Rickshaw Ambulance

Transport of patients in rural indian area

A Bachelor project in engineering design

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Spring 2011

Rickshaw Ambulance, Transport of Patients in Rural Indian Area
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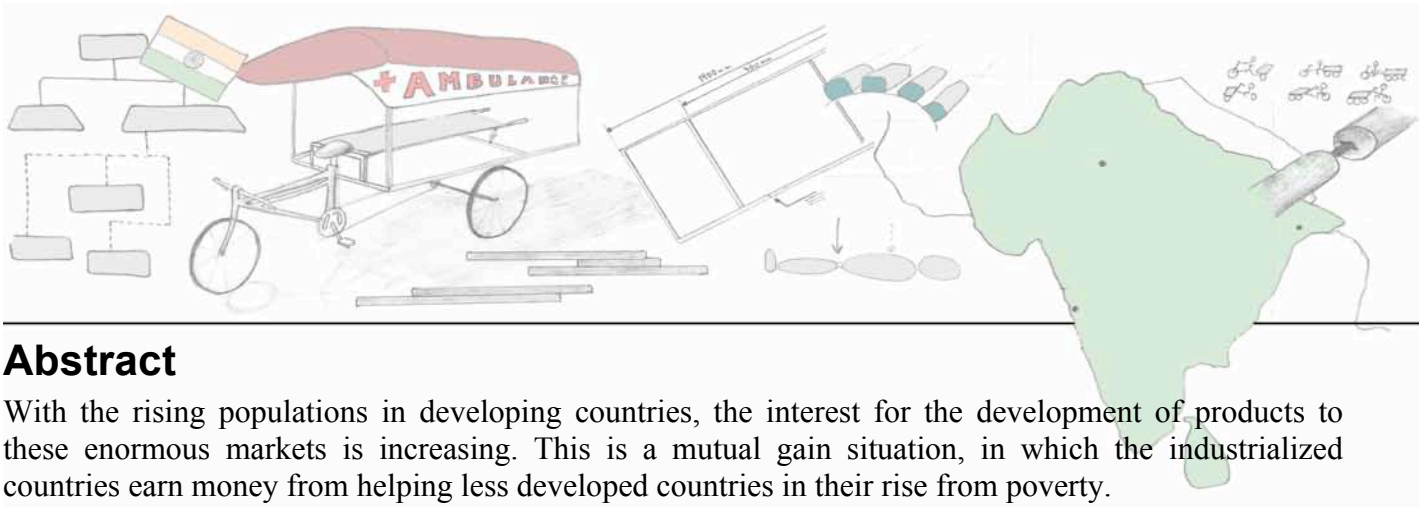
Bachelor project at The Technical University of Denmark
Supervisor: Torben Lenau



Abstract

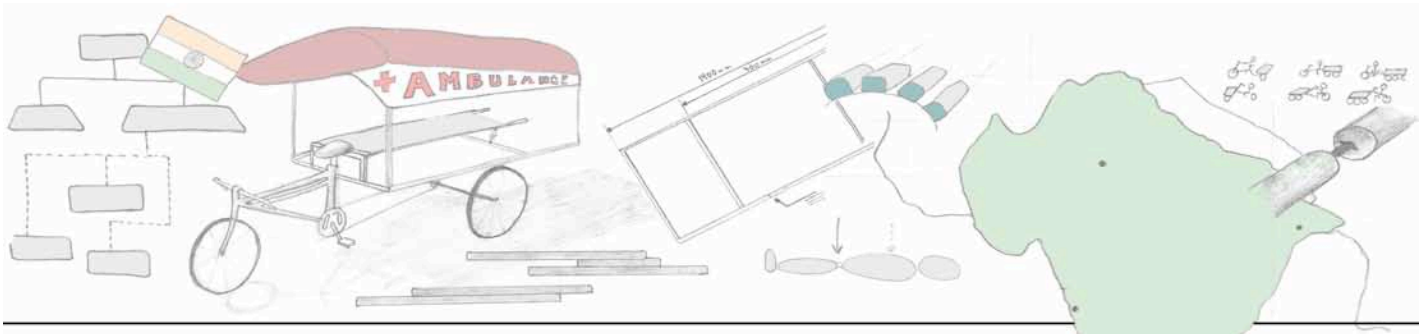
With the rising populations in developing countries, the interest for the development of products to these enormous markets is increasing. This is a mutual gain situation, in which the industrialized countries earn money from helping less developed countries in their rise from poverty.

The scope of this project has to design and build an ambulance for eastern rural India, more specifically in the area of Sunderbans. The hope is that this ambulance is going to allow more people from the rural areas to be included in the health care system.

The project has followed the product development process specified by Ulrich & Eppinger (2007) and Tjalve (2003). This process includes;
1) Considering existing solutions, 2) Identifying user needs, 3) Concept generation, 4) Concept selection, 5) Prototyping, 6) Prototype testing and concept evaluation, 7) Final concept detailing, 8) Implementation considerations and economical analysis.
A combination of sketches and the use of translators have been the primary mean of communication. A variety of interviews, questionnaires, workshops, role-plays and open forum discussion have been used to identify the needs of the users and stakeholders and to get feedback on ideas and various subjects. Tests have been performed to experimentally determine different product variables, and a economical analysis have been performed on the viability of the Rickshaw Ambulance.

The final product consists of; a full report on the product development process, a functional prototype and a construction manual for reproduction of the Rickshaw Ambulance. Vibration tests concluded that the ambulance is suited for patient transportation and positive feedback from all actors bear witness to a successful design.

The need for a transportation solution for the general population of Sunderbans is much needed. The prototype that was constructed and donated to a local NGO was received with overwhelming positive feedback, from all users and stakeholders. This leads the project group to believe that the current implementation of the prototype in an actual village community will have a similar successful outcome.



1 Preface

This is a 30 ECTS bachelor project at the Technical University of Denmark, created in close collaboration with the non-government organization (NGO), InnoAid and the local communities in West Bengal, India to obtain a BSc in mechanical engineering.

This report, together with a prototype and a manufacturing guide, is the result of five months work done on the bachelor project.

We would like to thank the two organizations behind the project JGVK and InnoAid. Especially the staff at the JGVK centre and the population of Sunderbans has shown great hospitality and friendliness towards us and provided valuable feedback on our ideas and prototype.

A special thank goes to Falck A/S and their leading physician in India, Rahul Khalia, for his and their contribution to this project, supporting us with both funds and knowledge about the Indian health care system. Finally we would like to thank Otto Mønsted Fonden and Ambu A/S for their financial contributions.

The project has been turned in on the 24th of June 2011

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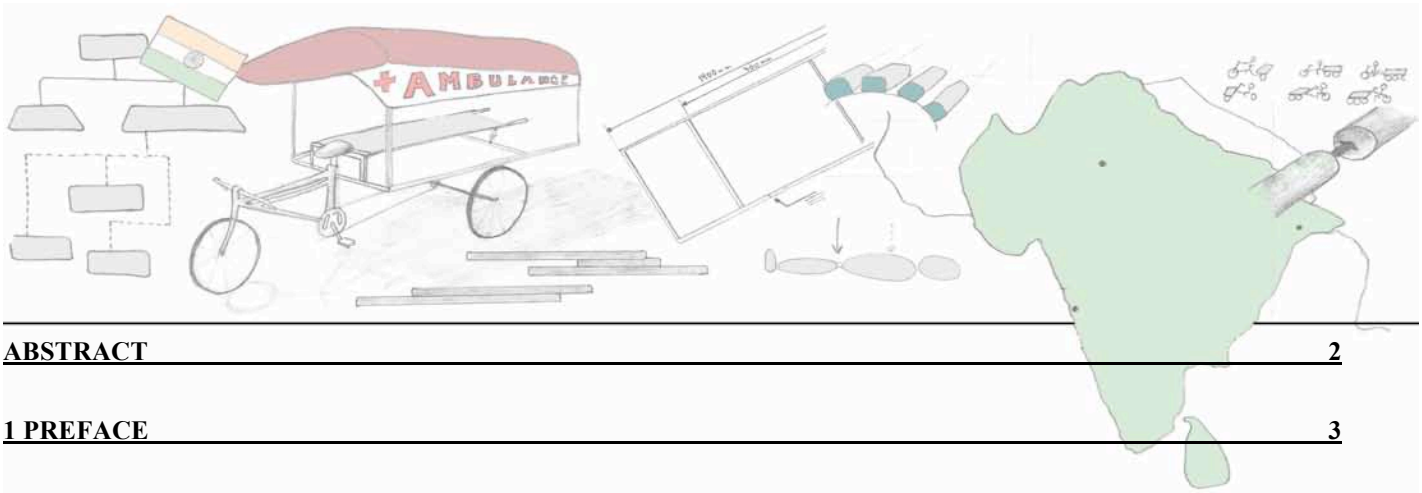
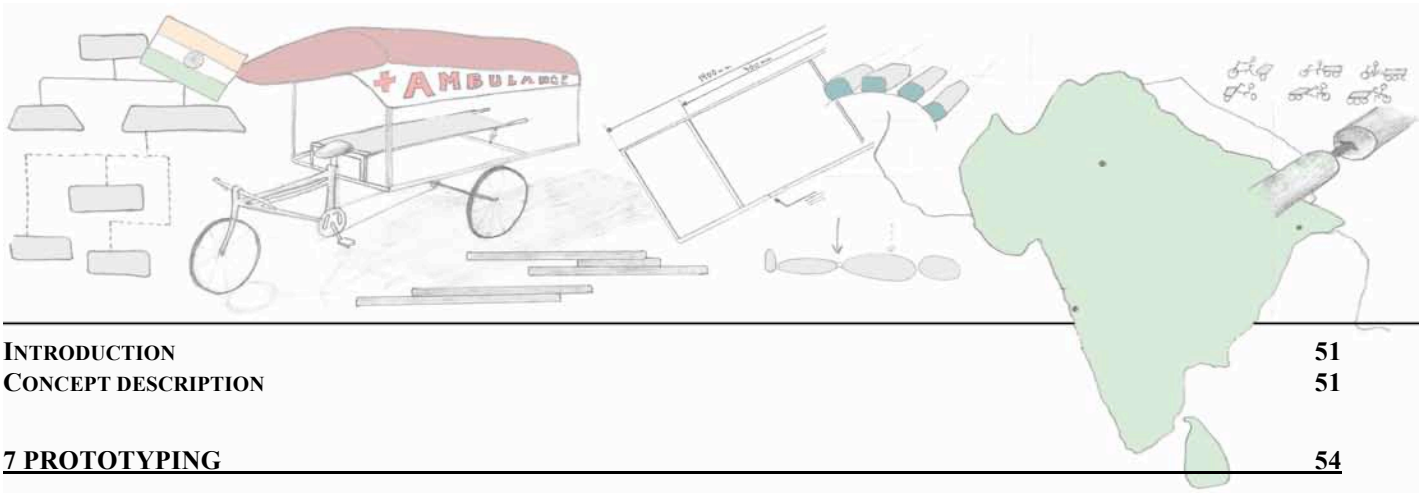
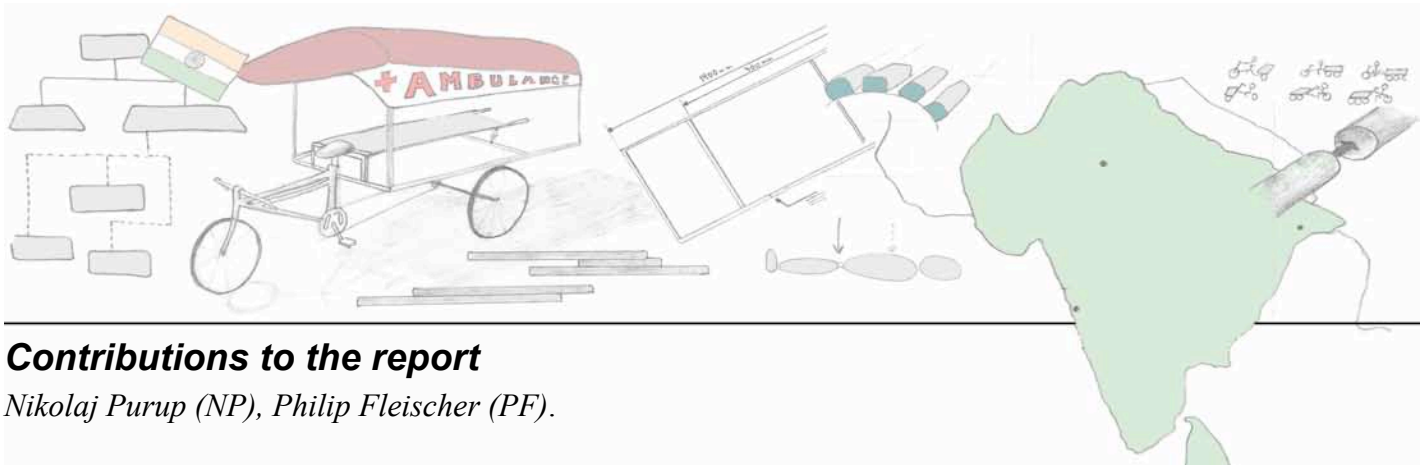




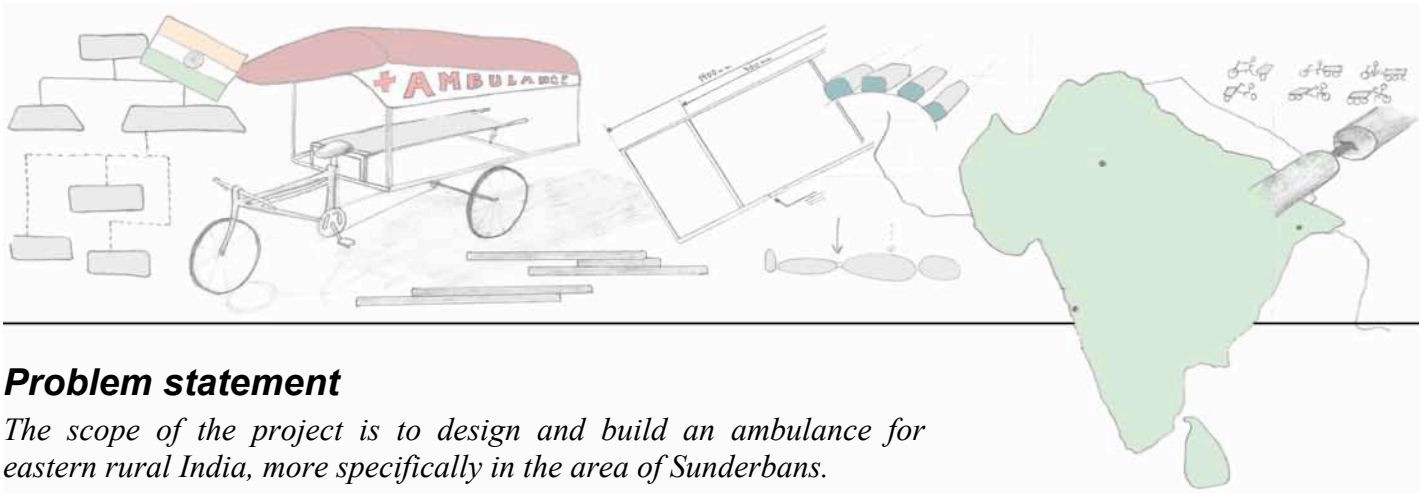


Contributions to the report

Nikolaj Purup (NP), Philip Fleischer (PF).

	1. draft	2. draft	1. review	2. review	3. review
Abstract	PF	NP	PF	NP	NP + PF
1 Preface	NP	PF	NP	PF	NP + PF
2 Introduction	NP + PF	NP + PF	NP	PF	NP + PF
3 Context	NP	PF	NP	PF	NP + PF
4 Identifying needs	NP + PF	NP + PF	PF	NP	NP + PF
5 Developing the ambulance concept	NP + PF	NP + PF	PF	NP	NP + PF
6 Concept for prototyping	PF	NP	PF	NP	NP + PF
7 Prototyping	NP+PF	NP + PF	PF	NP	NP + PF
8 Developing the final concept	PF	NP	PF	NP	NP + PF
9 The Rickshaw Ambulance	NP + PF	NP	PF	NP	NP + PF
10 Implementation	NP	PF	NP	PF	NP + PF
11 Conclusion and project evaluation	NP + PF	NP + PF	NP	PF	NP + PF
Bibliography	PF	-	NP	PF	PF
CAD drawings	NP	-	PF	NP	NP
Production Manual	NP	PF	NP	PF	NP + PF
Appendix layout	PF	-	NP	PF	NP + PF
Sketch work	NP + PF	-	PF	NP	NP + PF
Illustration	NP + PF	-	NP + PF	NP + PF	NP + PF
Final report layout	NP	NP + PF	PF	NP	NP + PF

Introduction



Problem statement

The scope of the project is to design and build an ambulance for eastern rural India, more specifically in the area of Sunderbans.

The aim of the project is the transportation of patients from the site of injury to a health clinic. The vehicle should be able to endure rough terrain and flooded roads, and servicing of the vehicle should be minimized. The maximum distance the ambulance will travel in one go is 25 km, and some of the traveling will be during the night. A typical case, where the ambulance is needed, is for work related injuries, female patients in labor and medical conditions like fever illness' where the patient is unable to move by him or herself.

The problem statement was formulated before the fieldwork and minor alterations was made to it after the field research was completed. The original problem statement can be found in appendix A3.

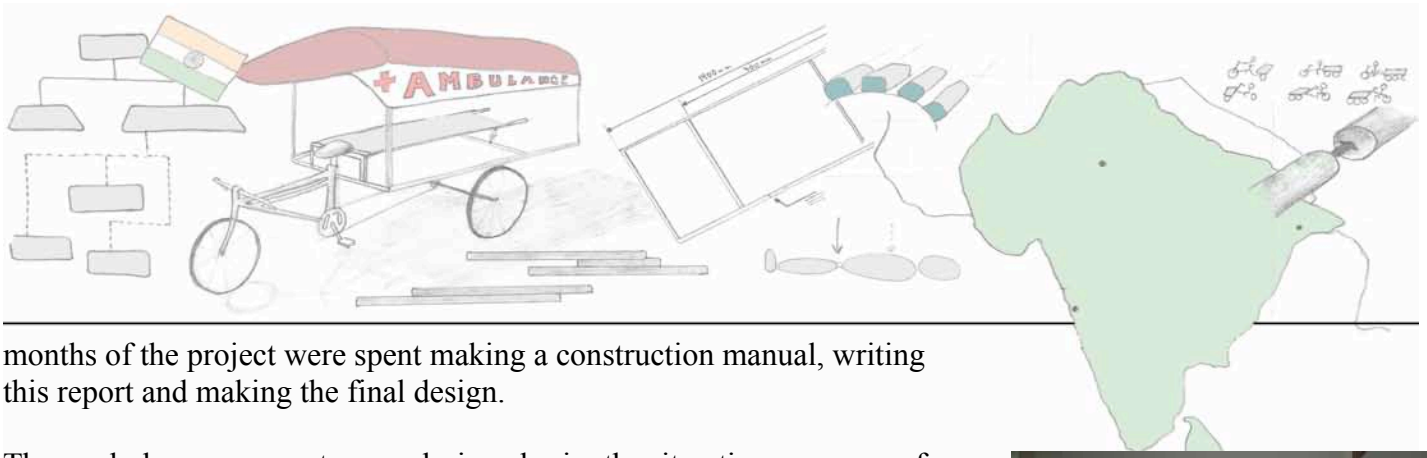
Motivation

With the rising populations in developing countries, the interest for the development of products to these enormous markets is increasing. Some call this "Designing for the other 90%" or "Design for the base of the pyramid" (Polak, 2011; Larsen 2010). A positive spin-off from this is new products and service solutions provided to the third world. It is a mutual gain situation, in which the industrialized countries earn money from helping less developed countries to rise from poverty.

This bachelor project is going to address the need for a specific solution: transportation of patients from the rural areas of West Bengal to medical clinics or hospitals. During the project the best solution was sought out in close collaboration with the local communities involving the use of workshops, interviews and observations. The project will not only look into the design of a physical artifact, but also examine the socio-technical network surrounding it. These examinations will provide useful information to help find the optimal way of implementing the Ambulance. Experiences from previous projects in developing countries will also be examined.

Process overview

The ambulance was designed during a four-month period. After the first month of desk research and planning, one month was spent in the rural area in India, where the ambulance will be implemented. The last



months of the project were spent making a construction manual, writing this report and making the final design.

The ambulance concept was designed via the iterative process of information gathering, problem analysis, concept development, prototype testing and concept detailing, where the theoretical foundation mainly rests on Tjalve (2003) and Ulrich and Eppingers (2007) research. Figure 2 shows a simplified process overview. A more thorough representation of the process can be found in appendix C4, project plan. The project plan was at all times the main planning tool, but weekly plans and post-it planning was used intensively to visualize tasks and to perform detailed day-to-day planning, see example in appendix C5 and Figure 1.

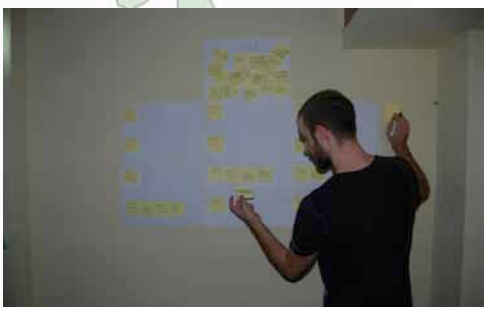


Figure 1. Day-to-day planning

During the project many comments were received, and workshops, interviews, design reviews and user tests resulted in a very iterative process, in which it was necessary to revise the plans and ideas countless times along the way. The process overview in Figure 2 is therefore a rough sketch of what actually happened.

