

**AMBULANCE
FOR DENSELY
POPULATED
METROPOLISIS**



PROGRAMME



Royal Academy of Design

Ambulance For Densely Populated Metropolis

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Index

6	The faster way to better health care
7	6 seconds = 10 minutes = 1 life
7	Methodology
8	The Ambulance
8	A brief historic summar
8	State of the art and future technology
10	Actor network
10	Stakeholders
12	Timeline
14	Elements
16	Designing for
18	Problem specification
20	Framing
22	Scope
24	Gaining empirical foundation
26	UN Goal
28	Theory
	Transportation design
	Pragmatic design - design thinking
	Inclusive design - health care design
30	Timeline
32	Focus
34	Delivery
36	Curriculum
37	References
40	Picture references

6 seconds = 10 minutes = 1 life

While going through different subjects to work within my final thesis, I tried to think of situation in my past, where I have wondered. One memory came to mind - very vivid and clear. After I finished high school I travelled for a full year around SE Asia. And I remembered an ambulance caught in heavy traffic in a growing metropolis. Not once, not twice - but often.

While the equation might seem flawed it is very much real. It takes at little as six seconds to pull your car to the side for an ambulance. If enough motorists choose to do so, an ambulance can easily save ten minutes - and ten minutes can easily make the difference between life and death in a severe situation.

The Faster Way to Better Health Care

I think we all hope to never need an ambulance. Not for ourselves - and not for the people around us. But if we do I think a most of us have certain expectations to the service. We have expectations to the paramedics, the condition of the ambulance and its equipment, and the time it takes for the ambulance to arrive to us and get to the hospital. Luckily, I live in Denmark and I know that quality of the Danish ambulance service is good. But the ambulance service varies around the world.

Methodology

In this program I will present my Masters in Industrial Design, where I will design, build and try to understand how an ambulance for densely populated metropolises should look. First, I will present a brief historic summary of the ambulance and give a short insight in how the ambulance look today and how it - maybe - will look in ten years. I will describe the stakeholders involved in the use of an ambulance and map their importance and make a timeline of when they encounter the ambulance. Then I look at what elements an ambulance contains to better understand where the ambulance can be improved and to understand what key elements is needed to give a good healthcare. Before defining my problem specification, I will describe my target group - I will examine statistics of ambulance dispatch times in India and compare them to countries in Europe - this will be followed up by statistics on population growth and a study of infrastructure.

Then I describe my framing, holding up dispatch times against size of the ambulance and therefore amount of medical equipment. Finding the balance between these two will be a key factor in this project. Then I present how I gain my empirical background through field studies and expert interviews. And lastly present theories to be used in the project - going through theories of transportation design, inclusive design and pragmatic design. Lastly, I present a timeline for the work with the ambulance

The Ambulance

A brief historic summary

An ambulance is a vehicle equipped with medical gear. The two key factors is bringing medical care to a patient and/or transporting patients to and from hospitals. In Spain 1487 during the Siege of Malaga the first ambulances were used to transport wounded soldiers but were first implemented for civilian use in the 1830s (Barkley, 1990). Both the aesthetics, content and the vehicle itself has changed significantly since, and today's ambulances are well equipped technological marvels compared to its predecessors (Vogt, 1976). But in large parts of the world the ambulance share more resemblance with its older counterparts. In large parts of the African continent medical transportation is often handled with horse and carts, as the time pre motorized transportation, and many urban areas - developing as well as developed countries - uses motorcycles for health transportation as they did in the first world war (Dickson, 2018).

State of the art and future technology

Today's ambulances are full of equipment that were not even available in prolific and well-equipped hospitals seventy years ago. EKGs, defibrillators, ventilators, suction units as well as an array of medical preparations gives ambulance personnel the possibility to assist, help and save patients with a wide variety of injuries (Tan, 2021).

Like everything else it can be difficult to guess exactly how ambulances will look in the future. Drones seems to be a returning element in one way or another. This can be as an aiding factor to monitor the area, guiding traffic and warn people around the place of accident (Schaft, 2018). Drones can also serve as a quick response with defibrillators, glucagon or thrombolytics can shave of precious seconds when treating, heart failures, diabetic chocks and blood clots (Nieljs, 2014). But some companies also work on human sized drones (technically not drones) to response to deadly injuries and can work in a fraction of the cost of manned helicopters and much quicker than any on ground vehicles (Chung, 2021). Back on the ground one of the big areas of development is in on board diagnosing through 5G - so called Smart Ambulances. This way a central placed group of doctors can aid multiple patients (euronews, 2020). Smaller equipment and planning also gives way to add more gear like ultrasound and x-ray. In the long run, off site controlled operating robots, could even further enhance the ambulances ability to be a mobile hospital instead of transportation (Tesser, 2020).

As presented, today's ambulances are full of technology, and are in an ever-growing development focused on one simple goal - giving better and faster treatment. But what about cheaper? As most of the progress comes from developed countries, cost is not a goal in itself, but merely a factor (Tesser, 2020).

