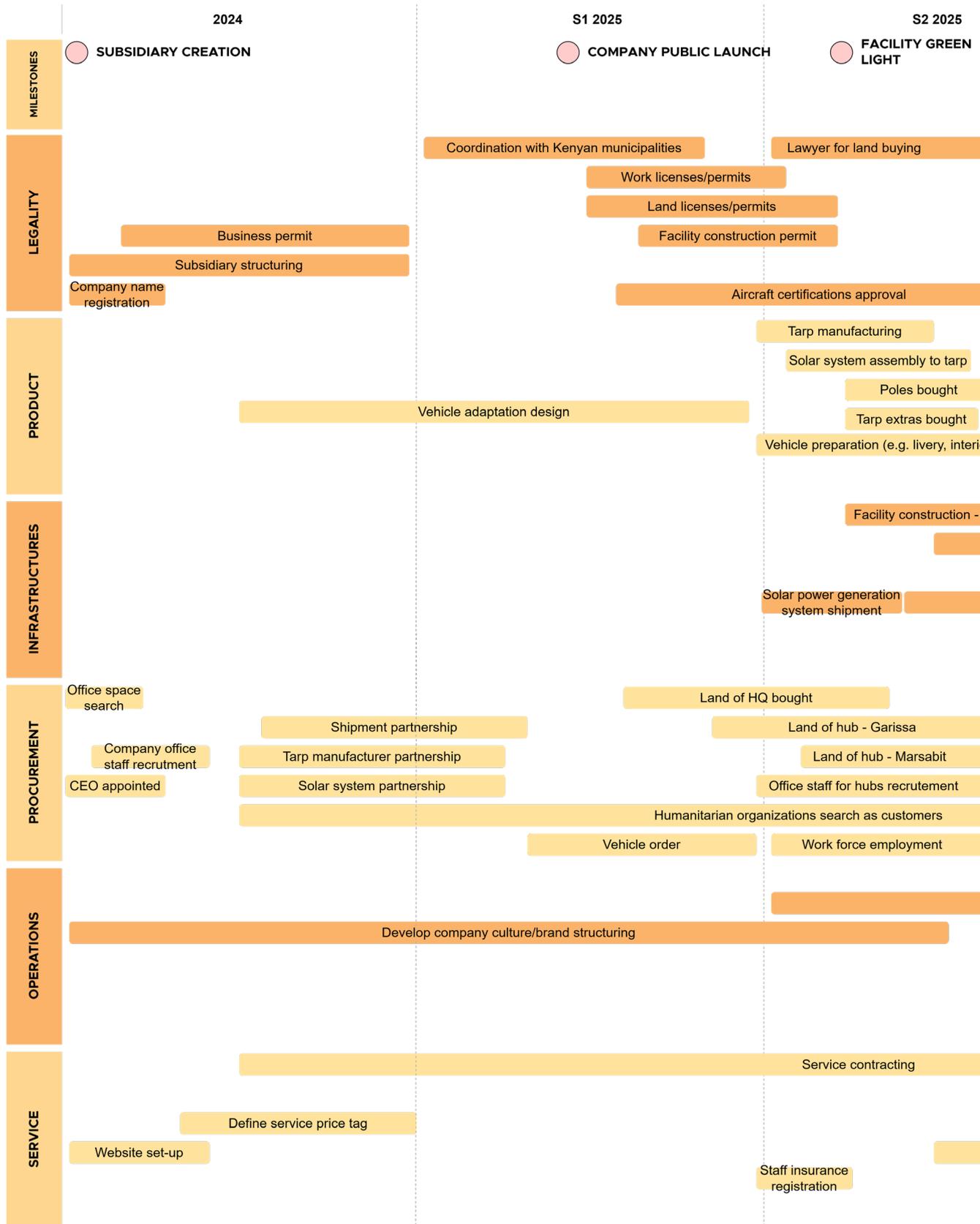


Figure 18: Business road map of EHAS

NATURAL CURIOSITY

Small girl peeking from her home
in Kampala, Uganda.

Photographed by: Bill Wegener [19]

CONCLUDING THE PROJECT

With the design of the product-service engraved, a pilot study is carried out with relevant customers to prove the feasibility, desirability & viability of the newly created solution. Then, future recommendations are provided to envision the continuation of the solution, offering the last elements for the conclusion of the project. To wrap up the thesis, a brief recapitulation is provided, reviewing the work carried out, followed by a reflection from a personal stand-point.



PILOT STUDY

The purpose of conducting a pilot study is to evaluate the feasibility and desirability of the product-service created. It allows us to iterate and optimize the solution, fitting more closely to the needs of the stakeholders. For that, two studies are carried out in order to encompass the perspectives of both the client - EmbraerX; and the customer - humanitarian organization, in this case Medecins sans Frontières (MSF). Once the study is settled, insights gotten are projected into potential iterations that will lead to numerous future recommendations.

EmbraerX's perspective

Overall, the product-service shows great promise of implementing a profitable and sustainable solution in the humanitarian sector. Although, specific issues need to be accounted for: using EVE in the humanitarian sector defines a risky strategy as the vehicle has not been built for this kind of environment. Its robustness needs to be improved in order to survive unforeseen factors that could damage the structure and require expensive maintenance. Modifications to the vehicle design are a must, which doubts if eVTOL define a potential solution. For this reason, it would be advised to perform a trade-off between adapting EVE or designing a whole new vehicle, and observe if the business proposal still shows promise. It would thus be valuable to add R&D cost in the financial plan, tipping the number and rearranging the initial needs.

Similarly, attaching the auxiliary station system to the vehicle is questioned as it present risks that have not been included in the product's development. EVE defines a good benchmark for the service structuring, but not for the actual product itself.

For this reason, the proposed next steps in the product-service evolution is a detailed study on requirements precision & execution. It is valuable to analyze if the requirements settled that pushes a vehicle modification are initially feasible and can be managed. It is probable that the requirements engraved by the auxiliary station system and the immunization operation needs would describe serious obstacles to the product development, and could impact the profitability of such solution.

Medecins sans Frontières' perspective

After proposing EHAS as service for humanitarian organizations, interest was present but not

for the right context. It was clearly shared that immunization programs are not a sustainable service and do not attract a serious market. The programs are usually short and sudden, lasting around three weeks. Generally, humanitarian organizations settle health care packages contracts, which encompasses numerous needs. If taking the example of a vaccination campaign, the humanitarian organization would provide additional services (e.g. assisting malnutrition) and offer crucial resources (e.g. shelter, water, food).

In this sense, drugs delivery to primary health care systems could define an easier business initiation. It is a permanent market that is carried out often, which justifies the benefits of using eVTOLs. Once things are set, it would be desired to expand the service to patient referrals, ranging from basic patient stabilization to patient saving. Currently, the patient referral system in Kenya is failing, defining a very expensive and difficult task that requires hard decision making. If there would be a cheaper alternative, MSF would most likely take it into consideration.

Another issue that was pointed out is the fact that the vehicle would not be able to land everywhere on the Kenyan landscape. Locations such as Dadaab and proximity to Al-Shabaab's camps provide a great risk to the functioning of the service, and shall be avoided. It is crucial to precisely select the region of operations in order to avoid any unforeseen factors that could put the medical team at risk.

Then, the chosen operation & secondary hubs locations are disputed. Wajir, which currently defines the location of the operation center, defines an administratively difficult community to initiate the business and become the point of shipping of the vehicles. Nairobi defines a better option due to its equipped infrastructure, stable economy, available workforce and wide range of partners. Some reconsiderations need to be made on the point of entry of the vehicles, providing an easier and cheaper method of approach.

The suggested next steps are: make a testing plan to validate the assumptions. By prototyping and interviewing focus groups, such as the humanitarian organization, local communities and interested companies, we could 'test the water' and analyze realistically the potential of the product-service.

FUTURE RECOMMENDATIONS

PROPOSED ITERATIONS

Due to the nature of the project and the current state of the solution, the product-service presented has been developed to a conceptual level. Even though its feasibility, desirability and viability are proven, numerous modifications, iterations and improvements need to be carried out in order to bring it to its next development phase. The solution is designed as a whole but the details that could impact the potential of the idea still need to be thought of. Even though diving into the next design process is out of the scope of this project, providing certain guidelines can become beneficial if the idea will further be looked at. For that, recommendations are given for the two foundations of the project: the product - EVE concept vehicle; and the service - EHAS. A summary of the future recommendations is given on the next page.

Improving the product - EVE

The main inaccuracy in the project that has additionally been pointed out during the pilot study is the fact that the development of the solution is based around EVE, an already demonstrated vehicle. An issue that appears from it is that, since EVE is designed for a completely distinct use-context, it is not made to fulfill the requirements that arise from the problem we stated. Instead of developing the product specifically to solve the mission we provided, we adapted it and created an unoptimized solution that needs to be iterated in order to increase the potential of the product-service.