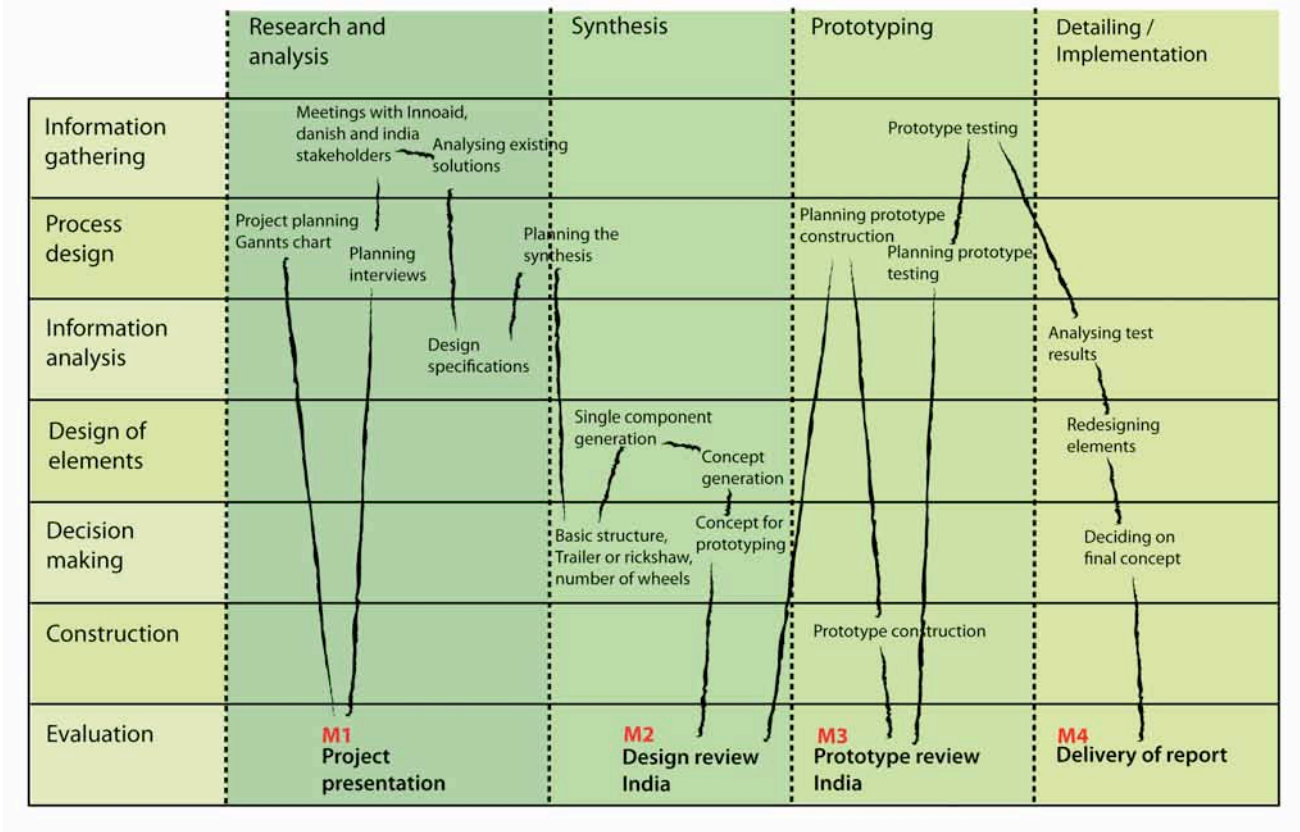
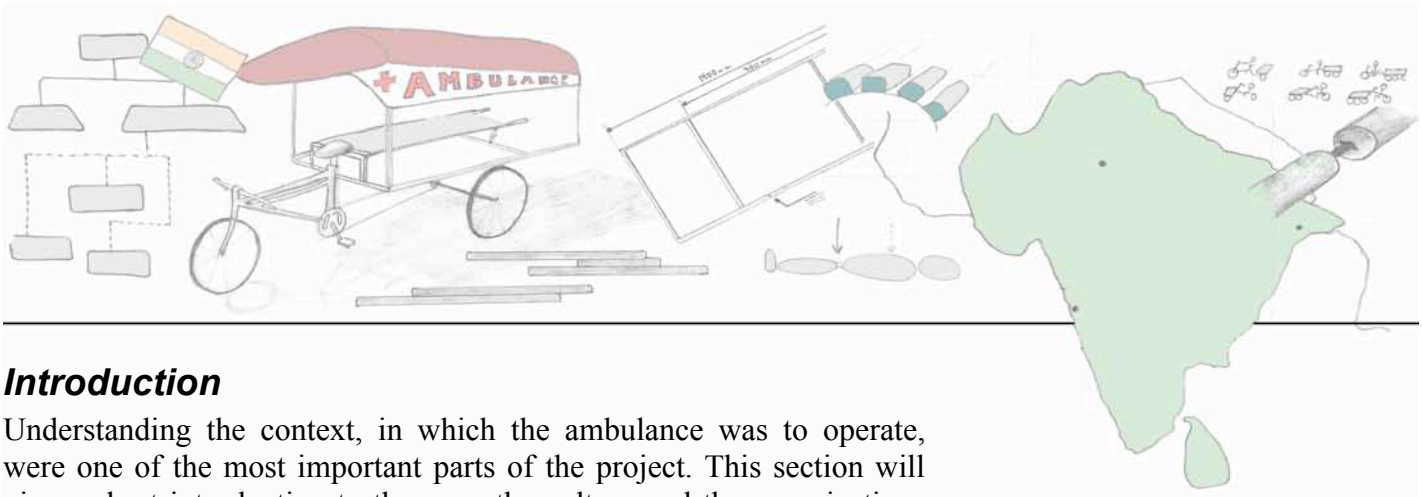


Figure 2. Process overview

Context



Introduction

Understanding the context, in which the ambulance was to operate, were one of the most important parts of the project. This section will give a short introduction to the area, the culture and the organizations behind the project. Finally three previously conducted projects, of which two have failed due to cultural misunderstandings, will be analyzed to learn from their experiences and use this knowledge in the project.

Organizations behind the project

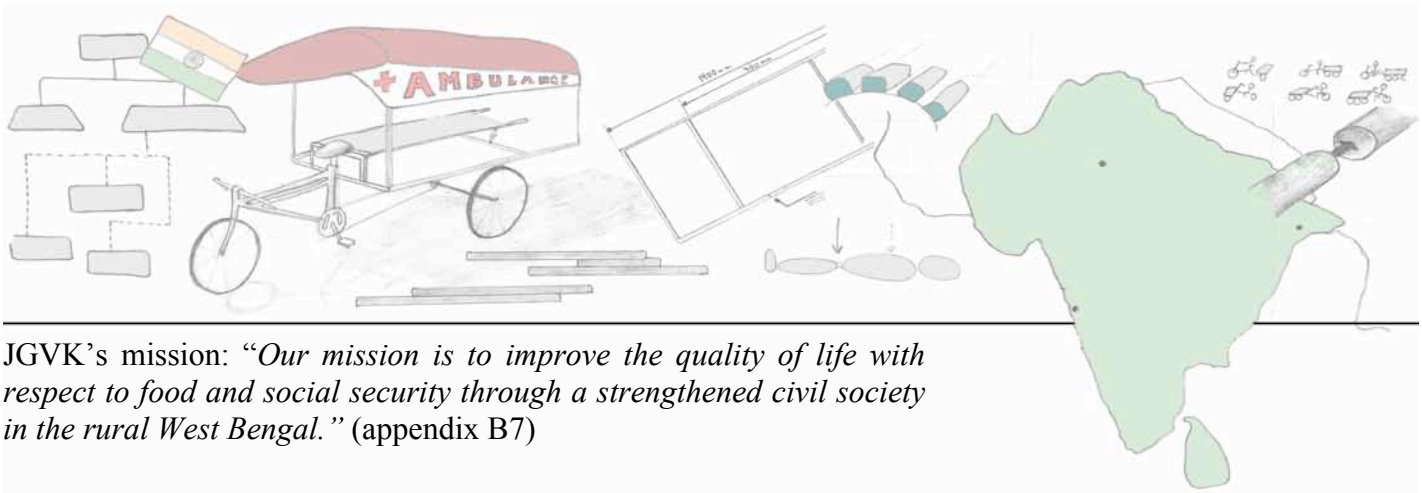
The need for the rural ambulance was originally raised by an Indian non-government organization (NGO). The need was then communicated to the Danish NGO, InnoAid, who then contacted the project group. The two organizations were deeply involved in the whole process and an important part of understanding the context of the project was to understand what these organizations stood for, and what their agendas were.

JGVK and IGF

Joygopalpur Gram Vikesh Kendra (JGVK) is an Indian NGO operating in Kolkata and Sunderbans. They are operating under a holistic approach, and are therefore managing projects with an impact on all aspects of village life. This includes programs in the fields of health, animal husbandry, education, water sanitation etc. JGVK is administrating more than 1500 women's self help groups, a health clinic and a school. Sustainability is very important to the organization, and with all projects comes a plan for how the local community can take over (appendix B7).

JGVK receives funding primarily from DANIDA (Danish International Development Agency), but also from private funds such as the Haldor Topsoe Foundation. Several organizations and universities are supporting JGVK with work and knowledge. The major contributor is Indien Gruppen Fyn (IGF), which JGVK has very strong ties to, but also InnoAid, DTU, AAU and AU are important contributors (IGF, 2011).

JGVK's vision: "*Our vision is to secure basic livelihood and to make a society on equal rights. Development should be sustainable with respect to social, environmental and economic context."* (appendix B7)



JGVK's mission: "*Our mission is to improve the quality of life with respect to food and social security through a strengthened civil society in the rural West Bengal."* (appendix B7)

InnoAid

InnoAid is a Danish non-profit organization, founded by students at the Technical University of Denmark and the organization currently consists of 7 active members. The organization strives to incorporate working with developing countries into the learning experience.
It is InnoAid who posted the ambulance project at DTU, and they are connected to JGVK and IGF. They are receiving founding from DANIDA, the most recent one being for a project, which addresses street food conditions in Kolkata (Cramer-Petersen, 2010).

InnoAid mission statement: *"Through cross-functional expertise and knowledge sharing InnoAid strives to identify, develop, support and implement user-oriented, sustainable solutions where aid is needed. It is further the interest of the network, to explore and develop new means of communicating and facilitating the involvement and participation of the local people from the Base of the Pyramid (BoP)."*
(InnoAid, 2011).

The local context

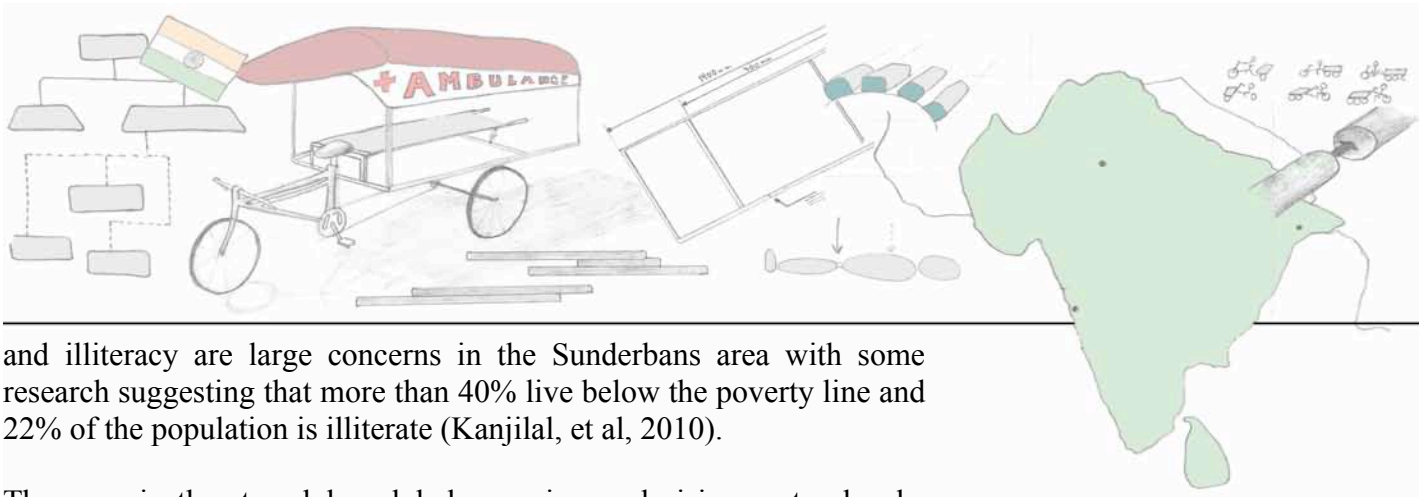
The following section will give a short introduction to the environment in which the ambulance is to operate. A deeper exploration of relevant subjects such as road conditions and the health care system can be found in the next section: Identifying Needs.

The area

Sunderbans is on the UNESCO world heritage list, and is one of the largest mangrove forest areas in the world (UNESCO, 2011). The area is split into hundreds of islands by the outrun of the Ganges, Brahmaputra and Meghna rivers. Most islands are part of a national park, and no one lives there. Figure 3, and Figure 4 illustrates where the area is located, and the location of the JGVK headquarter (JGVK HQ) has been marked by a red pin. The dusty yellow areas are farmed land and the green area is dense jungle. The context for the Rickshaw Ambulance is for this assignment limited to the island named Basanti, which can be seen on Figure 4.

Figure 3. India ©Google

The majority of the people in the area survive by farming and fishing the small ponds most of the inhabitants have by their house. Poverty



and illiteracy are large concerns in the Sunderbans area with some research suggesting that more than 40% live below the poverty line and 22% of the population is illiterate (Kanjilal, et al, 2010).

The area is threatened by global warming and rising water levels, which was experienced on the 25th of may, 2009, when the cyclone "Aila" hit the area. The cyclone ripped away roads and polluted the fresh water ponds with salt water, destroying crops and killing fish along with other household animals. Today the damages can still be seen as destroyed houses and salt polluted non-fishable ponds. The poorest families have not managed to rebuild much and at the market the food prices are still much higher than before the cyclone. The area suffers from cyclones every 3-4 years, so precautions to limit the impact of a disaster like "Aila" are crucial (appendix B12).

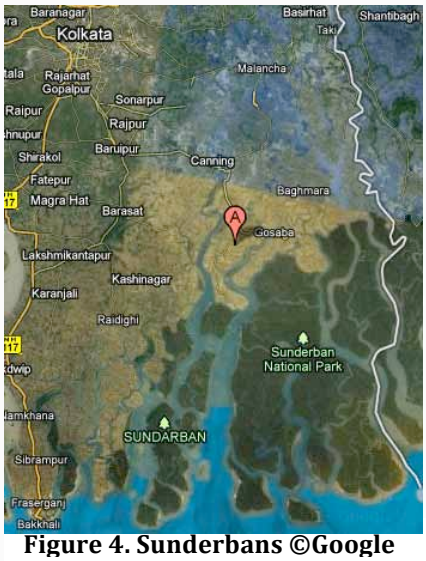


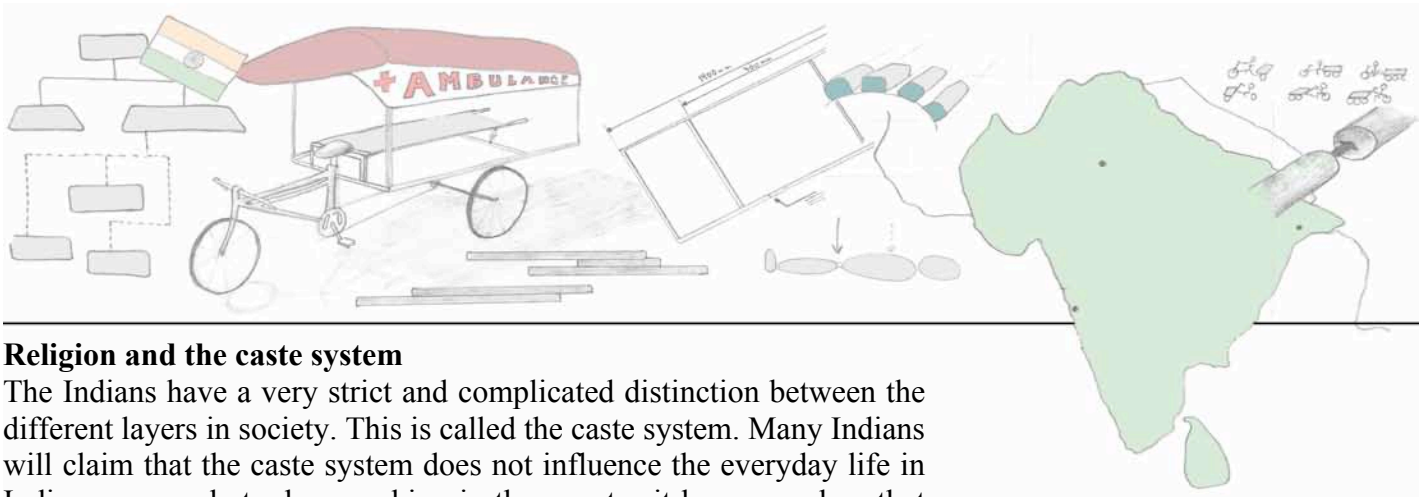
Figure 4. Sunderbans ©Google

How the Indian culture affects the development of the ambulance

Obtaining an understanding of the Indian culture is crucial, if the project is to succeed. To understand the Indian culture it is, as with any culture, important to understand the history that formed the norms and habits of the people. To successfully work with Indians, and especially if one wants to develop a product for them, it is important to have a basic knowledge of concepts like caste, karma and Indian religions. Before the fieldwork comprehensive research on Indian culture and religion was performed and during the stay regular corrections and evaluations within the project group was performed to avoid cultural misunderstandings.

European countries have been present in India since the 1600's, forming colonies and doing trading business. Then, in 1761 the Maratha-empire was dissipated. The empire had been protecting the European trade stations and the Europeans now had to defend their goods themselves. Eventually this resulted in British control of the country for almost 200 years until 1947.

Today India is still very much affected by the many years of English rule. This e.g. results in a large bureaucratic system and cricket being one of the largest sports in the country. It also means that white people still have great authority and will automatically be perceived as being at the top of the caste system (Tvevad, 2006).



Religion and the caste system

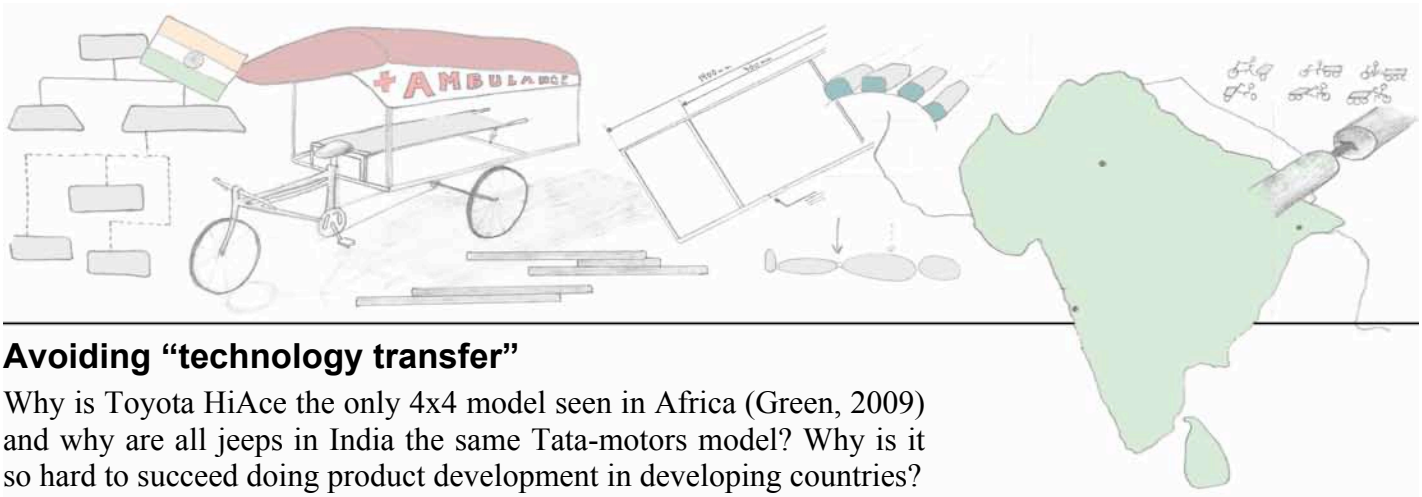
The Indians have a very strict and complicated distinction between the different layers in society. This is called the caste system. Many Indians will claim that the caste system does not influence the everyday life in India anymore, but when working in the country it becomes clear that this is far from the case. A person can therefore, because of his caste, be forced to work manual labor his whole life and changing to another job with higher prestige will be difficult. Most Indian people will accept this due to karma; the idea that a person for example will have to be suppressed in this life, for things done in a previous life. The ideas about caste and karma are closely connected to the Hindu religion, and the introduction of Christianity and Islam in most areas have given people a more loose perception of the caste system than before. India is a very diverse country when it comes to religion, having Hindus, Christians and Muslims living side by side in most areas without any major conflicts (Tvevad, 2006).

How does this effect product development in the country?