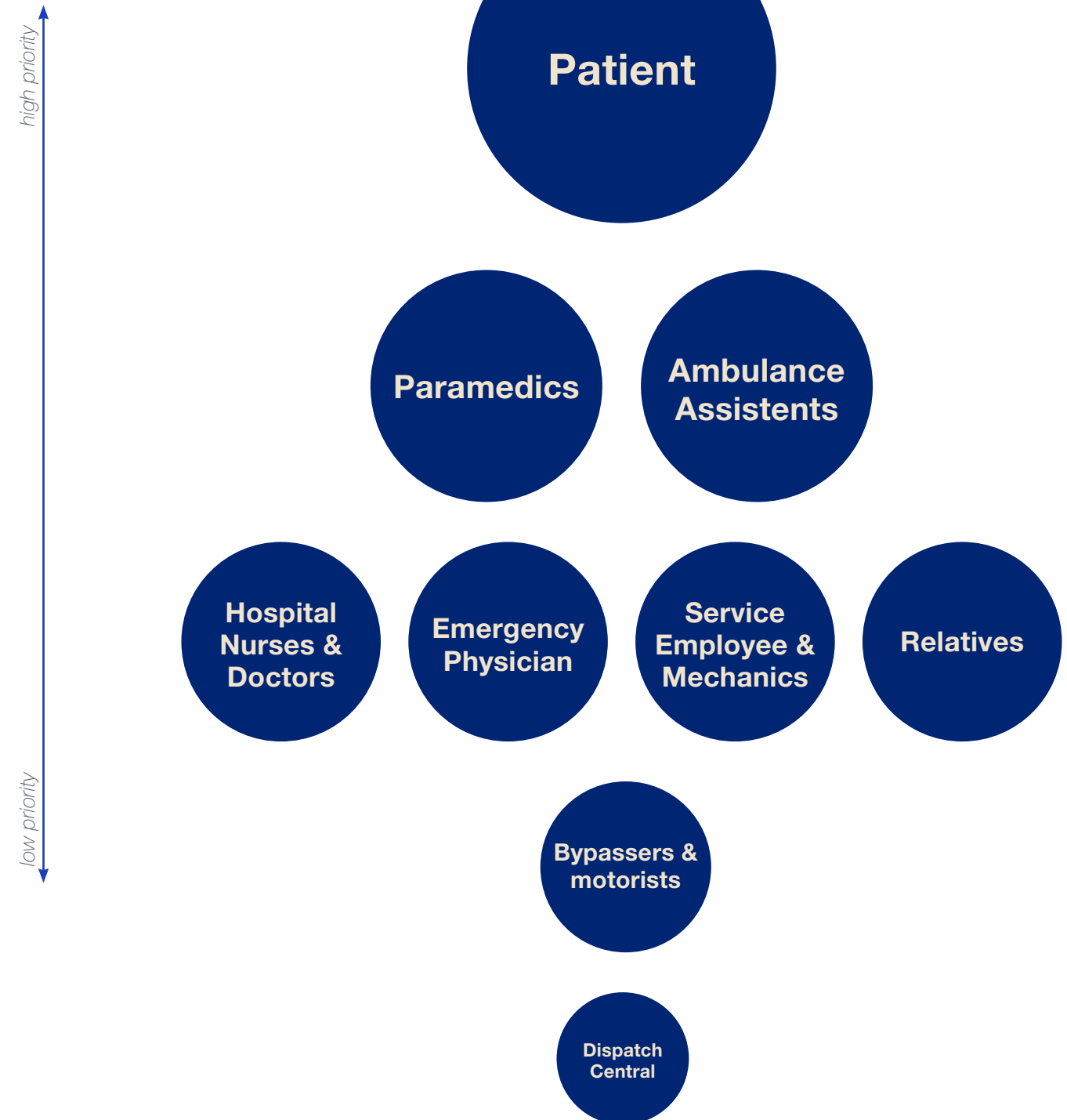


Actor Network

Actor-network theory (ANT) is an important tool for a holistic design process. As objects, according to ANT are created to mold and influence activities, actions and decisions. In this way the design of objects can impact and even change our morality and ethics by convey human relations (Yaneva, 2009).