EVE is primarily tailored for the comfortable transportation of passengers in an urban environment. Now, in our humanitarian context, comfort is not necessarily at the foundation and it is desired to improve the product in certain aspects. Ameliorating the performance of the vehicle is a must: the flight range needs to be increased in order for the staff to reach further communities without stopping in intermediate locations, which would potentially decrease the amount of resupply & maintenance hubs of the service (and thus leading to a decrease in costs). This can potentially be done by increasing the battery capacity of the vehicle, allowing for less charging stoppages and longer mission durations.

Secondly, a gain in propulsion power is desired, allowing for EHAS to transport more. The

payload weight is an important limitation in the adaptation of the product, which lead us to find alternatives such as using a second vehicle, simply for the transportation of additional equipment. By allowing the vehicle to carry more, we could potentially combine the payload of both the Mothership and Support into one, augmenting the operation's effectivity & efficiency, reducing operation cost and ultimately service cost for the customer. The solar generation system would thus not be halved in order to fit the weight requirements, allowing for a quicker charging of the vehicle as well as the traveling to additional locations that would erase the need for the communities to come to the operation destination. Preferably, the vehicle shall be able to carry a weight that is similar to the current air services (in the range of 1,000 kg), becoming the ultimate support vehicle.

Finally, the environment of operation can sometimes be unforgiving and requires a strengthening of the vehicle's structure. With impacts from the desertic climate, the lack of infrastructure and the nature of the mission, the vehicle is experiencing harsher environments compared to an urban context. To avoid the need of constant maintenance and overhaul, and damage to the vehicle's propulsion and electronic systems, changes to the vehicle's design are required that will take into account these factors. As it stands right now, the product is too fragile for operation in the humanitarian environment, which pushes further the need of designing a completely new vehicle for the fulfillment of the mission requirements.

Now, these changes require the development of a new vehicle, which in term of time is a colossal disadvantage. Since EVE Urban Air Mobility Solutions is currently focusing on urban mobility, switching their goals towards the humanitarian sector will not be beneficial and would most probably be denied. The development of a newly optimized vehicle for immunization programs would be carried out once EVE UAMS has set its standing in the eVTOL market. Thus, two solutions are available: EHAS invest into the research & development of this new vehicle with support of EVE UAMS, or the company will have to collaborate with a different company in order to achieve the desired ambitions.

Unfortunately, collaborating with a company that is not a subsidiary of Embraer S.A. could result in creating a new competitor in the eVTOL market, which understandably would be asking for trouble.

Nonetheless, it would be highly advised to co-create the new vehicle with humanitarian organization as they provide trustworthy knowledge on the needs emerging from the field.

During the pilot study with the logistician from MSF, it was pointed out that throughout the vaccination campaigns, the medical teams transport the vaccines through a passive cold chain, storing them in transport box that are cooled with dry ice. The box stays at the specific temperature range for around 6 days without the need of constant power. This offers a great opportunity of decreasing the payload weight and power requirements of the vehicle due to the refrigerator, especially since it is not fully known if it can be transported - as it uses a compressor, the traveling could influence the gas' stabilization. With that in mind, if it is decided to change the vaccines' storing method, some changes need to be made to the mission procedure in order to incorporate the new limitation of the vaccines' expiry duration of 6 days.

Improving the service - EHAS

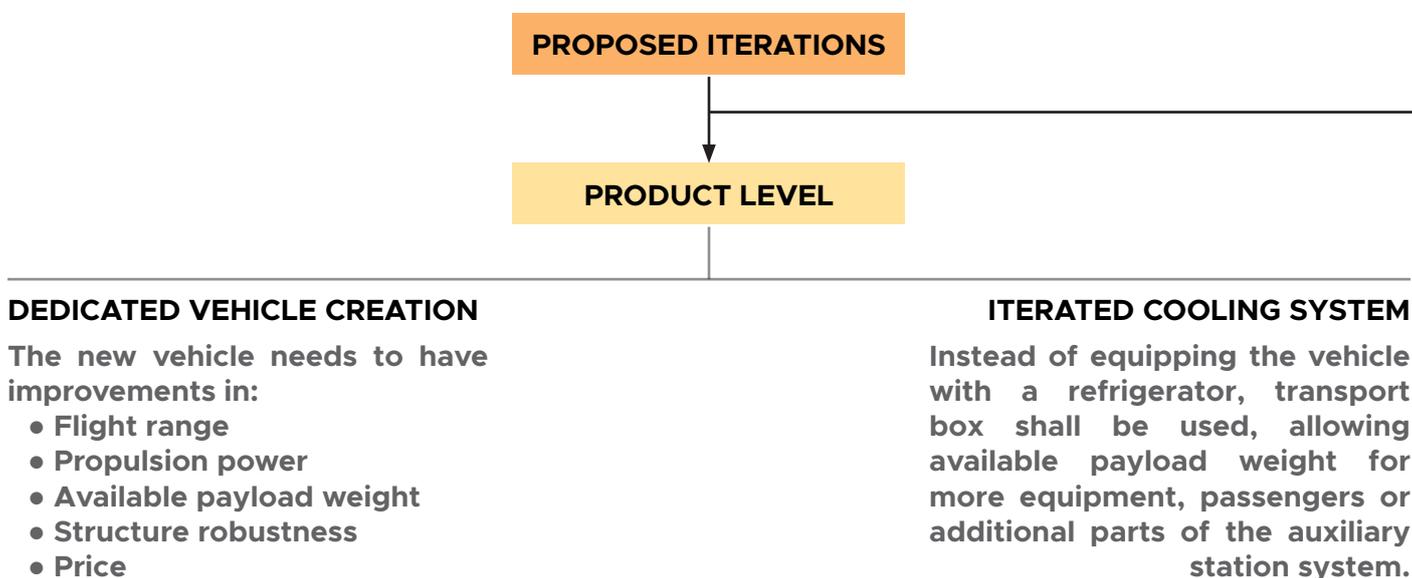
It is important to note that the service is highly influenced by the product's specifications, and is designed to encompass its limitations. Obviously, a more dedicated vehicle would result in a more evolved service that would potentially have a decrease in costs for both the company and the customer.

Currently, five hubs are planned to be constructed to support the immunization goals of EHAS. An increase in the vehicle's flight range

would reduce the number of required resupply & maintenance hubs, decreasing monetary obligations and allowing for the possible investment of other elements: more initial vehicles, more personnel, simultaneous new vehicle R&D process or even faster expansion into other regions of implementation.

Nevertheless, it would be interesting to analyze the distinctions if we took a more gradual approach in the construction of the product-service, in the sense of business expansion, facility construction and vehicle investment.

This new approach is define by a different business road map - starting small and gradually expanding the service throughout its years of operation. An iterated business structure map is shown in figure 19. We would split the country into prioritized regions, running programs in single areas in chronological order. Starting with the most underserved communities and towards more developed regions, it would allows us to have a reduced initial investment, a more concentrated supervision of the missions and a faster potential of improving the system on-the-go. Retrospectively, €12.5 million investment seems exaggerated and defines a risky strategy for any company. Dividing it into a timeline of evolution would allow to dissipate any risks and unforeseen factors, permitting for a more stable and convincing business plan. With a diminished region of operations, less facilities and vehicles are then initially required, and can be reaimed towards different regions after the mission goals are carried out. If we are able to expand faster towards more profitable and crucial operation choices such as patient referral, this approach defines the best option at widening the company's portfolio without putting the shareholders at risk.