When doing business, or collaborating in any other way, like say developing product with Indians it is even more important to know about the local caste system. Indians see intellectuals (doctors, engineers etc…) as being of higher caste, and this can pose a problem, when working closely together with foreigners.

When talking to an Indian doctor it might e.g. be hard to control the direction of the conversation because he might see you as a lower ranking person. It is therefore important to make your status, obtained through your competencies and education, clear from the very beginning. On the other hand it is important not to overwhelm, but to build up trust, with the local population, like schoolteachers, craftsmen or translators. They can offer valuable information about and insight into the local culture, that the higher positioned Indians might not be able to.

It is very important to keep the cultural differences and the Indian history in mind when interacting with the Indian people. When used correctly this can be of great advantage - whole projects have failed due to cultural misunderstandings. Cultural misunderstandings are however not the only cause of projects failing in developing countries; in the next section this issue will be examined further.



Avoiding “technology transfer”

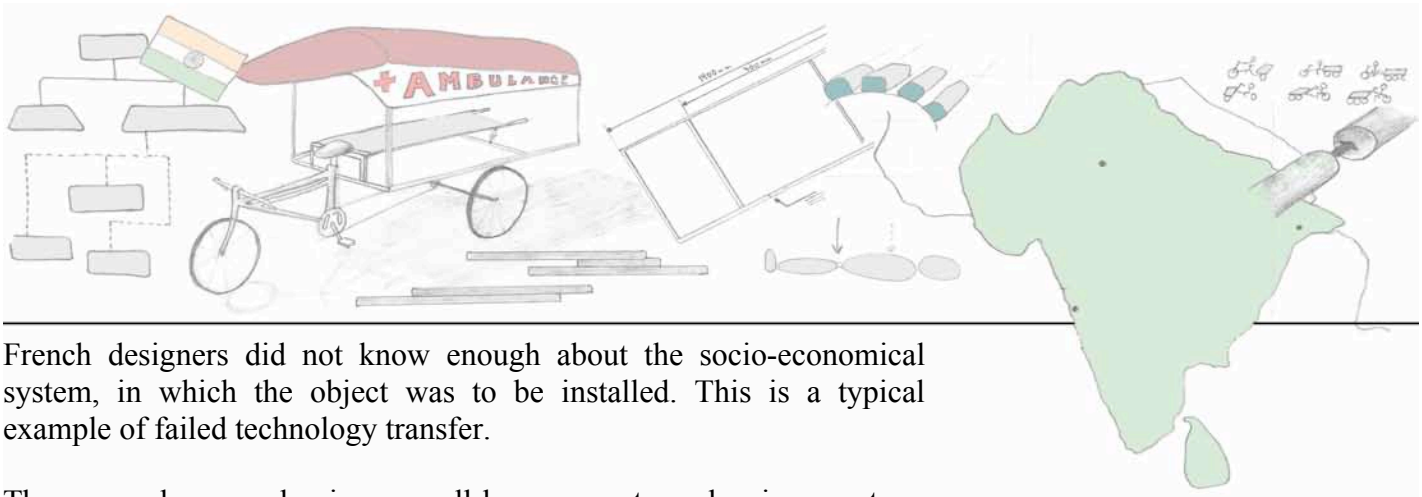
Why is Toyota HiAce the only 4x4 model seen in Africa (Green, 2009) and why are all jeeps in India the same Tata-motors model? Why is it so hard to succeed doing product development in developing countries? In this section examples of success and failures of previous projects performed in developing countries are analyzed and an attempt is made to identify important aspects to be aware of, if the Rickshaw Ambulance is to be a successful product.

The most difficult aspect of designing an object will often be to identify the user needs, and to think all aspects of use into the development. Designing products for users from another culture makes this even more difficult. Many experiences from success’ and failures have been documented, and before the fieldwork it was therefore important to get an overview of which dangers to be aware of when doing product development in developing countries. Below three characteristic examples are analyzed.

A photoelectric system designed and produced in France for users in Africa failing, partly due to non-standard plugs (Akrich, 1992).
A product for cleaning water wins design awards all over the western world while 66% of the users don’t want to use it in Africa (Boisson et al, 2009).
An African pump design succeeds because it is being produced locally and provides the possibility of customizing the product (de Laet and Mol, 2000).

The first two are examples of product development projects for developing countries that failed due to non-standard parts, misperceived needs and technologies unknown to the user.
In these two cases the designed object has defined the user, and not the other way around. When designing products for people from a different culture an inevitable difference will arise from the designers’ perception of the user and the actual user. As Akrick (1992) states: ‘*The obduracy or plasticity of objects, something that is established in the confrontation with users, is a function of the distribution of competences assumed when an object is conceived and designed’*.

This happened in the case of the photoelectric systems, where designers in France made a closed waterproof system, with components produced in France. This meant that local electricians were not able to repair the systems. Only a certified technician with parts brought from the capital would be able to do repairs. This resulted in lots of downtime for the systems and eventually no one wanted the system installed at all. The

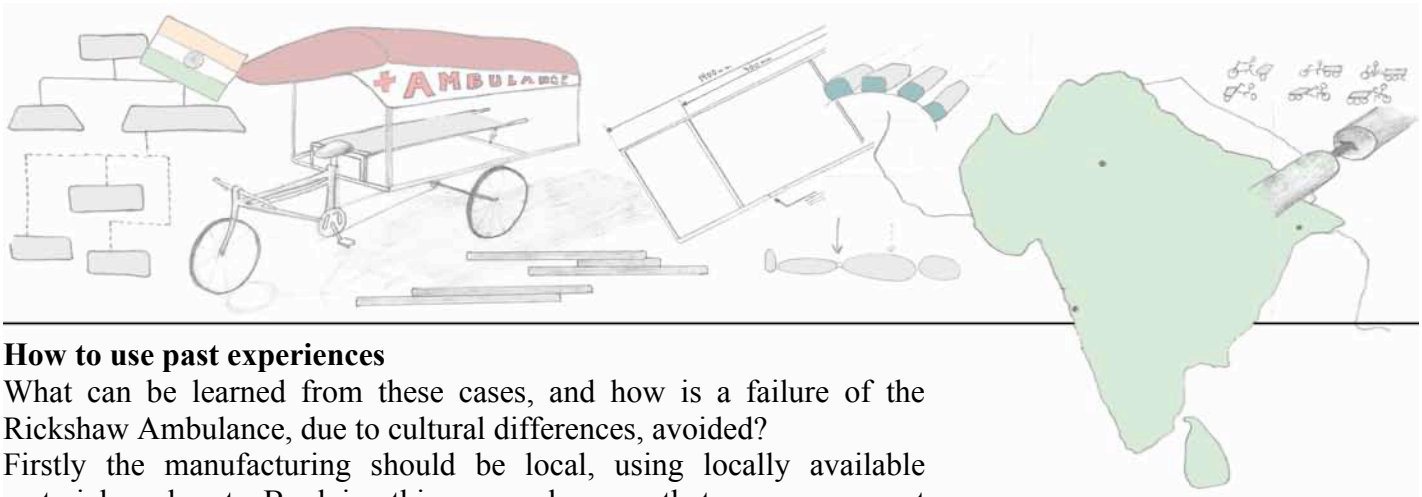


French designers did not know enough about the socio-economical system, in which the object was to be installed. This is a typical example of failed technology transfer.

The second example is a well-known water cleaning system, LifeStraw® (Vestergaard Frandsen, 2011), which has been winning design awards across the globe. But when the users in Africa were asked, one month after they received the product, 66% responded that they had stopped using it due to inconveniences or misunderstandings. Some thought it was to hard to suck water from the pipe and some just thought the packing was so beautiful that they put it on their shelf for display without ever unwrapping it.
What happened in this example is a classic problem in developing projects, where the purchaser of the product (such as a NGO or local government) is not the end-user, and where neither the purchaser, nor the designer has enough knowledge about the local context. The locals simply does not use it because it is inconvenient or looks too nice, which suggests that both the design should be altered, and the seriousness of drinking polluted water should be emphasized.
Also another issue in the case of the water cleaning system might be the lack of ownership of the product, since it is given for free as a humanitarian donation.

The third example is a success story about a product called the Zimbabwe bush pump. This is a pump design, winning market shares in Africa due to an open source design layout and locally produced parts, using locally available materials. The pump is bought by the local communities themselves, allowing them to choose the design which best fit their needs (they might want a specific color, material composition or capacity). The fact that they buy the product themselves as a community also helps develop a sustainable socio-technical network around the pump, where the pump gives the villagers a sense of unity. (de Laet and Mol, 2000)

What is seen in the cases of the water cleaning product and the photoelectric system is a large difference between inscription and description of the object. In other words the relationship between how the designer intends the object is going to be used (what is inscribed in it) and how the user understands this (what is described from the design). It is therefore extremely important to have a thorough insight in the culture the product is being designed for, before the design phase, when the designer and user are from different parts of the world (Akrich, 1992).



How to use past experiences

What can be learned from these cases, and how is a failure of the Rickshaw Ambulance, due to cultural differences, avoided?

Firstly the manufacturing should be local, using locally available materials and parts. By doing this, one makes sure that every spare part is available nearby and that the object only contains known technologies, thereby making the product locally repairable.

Another very important aspect is to really *understand* the end-user and the system in which the product is to be implemented. This cannot be done solely by reading literature, but must include meetings, interviews, workshops and observations in the context of later use. This also includes designing not only *for*, but also in close collaboration *with* the user.

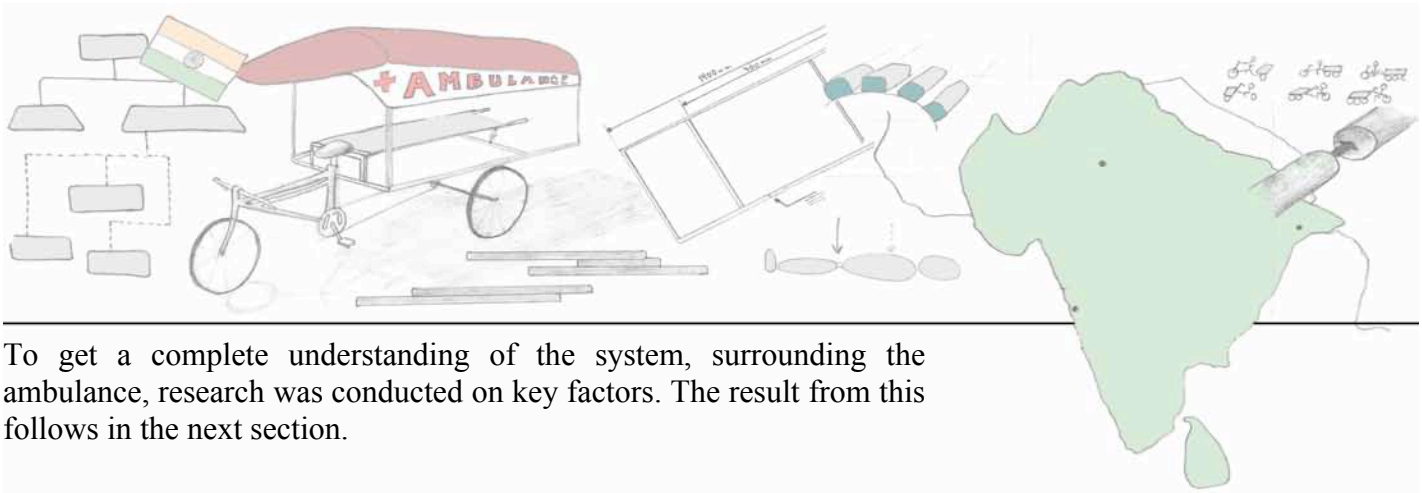
The last important lesson is to give the end-user a kind of ownership over the product. This is achieved by the construction of a socio-technical network surrounding the object using a holistic approach where economic, cultural, technical and social needs are addressed (Larsen, 2010).

A good example of this is the use of the same few car models in many developing countries. The manufacturers of these cars have somehow succeeded in making an easy repairable and durable car. This have caused them to be an incorporated part of the society with a socio-economic-technical network of spare parts, knowledge and jobs created in direct relation to these specific models.

Conclusion on the context

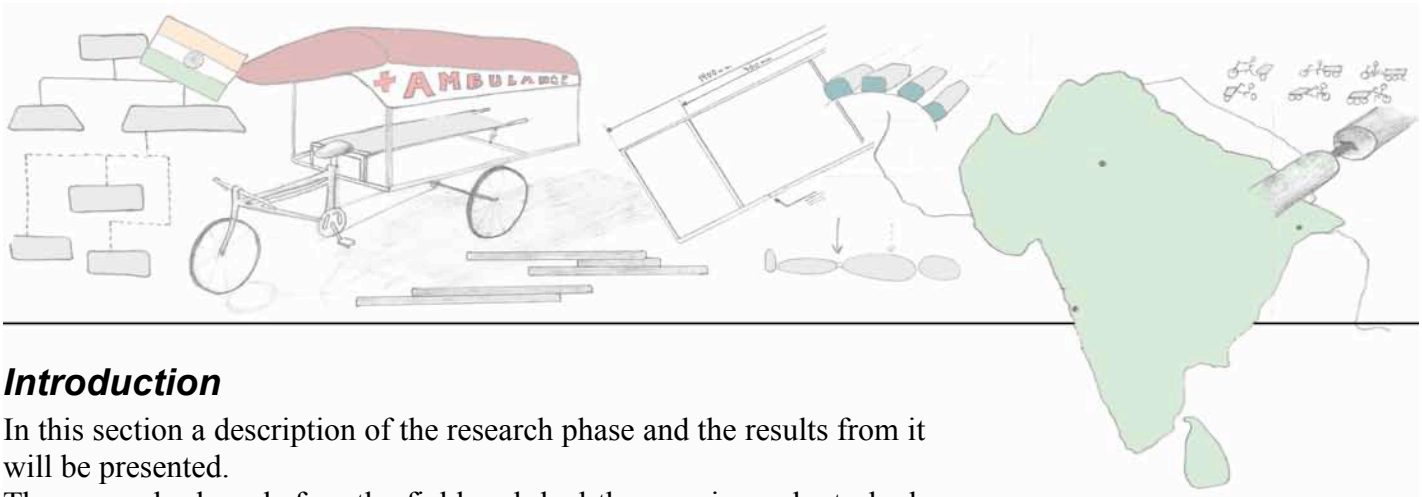
To understand the context, in which the ambulance is to operate, is the most crucial part of developing a successful concept. The fieldwork and the experience of living among the locals gave a deep understanding of the local culture, which were important not to forget when developing the concept. Involving the locals in the development phase through design reviews, interviews and workshops ensured this. By doing this it was made sure not only to design for, but also with the locals.

The experiences from previous projects are also important to take into account. Many projects like the Rickshaw Ambulance have failed in the past, and taking the lessons learned from these into consideration is crucial for the project to succeed. One of the most important lessons to be aware of is the concept of “technology transfer”. It should be of high priority in the concept development phase to avoid this phenomenon.



To get a complete understanding of the system, surrounding the ambulance, research was conducted on key factors. The result from this follows in the next section.

Identifying needs



Introduction

In this section a description of the research phase and the results from it will be presented.
The research phase before the fieldwork had three main goals; to look into successes and failures of previous projects in developing countries, to get an overview of previously constructed bicycle-ambulance concepts and to contact the main stakeholders in Denmark and get their perspective on the project. Various methods for gaining insight in these areas were used. Many hours were spent on desk research and reading literature, but a lot of time was also spent on expert interviews. The focus before departure was on finishing everything where Internet access or Danish stakeholders were needed.

During the fieldwork comprehensive research was performed via interviews of users, experts and main actors. This was important in the first phases of the project in order to understand which problem the Rickshaw Ambulance actually was to solve. Another important activity during the fieldwork was to get an overview of the infrastructure in the area, what materials were locally available and which manufacturing methods the local handcrafters were able to use.

Existing solutions

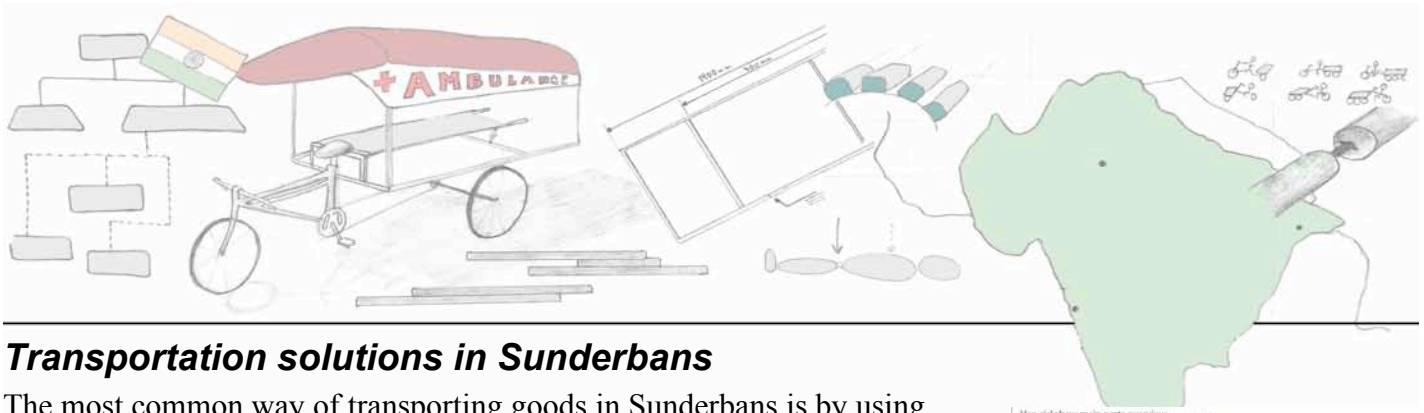
An Internet search was conducted to find as many bicycle ambulance projects as possible. The result can be found in appendix B3. The African solutions are mainly constructed as trailer concepts, except a single concept from the Danish company Baisikeli, which is a three-wheeled bicycle solution. The reason for the overrepresentation of trailer concepts might be the possibility of connecting it to a normal two-wheeled bicycle, as it appears rickshaws are not commonly used in many African countries.

Figure 5. Zumbulance

The concepts found are all very much alike and the largest differences appear in the sheltering and the positioning of the seat. Some of the concepts are not sheltered at all (Figure 6) while others are completely closed (Figure 5).

Figure 6. The bambulance

The main purpose of the search for existing solutions is to give an overview of present solutions available on the market. The pictures are also meant to be used in workshops and when interviewing Indian stakeholders to inspire them to come up with innovative ideas and reveal latent needs.



Transportation solutions in Sunderbans

The most common way of transporting goods in Sunderbans is by using a so-called "van-rickshaw" like the one in Figure 8. Motorbikes are only available to the wealthiest, and cars are far too expensive for the people in the area. The design of the van-rickshaw is the same all over the region and local blacksmiths, using only empirical knowledge, make the construction. The design of the van rickshaw therefore holds important knowledge of how to design bicycles for the area. Based on this, it was decided to do a detailed breakdown of the components and functions of the van-rickshaw. See appendices B23 and B24 and Figure 7 for details.

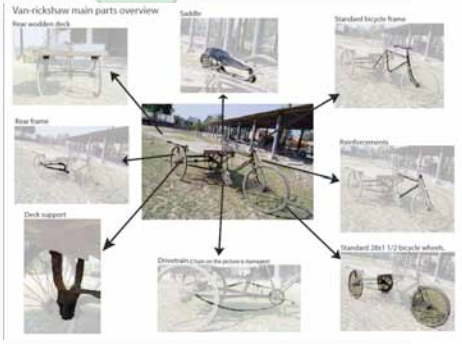


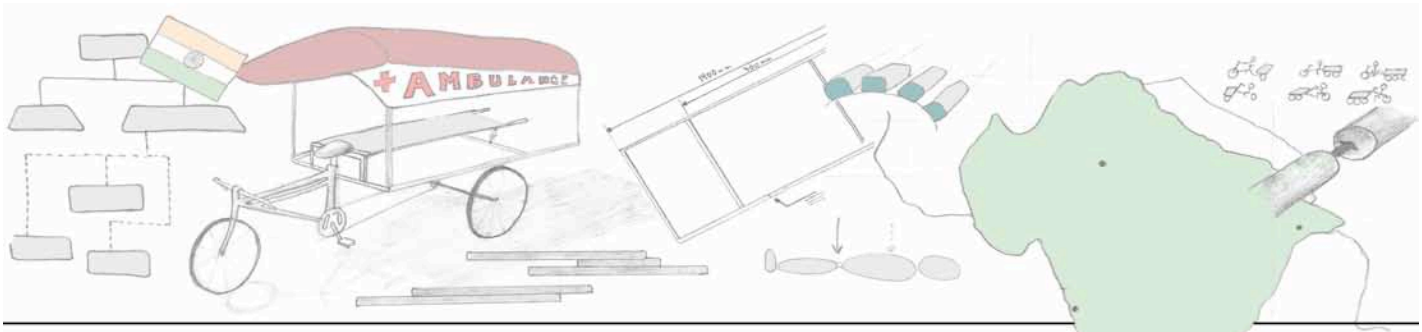
Figure 7. Appendix B23. Component breakdown

Generally it was concluded that the design was very sturdy. Most of the components are designed to last for a very long time, and it is possible to replace the components, which will be worn out first, like the wooden deck for instance.

Actors and stakeholders

A large number of stakeholders were influencing the project. The actors surrounding the Rickshaw Ambulance were all important, but they did not have the same influence on or interest in the project. Some were also significantly more powerful than others, and in the following section an overview of the actors and their power relationship are sought through actor-network-theory (Latour, 2005).
The actor network is divided into two parts (Danish actors and India actors) to ease the overview.