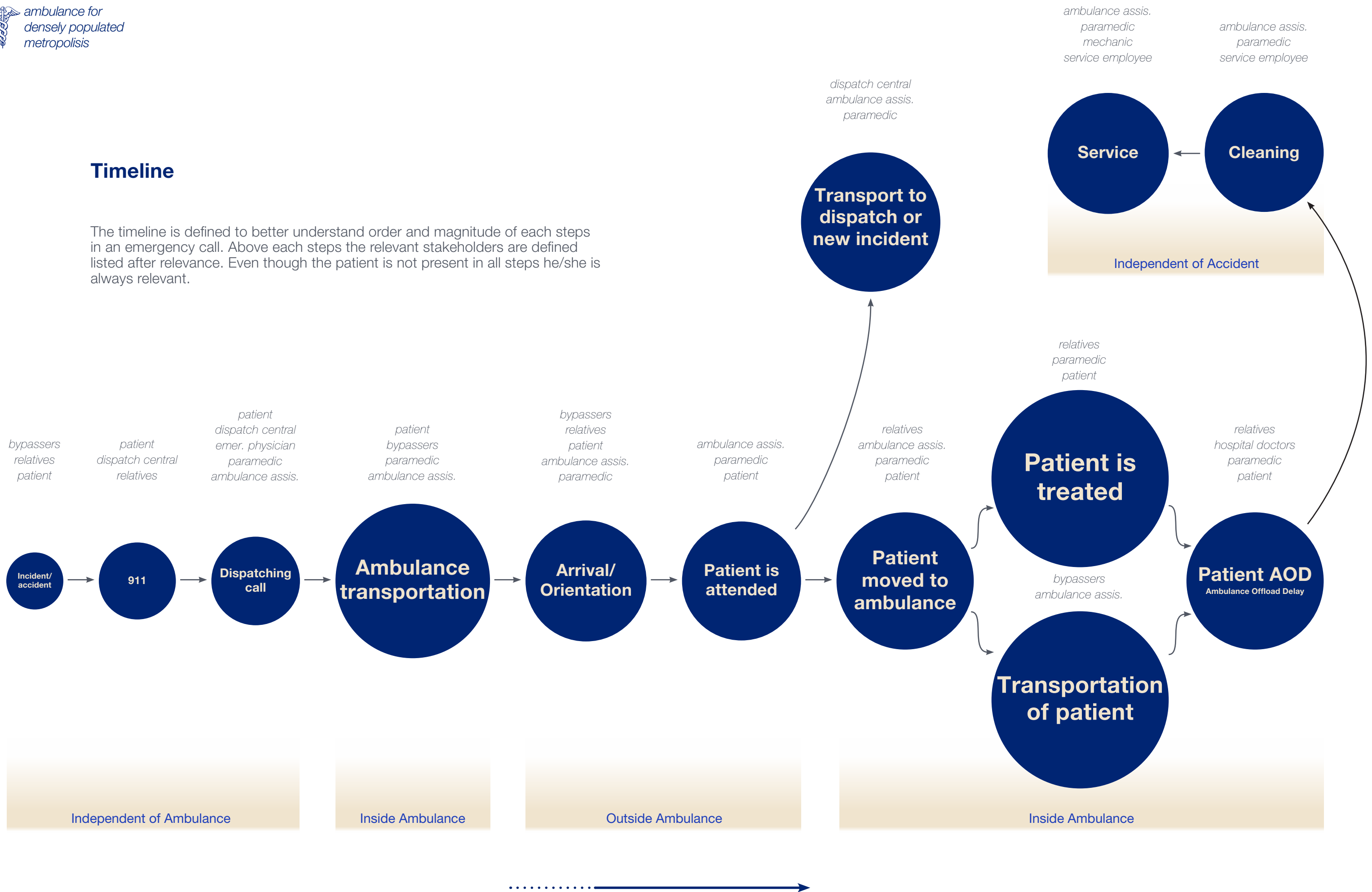
Stakeholders

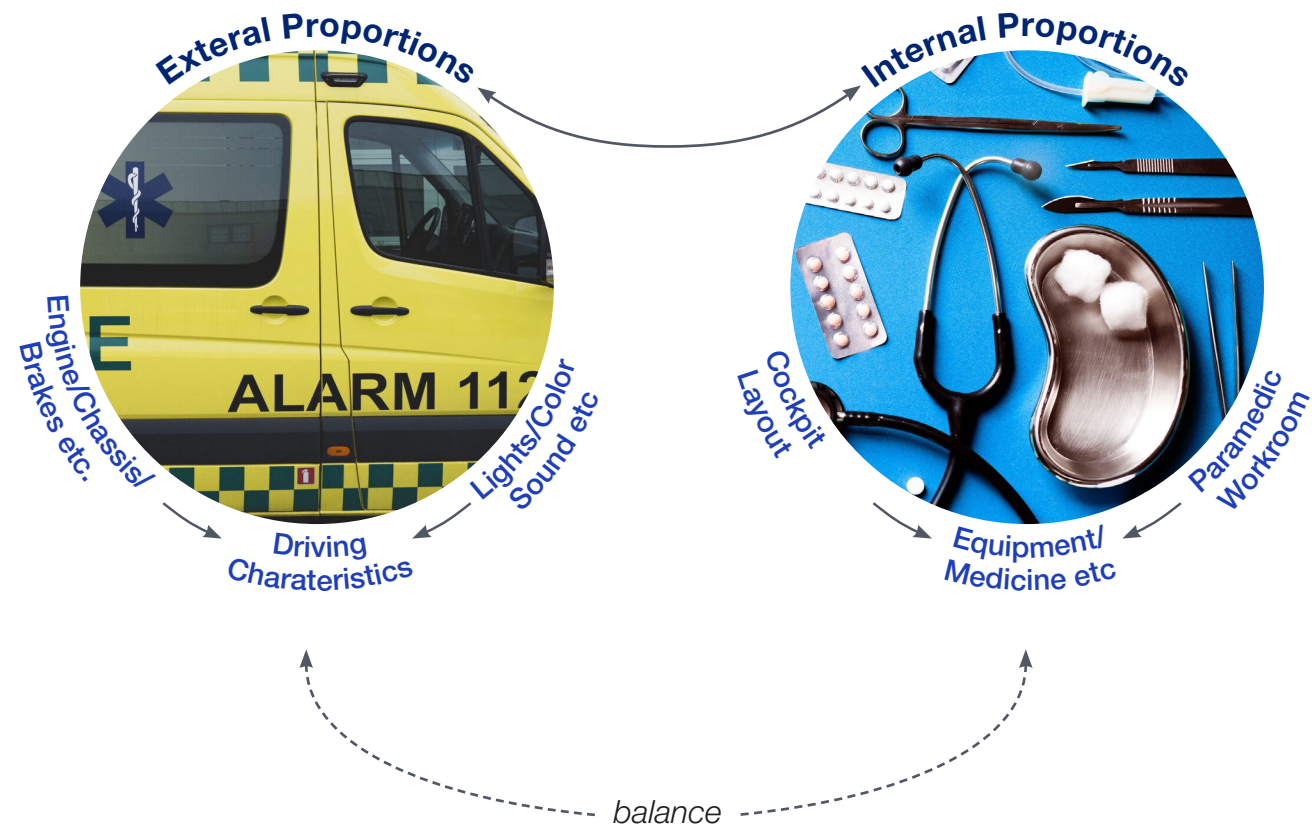
There is a line of relevant stakeholders in the day to day use of an ambulance - all in a different order of priority. Even though the ambulance assistant and the paramedic use the ambulance every day, for a long time, the patient is at the top of my hierarchy. The key requirement of an ambulance is to give the patient, as fast, lifesaving and comfortable treatment as possible. All interventions should be with the patient in mind. The patient should feel secure, relaxed and important (O'Hara, 2015). But to fulfill those requirements the paramedics and ambulance assistants should have the tools they need. The interior design of the ambulance should support the paramedics role of caretaker, authority but first and foremost as a treater. The paramedic should be able to have eye contact with the patient and access to patient for treatment - and should have easy access to all the tools and equipment in the ambulance. The paramedic should be safe and secure, in case of hard brakes, sharp turns or accidents (O'Hara, 2015). Hospital personnel will be relevant in the transition form ambulance to ambulance as well as the emergency physician will be relevant in severe accidents. Relatives might travel with the patient in the ambulance - and be able to talk and look at the patient. This can help calm the patient down in stressful situations (O'Hara, 2015). Service personnel take care of the stocking and condition of the ambulance and its equipment. Motorists' perception and awareness of the ambulance is a key factor in fast transportation. The motorists should be able to hear and see the ambulance very clearly - while giving stubborn road users and incitement to clear the road (Saunders, 2003). A goal for the ambulance assistant is to use the sirens as little as possible to avoid unwanted sound pollution.