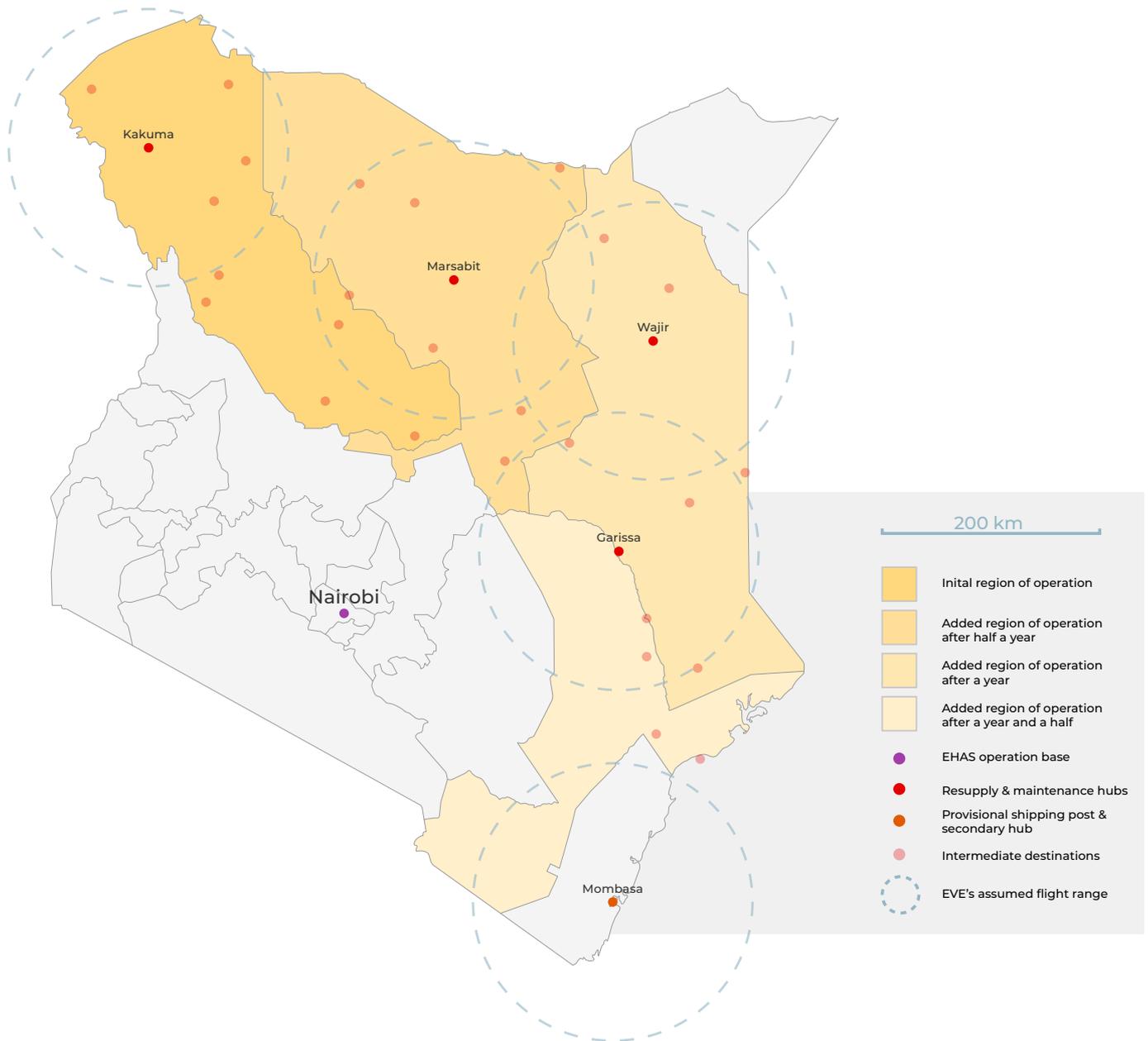


Figure 19: Proposed iterated business approach map

SERVICE LEVEL

DIFFERENT BUSINESS APPROACH

Instead of going 'big' from the beginning, taking a more gradual approach could be recommended. Prioritizing the regions of operation would allow for a reduced initial investment, reducing risk to the shareholders.

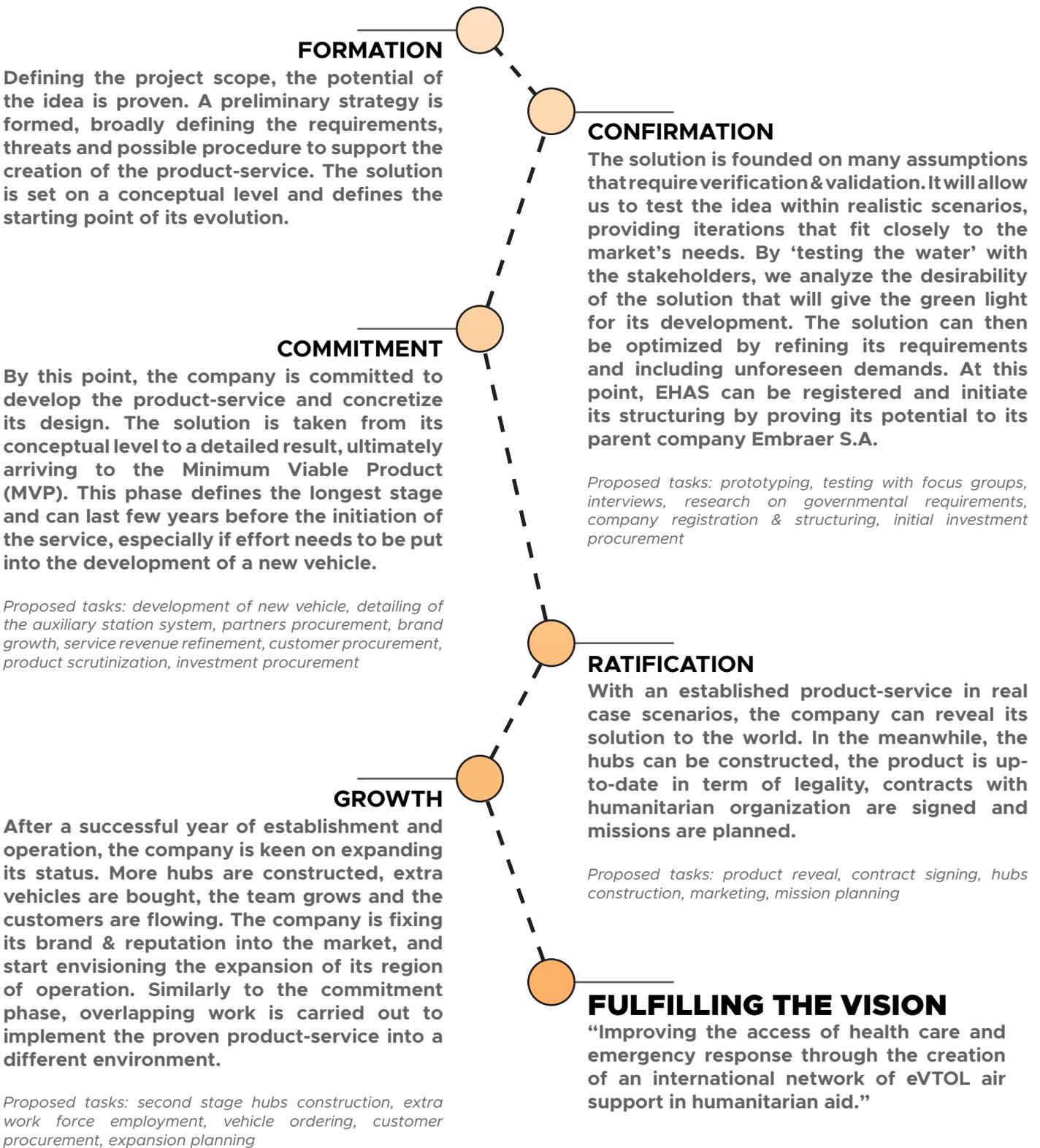
ITERATED BUSINESS MAP

The operation hub are relocated, a secondary hub is moved, and a new method of importing the vehicles to Kenya is thought of (using Mombasa's port and truck transportation in-country).

ROAD MAP

Throughout the project, we achieved to demonstrate the potential of using eVTOL technology in the humanitarian sector and how it could benefit EmbraerX in term of sustainability and profit. Although, executing the idea requires a substantial amount of work before becoming a functional solution. The starting point and the

strategy are settled, but projecting the necessary following steps to achieve our project mission defines a necessary stage in the design process. For that, a road map is shown below, envisioning the phases that the new product-service should undertake in order to reach its functional state.



PROJECT RECAPITULATION

Humanitarian organizations are constantly spending effort on the improvement of their operation procedures through technological innovations. But, even with their endeavors, access to basic health care still poses a serious problem around the world and requires a change in order to reach the unreachable. Humanitarian organizations have found an interim solution - Mobile Health Units, that sends a designated team of medical professional to offer health support to remote communities. But, due to the lack of well-maintained infrastructures, presence of seasonal environmental impacts and absence of stable health care systems, their current operation procedures, and specifically their methods of transportation have been found to be inefficient and rather dependent on local factors.

Throughout the project, we focused specifically on the immunization of such communities as we have identified a gap in the humanitarian market that will allow for an easy initiation of the designed solution. With advancement in air mobility solutions, we have defined the opportunity of offering a new air service that surpasses the identified obstacles. In collaboration with EmbraerX, the solution is based on the adaptation of its eVTOL vehicle - EVE. With modifications to its interior, the addition of a military grade auxiliary station system and a suitable selection of the necessary payload, the vehicle is transformed into a self-sufficient, sustainable and sophisticated mobile immunization unit.

Nevertheless, the product solely describes the first step in achieving the project's mission. By constructing a service around it, we are able to propose a business plan that takes into account the operation logistics, business structuring and financial projection. It enables us to propose a feasible and viable business that carries out the functioning of the solution, and becomes attractive to investors. The newly formed company - Embraer Humanitarian Air Service, also known as EHAS, reached the pinnacle of using recent air mobility innovations to support humanitarian operations. Offering to plan, operate and manage the new generation fleet, EHAS takes the hardship of updating the current methods of transportation out of the hands of the humanitarian organizations. The product-service does not solely provide immunization programs to outreach communities, but support the development of the local society through the creation of jobs, knowledge transfer and investment attraction.

Numerous refinements can be made to improve the effectivity of the product-service, bringing the idea from a concept to a well functioning system. The potential of the idea is proven and now lies the biggest part of the business evolution - the development of the solution. It will be lengthy and the process will face challenges on the way. But at the end, these hardships will be translated into standardizing the access to basic health care around the world.