Figure 8. Loaded van-rickshaw



Actors and Stakeholders (India)

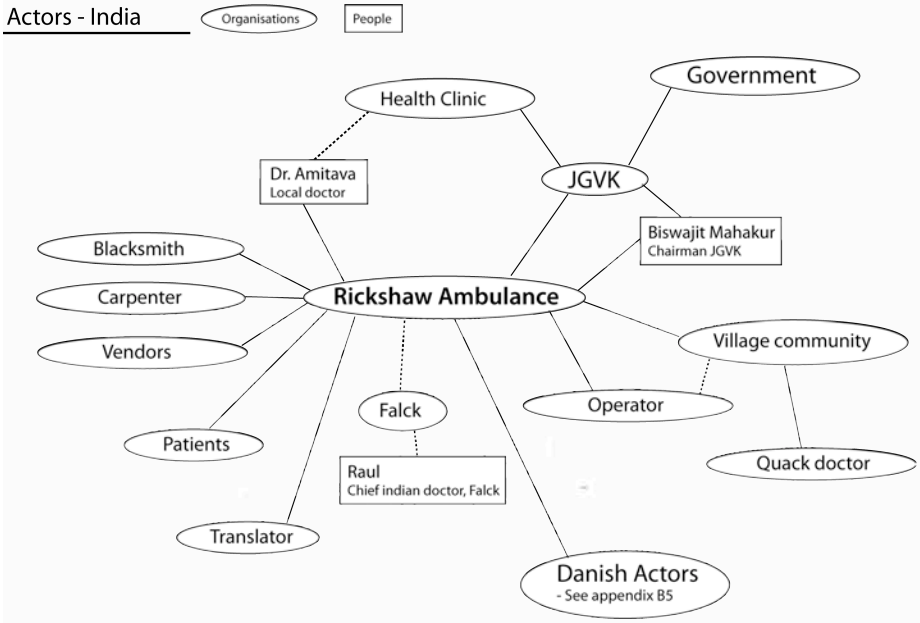
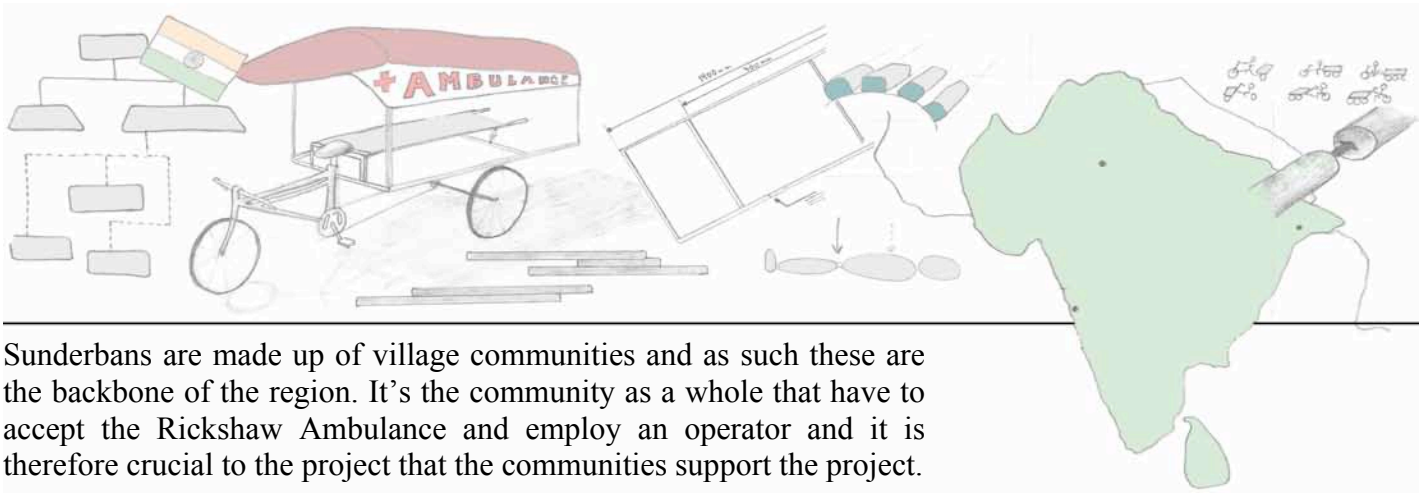


Figure 9. Actors network – India, appendix B6

The main actor and stakeholder is JGVK. Because they are the ones who are eventually going to decide if the ambulance is to be implemented, they have a large influence on the final design. They facilitate the contact with the locals and accommodate foreign workers by providing translators for research and the general necessities needed for everyday life. They furthermore have ties to almost all the other actors due to their widespread reach and many projects within the Basanti region. This includes water sanitation projects, health clinics and more than thousand women self-help groups.
JGVK is a NGO representing the Sunderbans region, and as such it has ties to the Indian government. The chairman of JGVK is Biswajit Mahakur, and because he has the last say in matters concerning JGVK he is a very powerful stakeholder.
It's fair to say that without JGVK the project would not be possible. For more information on the organization see the JGVK Folder appendix B7.

Dr. Amitava has ties to JGVK through the health clinic (operated by JGVK) where he works as a general physician servicing the surrounding area. He has great local authority, and his medical expertise, good English skills and many technical ideas makes him a valuable asset to the project. He is the one who initially raised the need for a rural ambulance.



Sunderbans are made up of village communities and as such these are the backbone of the region. It's the community as a whole that have to accept the Rickshaw Ambulance and employ an operator and it is therefore crucial to the project that the communities support the project.

The quack doctors are the medical alternative to visiting a health clinic and they combine medical practice with alternative treatments like healing, spirit communication and herbal treatment. They have always been around, and because more and more people seek out conventional medical help when ill, this is stealing business from the quack doctors. They can thus be expected to oppose the idea of the Rickshaw Ambulance.

The actors who have practical ties to the project are the Blacksmith, the Carpenter and the street Vendors. Their interest in the project is mainly profit orientated. They are important in the sense that without them the actual construction of the ambulance would not be possible and they are a valuable source of empirical knowledge.

The patient transportation company Falck is not a main actor because they do not have direct influence or control over the project. Nevertheless they are currently setting up business in India and have expressed a similar need as the one defining the project. They have supported the project financially thereby showing their dedication.

Actors and Stakeholders (Denmark)

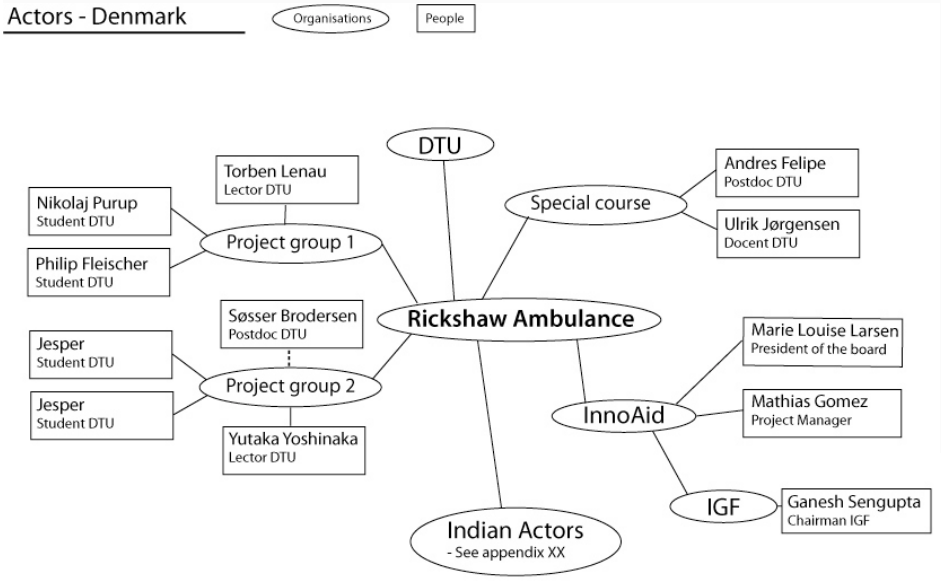
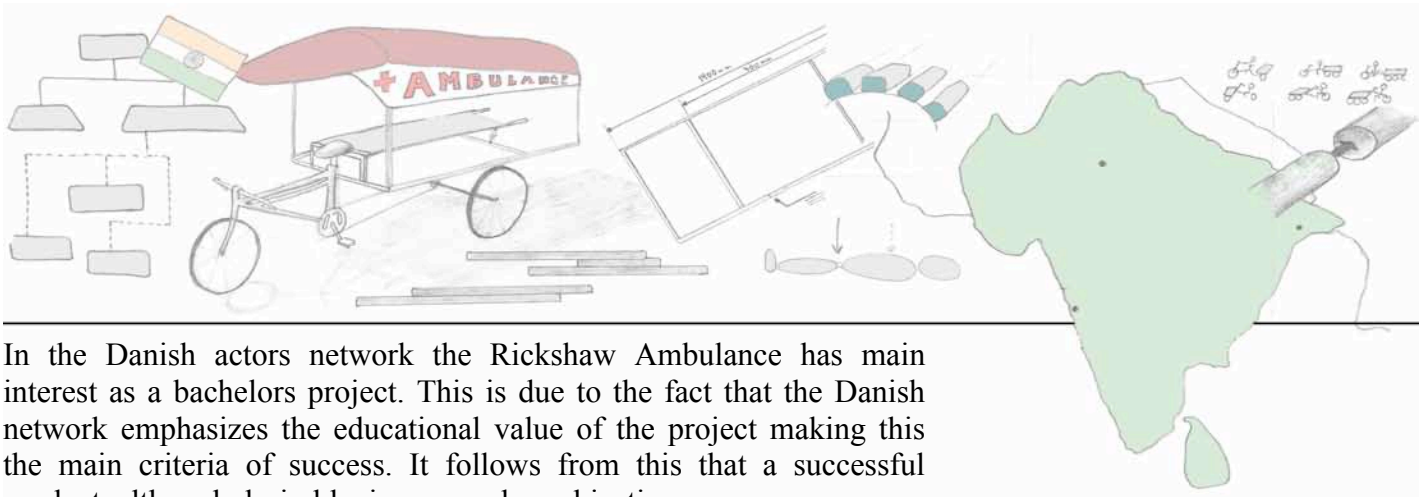


Figure 10. Actors network Denmark, appendix B5.



In the Danish actors network the Rickshaw Ambulance has main interest as a bachelors project. This is due to the fact that the Danish network emphasizes the educational value of the project making this the main criteria of success. It follows from this that a successful product, although desirable, is a secondary objective.

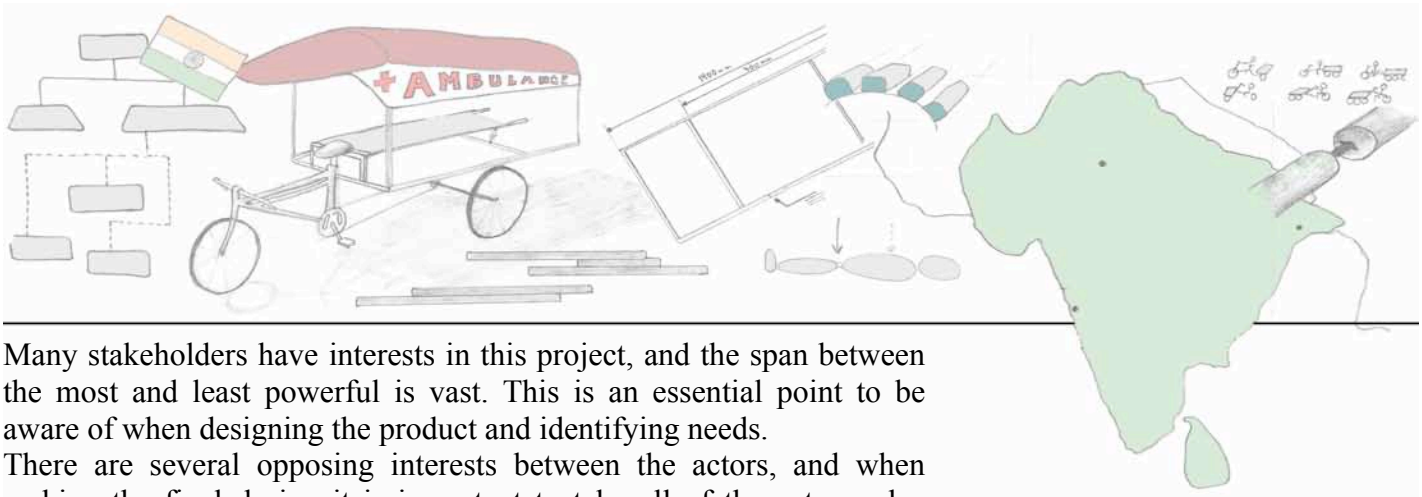
The two main Danish stakeholders are the Technical University of Denmark (DTU) and InnoAid. Together these two actors define the overall boundaries of the project. DTU as the institutional authority verifying the relevance of the project while InnoAid is the project owner. Their interests are in some aspects contradicting, DTU having more academic interests, while InnoAid has a more practical approach. Each of the two's ability to control the project are restrained by the other and as such they are inevitably interlinked, sharing this control (DTU, 2011).

Marie Louise Larsen (MLL), Matias Gomez (MG) and Torben Lenau (TL) represent InnoAid and DTU respectively.
MLL and MG have a personal interest in the Rickshaw Ambulance, and they have a lot of influence over the project through their knowledge of the area, the culture and the specific system in which the ambulance is going to operate.
TL has through his extensive experience in the field of product development and prototype construction a great deal of influence over the final product. Also in his role as project supervisor he has a professional interest in the success of the project.

IGF communicates the needs of JGVK to InnoAid. The interests of IGF and JGVK are very much interlinked and IGF can be seen as the Danish division of JGVK (IGF, 2011).

The Special Course in intercultural interaction has Andres Pineda (AP) and Ulrik Jørgensen (UJ) as the course teacher and the course supervisor respectively. The course contributes to the bachelor project with the sociological aspect, and has great value and even greater influence on how to perceive and approach the project.

The second project group has a very concrete interest in the Rickshaw Ambulance, as they are concerned with the socio-technical system in which the ambulance is going to operate. The sharing of knowledge will inevitably serve to support both groups, and their findings will have a great impact on the project.



Many stakeholders have interests in this project, and the span between the most and least powerful is vast. This is an essential point to be aware of when designing the product and identifying needs.
There are several opposing interests between the actors, and when making the final design it is important to take all of the actors, also most notably the least powerful for instance the villagers, into consideration.

Local available materials

The ambulance should be produced with as many locally available components and materials as possible. A research of which materials were locally available was conducted. In appendix B8 a full overview of the result can be seen.

Figure 11. Local shop selling lubricants

Most standard spare parts for motorcycles, scooters and bicycles (cogwheels, suspension, gears, headlights, etc) were available at small, specialized shops at the markets. As seen in Figure 11 and Figure 12 these shops were very small, but had lots of prefabricated parts like chains, oil, screws etc.

A wide variety of raw materials were available as well. A selection of steel and iron profiles were on hand at the blacksmith and materials as robe and plastic sheets were available on the larger local markets.

Figure 12. Bike shop at the market

Natural materials like palm leaves were plenteous available and most tropical wood sorts like bamboo and dark wood were also very cheap and widely available.

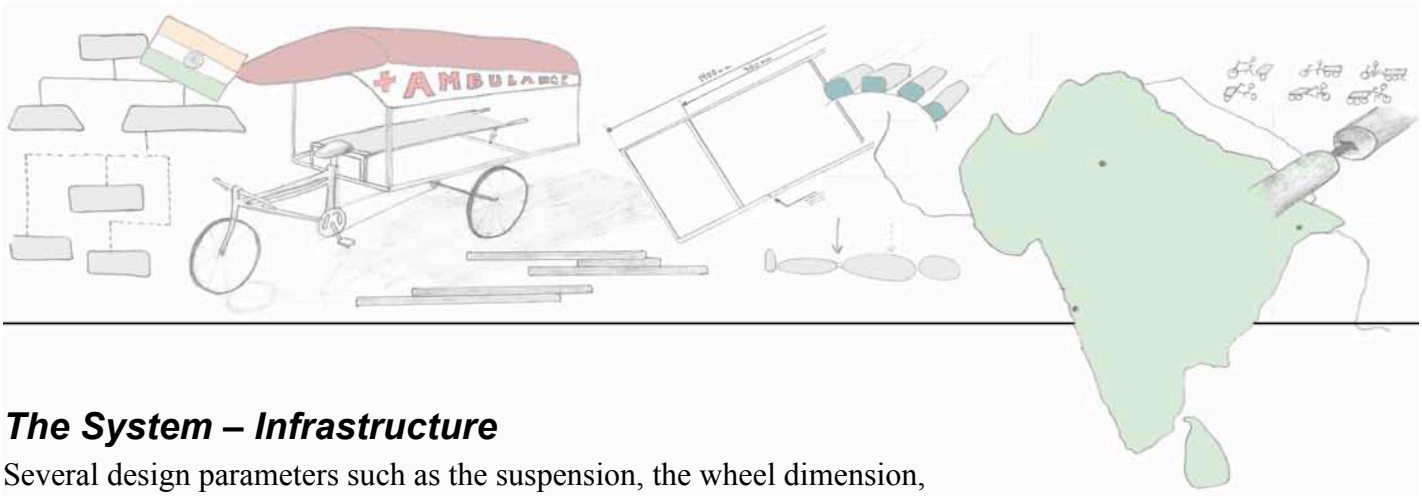
In Kolkata all modern materials was available, and many of the same parts as on the smaller markets were available, but in a better quality.

Available production methods

Just as the ambulance should be produced with locally available materials, it should also be possible to produce it with local manufacturing processes. This ensures that the rickshaw ambulance can be repaired and reproduced in the local community. The Indian craftsmen are working with simple manufacturing processes, but were very skilled.

Figure 13. Cold forging at the blacksmith

Most manual manufacturing processes were available, and if using the materials they knew, almost every construction was possible. A full overview of the manufacturing processes can be seen in appendix B9.



The System – Infrastructure

Several design parameters such as the suspension, the wheel dimension, the weight of the construction and the position of the patient in relations to the ground are directly dependent on the road conditions. It is therefore interesting to conduct thorough research on this matter.

The roads of Sunderbans are as diverse as can be expected of any area that suffers from draught like conditions during the dry season and as much as 350 mm of rain/month in the wet season (Tvevad, 2006).
Two days were spent collecting data, observing and documenting different road types. The area where the investigation was conducted is limited to Basanti and the islands in the close vicinity. This is assumed to be the primary service area of the Rickshaw Ambulance in the first implementation phase. From this follows that the ensuing analysis is restricted to only take into account this specific area and general statements made about roads and road conditions consequently only applies to this area.
The research took place during the dry season, but great effort was put into investigating how the conditions are in the wet season.

Road types

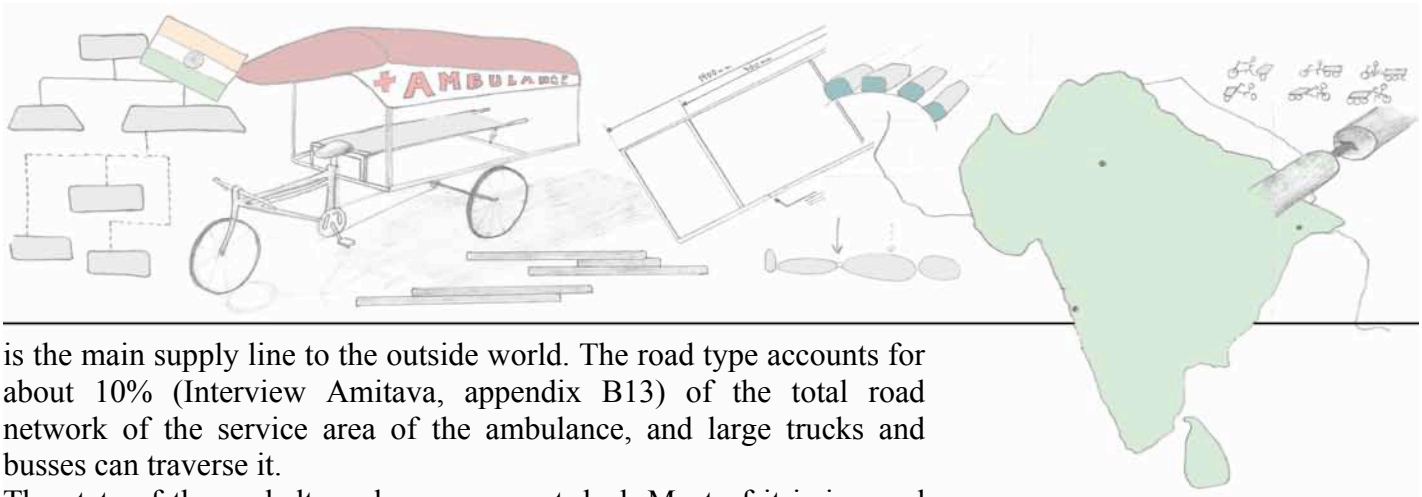
It was decided to divide the roads into 4 categories and a category for water crossings that the ambulance obviously cannot traverse. Each category covers a road type as well as the extreme condition of the road type displaying the best and the worst example of the given type.

The 4 categories are:

- *Asphalt Road*
- *Brick Road*
- *Mud Road*
- *Mud Path*

Images supporting the below descriptions can be found in appendix B10.