Timeline

The timeline is defined to better understand order and magnitude of each steps in an emergency call. Above each steps the relevant stakeholders are defined listed after relevance. Even though the patient is not present in all steps he/she is always relevant.





Elements

To better understand where innovation could be needed, I have divided the ambulance into elements. The two main groups internal proportions and external proportions affects each other. The internal proportions effect the cockpit, the workroom for the paramedic and the equipment in the ambulance. The external proportions effect the mechanics (engine/chassis etc.) and lights/color/sound which all effect the driving characteristics. The key to a faster dispatch time could be by finding the right balance between the driving characteristics and the equipment. If the ambulance contains less equipment the ambulance can be smaller and therefore travel faster in congested traffic. To be able to find this balance i need to know more about the environment the ambulance is going to be used, and what equipments there are in an ambulance and their importance.



Equipment

There are a lot of variation in ambulances equipment depending on the country of origin. Two-way radios and mobile data terminals are key for the communication between the ambulance, dispatch central and the hospital. Bag valve mask, ventilator and suction units are used for aiding and clearing air paths and the ECG monitors the patient's vitals and are vital in the case of heart failures. Cervical collar and spinal board are used to clamp the patients where the patients neck or back are in danger. But one of the most important tools is the Jump bag containing all health care essential including a well-equipped medicine bag, Haemoglucometer (HGT), cold packs, gaze, coban (tape), tourniquet (blood loss), saline washing, stethoscope, blood pressure cuff, Rad measure (oxygen saturation, pulse etc.), nebulizer (drug delivery), Co2 monitor, needle decompression, bone drill, catheter and incubation kit (PrepMedic, 2018) (Tan, 2018).

Designing For

Densely populated cities

Today in 2021 there are more than 80 cities with +5M inhabitants and in 2030, 60% of the world's population will live in cities 500.000 inhabitants or more (World Urbanization Prospects, 2018). As we move towards 2070 the world's population will grow and grow, and of them more and more will live in urban settlements. This means that the problems we see in densely populated cities today will become bigger and new problems will arise. And India is the country in the world contributing the most to urban population growth. (Chee, 2018). Furthermore, the standard of living is increasing and more and rises to the middle class and therefore more will use the ambulance services while the traffic will increase (India Datasheet, 2018).

Traffic congestions and the cost

The most densely populated cities have well more than 30.000 people pr square kilometer which cause several problems - traffic congestions being one of them. In only four mayor cities in India (Delhi, Mumbai, Bengaluru and Kolkata), traffic jams cost more than \$60M - a day! (Tandon, 2018). But more importantly the congestions slow down essential infrastructure including ambulances. Distances that should be covered in 15 minutes takes up to an hour. In India over 40.000 dies annually in ambulances due to traffic jams, over 30% of all ambulance deaths - this means that 1% of all patients dies on ambulance rides (TOI, 2019), compared to under 0,1% Denmark (Petersen, 1997).

Time: From accident to help

But how does the traffic affect the dispatch times. In Copenhagen and most western capitals the average dispatch times of category A (most urgent cases with sirens and lights) are around 6 minutes and 90% percentile of 13 minutes (Akutberedskabet, 2018). This is generally accepted times and fulfill the danish governments own goals for dispatch times. But how is this compared to giant, heavily congested Indian metropolises? In Delhi, the average time for ambulances are 25 minutes and this is even though the ambulance fleet is larger than ever. A big reason for this is because of ineffective dispatching routines, but traffic times are a key factor as well.

The price is right

In the UK, the average price of a fully equipped ambulance is around \$350.000 (Hammond, 2004) and the salary of an ambulance team is around \$285.000 yearly (4 shifts pr week) (AGCAS, 2020). With a depreciation on 10 years for the ambulance the value of the ambulance itself is only responsible for only 10% of the annual cost (simplified calculation). Therefore, upgrades in ambulances and its equipment to make the ambulance more effective, is a great investment. In India, the ambulance costs around \$220.000 (Frazer, 2019), and an average ambulance team earns \$12.000 yearly (3 shifts pr week) (payscale, 2021). With a depreciation on 10 years for the ambulance the value of the ambulance itself is responsible for only 65% of the annual cost (simplified calculation). In India it therefore makes more sense to have cheaper ambulances and more of them to cover a larger population and area.

Why India then?

- India has the second most million cities.
- India is contributing the most to urban population growth
- India's ambulances have very slow ambulance dispatches,
- and high death count due to traffic jams
- India's economy is on the rise and more and more people have economy to pay for ambulance services
- Low wages and expensive ambulances make gives incentive to cut down on the cost of the ambulance



Problem Specification

How will an ambulance look specified to high density cities like Mumbai and Delhi, India?