EHAS

REACHING THE FORGOTTEN

REFLECTION

Looking back at the project and the effort that was put into it, I can truly say that I am satisfied with the outcome. Obviously, the project has not met its full potential and could have been greatly improved, from a personal perspective. But, this journey allowed me to grow and refine my skills, showing me that even the hardest set-backs have a certain positive outcome.

The utilized design approach encouraged the use of logical steps and avoided any side tracking that would become irrelevant to the project. This made the design process very linear, making the steps fall into place. It has been highly practical for the project but since we envision the implementation of the solution in a few years time, having a less bounded approach could have been captivating. Nonetheless, one crucial recommendation I would have given myself is to carry out a user feedback session after the definition stage in order to validate my assumptions and put me on the right track. After performing the pilot study at the end, it was pointed out that numerous other mission goals could have made the solution more relevant. By knowing this at the beginning, the solution would probably not be as different as it is currently, but it would have been based on current needs rather than latent ones. It does not necessarily define an error but as I learned throughout the project, what sounds logical in theory does not necessarily apply on the field. By taking a more retrospective approach, one could refine its steps and results, fitting closely to the realistic scenario that we all aim for.

Another aspect to point out is the importance of working on a topic that you appreciate and have interest towards. By choosing my own project topic, I was fortunate to enjoy every step of the way which aligned with my personal ambitions. Even though the topic needs to fulfill numerous requirements for the graduation thesis, there is always a work-around that allows for all parties to be satisfied.

This is additionally supported by having a strong supervisory team and people that are willing to help you out. Working on a single project for 20 weeks can narrow down the design vision and without recognizing distinct perspectives, it can easily drop you into a spiraling process of fixated work. Even though co-creation sessions would have been beneficial for the outcome of the project, constantly asking for feedback is a

necessary step in achieving quality work. It is important to note that self-excitement towards the topic is projected when asking for help. People become more willing to cooperate when they see the motivation that is founded from the work that has been carried out. For them, it becomes more of a will than a necessity.

So, did I fulfill the ambitions I have set at the beginning? I did, but honestly I achieved way more than initially projected. The project has sparked an interest in finding solutions in sustainable contexts, especially in the humanitarian sector, while still fitting my passion towards new aerospace technologies. Working in collaboration with Embraer allowed me to take a business-like approach, and I am grateful for the opportunity of taking its product to new heights.

With this thesis being my last academic work, I enjoyed the possibility to dream and tackle the selected problem without being bounded by bureaucracy. There is still so much more to achieve in the humanitarian sector, and the world needs it now more than ever. Maybe one day we will see flying eVTOL vehicles helping the unfortunates. **Let's make it happen.**



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APPENDIX A

MHU PRE-MISSION ASSESSMENT

STEP 1 PRE-MISSION ASSESMENT	STEP 2 MOBILE CLINIC CONSIDERATION	STEP 3 OPERATION LOGISTICS
What is happening? Getting thorough knowledge of the various actors involved.	Can it be done without MC? Are there fixed health systems, what is the choice for making MC.	How long is the service? Decisions relating to timing, defining the required resources and mission scope/limitations
What is important? Identifying the problems with highest priority.	What service will it provide? Related to the problem with highest priority, what exactly is required from the health team.	What local resource are available? Assessment of resources that are already on the field that can be used (e.g. staff, shelter, water systems)
What can be done? SWOT analysis, target group and constraints study.	How will it be done? (1) Definition of required activities, determining the mode of action and strategy.	Is it in accordance with local communities? Pre-mission preparations with the local communities and negotiation with rebel groups.
What will be done? Analysis of political and health situation, noting existing norms and constraints. Setting objectives.	With what will it be done? Planning of the required resources (e.g. human, financial) and consideration of collaborations.	What is needed for the operation? Resources needed (e.g. number of vehicles, kits, medication)
	What service frequency is required? Road mapping of the problem.	What is the service procedure? Human movement organization, triage, documentation and labeling.
		What are the tools for risk mangement? Management of potential scenarios throughout the operation (e.g. patient transport, health institute referring).
STEP 4 CARRYING OUT MISSION	STEP 5 EVALUATION & SURVEILLANCE	
Are the present resources sufficient? Assessment of the operation state and the need of additional resources (e.g. medication, tools).	Was the quality of the service adequate? Assessment of the quality of the service, impact on the victims' health and potential improvements.	Where will it be stationed? Finding space for the operation, maximizing patient visit efficiency and access.
Is the mission time span sufficient? Understanding if additional visits are required, or if referring to local health institutes is required.	Were the resources sufficient? Better evaluation of the required resources for future missions.	
	Any delays during the operation procedure? Evaluation on the procedure for efficiency improvements.	

Figure 20: MHUs usage consideration chart

The queries in the chart support the consideration of using a mobile health unit (MHU) on a proposed operation. By answering, one can identify if MHU define the best solution to fulfill the mission's goal, and create an overview of the WWWWWH: who, what, where, when, why, and how.

APPENDIX B

LIST OF REQUIREMENTS

Table 10: List of Requirements - part 1

TOPIC	IDENTIFIER	REQUIREMENT	VALUE	UNIT	TYPE	VERIFIED?	VALIDATED?	REASONING
POWER	SS-B-001	Battery shall be charged through external charger	-	-	Demand	YES	YES	Vehicle's requirement
	SS-B-002	Battery shall be chargeable without moving them from vehicle	-	-	Demand	YES	YES	Solar system equipped
	SS-B-003	The vehicle shall be equipped with a charging system	-	-	Demand	YES	YES	Solar system equipped
PAYLOAD	SS-PL-001	The payload shall be easily accessible for medical staff of various heights	-	-	Wish	NO	NO	Unstable
	SS-PL-002	Medical equipment included shall be considered "essential" in order to limit weight	-	-	Demand	YES	YES	Payload list created with essential components included
	SS-PL-003	The vehicle's cargo shall allow for modularity based on required mission's kits	-	-	Demand	YES	YES	The cargo space is empty and can be adapted
	SS-PL-004	The vehicle shall allow for additional payload than the pre-packaged kits	-	-	Demand	YES	YES	Extra space is provided in the middle for kits
	SS-PL-005	The vehicle shall be able to fit MSF kits.	-	-	Demand	YES	YES	Extra space is provided in the middle for kits
	SS-PL-006	Adequate infection control supplies shall be provided (e.g. biohazard containers) ¹	-	-	Demand	YES	YES	Medical equipment provided by HO so specific to operation needs
	SS-PL-007	The vehicle shall include sufficient supply of PPE for the medical staff ¹	-	-	Demand	YES	YES	Medical equipment provided by HO so specific to operation needs
	SS-PL-008	The auxiliary system shall include a seat to provide optimal positioning of anatomic site and injection angle of the patient ¹	-	-	Demand	YES	YES	Foldable chair added
LOGISTICS	O-LO-001	Loading/Unloading of payload shall be done in a minimal amount of time	< 5	minutes	Demand	NO	NO	Unstable
	O-LO-002	Reach depth into vehicle shall be minimized to reduce strain during loading/unloading and medical treatment	675 - 696	mm	Wish	NO	NO	Unstable
	O-LO-003	The auxiliary system shall be set and packed up in less than X	1	hour	Demand	NO	YES	Unstable
	O-LO-004	The required payload for the operation shall not exceed the maximum allowed payload weight of the vehicle	-	-	Demand	YES	YES	We are staying within the weight limitations
	O-LO-005	The mission shall have an adequate traffic control plan	-	-	Wish	-	-	Will be carried out by assessment team
	O-LO-006	The operational dates shall be communicated to the public beforehand	-	-	Demand	YES	-	Will be carried out by assessment team
AUXILIARY SYSTEM	SS-AS-001	The auxiliary system shall not cost more than	6000	€	Demand	NO	YES	Solar generation system overstretch the cost
	SS-AS-002	The auxiliary system be made of sustainable materials	-	-	Wish	NO	YES	Durability over sustainability
	SS-AS-003	The auxiliary system shall be able to operate year round	-	-	Demand	YES	YES	Material chosen is resistant to all harsh environments