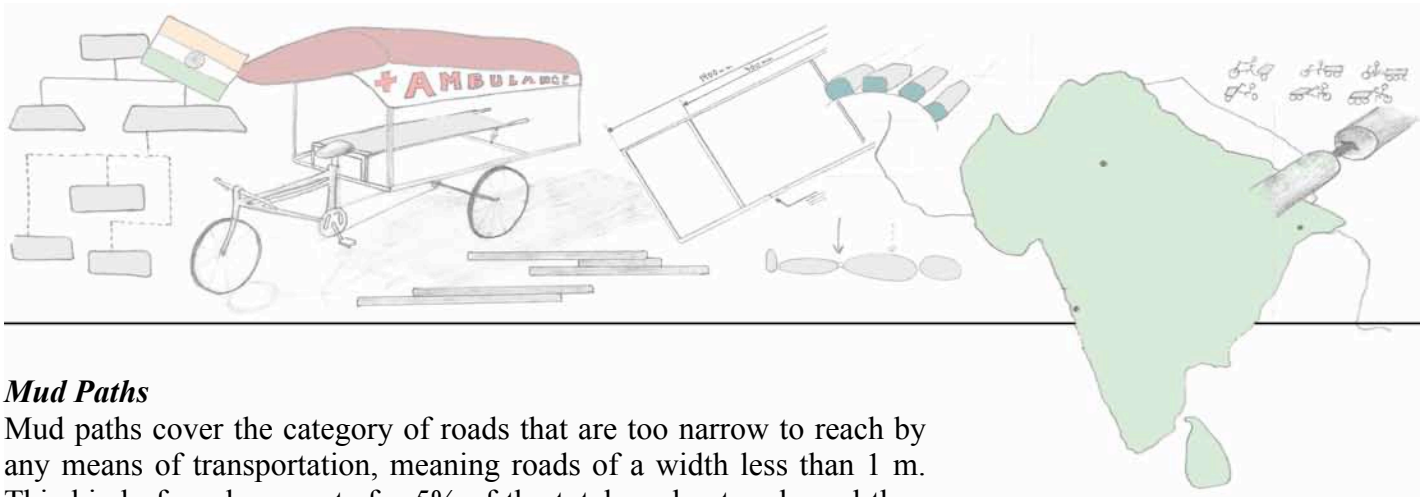
Asphalt Roads
These are the largest roads in Sunderbans and they have a width of approximately 5-6 meters. The asphalt roads provide the main roads of the region, connecting all other roads to it at some point. The road type also encompasses the only bridge that leads of the Basanti Island, and it



is the main supply line to the outside world. The road type accounts for about 10% (Interview Amitava, appendix B13) of the total road network of the service area of the ambulance, and large trucks and busses can traverse it.
The state of the asphalt roads vary a great deal. Most of it is in good shape, but some parts further inland are uneven and full of potholes. The Rickshaw Ambulance, however, is not significantly affected because of the relatively low speeds at which it operates.

Brick Roads
The brick roads are a common sight and one cannot get to anywhere in the region without having traveled them. The width of the roads is about 1½ - 2 m. From the interview in appendix B13, it follows that approximately 40% of the roads in the region are brick roads. However the research conducted during the project suggests that the share of brick roads is around 60% of the total roads. This is based on observations made during two days of traveling the region on the back seat of a motorcycle with a local guide.
The brick roads can be negotiated by car, at moderate speeds, and motorcycles, van rickshaws and normal bicycles can easily use them. The bricks is in surprisingly good shape and the roads are neatly laid. A number of the roads seem recently constructed and that ensures many years of smooth navigation before they are no longer traversable. A comparison is that by far the worst brick road encountered was about 35-40 years old and still accessible by van rickshaw and even by a jeep at low speed.

Mud Roads
This type of road accounts for approximately 25% of the total roads, and is the most diverse category of the four. The width of the road can be anything from 1-2½ m, and the variation of the surface varies from smooth and flat to bumpy and curved. Mostly the former is the case during the dry season, but in the wet season the roads can become quite muddy. Two months each year not even a van rickshaw can negotiate the roads without assistance from additional people pushing (Interview Chandan, appendix B15). These roads are different from the previous mentioned, because heavy rainfall affects them in a radical way.
Mud roads usually go out a short distance from the brick roads to reach clusters of houses. The long mud roads however mainly exist as far-out connections between houses, and are therefore last in line to be made in to brick roads due to their non-critical nature. Only very few villages do not have a brick road close by, and these are the first in line to be connected to one. However it is the village community that pays for the paving of a road and it is therefore the poorest communities of the region that live farthest away from a brick road.



Mud Paths

Mud paths cover the category of roads that are too narrow to reach by any means of transportation, meaning roads of a width less than 1 m. This kind of road accounts for 5% of the total road network, and they are present exclusively to and from a household. These roads are the most affected during the wet season.

Mud paths can only be negotiated on foot and that makes them impossible for the Rickshaw Ambulance to access. However these roads are seldom longer than 50 meters and can therefore be accessed by two men with a stretcher.

Transportation Scenarios

To illustrate the diversity and distribution of road types during a typical situation where the Rickshaw Ambulance would be summoned three fictive transportation scenarios were constructed, see figure 14 and figure 15. Full size images can be found in appendix B11 and B12.

In each scenario it is assumed that the ambulance is within close range of the position of the emergency call, and as such the starting point of each scenario is the place of origin of this call. Furthermore each route has been completed on a motorbike in dry season to approximately validate the variety of the road type. However any water crossing and length of road traveled on any other island than Basanti have been estimated since this part of the distance was not actually completed. Also it is assumed that the Rickshaw Ambulance cannot cross any rivers, but rather that there is one driving the patient to the boat and another that picks up the patient on the other side.

The three scenarios together cover the multiple road types and each route has been chosen because it represents a different type of distance the ambulance would be likely to travel to answer an emergency call.

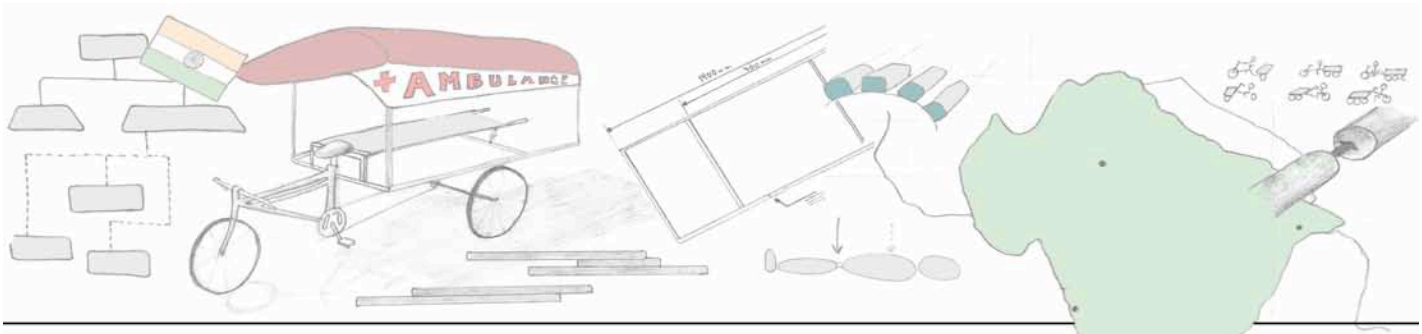


Figure 14: Sunderbans map, appendix B11

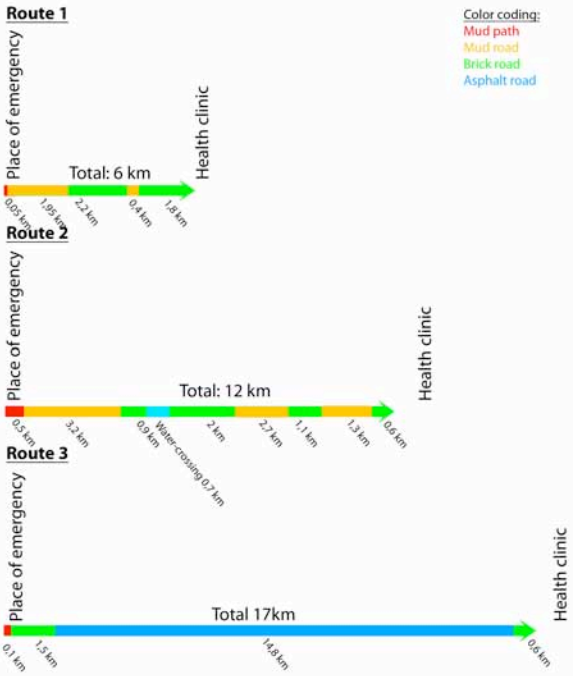
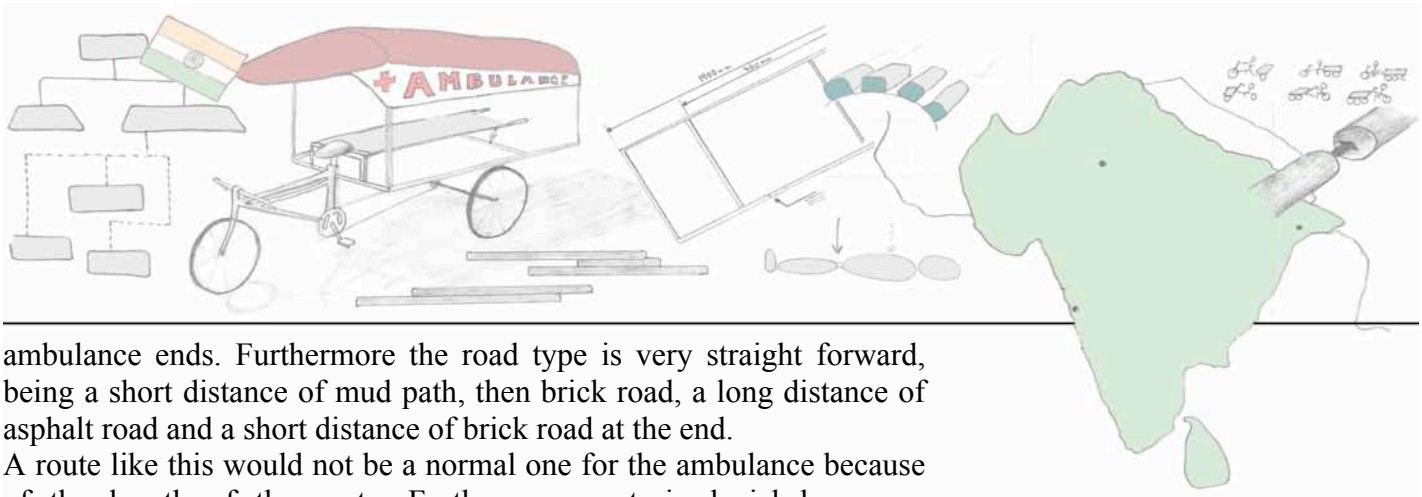


Figure 15. Route specification appendix B12

Route 1 is a typical route used by villagers and it travels along the coast on mud roads for approximately 2 km before steering out towards the brick roads and the health center. This is the most direct route and the ambulance would use it in the dry season. In the two wettest months of the wet season the ambulance would travel straight out to the asphalt road and then follow this to the health center. The distance would be slightly longer, but the ambulance would be able to use almost only brick and asphalt road, making it the fastest route.

For Route 2 it has been assumed that the first stretch of road on the other island is only mud road. This is unlikely, but since no observations have been made the decision was made to suppose the worst possible conditions.
After the water crossing and to the health clinic the road type alters between brick and mud roads. The area close to the water houses the poorest people on Basanti and this is why there are so little brick roads laid out. The infrastructure in this area is one of the biggest challenges the Rickshaw Ambulance has to face. This route is therefore exactly what the Rickshaw Ambulance has been designed for, overcoming areas that conventional motorized vehicles cannot access.

Route 3 is the longest route and represents the longest distance the ambulance would have to travel in one go. The route stops at the edge of the forest reservation of Sunderbans where the service area of the



ambulance ends. Furthermore the road type is very straight forward, being a short distance of mud path, then brick road, a long distance of asphalt road and a short distance of brick road at the end.
A route like this would not be a normal one for the ambulance because of the length of the route. Furthermore motorized rickshaws are commonly available on the asphalt road, and they would be the logical choice in an emergency situation, assuming that the patient can afford the ride. However there is no nighttime transportation in the region, making the Rickshaw Ambulance the only option, should the need of urgent medical attention arise.

The health care system

The health care system on the Sunderbans islands is rather complicated due to the many actors competing or collaborating in the area. The health care infrastructure consists of a combination of quack doctors, birth helpers (local midwifes without a formal education), nurses and professional doctors and both NGO's and the government's own health clinics and hospitals. An understanding of the local health care system is highly important to understand precisely which needs the rural ambulance is to fulfill. See Figure 14 and appendix B20 for an overview.

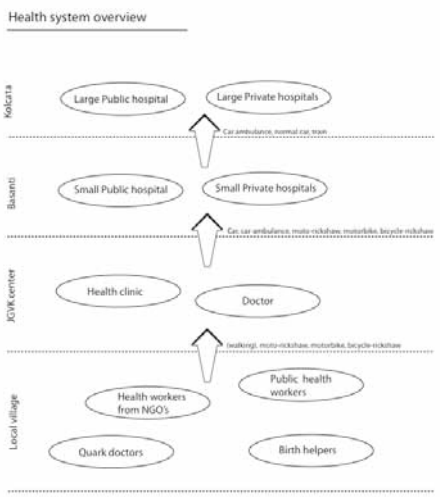
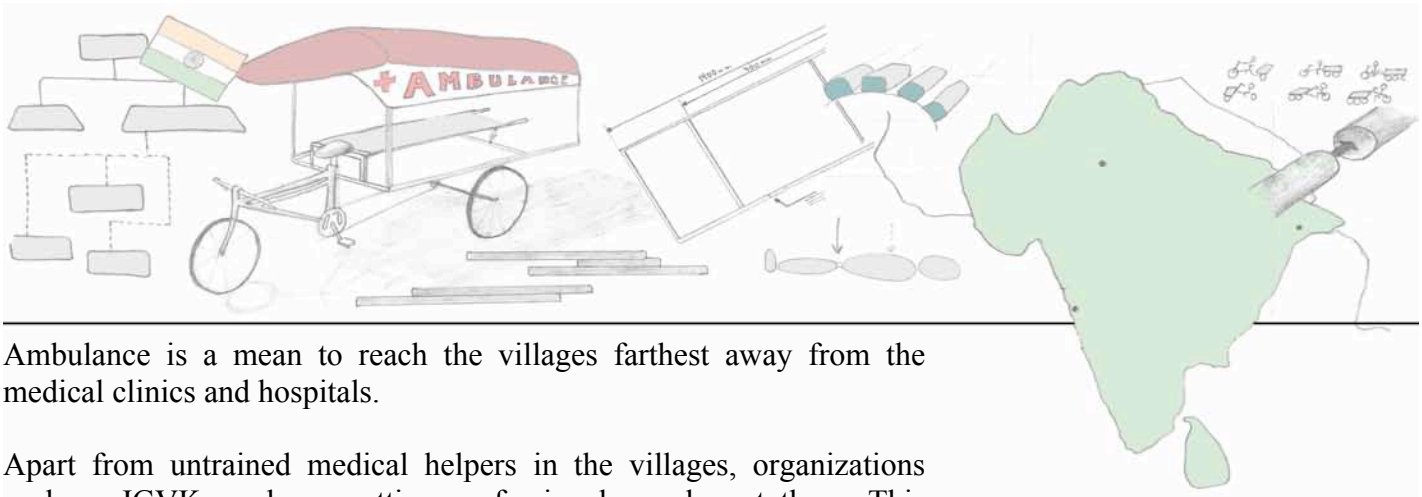


Figure 14: Health care system overview, appendix B20

Until recently the local quack doctors were the main actors in the rural Indian health care system in Sunderbans. A quack doctor normally has a minimum of medical training and builds his/her medical knowledge on myths, superstition and empirical experience. Apart from quack doctors a village will also have a few birth helpers. A quack doctor will typically be able to use a saline bag and oxygen tank (appendix B13), but they will also use "magic" potions or other superstitious methods, which will sometimes worsen the condition of the patient.

"*The quack doctor who delivered my third baby hit me on the legs if I made too much noise. He hit me so hard that I got badly bruised on my legs."* (From appendix B38, single mother interview II)

In recent times there has been a larger focus on getting trained medical staff out to the villages and to get the villagers to go to the hospital. In short, to get the rural population included in the health care system. This is partly due to the improved public health care system, partly due to organizations such as JGVK doing awareness campaigns and opening health clinics in the rural areas. Together with the improving school system this makes many people from the younger generations more aware of the less attractive sides of the old system. The Rickshaw



Ambulance is a mean to reach the villages farthest away from the medical clinics and hospitals.

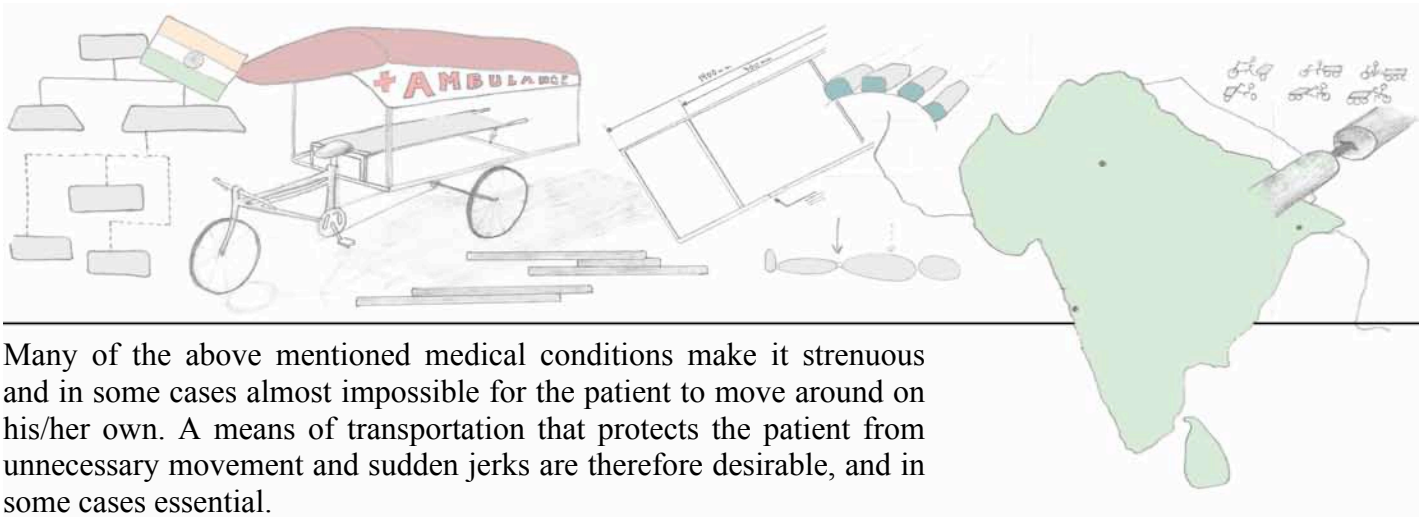
Apart from untrained medical helpers in the villages, organizations such as JGVK work on getting professional people out there. This involves a medical assistant from the public health care system visiting the villages a few days a week, training health workers who live in the villages and helping with the building of health clinics in the rural areas. These clinics will have a doctor attending a few days a week doing consultation. The health workers trained by JGVK will be able to lay a drop and will be available at all times during a day. This makes them very important to the infrastructure of the ambulance system and if needed they can be trained to do specific tasks when the ambulance is implemented (Interview Leela, appendix B19). If injuries are acute the patients will in most cases have to be taken by car-ambulance to a hospital capable of treating complicated injuries. These hospitals will in most cases be on the mainland.

After conducting research on how the rural health care system is composed it can be concluded that in every village there will at all times be some kind of medical assistant. The research also revealed that the drivers of the ambulance would not need any specific training in medical assistance, due to the many kinds of medical staff in the area. Also, it can be concluded that the medical equipment onboard the ambulance cannot be more complex than an oxygen tank and a saline bag without training the drivers or medical helpers in the villages further.

Patients

A patient record is kept for each person who sees the doctor at the health centre at JGVK HQ. This record contains information like; age, weight, gender, date of last visit and type of illness.
From this record a random sample of approximately 40 recent cases were selected and translated from Bengali to English. This was done to get an overview of the most common types of non-lethal illnesses that occur in the area. The translated journals can be found in appendix B21.

The most common illnesses are related to pains in the abdominal region, body pains, headaches and nausea. Also pregnancy and new borne check-ups, fewer, accidents (cuts and bruises), infections and skin conditions seem like regular illnesses.



Many of the above mentioned medical conditions make it strenuous and in some cases almost impossible for the patient to move around on his/her own. A means of transportation that protects the patient from unnecessary movement and sudden jerks are therefore desirable, and in some cases essential.

What makes an ambulance in Sunderbans

An important aspect to take into account when designing the ambulance is how the local population defines an ambulance. The majority of the people in the area have never been outside West Bengal, and neither do they have a television. Their perception of ambulances are therefore very much defined by the designs already present in the area. This was quite clear in the workshop at a local school where all of the kids drew the same JGVK ambulance, see appendix B22

Figure 15. Ambulance in Kolkata

There is not a single design, which can be defined as the ambulance design in Sunderbans because many different ambulance operators (public institutions, commercial companies and NGOs) co-exist in the same area. This also means that many of the ambulances are just rebuild cargo-vans painted in ambulance colors and equipped with a stretcher.