Follow up questions:

How to compromise between size and speed of ambulance, to arrive as fast as possible with the right tools?

How can design thinking tools make the ambulance in use more cost effective?

How can future technologies in the health field, influence the design of ambulances in lower income countries?

Framing

As presented in the Elements chapter, one of the biggest challenges with this project is to find the balance between the size of the ambulance and the amount and type of equipment.

Size

In Denmark and in the western world the size of the ambulance has increased during the years. In the 40s the ambulance was the size of a hearse - in the 90's the ambulance was a small van - and today a larger van (looked through picture references). In India, the ambulance is still today like a small van. This could be because of the ambulance cost relative to the paramedic wages - and the cost of the ambulance and health care relative to the average wages. But in addition to the larger ambulances, many densely populated cities have a fleet of motorcycle ambulances (Tesser, 2020). These are used as first responders if traffic congestions keep the ambulance from arriving on time. The motorcycles are equipped with a reduced equipment package and are held from transporting the patient back to the hospital.

Content

These considerations should be held up against the health care possible with the given amount of medical equipment. To evaluate what equipment to keep, what to leave and what to change it is important to understand what equipment is used for lethal and to unlethal injuries - but also how often the equipment is used. But to evaluate these compromises I need to strengthen my empirical foundation. In the following chapter I will describe how this is achieved.

Today, tomorrow, to the future

This project is not focused for our world in 50 years but for our world tomorrow. In this way I can make relevant solutions to problems as they are now and with tools and production tools that exists today.



Scope

Concept

I will define my concept of an ambulance for the fast growing metropolises. As described in Framing section the primary goal will be to find the balance between size and the content of the ambulance.

Interior Layout

As the ambulance gets smaller the layout of the ambulance's interior will be more important. An important task will be to define the inside space of the ambulance to maximize the amount of medical equipment, but also to give a paramedic the best amount of workroom.

Interior Design (draft)

Giving the new layout of the ambulance equipment, I will also propose a design of the equipment storage. Here I will focus on the storage of the equipment and not the equipment itself.

Exterior Design

An ambulance will have to stand out in the cityscape. An ambulance must be heard - but also have to be seen. I will design the exterior of the ambulance to be seen even though it is going to be smaller.