Table 11: List of Requirements - part 2

TOPIC	IDENTIFIER	REQUIREMENT	VALUE	UNIT	TYPE	VERIFIED?	VALIDATED?	REASONING
AUXILIARY SYSTEM	SS-AS-004	The auxiliary system shall last longer than 2 years	-	-	Demand	NO	YES	Unstable
	SS-AS-005	The auxiliary system not be heavier than	100	kg	Demand	YES	YES	New calculations shall be done for new material choice
	SS-AS-006	The auxiliary system shall be reliable (chances of failure that are acceptable)	-	-	Wish	YES	YES	Military grade material for the system
	SS-AS-007	The auxiliary system shall be waterproof	-	-	Demand	YES	YES	Material selection allows for that
	SS-AS-008	The auxiliary system shall reach a technology readiness level of more than	5	-	Demand	YES	YES	Tarps available on the market
	SS-AS-009	The auxiliary system shall be user friendly	-	-	Wish	YES	YES	Similar to the set-up of a normal pole tent
	SS-AS-010	The auxiliary system shall be cleaned using standard home supplies	-	-	Demand	-	YES	-
	SS-AS-011	The auxiliary system shall be easily stored	-	-	Wish	YES	YES	Tarps and poles are foldable
	SS-AS-012	The auxiliary system shall be dust proof	-	-	Demand	YES	YES	Material selection allows for that
	SS-AS-013	The auxiliary system shall be easily transported	-	-	Wish	YES	YES	Tarps and poles are foldable
	SS-AS-014	The auxiliary system shall have the required humanitarian organization representation (e.g. stickers)	-	-	Demand	YES	YES	Representation can be added to tarps
	SS-AS-015	The auxiliary system shall have a designated area for management of patients with urgent medical problems (e.g. fainting) ¹	-	-	Demand	NO	NO	Designated rooms have been removed due to being unnecessary
	SS-AS-016	The auxiliary system shall have a designated clean area for vaccine preparation ¹	-	-	Demand	NO	NO	Designated rooms have been removed due to being unnecessary
	SS-AS-017	The auxiliary system shall have a designated area for registration, screening for contraindications and precautions, and administrative work ¹	-	-	Demand	NO	NO	Designated rooms have been removed due to being unnecessary
	SS-AS-018	The auxiliary system shall be detachable from the vehicle	-	-	Demand	NO	NO	Currently, the system is not detachable from the vehicle to avoid extra weight due to more poles needed
	SS-AS-019	The auxiliary system shall be equipped with adequate lighting	-	-	Demand	-	-	-
	SS-AS-020	The auxiliary system shall be suitable for any kind of environment condition	-	-	Demand	YES	YES	Material selection allows for that
	SS-AS-021	The auxiliary system shall be easily maintained	-	-	Wish	-	YES	-

Table 12: List of Requirements - part 3

TOPIC	IDENTIFIER	REQUIREMENT	VALUE	UNIT	TYPE	VERIFIED?	VALIDATED?	REASONING
VACCINATION	O-VA-001	Vaccines shall be transported within the temperature range recommended by the manufacturers ¹	-	-	Demand	YES	YES	Vehicle is equipped with refrigerator
	O-VA-002	Vaccines shall be used in the appropriate time frame ¹	-	-	Demand	NO	YES	It depends on which vaccines is used and if it can last for at least a month
	O-VA-003	Vaccines shall be placed in proper storage equipment throughout the mission's time frame to fit the recommended temperature range ¹	-	-	Demand	YES	YES	Vehicle is equipped with refrigerator
	O-VA-004	Vaccines shall remain protected from light until ready for use ¹	-	-	Demand	YES	YES	Vehicle is equipped with refrigerator
VEHICLE	R-VE-001	The vehicle shall not have military affiliation and equipment ²	-	-	Demand/ regulation	YES	YES	No tools/equipment or representation of military purposes have been added
	R-VE-002	The vehicle shall be registered with the required aviation certificates ²	-	-	Regulation	-	-	
	R-VE-003	Flight plans shall be filed before carried out the mission ²	-	-	Regulation	-	-	
	R-VE-004	Air Traffic Control (ATC) shall be made aware of the vehicle's operation ²	-	-	Regulation	-	-	
	R-VE-005	The vehicle shall transport a minimum of X passengers.	2	pax	Demand	YES	YES	2 passengers weight added to vehicle design
MISCELLANEOUS	SS-M-001	The vehicle shall be equipped with reliable communication system	-	-	Demand	YES	YES	Vehicle's base feature included
LANDING AREA	SS-LA-001	The vehicle shall be able to land on a X size landing zone ³	40x40	foot ²	Demand	YES	YES	Fulfilled by the vehicle already
	SS-LA-002	The landing zone shall be lit with helipad lighting	-	-	Demand	YES	YES	Avlite lighting kit is carried by second vehicle
	SS-LA-003	The landing zone shall be free of debris ⁴	-	-	Wish	YES	YES	Groundsheet is used as a designated landing zone
	SS-LA-004	The landing zone shall have a clear X sized safety zone during landing and take-off manoeuvres ³	82x82	foot ²	Demand	YES	YES	Stripes & poles are used to represent the safe area
	SS-LA-005	The vehicle shall not land on a zone that has a higher ground slope than X	15	degrees	Demand	-	-	-

¹ <https://www.izsummitpartners.org/content/uploads/2019/02/off-site-vaccination-clinic-checklist.pdf>
² <https://www.kcaa.or.ke/sites/default/files/regulation/Civil%20Aviation%20%28Unmanned%20Aircraft%20Systems%29%20Regulations%202020.pdf>
³ <https://moaams.org/pdf/HelipadRecommendations.pdf>
⁴ <https://www.firehouse.com/home/news/10544672/helicopter-landing-zones-setup-safety>

APPENDIX C

SOLAR POWER CALCULATIONS

By estimating the rear wing span of EVE through image scaling, we can assume that the area of the overhead tarp (if it is square shaped, and 90 % of the length is usable for the solar panels due to edges margins) is:

$$(11.6 \times 0.9)^2 = 109 \text{ m}^2$$

Using PowerMod solar tarp's power production per m² (FTL solar, 2020), and assuming a work efficiency of 75% and an average of 6.9 hours of sunlight in Kenya (ClimaTemps.com, 2014), we have that the average daily energy output is:

$$(77 \times 109) \times 0.75 \times 6.9 = 43.4 \text{ kWh}$$

From (Moller, 2020), we have that the cruise power at 200 mph is 174 kW for the Joby S4 model. Assuming the same power usage for EVE, and using the previously mentioned flight range of 97 km, we have that:

$$\begin{aligned} \text{Range} &= (\text{Battery capacity}/\text{Cruise power}) \times 200 \\ \Rightarrow \text{Battery capacity} &= (\text{R} \times \text{Cruise power})/200 \\ \Rightarrow \text{Battery capacity} &= 52.2 \text{ kWh} \end{aligned}$$

Taking into account 20% reserve battery energy and 10.7 kWh for one minute of VTOL power (landing & take-off), we have that:

$$\begin{aligned} \text{Total battery capacity of EVE} &= 52.2 \times 1.2 + 10.7 \\ &= 73.34 \text{ kWh} \end{aligned}$$

Thus, using the overhead tarp with solar panels, the vehicle can be fully charged in **1 day and 5 hours**. But, if we take the nominal battery capacity of 140 kWh provided by (Uber, 2016), the batteries will be 100% charged in **3 days and 2 hours**.

APPENDIX D

BILL OF MATERIALS

Table 13: Bill of Materials - part 1

TOPIC	NAME	MATERIAL	MASS [kg/unit]	COST [€]	QUANTITY	LINK
MEDICAL	Refrigerator	-	70	570	1	http://www.redcross.int/en/eric/eric/screen%20tome%202/05Xscreen/XCOLprint/213XCOLFRID1E.pdf
	Mobile oxygen concentrator	-	0.8	1070	1	https://www.cascadehealthcaresolutions.com/airsep-focus-portable-oxygen-concentrator/
	Defibrillator	-	0.45	2095	1	https://aedcompany.nl/schiller-fred-easyport-semi-automaat-aed
	Pulse oximeter	-	0.053	200	1	https://www.medischevakhandel.nl/en/nonin-nonin-onyx-vantage-pulse-oximeter-9590.html
	Forceps	-	-	-	1	FROM MSF ¹ 1 https://bibop.ocg.msf.org/docs/45/L045CATM10EFP_CatKit-2020.pdf
	Cotton swabs	-	-	-	-	FROM MSF ¹
	Metal file	-	-	-	1	FROM MSF ¹
	Bandage rolls	-	-	-	-	FROM MSF ¹
	Disposable gloves	-	-	-	-	FROM MSF ¹
	Face masks	-	-	-	-	FROM MSF ¹
	Syringes	-	-	-	-	FROM MSF ¹
	Disposable needles	-	-	-	-	FROM MSF ¹
	Sterilizing wipes	-	-	-	-	FROM MSF ¹
	Bandages	-	-	-	-	FROM MSF ¹
	Vaccines	-	2.19	-	10,000	Provided by HOs, samples weight without glass weight
	Sticky tape	-	-	-	-	FROM MSF ¹
	Soap	-	0.2	-	-	FROM MSF ¹
	"Adverse Events Following Immunization (AEFI) kit"	-	-	-	-	FROM MSF ¹
	Basin	-	-	-	1	FROM MSF ¹
	Towel	-	-	-	-	FROM MSF ¹
Ice packs	-	0.175	-	-	FROM MSF ¹	
Thermometer	-	-	-	1	FROM MSF ¹	
Scissors	-	-	-	2	FROM MSF ¹	
FURNITURE	Foldable chair	Plastic	0.1	20	1	https://bit.ly/3zPTu5d
	Fodable table	Plastic	2	35	1	https://bit.ly/3vXHOKB
	Scoop stretcher	Plastic	7.7	152	1	https://ebay.to/3wQdLp5
AUXILIARY SYSTEM	Overhead tarp	Knitted Polyester Scrim	69	1102	1	https://www.tarpsnow.com/military-spec-prf-20696f-t2c2-fabric.html
	Sidewalls tarps	Knitted Polyester Scrim	60	1102	3	https://www.tarpsnow.com/military-spec-prf-20696f-t2c2-fabric.html
	Separator tarps	PolyMax	16.4	397.6	2	https://bit.ly/3gYuwrF
	Poles	Aluminum 7075	7.3	50	5	https://bit.ly/3gVg9UX