"Many different ambulance operators are present in west Bengal. Often the ambulances will just be cargo vans repainted to send a nice photo home to a sponsor"(From appendix B43, Interview Rahul)

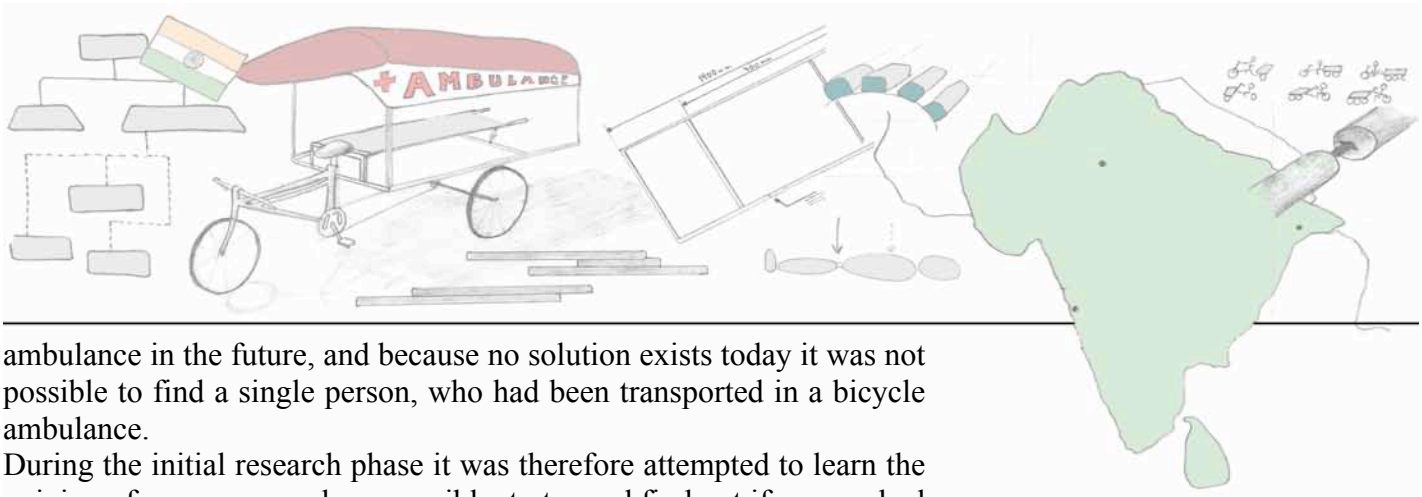
Figure 16. The JGVK ambulance

Pictures of another ambulance and JGVK's car-ambulance in the area are displayed in Figure 15 and Figure 16, respectively.

Generally it can be concluded that the most important characteristics of an ambulance in Sunderbans is the combination of red/white colors, a horn, the red cross or caduceus (the twisted snakes medical sign) and the text "AMBULANCE" clearly written on it. The green color is included in the JGVK design because this is the color of the organization. It was considered if "AMBULANCE" should also be written in Bengali, but this was not seen on any other ambulance, and it was not possible to get a clear word for it.

User interviews

One of the most important parts of revealing needs is to talk to the people who are going to be the users of the ambulance when it is finished. It is of course impossible to determine who is going to use the



ambulance in the future, and because no solution exists today it was not possible to find a single person, who had been transported in a bicycle ambulance.
During the initial research phase it was therefore attempted to learn the opinion of as many people as possible, to try and find out if anyone had tried to be transported by a rickshaw while sick. Also it was sought to find out what the opinion on a bicycle ambulance might be. This did not reveal anything specific because many of the people who were asked had a hard time relating to a "bicycle ambulance", because they had not previously encountered one.
Some of the interviews were written down and can be found in appendix B14. Due to the time restrictions and the limited results from the user interviews it was decided not to spend much time on them at that time, but to move on and get a prototype finished, so that it would be possible to get feedback on a physical object instead.

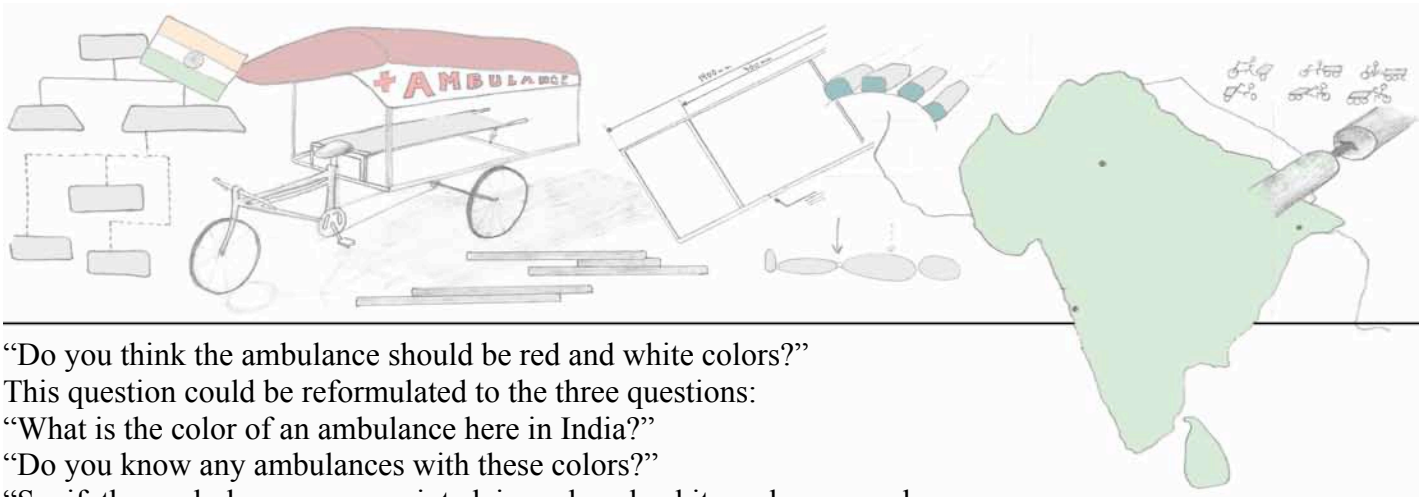
However a comment made by the children during the workshop at the school sums up what people generally think of being transported on a regular van-rickshaw when sick:

"The kids don't want to draw how they are getting transported at the back of a rickshaw. They say it is the worst they know. First they are sick at home and then they have to go on that bumpy rickshaw to get more sick." (From appendix B22, Workshop at school)

Techniques for obtaining insight

Obtaining an honest critical answer right away was not always easy in India. The strong hierarchy was the largest barrier, which was clearly seen in the different answers received from a doctor and a peasant. Generally it was a good idea not to cut straight to the subject, but to try and ease the tension by for instance allowing the interviewee to ask some questions first. This way the interviewee gets a chance to familiarize him or her with the interviewer first, which usually deflates the seriousness of the situation, and creates a more relaxed atmosphere.
Other ways of creating a more relaxed atmosphere could be by introducing games, known translators or familiar subjects to the interviewee.

When asking questions it was a good idea not to ask a direct yes/no type of question, where the interviewee had to make a definite statement about a subject. Instead creating a logical path of questions made it easier to visualize the answer to the original question.
An example of a direct question could be:

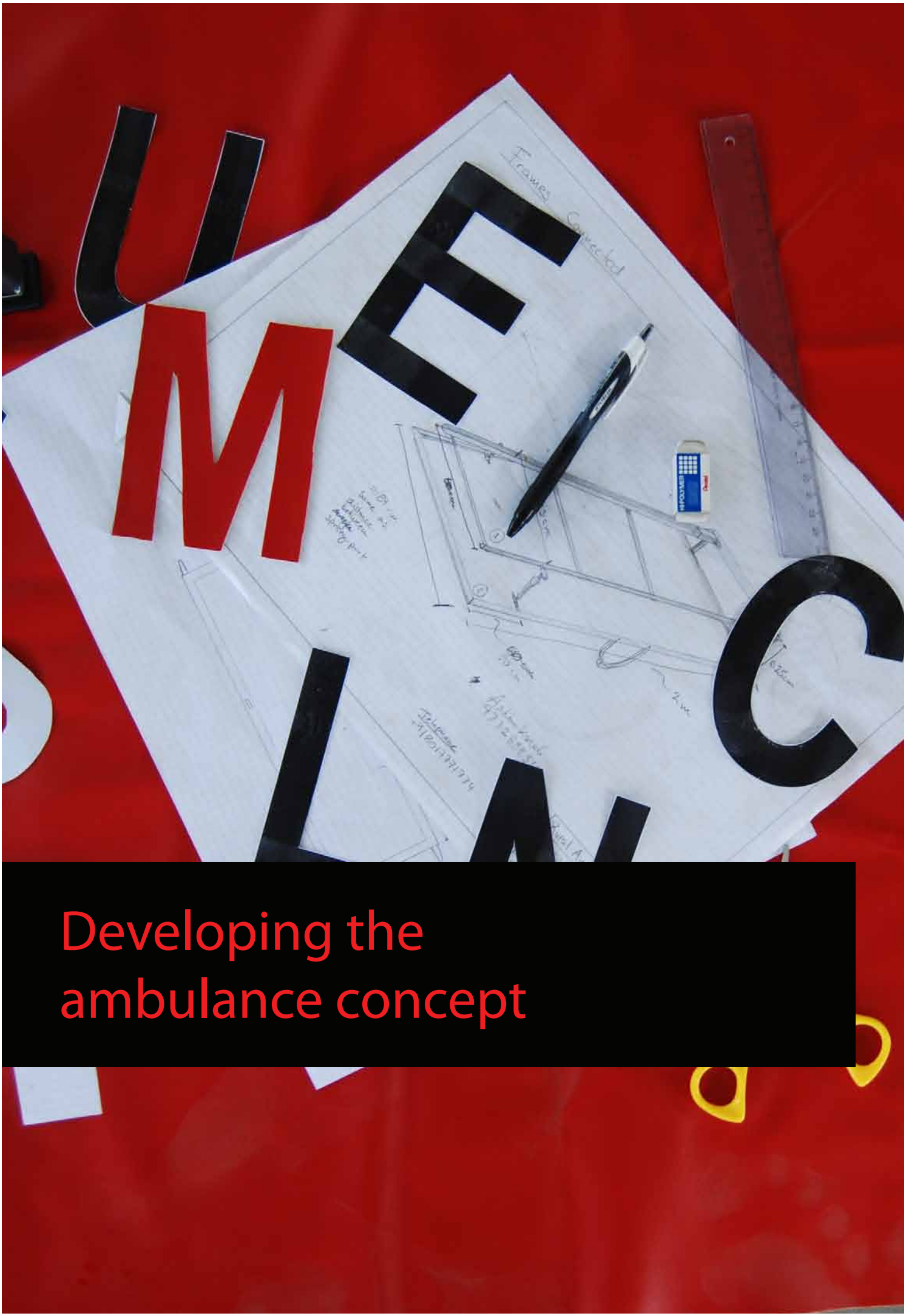


“Do you think the ambulance should be red and white colors?”
This question could be reformulated to the three questions:
“What is the color of an ambulance here in India?”
“Do you know any ambulances with these colors?”
“So if the ambulance were painted in red and white colors, people would understand that it is an ambulance?”

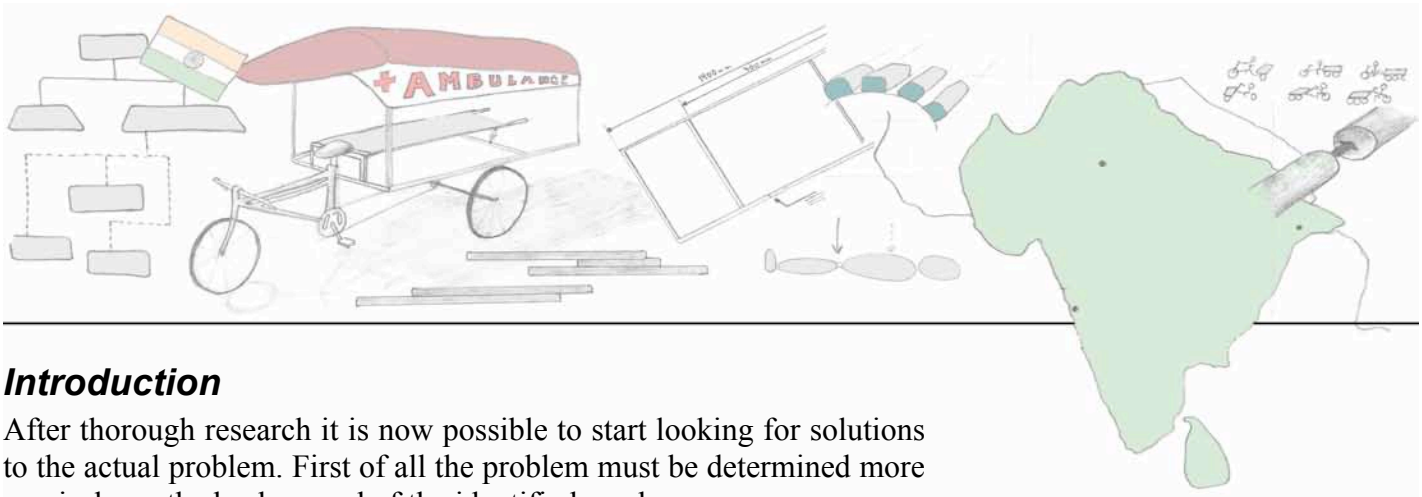
Conclusion on identifying the needs

The research revealed a great number of new needs and it redefined others. Many of the conditions in the area were different from what was initially expected, which caused the problem statement to change slightly. Some of the most important changes were the realization of the impossibility of transporting patients with an urgent need of medical attention; transporting them on a bicycle ambulance is simply too time consuming. Another factor, which deviated from what the initial research revealed was the infrastructure. The roads were in a much better condition than anticipated, and the need for a floating function for crossing water proved to be unnecessary due to the width and depth of the rivers.

During the research a large amount of needs were identified and to systemize and administrate them they were collected in a set of design specifications. This is part of the next section; Developing the ambulance concept.



Developing the ambulance concept



Introduction

After thorough research it is now possible to start looking for solutions to the actual problem. First of all the problem must be determined more precisely on the background of the identified needs.

Detailed problem description

After the research and fieldwork in Sunderbans it was found that the initial problem statement holds true, but that it needed some further detailing before the designing could begin. An important part of this detailed problem statement was “The Pain”. This is a single sentence determining precisely what the problem is. In the beginning of the project this was very hard to decipher, but as the project evolved it became clearer. The pain was determined to be:

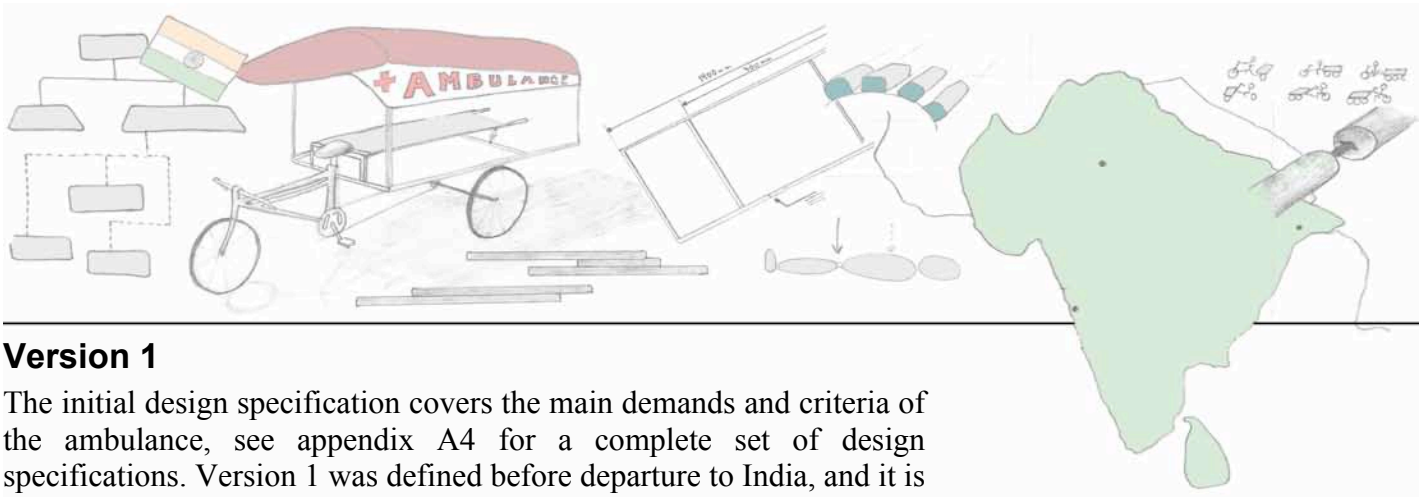
“The ambulance should get more people from the rural areas to be included in the health care system”

Before the fieldwork, the problem was thought to revolve around the survival rate in the area. But after further research it became clear that the ambulance would not as much be used for emergencies, as it would for transporting less sever cases. If the emergency is urgent, the ambulance is simply to slow, and the patient will either have to be transported sitting on the back of a motorbike, or a local medical assistant would need to stabilize the patient before transportation.

Further on it was found that the ambulance would be used to transport people who would not normally go to the hospital because they can not afford to go with a “real” ambulance and it is too uncomfortable to go on the back of a bicycle rickshaw. This means that the Rickshaw Ambulance is not only going to be used because of its ability to get into rougher areas than a car-ambulance or motorbike, but also because it is economically possible for the local population to use it.

Design specification

To summarize and systematize the needs identified during the research, a set of design specifications was created. In this section the first two versions of the design specification will be described. They are both made before the development of the prototype concept and a third set of revised design specifications were made after the prototype testing.



Version 1

The initial design specification covers the main demands and criteria of the ambulance, see appendix A4 for a complete set of design specifications. Version 1 was defined before departure to India, and it is based upon information gathered through various sources (Mikkelsen et al, 2010; appendix B13), and the previous section in this report: Avoiding "technology transfer".

Design specification version 1.0 (before departure)

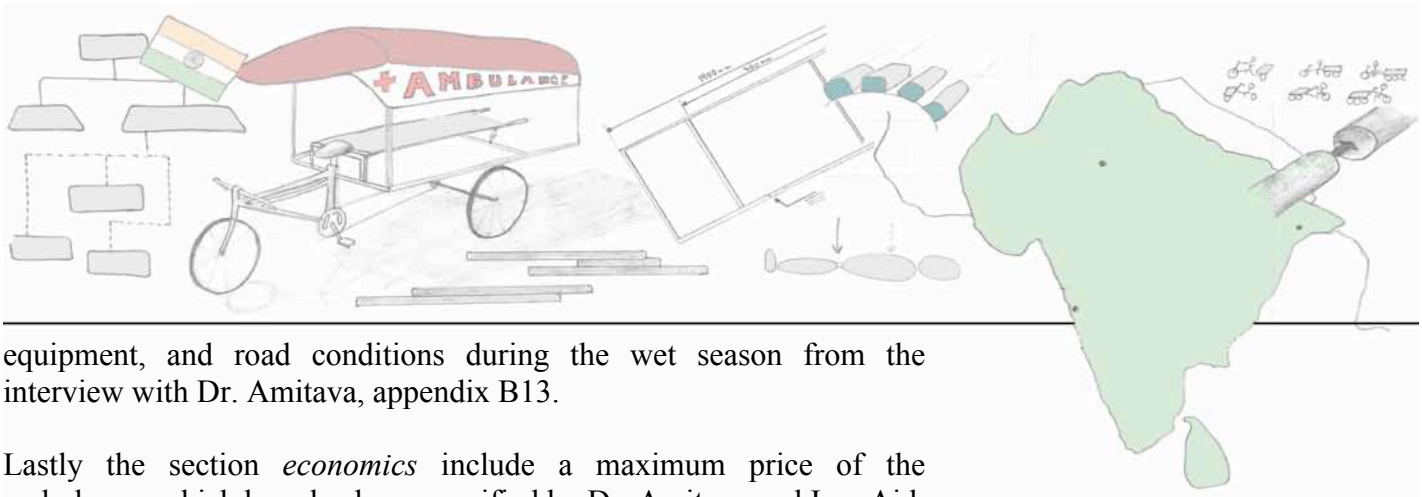
	Demands	Criteria	Comments
Construction			
Stability	Vibrations should be kept to a minimum		Damping and shock absorbtion
Usability	Should be able to be used both day and night		Lights
	The ambulance should be operated by a single man		
Visibility		Should be visible at night.	A bright color might be applied
Usage	The pace of the		

Figure 17. Design specifications V1, See appendix A4 for full specs.

The specifications are divided into four primary categories; *Construction*, *Production*, *Dimension* and *Economics*.

The *construction* category deals with the desirable features that the product should have, which should be thought into the construction phase of the product. Some suspension and damping should for instance be integrated in the ambulance to reduce vibrations. The category is furthermore divided into sub categories such as *stability* and *visibility* to provide a better overview.

The limited number of manufacturing methods and materials available should be taken into consideration when designing for sustainability. The category *production* emphasizes this by demanding the use of local materials and the need for the product to be locally repairable.
In the first set of design specifications the dimensioning of the ambulance were deduced from statements about crucial medical



equipment, and road conditions during the wet season from the interview with Dr. Amitava, appendix B13.

Lastly the section *economics* include a maximum price of the ambulance, which has also been specified by Dr. Amitava and InnoAid, and can be found in the aforementioned appendix. This category also includes a need to keep the maintenance costs down.

The first design specification strives to identify the essential demands of the ambulance without knowing the full meaning and authenticity of them. This is due to fact that at this point the needs have been communicated through others, and the importance of each need should not be overestimated.