Concept →



Interior
Layout →



Interior
Design →



Exterior
Design →



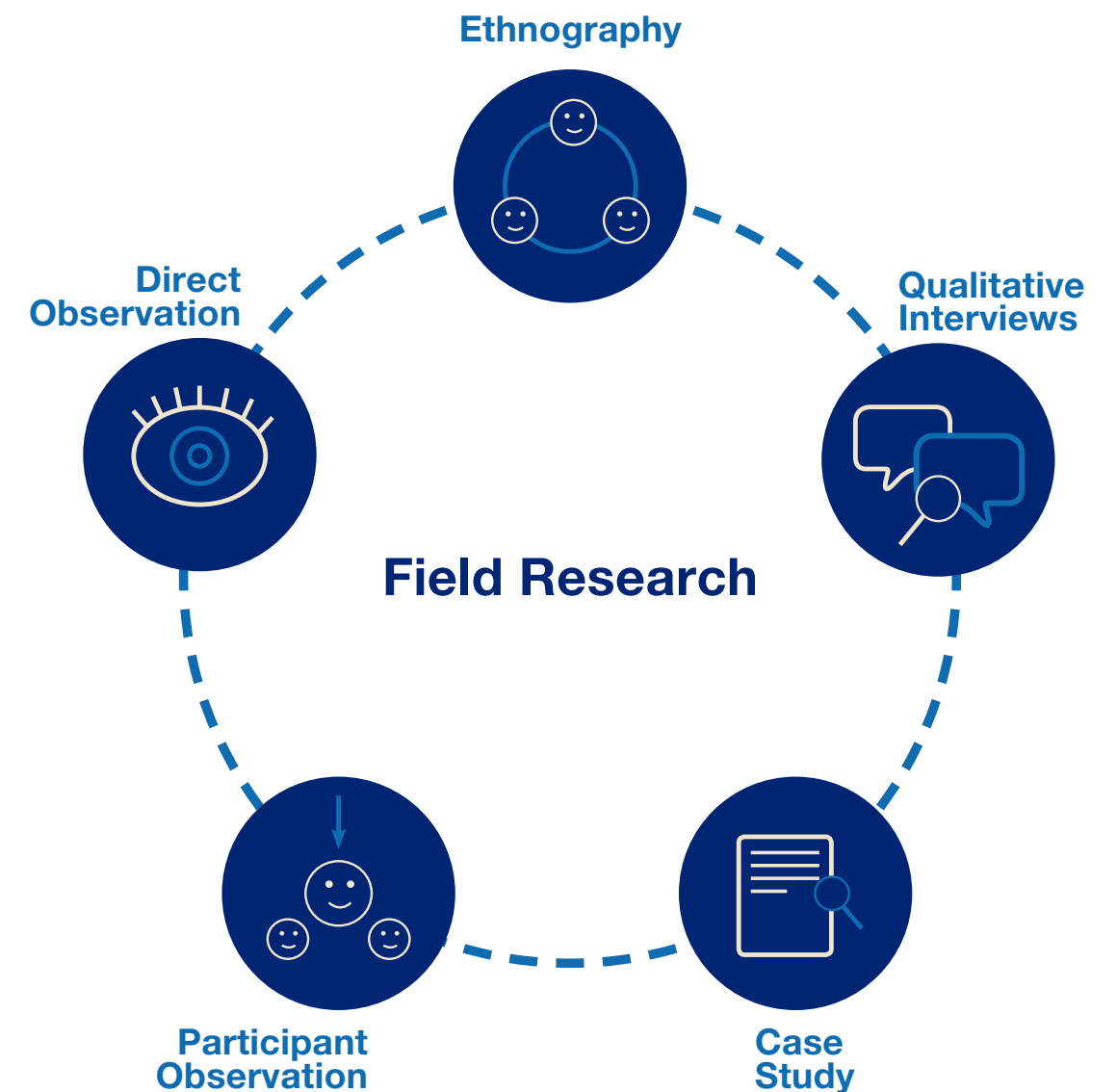
Gaining empirical foundation

As described in the Framing section I need to base my choices on empirical knowledge. I will achieve this knowledge by different areas of Field Research. I wish to make direct observations by following an ambulance in its daily routine of picking transportation, attending patients, cleaning etc. I will make a short participant observation by putting myself in both the patients and the paramedics place - noting the access to the patient and the equipment. In the "Actor Network" I have made a case study on the ambulance itself mapping the actors and when and how they interact with the ambulance - an in the Elements section I focused on the physical elements of the ambulance. I will make qualitative interviews with relevant personnel. Lastly, I will make short ethnographic studies on the behavior of motorists in an emergency response, through videos on the internet. In this way i have included all levels of field research theory (Stiffman, 2009). However - the current Covid-19 situation is limiting my possibilities. I will work to find compromises accordingly.

Field Research

I have and will gain my empirical knowledge by performing following action:

- Attending paramedics for a day
- Participate in actions related with ambulance work
- Studying motorist's behavior in emergency responses
- Making a case study of the ambulance and its elements
- Interviewing paramedics on their experience with the ambulance understanding hurdles, getting advices and knowledge from the personnel working with the ambulance daily
- Interviewing emergency physicians to help me prioritize the equipment of the ambulance against the size, and getting insights
- Interviewing service employees to understand what elements need additional maintenance, and getting insights
- Interviewing traffic and population researcher to get additional knowledge of traffic in the future



UN goals

Goal 03

is about securing good health and improve the wellbeing of all age groups. Faster ambulance service will improve greatly on this goal in general and especially on sub goal 3.6, about decreasing amount of the deaths from traffic accidents. This is because most patients dying from slow ambulance infrastructure comes from traffic accidents (TOI, 2016)

Goal 09

is about building robust infrastructure and support innovation. Faster ambulance service could help fulfill sub goal 9.a and 9b about focusing innovation and infrastructure in developing countries. Even though India is not a developing country, some of the infrastructural problems they are facing, can soon be actual in third world countries.

Goal 10

is about reducing inequalities in and between countries. Building a faster, but more important cheaper, ambulance service, health care can be provided for a greater range of citizens.



Theory

In this project I will study and use different theories on transportation, design thinking/pragmatic design and inclusive design. In this chapter I will shortly describe my curriculum.

Transportation

In "Car Design Essentials Part 1: Bones", Nick Hull (2018) presents a way to perceive automotive form. Hull breaks down a car design into three steps: bones, muscles, and graphics. Together they form a set of principles for understanding automotive form.

In "Emotional Design" Donald Norman (2004) explains how humans feelings and emotions are defining how perceive the world around, including designed objects. And furthermore, how this perception influences the way we act and make decisions. This theory is relevant in designing both the exterior and interior design of the ambulance

Pragmatic Design - Design Thinking

In "Pragmatic design: how does design thinking fit into the real world?", Davey van der Woert briefly explains the values of design thinking in creative proceses, and how a simple line of methods can yeild a more effective and pragmatic result. Circling between *Empathize, Defining, Ideate, Prototype and Testing* is of the most well known design thinking approaches, and is method I usually find useful.