Table 14: Bill of Materials - part 2

TOPIC	NAME	MATERIAL	MASS [kg/unit]	COST [€]	QUANTITY	LINK
AUXILIARY SYSTEM	Guy lines	Polyester + nylon + reflective silk, cord adjuster/carabiner: aluminum, tarp clip: PP	0.32	41.8	12	https://www.amazon.co.uk/Azaraxis-Reflective-Tensioner-Carabiner-Ggazebos/dp/B08CTZJGCS?th=1
	Pins	Aluminum 7075	0.156	13.2	12	https://amzn.to/3vXJ2pb
	Hooks	Aluminum 7075	0.2	8.2	10	https://amzn.to/3qkqfTO
MISCELLANEOUS	Hookable lights	-	0.075	20.5	8	https://amzn.to/3j4XB7w
	Hazard-safe container	-	-	-	-	FROM MSF ¹
	Tie wraps	-	-	-	-	FROM MSF ¹
	HO vests	-	-	-	-	FROM MSF ¹
	Stripes & poles	-	-	-	-	FROM MSF ¹
	Signs	-	-	-	-	FROM MSF ¹
	Megaphone	-	-	-	-	FROM MSF ¹
	Immunization cards	-	-	-	-	FROM MSF ¹
	Papers & pens	-	-	-	-	FROM MSF ¹
	Jerrycans	-	-	-	-	FROM MSF ¹
SOLAR SYSTEM	Solar panels	-	134.56	56700	-	https://bit.ly/3gXkHtN
	Solar string inverter	-	12.5	595	1	https://bit.ly/2TWyGbK
	Solar charge controller	-	16.6	822	1	https://bit.ly/3x1LwnP
	Cabling	-	-	-	-	-
	Staff	-	210	-	3	-
TOTAL	Standard package with all materials identified above		610.78	61059.3		
	Without solar system		447.12	2942.3		
	With reduced tarps and half the amount of solar panels units		472.55	31235.87		OVERWEIGHT by 22.55 [kg]
	With reduced tarps, halved solar system, and reduced payload for vehicle #2		386.88	28716		UNDERWEIGHT by 63.12 [kg]

Note: The equipment delivered by MSF directly is assumed to be free as the humanitarian organization will provide its own needs depending on the operation.

APPENDIX E

TARPS MATERIAL SELECTION

Selecting fitting materials for the auxiliary station system is a crucial step in the design, allowing the fulfillment of certain requirements. As presented in the Design Option Tree on page 44, various potential materials are offered for the tarp, the groundsheet, and the poles, all with their own advantages and disadvantages. Important factors in the selection of the materials are

mostly influenced by the harsh environment on the field, asking for a resistant, flexible, and cost-effective solution.

After thorough research and decision making, the materials chosen for the auxiliary station system are shown below, further defended by their characteristics.

GROUNDSHEET
PolyVinyl Chloride (PVC)
<ul style="list-style-type: none">• Waterproof• Abrasion resistant• UV resistant• Weather resistant• Mildew and grease resistant• Flame retardant• Strong• High tear strength• Widely available• Cost-effective

TARP
Knitted Polyester Scrims
<ul style="list-style-type: none">• High strength• Increased flexibility• Tearing prevention• Durable• Waterproof• Mildew resistant• Flame resistant• UV resistant• Withstand intense heat• Lighter than cotton• Cost-effective

POLE
Aluminum
<ul style="list-style-type: none">• Lightweight• Strong• Maintainable• Durable• Impact resistant• Corrosion resistant• Cost-effective

APPENDIX F

MEASLES VACCINE ESTIMATIONS

Province	Population (2019)	Percentage (%)
Kenya (country total)	47,564,296	
Nairobi (capital city)	4,397,073	9.24
Central	5,482,239	11.53
Coast	4,329,474	9.10
Tana River	315,943	0.66
Taita/Taveta	340,671	0.72
Lamu	143,920	0.30
Eastern	6,821,049	14.34
Marsabit	459,785	0.97
Isiolo	268,002	0.56
North Eastern	2,490,073	5.24
Garissa	841,353	1.77
Wajir	781,263	1.64
Nyanza	6,269,579	13.18
Rift Valley	12,752,966	26.81
Turkana	926,976	1.95
Samburu	310,327	0.65
Western	5,021,843	10.56

Age 0-14 popul.	In %
18564345	39.03
Age 0-12 popul.	In %
15901845	33.43

Concerned total popul.	Note
1,070,976	Assuming urban & age 0-12 percentages are proportional to total + w/o urban areas
1467091	Including urban areas

Urbanization (%)
27

Concerned popul. partition per district	Vaccination operation duration with one air team	With 3 air teams
Coast	267639	372 days 12.2 months 4.1 months
Tana River	105628	147 days 4.8 months 1.7 months
Taita/Taveta	113895	159 days 5.2 months 1.8 months
Lamu	48116	67 days 2.2 months 0.8 months
Eastern	243317	338 days 11.1 months 3.7 months
Marsabit	153717	214 days 7.0 months 2.4 months
Isiolo	89600	125 days 4.1 months 1.4 months
North Eastern	542479	754 days 24.7 months 8.3 months
Garissa	281284	391 days 12.8 months 4.3 months
Wajir	261195	363 days 11.9 months 4.0 months
Rift Valley	413660	575 days 18.9 months 6.3 months
Turkana	309910	431 days 14.1 months 4.8 months
Samburu	103750	145 days 4.8 months 1.6 months

Concerned popul. partition per district	
Coast	267639
Tana River	105628
Taita/Taveta	113895
Lamu	48116
Eastern	243317
Marsabit	153717
Isiolo	89600
North Eastern	542479
Garissa	281284
Wajir	261195
Rift Valley	413660
Turkana	309910
Samburu	103750

Total duration		Corrected	
491 days	16.1 months	4201 extra patients	498 days
Nb. of air teams		2 air teams	

446 days	14.6 months	3820 extra patients	453 days
Nb. of air teams		2 air teams	

743 days	24.4 months	8525 extra patients	755 days
		8659 extra patients	
Nb. of air teams		3 air teams	

2nd year

567 days	18.6 months	6494 extra patients	576 days
Nb. of air teams		3 air teams	

Total vehicles	20
Total air staff	120

REFERENCES:

- https://en.wikipedia.org/wiki/Demographics_of_Kenya
- <http://housingfinanceafrica.org/app/uploads/VOLUME-II-KPHC-2019.pdf>

APPENDIX G

FINANCIAL PLAN - CNP

Table 15: Capital needs planning - part 1

COST GROUPS	SPECIFICS	EXCL. VAT	QUANTITY	COMMENTS	REFER-ENCES
Investments	Vehicles	€ 492,000.00	20	Projected price of an eVTOL vehicle. Price estimated for annual production of 500 units. This defines a transfer price between EVE and HAS, since both are affiliated with Embraer S.A.	[1]
	Auxiliary station system	€ 2,848.00	20		
	Solar generation system (vehicle)	€ 29,060.00	20		
	Real estate (land)	€ 3,656.00	5	Assuming 400 m ² land	[2]
	Real estate (construction)	€ 38,499.90	5	Assuming 220 m ² building	[3]
	Solar generation system (hubs)	€ 82,604.00	5	Assuming a need of 50 kW	[4]
	Spare parts	€ 4,920.00	20	Assuming 1% of vehicle price	
	Furniture & fixtures	€ 3,000.00	5		
	Offices electronics	€ 3,000.00	5		
TOTAL		€ 11,230,359.50			
Assistance	Permits	€ 80.00	5		[5]
	Certifications	€ 762.00	20	Assuming 100000 Kshs per vehicle	[6]
	Licenses	€ 152.50	20	Assuming 20000 Kshs per pilot	[6]
	Lawyer	€ 267.00	5		[7]
	Legal fees	€ 36.56	5		[7]
TOTAL		€ 20,207.80			

REFERENCES:

- [1] https://www.mitsui.com/mgssi/en/report/detail/_icsFiles/afieldfile/2019/07/18/1906m_kinjo_e.pdf
 [2] <https://www.pulselive.co.ke/bi/land-here-is-what-an-acre-of-land-costs-at-these-10-fastest-growing-kenyan-counties/9e10k3v>
 [3] <https://www.buildingsguide.com/blog/planning-steel-warehouse-building/>
 [4] <https://powersolarphoenix.com/commercial-solar-panels-cost/>
 [5] <https://urbankenyans.com/cost-of-single-business-permit-in-kenya/>