Version 2

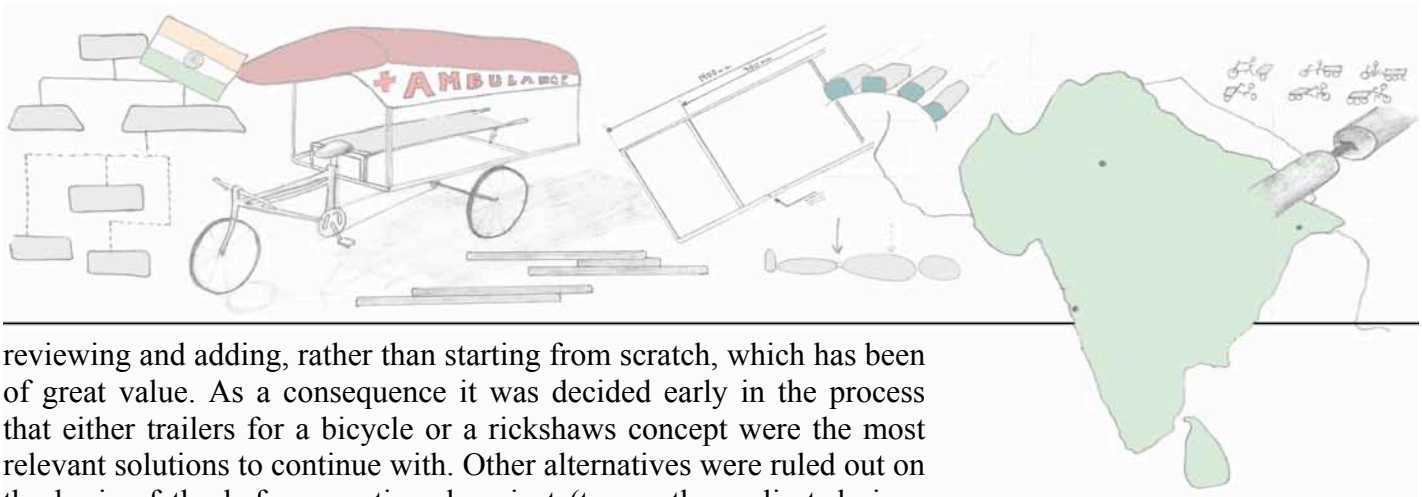
The second set of design specifications was formulated during and after the research phase in the local area. The first version of design specifications was based on the observations of others.
Consequently the second version is a lot more specific, and new demands have been identified and added. In contradiction to the first design specification every point on the second version has roots in a specific need uncovered in the effort to determine the needs.
The main changes compared with the first version relate to the operation of the ambulance, the dimensions of the stretcher and some medical equipment specific needs. The turning radius of the ambulance has for instance been specified and so has the need for installation of medical equipment.

A new primary category is likewise added to the specification, the category *Medical*. This was done to define the needs for the stretcher, the medical equipment and handling of the patient, more sharply from a medical perspective.

The second set of design specifications is more concrete on certain points, and it is the cornerstone for designing and building the prototype. The full list of specification can be found in appendix A5.

Basic Structure

The initial phases of the concept development process such as initial brainstorming and a full expansion of the space of solutions was greatly reduced due to previous work done by a design group working on the project (Mikkelsen et al, 2010). The extensive work done allowed for



reviewing and adding, rather than starting from scratch, which has been of great value. As a consequence it was decided early in the process that either trailers for a bicycle or a rickshaws concept were the most relevant solutions to continue with. Other alternatives were ruled out on the basis of the before mentioned project (to see the earliest designs from the project, go to appendix B1).

The 3-wheeler rickshaw concept was an obvious choice due to its vast availability in the Sunderbans area, documented by pictures, video clips and reassured by InnoAid. The trailer concept was chosen partly because of the conclusive design reached by the holistic design group and partly because the materials to construct it would be similar to the ones used for the 3-wheeler, thereby making it plausible. Furthermore the trailer concept is attractive as it can be attached to any bicycle available, advocating it as a more diverse solution. The trailer solution is also the most commonly used solution in other developing countries, which suggests that it must have some advantages (see section 3, Existing solutions).

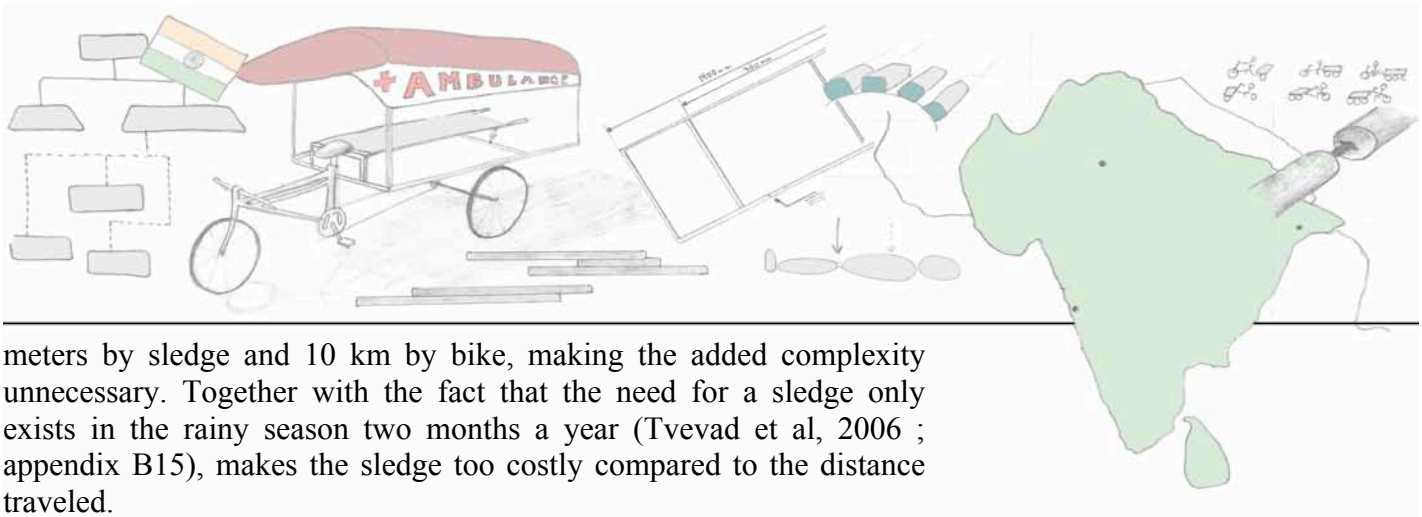
Initial design concept from the Holistic design group

The combined sledge/boat/trailer solution designed by the holistic design group (Mikkelsen et al, 2010) was considered thoroughly, but was discarded in the end. The complex design and maintenance together with the material requirements and weight of the sledge/boat/trailer did not outweigh its advantages. The materials required would have to be ordered from a larger city, like Kolkata, and be custom-made, raising the cost substantially and thereby defeating the purpose of keeping production local and affordable.

In Figure 18 the holistic design concept can be seen. As seen in the pictures this concept can be transformed into a “boat” which can also be pulled through mud.

Figure 18. Final concept from the holistic design group. Reproduced with permission from the holistic design group (Mikkelsen et al, 2010)

The distances the sledge function would come into play are minimum compared to the full length of the trip. A typical ratio would be 50



meters by sledge and 10 km by bike, making the added complexity unnecessary. Together with the fact that the need for a sledge only exists in the rainy season two months a year (Tvevad et al, 2006 ; appendix B15), makes the sledge too costly compared to the distance traveled.

The boat function is undesirable simply because a river that is too deep to cross with a 3-wheeler or trailer with a high positioned loading platform, is too deep to cross at all. This is mainly because if the driver looses connection with the bottom of the river, there is no way to control which direction the ambulance-turned-boat floats. Also there are sharks, crocodiles and plenty of snakes in the waters in the area. This makes the crossing with an actual boat the safest solution, eliminating the need for the ambulance boat function.

Selecting the basic structure

Based on the above it was decided to move on with either a simple trailer or a rickshaw solution without the sledge/boat function. Quantified structure variations were made over these two kinds of solutions.

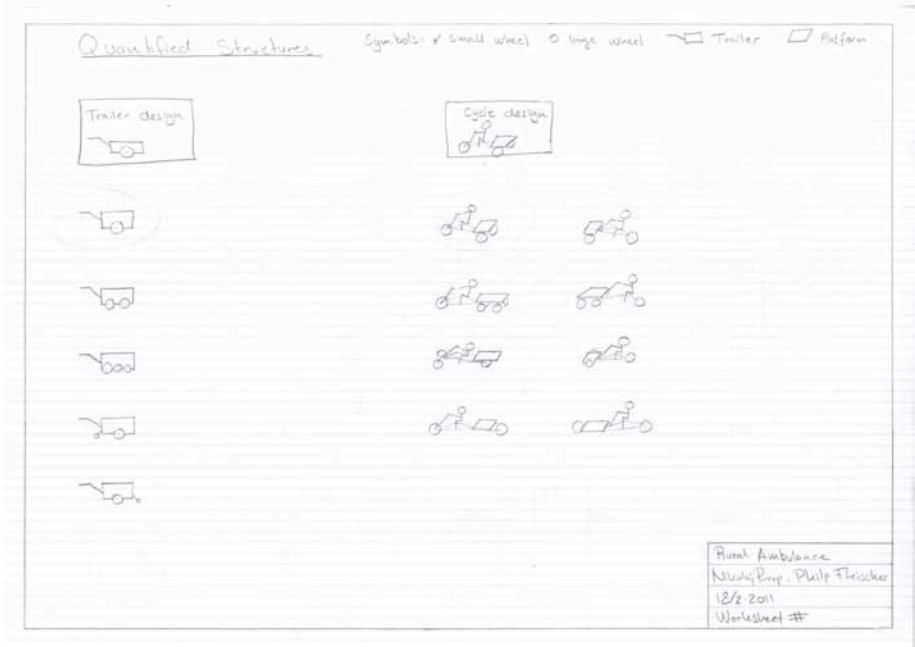
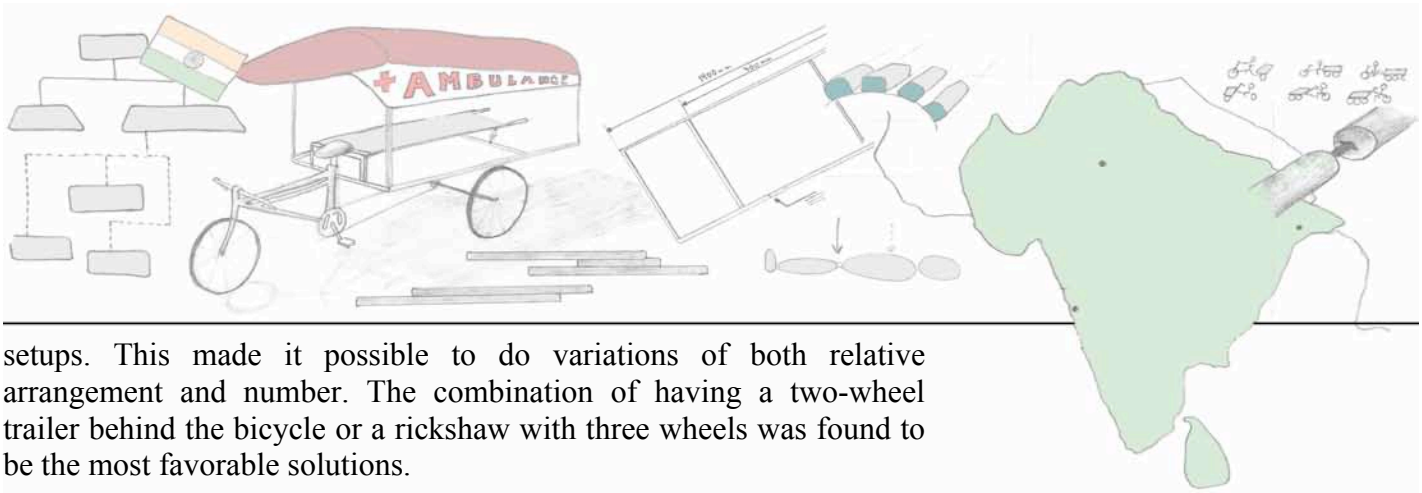


Figure 19. Quantified structures, see appendix A7 for full size.

As seen in Figure 19, several kinds of setup were tried out. To make sure all solutions were considered a systematic approach was adopted, where the same numbers of wheels were considered for different



setups. This made it possible to do variations of both relative arrangement and number. The combination of having a two-wheel trailer behind the bicycle or a rickshaw with three wheels was found to be the most favorable solutions.

Deciding on moving on with these two kinds of solutions was done according to the obtained knowledge of vehicle design and the design specifications version 2 which states: *"The capital cost is no more than 11.000 rupees"* and *"Maintenance costs are kept at a minimum"*. Giving the trailer or the rickshaw more than two or three wheels respectively would only add complexity to the design, which would lead to rising costs. The obtained knowledge of vehicle design suggests that the ambulance would not be able to turn very well with more than two or three wheels (Boyhus and Larsen, 2009; McComrmick, 2011; Ofira, 2011).

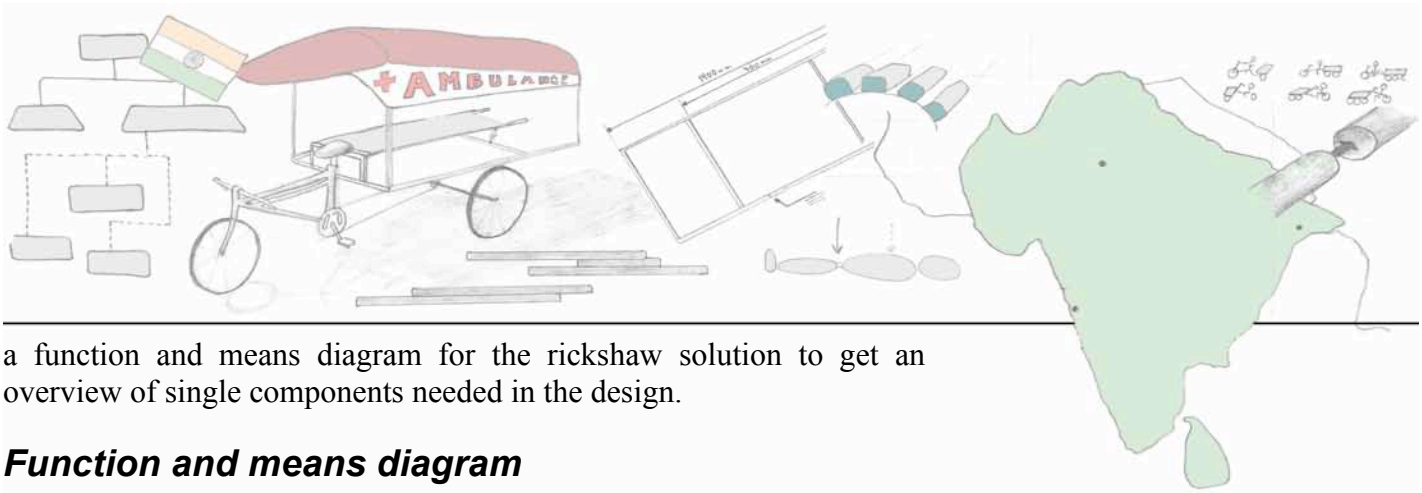
To decide between the trailer and the rickshaw proved to be a difficult choice and it was necessary to use a systematic approach. A weighted Pugh's matrix (Pugh, 1990) was used for the purpose, the result can be seen below.

Pugh concept selection (Concept scoring)

		Concept			
		3-wheeler		Trailer	
Selection Criteria	**Weight**	**Rating**	**Weighted score**	**Rating**	**Weighted score**
Complexity	30%	5	1,5	2	0,6
Weight	5%	3	0,15	1	0,05
Turning radius	5%	3	0,15	1	0,05
Attachment potentia	10%	0	0	5	0,5
Room for relatives	10%	1	0,1	4	0,4
Linkage strength	20%	5	1	2	0,4
Capital cost	15%	4	0,6	3	0,45
Center of gravity	5%	3	0,15	5	0,25
	Total Score	3,65		2,7	
	Rank	**1**		2	
	Continue?	**Develop**		No	

Figure 20. Pughs matrix, trailer vs. three-wheeler, see appendix A8.

A reference concept was not used in this Pugh's matrix since there were only two concepts and they were rated on how well they fulfilled the criteria in relation to each other.
As seen from the matrix in Figure 20 the 3-wheeled Rickshaw was the winner. Added to the fact that this was a design that the locals were already familiar with (see section 3, Avoiding "technology transfer") and because this was the solution that felt best intuitively, it was decided to proceed with this basic structure. The next step was to make



a function and means diagram for the rickshaw solution to get an overview of single components needed in the design.

Function and means diagram

The functions and means diagram (Ulrich and Eppinger, 2007) covers every function of the design and was used to get an overview of exactly which single components were needed. It begins with the mean: "Rickshaw Ambulance" and works its way down to the different single functions to solve the detailed means the design has to satisfy to fulfill its purpose, a large scale diagram can be found in appendix A9.

The main functions the artifact is to perform was defined to be:

- *Patient handling* is referring to the part of the ambulance, which is in direct contact with the patient.
- *Lights,* is the light enabling the ambulance to operate at night.
- *Steering* strictly in relation to the handling of the bike.
- *Sheltering* is the sheltering of the patient and driver.
- *Braking system* referees to both the breaking of the moving and the fixing of the stationary vehicle.
- *Drivetrain* encompasses the forward movement of the vehicle.
- *Medical storage*, contains the medical equipment and how it is stored
- *Core,* includes the bicycle frame and the wheels.

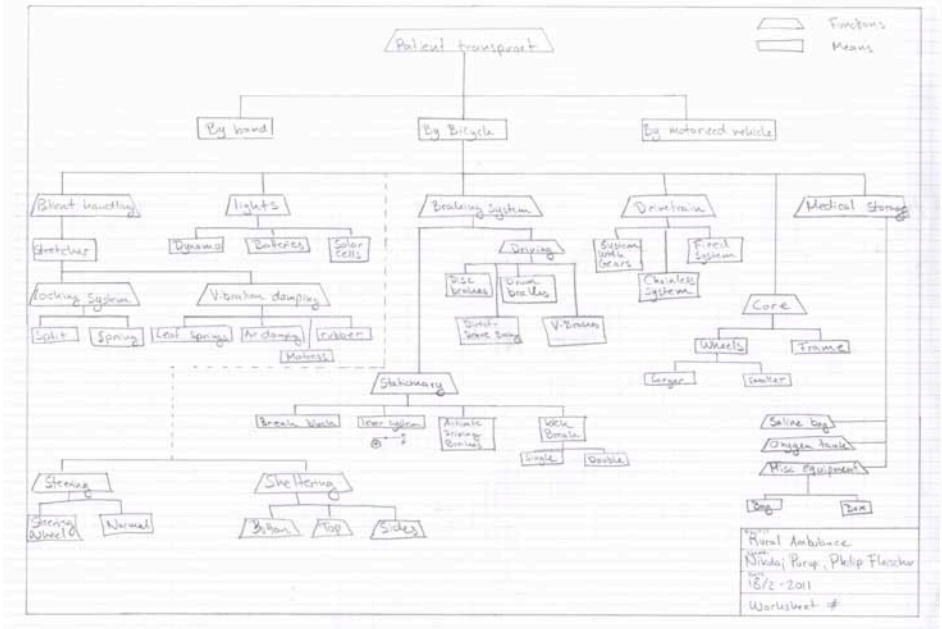
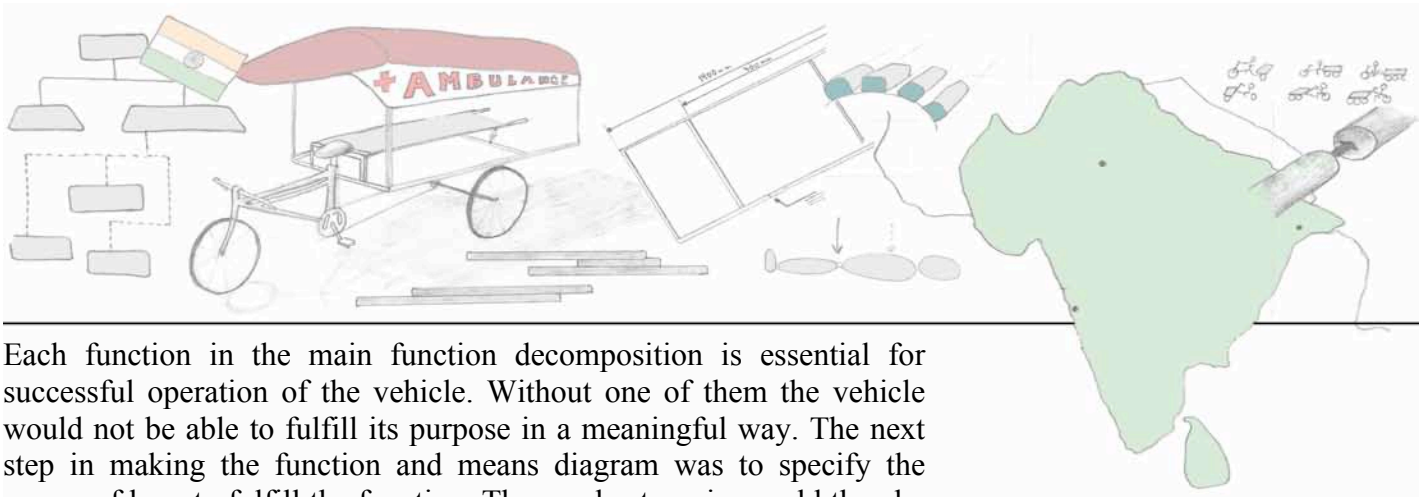


Figure 21. Function and means diagram, appendix A9



Each function in the main function decomposition is essential for successful operation of the vehicle. Without one of them the vehicle would not be able to fulfill its purpose in a meaningful way. The next step in making the function and means diagram was to specify the means of how to fulfill the function. These subcategories could then be translated almost directly to the single components that make up the artifact.