Health Care Design For Non Western Countries

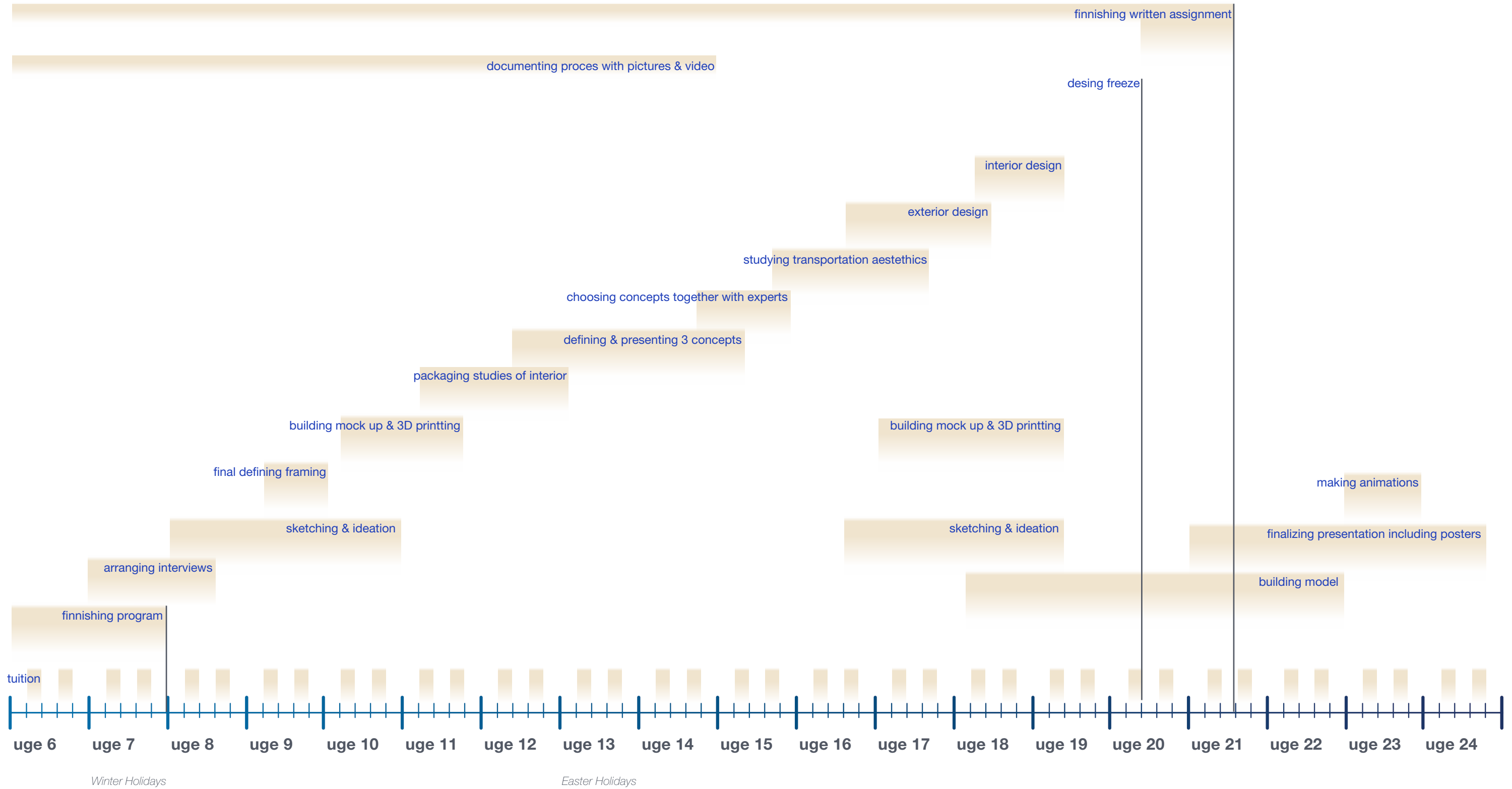
In "Designing incentives for rural health care providers in developing countries" Jeffrey Hammer is describing the difficulties in implementing new medical equipment and processes. This insight can help me defining a scalable solution that can easier be implemented in other countries, especially in fast growing third world countries in Africa.