Table 16: Capital needs planning - part 2

COST GROUPS	SPECIFICS	EXCL. VAT	QUANTITY	COMMENTS	REFERENCES
Pre-launch	Personnel (Administration)	€ 263,107.00	2	Assuming 1 CEO + 1 product manager + 1 business development manager for 2 years + 1 strategic partnership manager for 1 year	[8]
	Personnel (Procurement)	€ 104,028.00	1	Assuming 1 sales representative & 1 procurement specialists for a year	[9]
	Shipping	€ 14,215.00	20	Probably cheaper in bundle	[10]
	Risk mitigation cost	€ 30,000.00	1	Money left aside	
	Insurances (vehicles)	€ 164.00	20		[11]
	Office space	€ 25,500.00	2	Office space for 2 years	[12]
	Advertising	€ -	-	The service is mostly based on specific customer acquisition (thus, no general marketing)	
	Traveling	€ -	-		
TOTAL		€ 998,822.00			

CAPITAL NEEDED	€ 12,249,389.30
-----------------------	-----------------

FUNDING					
Equity capital	Personal	€ 11,000,000.00		Wholly owned subsidiary of Embraer S.A.	
	Investors	€ 1,500,000.00		From partners (e.g. EVE Urban Mobility Solutions)	

Debt capital	Bank loan	€ -			
	Private loan	€ -			

FUNDING TOTAL	€ 12,500,000.00
----------------------	-----------------

REFERENCES:

- [6] <https://www.kcaa.or.ke/sites/default/files/charges/KCAA%20%20CHARGES%20%26%20REGULATORY%20FEES-%20AIC%209.17.pdf>
[7] <https://commercialpropertykenya.com/transaction-costs-when-buying-property-in-kenya/>
[8] [https://www.payscale.com/research/US/Job=Chief_Executive_Officer_\(CEO\)/Salary/e50b3db3/Florida-FL](https://www.payscale.com/research/US/Job=Chief_Executive_Officer_(CEO)/Salary/e50b3db3/Florida-FL)
[9] <https://www.indeed.com/career/sales-representative/salaries/FL>
[10] <https://www.myus.com/where-we-ship/kenya/>
[11] <https://www.trustedchoice.com/professional-liability-insurance/pilot-coverage/airplane-aviation/>
[12] <https://www.point2homes.com/cre/commercial-property/us/fl/boca-raton/wells-fargo-plaza-1/>

APPENDIX H

FINANCIAL PLAN - SRP

Table 17: Service revenue planning

YEAR	SERVICE PRICE (per hour, incl. VAT 14%)	NUMBER OF VEHICLES	OPERATION HOURS (best case)	OPERATION HOURS (worst case)	SALES REVENUE (best case)	SALES REVENUE (worst case)	AVERAGE SALES REVENUE
1	€ 161.24	20	3000	1800	€ 9,674,400.00	€ 5,804,640.00	€ 7,739,520.00
2	€ 153.98	40	3000	1800	€ 18,478,104.00	€ 11,086,862.40	€ 14,782,483.20
3	€ 147.05	80	3000	1800	€ 35,293,178.64	€ 21,175,907.18	€ 28,234,542.91
4	€ 140.44	120	3000	1800	€ 50,557,478.40	€ 30,334,487.04	€ 40,445,982.72
5	€ 134.12	200	3000	1800	€ 80,470,653.12	€ 48,282,391.87	€ 64,376,522.50
COMMENTS							
<p>We assume a eVTOL cost decrease of 15% over 5 years. A nominal price margin has been set to 25%, added to the estimated cost per hour in order to cover for initial investments.</p>							
<p>The defined hours are based on the estimated vaccination effectivity. As it takes 25 days to vaccinate 18,000 patients, best case scenario is for a non-stop vehicle operation within the month, with the rest of the days used for maintenance/resupply/traveling</p>							
<p>A nominal quantity of 20 vehicles is used. It is expected to double the amount the year after, and faster increase of the fleet over the years due to decreasing production cost. Although, increase of vehicles means increase in infrastructure investment needs and expansion of the business. The increase of vehicles is not exponential as the priority of EmbraerX would still be urban transportation.</p>							
REFERENCE							
<p>https://www.lek.com/insights/ei/advanced-air-mobility-cost-economics-and-potential</p>							

APPENDIX I

FINANCIAL PLAN - IS

Table 18: Income statement - part 1

SPECIFICS	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	COMMENTS
Service revenue	€ 7,739,520.00	€ 14,782,483.20	€ 28,234,542.91	€ 40,445,982.72	€ 64,376,522.50	
Personnel wages (Kenya)	€ 581,558.40	€ 1,094,107.20	€ 2,112,907.20	€ 3,100,488.00	€ 5,101,848.00	Wages for staff on the field
Personnel wages (Florida)	€ 399,857.00	€ 399,857.00	€ 399,857.00	€ 399,857.00	€ 399,857.00	Wages for staff in office (company's core) - 1 CEO, 1 Product manager, 1 Sales representative, 1 Partnership specialist, 1 Procurement specialist, 1 business development manager
Insurances	€ 4,139.84	€ 6,818.56	€ 12,297.76	€ 17,289.92	€ 27,639.52	https://www.pesaba-zaar.com/blog/affordable-medical-insurance-covers-in-kenya
Utilities	€ 4,662.00	€ 4,662.00	€ 4,662.00	€ 4,662.00	€ 4,662.00	https://www.num-beo.com/cost-of-living/country_result.jsp?country=kenya
Internet/ phones	€ 2,559.96	€ 2,596.44	€ 2,596.44	€ 2,614.68	€ 2,614.68	https://www.num-beo.com/cost-of-living/country_result.jsp?country=kenya
Shipping	€ 426,450.00	€ 852,900.00	€ 1,279,350.00	€ 2,132,250.00	€ -	https://www.myus.com/where-we-ship/kenya/
Vehicles	€ 9,348,000.00	€ 17,712,000.00	€ 16,728,000.00	€ 31,488,000.00	€ -	Assuming production cost decrease 5% every year
Auxiliary system	€ 55,820.80	€ 109,363.20	€ 107,084.80	€ 209,612.80	€ -	Assuming production cost decrease 2% every year

Table 19: Income statement - part 2

SPECIFICS	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	COMMENTS
Solar system vehicle	€ 559,243.56	€ 1,074,574.22	€ 1,030,661.33	€ 1,973,496.89	€ -	Solar PV prices should drop by another 34% by 2030 (https://www.the-solarnerd.com/blog/will-solar-get-cheaper/)
Spare parts	€ 93,480	€ 177,120.00	€ 167,280.00	€ 314,880.00	€ -	Decrease of spare parts cost due to production cost decrease
Office space FL	€ 25,500	€ 25,500.00	€ 25,500.00	€ 25,500.00	€ 25,500.00	Administration space in Florida
Fixed costs	€ 20,207.80	€ 38,497.80	€ 75,077.80	€ 111,657.80	€ 184,817.80	Assistance cost from capital needs planning
TOTAL	€ 11,521,479.36	€ 21,497,996.42	€ 21,945,274.33	€ 39,780,309.09	€ 5,746,939.00	
Debt interest	€ -	€ -	€ -	€ -	€ -	No bank loans
Depreciation on investment	€ 572,894.00	€ 572,894.00	€ 572,894.00	€ 572,894.00	€ 572,894.00	Salvage price used for both the vehicle and solar system
Profit	-€ 4,354,853.36	-€ 7,288,407.22	€ 5,716,374.58	€ 92,779.63	€ 58,056,689.50	Taxes not included
	LOSS	LOSS	PROFIT	PROFIT	PROFIT	

Note: The colossal drop in profit in Year 4 is due to the investment of 80 new vehicles, and thus leading to more personnel (increasing total payroll cost), shipping, auxiliary station system, spare parts, & legal costs.

APPENDIX J

PROJECT BRIEF

Adaptation of eVTOL vehicles for humanitarian aid operations in Africa. project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date 01 - 03 - 2021 23 - 07 - 2021 end date

INTRODUCTION **

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

Medical organizations, such as Medecins Sans Frontieres or Red Cross, have operations in third world countries that assure the health of people in need. Two main operations are in the scope of the graduation project: mobile treatment, designating teams to move around, raising awareness of diseases, and providing free testing and treatment for people in need; and emergency response, supporting the local medical staff with immediate help of victims of disasters and conflicts. Currently, these organizations use vehicles with limitations: the lack of space and fuel, unavailability of proper infrastructures, and the power to carry the necessary payloads.

This is where the client, Embraer X, comes into play. Being a department within the Embraer aerospace company, the client specializes in creating a future consisting of Urban Air Mobility solutions. Embraer X has shown interest related to sustainability and social value, potentially solving challenges defined by the 17 goals of the UN (and thus, in this case, Challenge #3: Good health and well-being). Leaning towards the less unfortunate and thus third world countries, Embraer's desire is to create jobs and opportunities. The goal is to apply their aerospace knowledge and expertise into useful and practical solutions, to solve salient needs.