Inclusive Design - Health Care Design

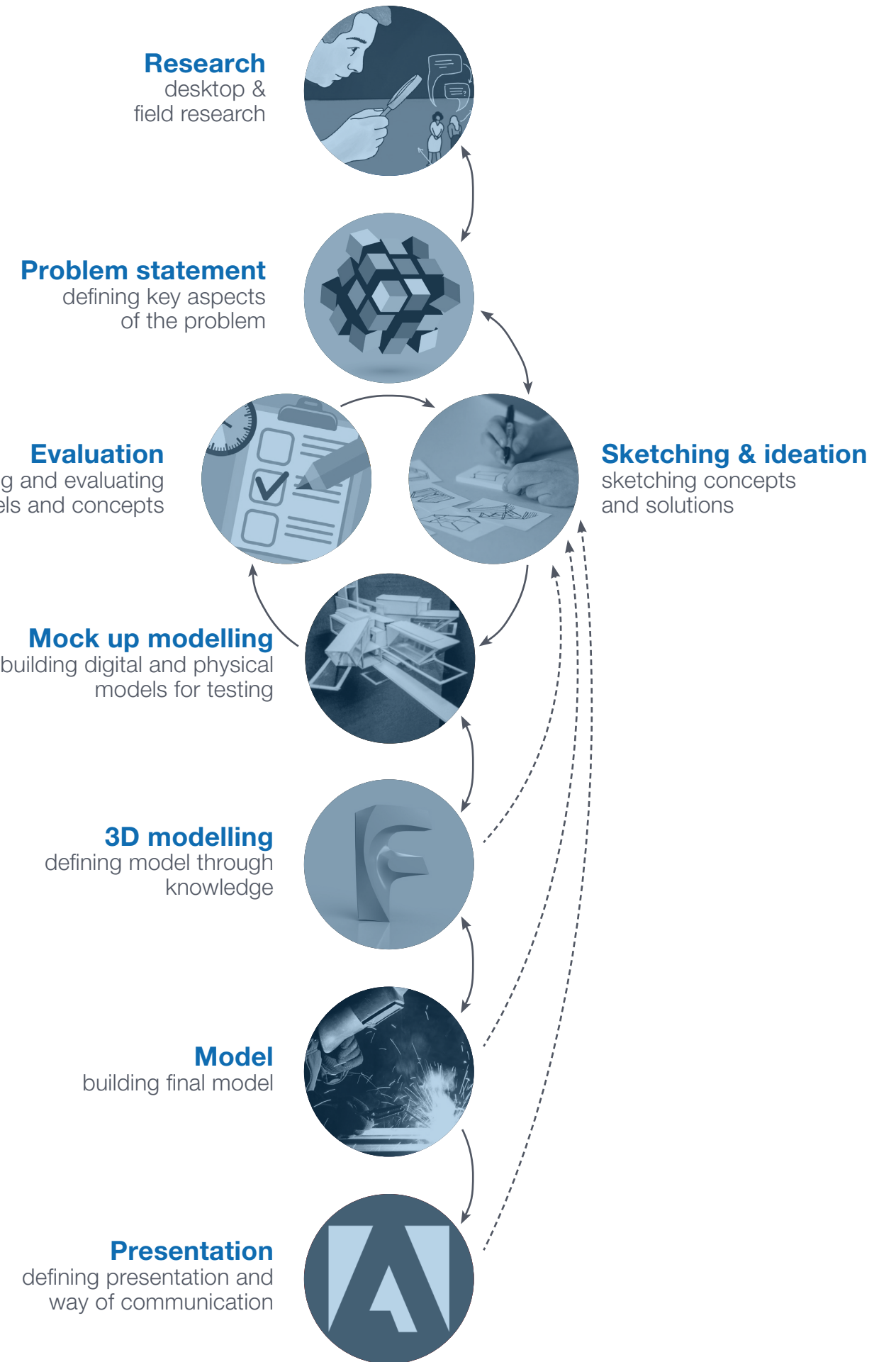
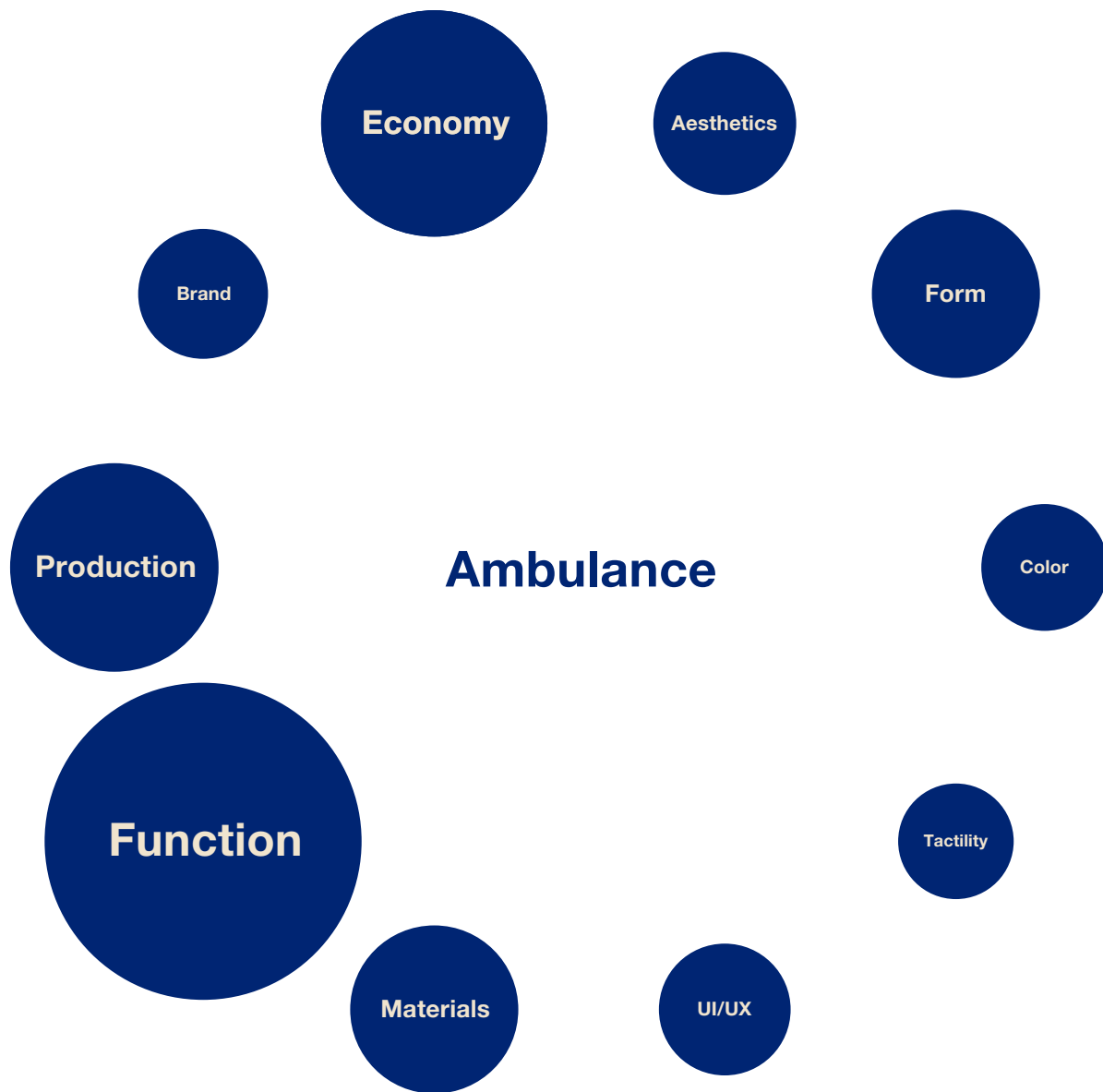
In "Designing inclusive environments and the significance of universal design" Rob Imrie (2014) describes how the designed environment affects the process of rehabilitation. This theory is relevant to the design, mainly of the interior, but also exterior of the ambulance. The patients relation to the objects affects the patients relation to the treatment.

In "Socially Inclusive Design: a People-centered Perspective" Rama Cheerawo (2015) makes the case for Inclusive Design as well as Imrie. More precisely he describes the process ethnographic analysis (Ethnographic Design) and presents tools to a achieve it in a design process.

Timeline



Focus



Deliveries

Program

10 pages - process oriented, research framing, time plan etc.

Written Assignment

15 pages - theoretical, methodical and process oriented.

Presentation

30 min. Describing problem, empirical evidence, process decisions and end design including materials, production, price, form, details etc.

Process documentation

Mock-up models and sketches

Posters

Briefly describing project and 1:1 or 1:2 technical drawings

Video

Standalone project video (roughly 2min) or interwoven in presentation, specifying details and more.

Model

Depending on Covid-19 - scale model 1:5, 3D printed parts - or scale model 1:5 and 1:1 mock-up model.



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