The main opportunities and limitations in the define problem context are presented below:

- Technology: an opportunity is to replace the current vehicles (cars & trucks) with air mobility solutions (eVTOL vehicle). With the fast advancing propulsion and power train technologies, the range and lift power of the air mobility solutions increases, allowing for a more efficient, effective and determined method of transportation. Although, the main limitation is charging, as electricity generation stations are scarce in large unpopulated areas, which asks for a self-sufficient system.
- Social: replacing terrain vehicles with air mobility solutions defines a big switch. Understanding the user as well as the local cultures, the governmental bodies and airspace organizations, is needed to simplify the integration of the new solutions, bringing a sense of safety and ease to the patients. Acceptability will be a big issue to cover in order to improve the success of the implementation of the new technology.
- Resources: Medecins Sans Frontieres spends an annual budget of its emergency and medical programs of approximately \$360 million (including transportation - which defines the operation, maintenance and update of current vehicles). The longer the operations last, the more resources they requires, and using eVTOL vehicles to replace the current methods would not only be cost-effective, but would also shorten the duration required for a mission and improve its effectivity. Although, as MSF is an NGOs, showing the benefits of replacing (or at least supporting) their current vehicles with an eVTOL vehicle product-service system becomes an important matter.
- Logistics: since low altitude air vehicles are not as common in these regions, air traffic control logistics won't face crucial difficulties. The eVTOL vehicle will fly at a lower altitude (800-1000 meters) than the current small payload planes (e.g. Cessna - 4000 meters flight altitude) and won't have the risk of collision. Additionally, the required process of certifying and regulating the new vehicles will be thought of, defining a valuable business plan.

space available for images / figures on next page

introduction (continued): space for images



image / figure 1: Embraer X's Eve concept vehicle - the basis for the solution of the project.



image / figure 2: Doctors without Borders' mobile operation in DRC - treating people suffering from sleeping sickness.

PROBLEM DEFINITION **

Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

One of the biggest challenges MSF faces is getting medical care to those that need it the most: those living in remote, insecure areas with little or no health care access; whether it is because of seasonal rains that flood roads or active armed conflict that forces people to leave their homes. Due to these limitations, the numbers of missions are still low and the number of people in need for treatment is rising. One of MSF's current project is the Mobile Unit Surgical Trailer (MUST), which can be set-up and operational within the span of few hours, and can pack up within the same time in case of threat. Although, due to the lack of roads and limitations of the terrain vehicles, organizing mobile treatment missions without the spending of a high amount of resources (people, money and time) becomes a challenge. Finding a more efficient and effective method is required that does not take into account these limitations. Thus, the vision is to adapt Embraer X's Eve concept vehicle to create a smaller version of the MUST project, replacing the current vehicle systems used for the mobile treatment operations of Medecins Sans Frontieres (and other humanitarian aid organizations), allowing for the quick set-up and pack-up of a mobile treatment auxiliary system.

Now, Embraer Eve's concept vehicle is design for urban usage. Thus, some of its subsystems are potentially not fit for the harsh environments that may occur in Africa (e.g. dust impact on the rotors, or gravel damage on the structure). Although, this is out of the project's scope and we will assume that the vehicle can operate anyway. The eVTOL solution allows to disregard the lack of roads and infrastructure, the inaccessibility of regions due to flooding, and can be in location much faster than terrain vehicles.

More information on the MUST:

<https://newatlas.com/medecins-sans-frontieres-mobile-operating-surgical-trailer-must/50242/>

Video on DwB's mobile treatment operations: <https://www.youtube.com/watch?v=SviuR7m5J14>

ASSIGNMENT **

State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

Design an auxiliary medical treatment station system to fit in the Embraer X's Eve concept vehicle, to be used as part of a humanitarian aid product-service system that provides medical care to people living in remote areas in East Africa.

The project will focus on the design of an auxiliary medical treatment station system that will be fitted into the Eve eVTOL vehicle, allowing for the use of air support for humanitarian aid. The system can be set-up/pack-up and operational within the span of few hours, fitting the needs of the medical team, in the sense of: payload to carry, operating requirements, extra space to treat patients, and the necessary energy/charging requirements. The vehicle's operating systems and specifications are settled and won't be modified.

The solution is to be designed for Eastern African countries (specifically Ethiopia and Kenya) where the medical NGOs operate, with scarce infrastructures, lacking energy generation stations and villages that are separated by large unpopulated regions.

Defining logistical the most effective method of operation (i.e. mission time planning, locations for landing, restocking, maintenance period) should also be thought of, and thus the structuring of the product-service system will be worked on. Additionally, public acceptability, scrutinization requirements (governmental and airspace) and operational challenges will have to be looked at as they define important obstacles that can disrupt the implementation of eVTOL vehicles.

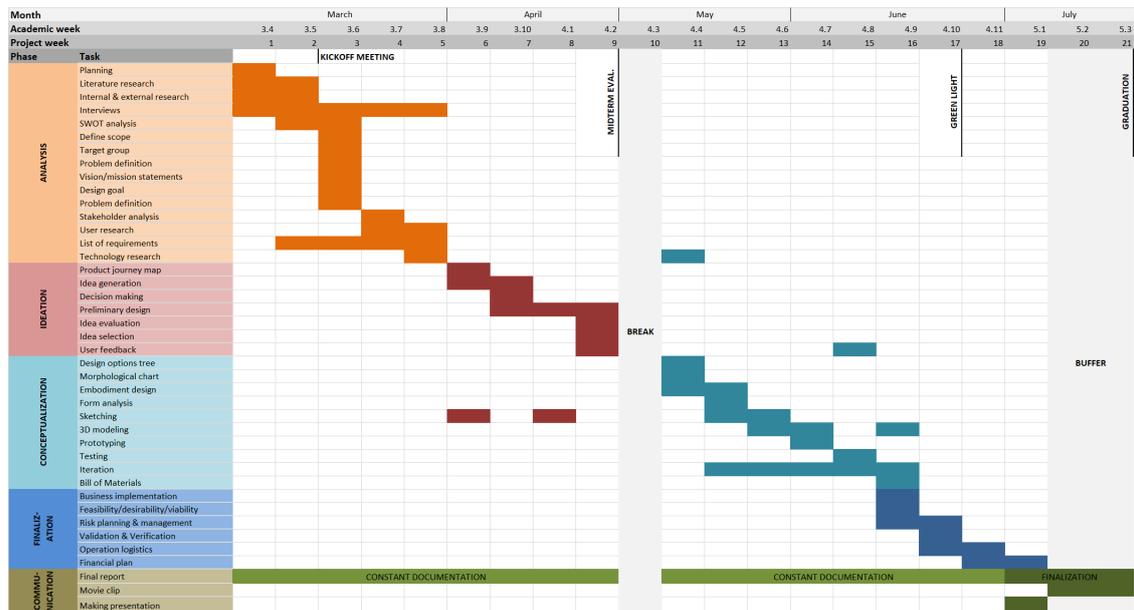
The deliverable for the project would be a model that describes the auxiliary system, supported by a physical prototype and explanatory video, additionally showing logistically the operation of the product-service system.

Personal Project Brief - IDE Master Graduation

PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

start date 1 - 3 - 2021 23 - 7 - 2021 end date



A week break has been set between the Ideation and Conceptualization phase in order to take some time off the project and recuperate. The last two weeks of the project has been set as a buffer phase for insurance, allowing time to wrap up and create final touches. Some tasks seem too short to be performed for a whole week, but it leaves a certain margin in case other tasks take longer than expected.

MOTIVATION AND PERSONAL AMBITIONS

Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology, Stick to no more than five ambitions.

Urban Air Mobility Design (UAM) has been on my radar ever since I started my Master: it incorporate my aerospace background; the market is still in its initial state which allows for a lot of opportunities; and I will be able to apply my design skills to create original vehicles. Now, I do want to contribute to society by bringing necessary solutions to problems that are yet to be explored. The medical field is broad and has identified issues that can be solved using an update of support vehicles, especially in regions where resources and infrastructures are scarce.

So what are my learning objectives?

- First, I aim to apply the knowledge learned from my bachelor and from the AED course (which was also performed on a UAM solution) in order to create a beneficial and profitable solution. Now that will be working in cooperation with Embraer, I will be closer to getting more specialized knowledge on eVTOL vehicles and hopefully get my networking going (for after my graduation project).

- Secondly, I want to improve my user research abilities, given its importance. Since the project's goal is to improve the current methods used by the medical organizations, understanding exactly the needs of the clients as well as the customers is crucial, especially during the pandemic where finding and contacting the right people is found to be challenging (and thus, steeper learning curve).

- Thirdly, sustainable design seems to be very popular now-a-days, which defines one of my weaknesses. Although, a lot of it is focused on negatives impacts on the environment and less on the societal needs of health and comfort (the people's pillar in the triple bottom line framework). In other words, I aim on becoming a more responsible and supporting designer.

- And finally, designing is only one part of the project but understanding how to integrate it into a well-functioning business is another. I aim on looking into factors that concerns the improvement of the viability of the idea, since if it is found to be beneficial, integrating it into the current framework would be highly educational, especially when it is supported by Embraer and used for NGOs.

FINAL COMMENTS

In case your project brief needs final comments, please add any information you think is relevant.