Exploring the space of solutions

Now that the basic structure of the artifact was determined, it was time to look into the single components that make up the ambulance. In this phase design functionality and economics are of the highest priority, which means that single components take precedence over the total design. Different approaches were adapted for the different parts of the ambulance; firstly the ideas of functional surfaces were used when designing the support of the frame.

Support of the outer frame

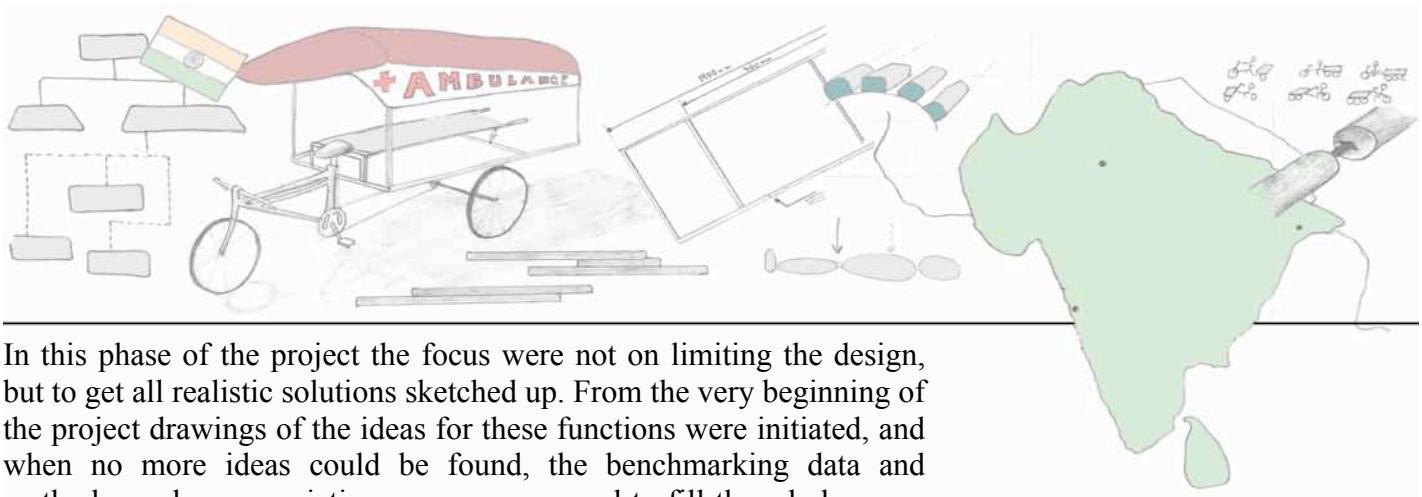
The principles of functional surfaces (Tjalve, 2003) were applied to the support of the outer frame. Number and form variation was performed simultaneously; with number variation in the horizontal direction and form variation in the vertical direction as can be seen in Figure 22 and appendix A20. This helped make sure that all solutions were considered. The functional surfaces in this case were where the support was fixed to the frame and the rickshaw.

Figure 22. Form variation of support, for full size see appendix A20

It was decided to use 2 support points on the outer frame, forming an arch that connects at the nave of the wheel (the one forming a U in the middle row on Figure 22). This design was chosen because it focuses the forces from the frame load on the nave of the wheel. This was also already an existing solution in the area. This proved not only that it was a rigid support, able to support far more than specified, it also reduces complexity, being an already known construction to the manufacturer.

Structure variation of single components

The single components structure variation is a natural continuation of the function means analysis. Each function is addressed focusing on a specific set of components that fulfils the given function. In the appendices A10-A12 the result from this can be seen.

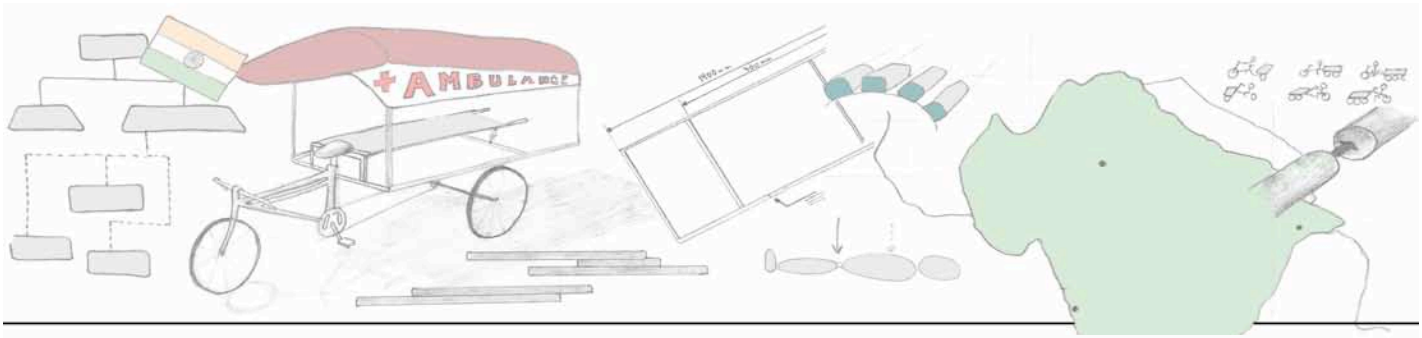


In this phase of the project the focus were not on limiting the design, but to get all realistic solutions sketched up. From the very beginning of the project drawings of the ideas for these functions were initiated, and when no more ideas could be found, the benchmarking data and methods, such as association games, were used to fill the whole space of solutions. The fieldwork was a great inspiration, and many new ideas were generated on the basis of local solutions and materials. A number of ideas from before the fieldwork could also be ruled out, when a better understanding of the context of the ambulance had been obtained. The single components were then combined to form the morphology.

Morphology

The single components were set up in a morphology scheme such as can be seen in Figure 23, and more detailed drawings of each component can be found in appendix A10, A11 and A12. The main purpose of the morphology is to present a systematic overview of the single components to consider all possible combinations (Zwicky, 1969).

The functions were divided into 8 different areas in accordance with the function means diagram. 30 realistic components were found for utilizing all the functions allowing the space of solutions to be thoroughly explored.



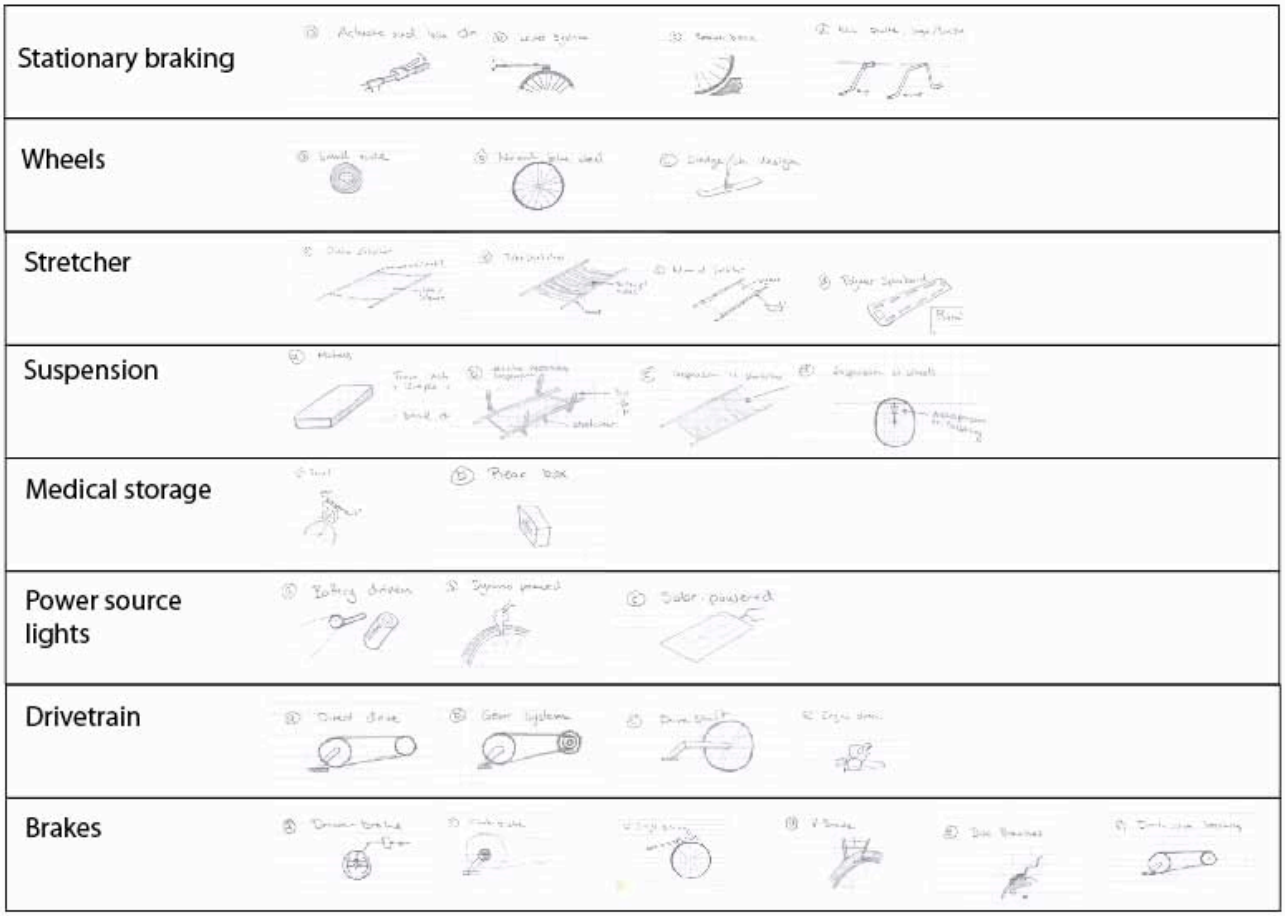
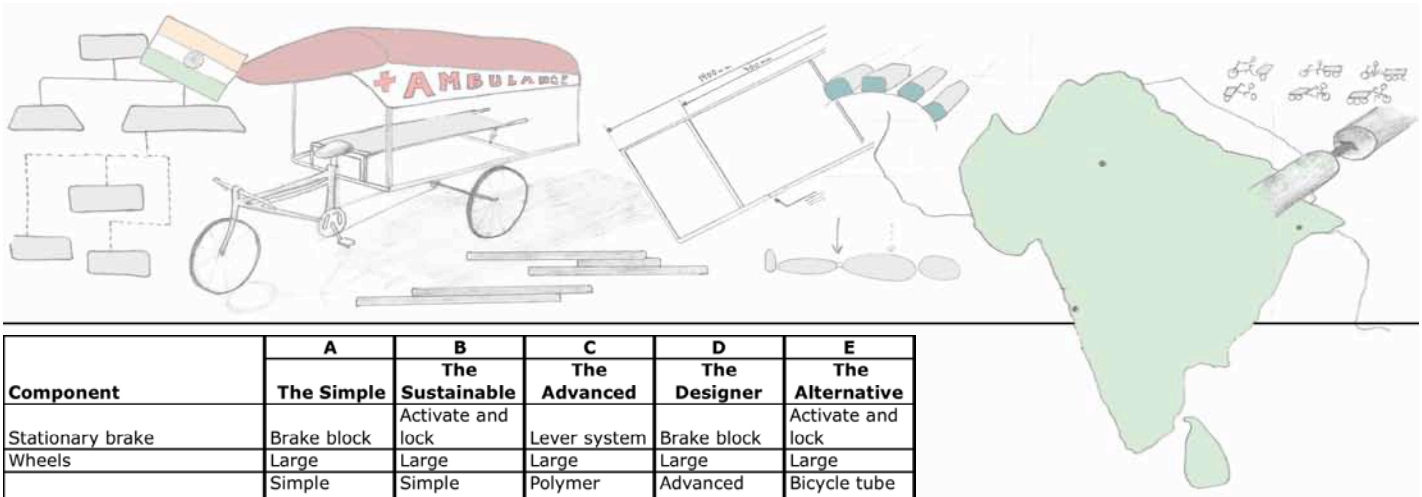


Figure 23. Morphology, see appendix A10, A11 and A12 for details

Concept generation

The process of concept generation combines the single components presented in the morphology, into a number of thought concepts, in this case five concepts, that each represents different types of solutions for the final concept. Sketches of all concepts resulting from the concept generation can be found in appendices A14-A18.

From the morphology it is possible to make thousands of combinations. Not all of these are reasonable not to mention realistic and the approach have been to identify the sub functions that best fit the needs of the users, and make a few plausible and different concepts from these. Figure 24 shows the combination of sub functions for the five concepts A to E. The five concepts were given characteristic names to underline their specific properties.



Component	A The Simple	B The Sustainable	C The Advanced	D The Designer	E The Alternative
Stationary brake	Brake block	Activate and lock	Lever system	Brake block	Activate and lock
Wheels	Large	Large	Large	Large	Large
Stretcher	Simple stretcher	Simple stretcher	Polymer spine	Advanced stretcher	Bicycle tube stretcher
Suspension	Coil spring	Bicycle tubes	Coil spring	Madress	Fixed
Medical Storage	Front	Back	Back	Front	Front
Power	Dynamo	Solar powered	Battery	Dynamo	Dynamo
Brakes	Direct brake	V-brake	Crank brake	Lever system	Lever system
Drivetrain	Direct	Direct	Gears	Direct	Direct

Figure 24. The four concepts A-E in a table, appendix A13

After selecting the five concepts it was time to choose a single combination of sub functions to continue the process.

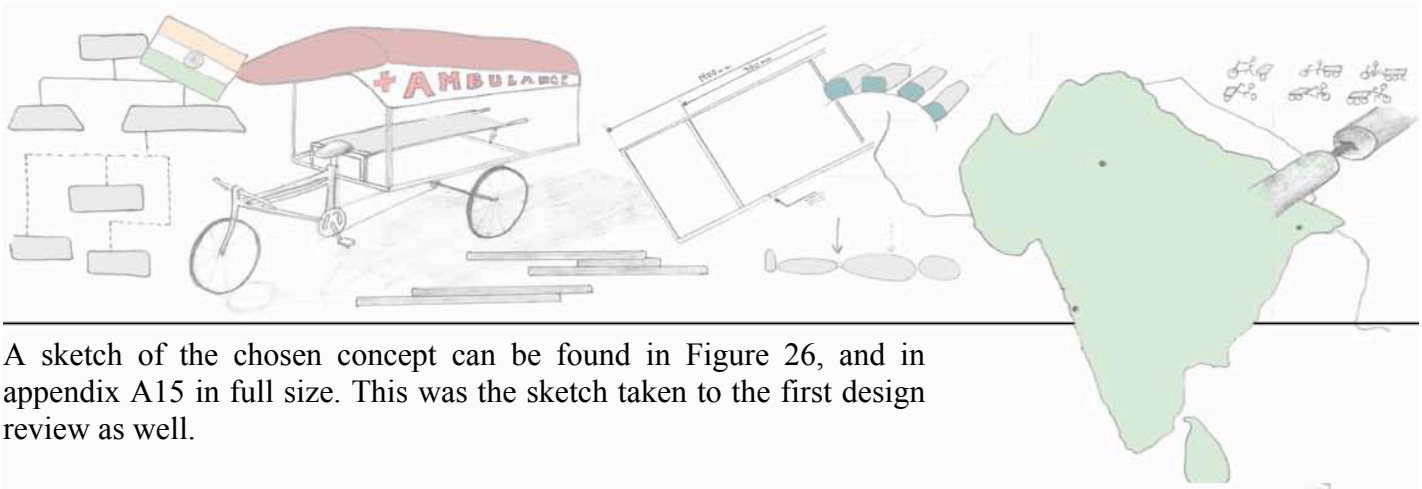
Concept selection

Pughs matrix for concept screening (Pugh, 1990) was chosen for making the decision. The matrix provides a systematic approach and ensures that the solution, which is taken to the design review, is the one fulfilling the needs clarified in the design specification in the best way possible. Concept A: ”The Simple” is chosen as reference in an attempt to make the screening as objective as possible.

Selection Criteria	A (Reference) The Simple	B The Sustainable	C The Advanced	D The Designer	E The Alternative
Vibrations are kept at a minimum	0	-	+	-	0
Everything is locally repairable	0	+	-	-	+
Steel, wood and other locally available materials are used	0	+	-	-	+
There are no sharp edges, pointy objects or similar hazardous components in direct contact with the patient	0	0	0	+	-
There is space for medical equipment	0	+	+	0	0
The stretcher is easy to clean (Criteria)	0	0	+	-	-
The capital cost is no more than 11.000 rupees	0	+	-	0	+
Sum +'s	0	4	3	1	3
Sum 0's	7	2	1	2	2
Sum -'s	0	1	3	4	2
Net Score	0	3	0	-3	1
Rank	**3**	**1**	**4**	**5**	**2**
Continue?	No	Yes	No	No	No

Figure 25. Pughs concept screening matrix, appendix A19

As seen in Figure 25 concept B: “The Sustainable” was clearly the winner. Concept C: “The Advanced” had some good aspects as well, but the coil spring suspension made the design to expensive. The fact that concept B “The sustainable” was so superior compared to the others made it unnecessary to detail the matrix further and do concept scoring.



A sketch of the chosen concept can be found in Figure 26, and in appendix A15 in full size. This was the sketch taken to the first design review as well.

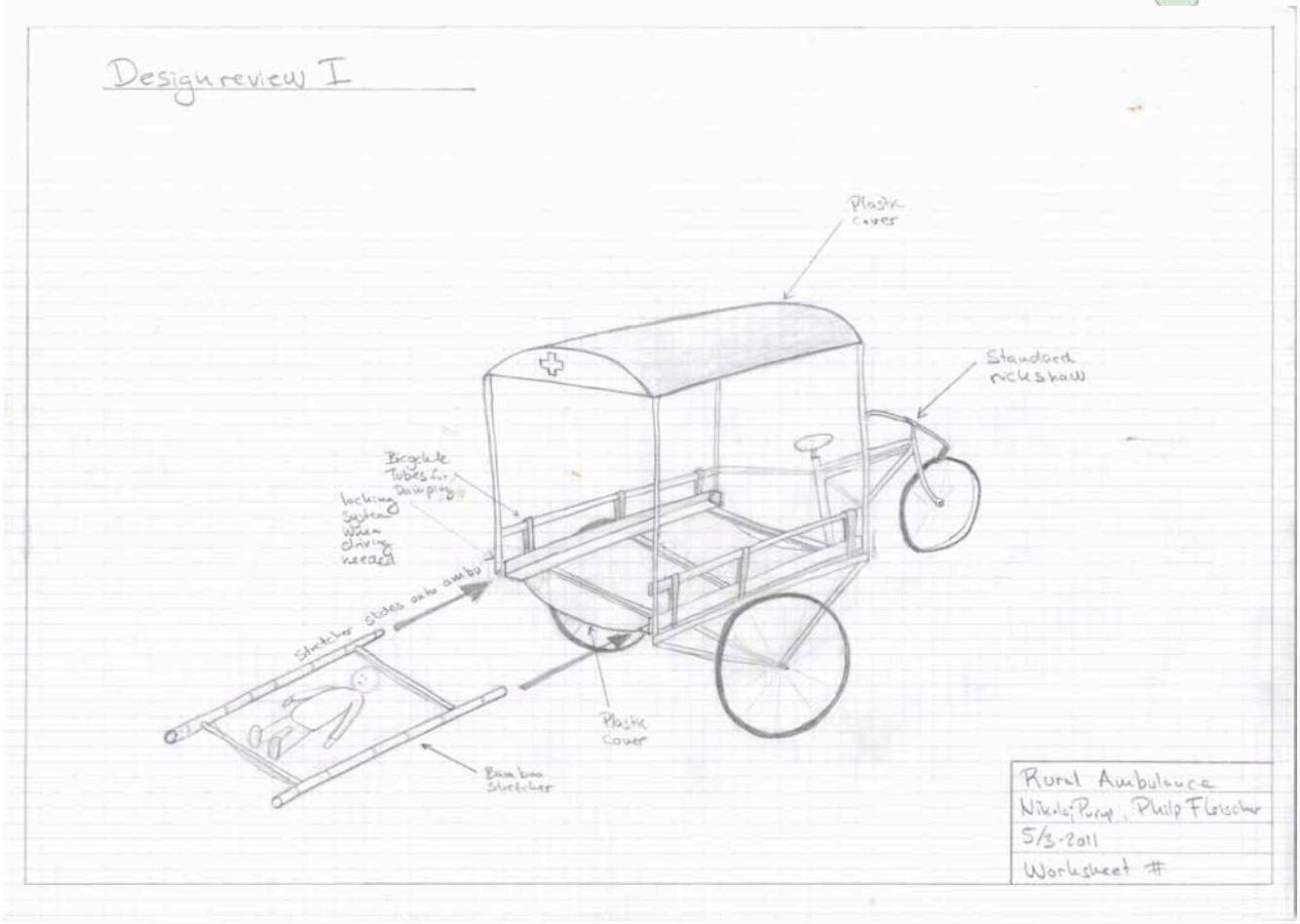
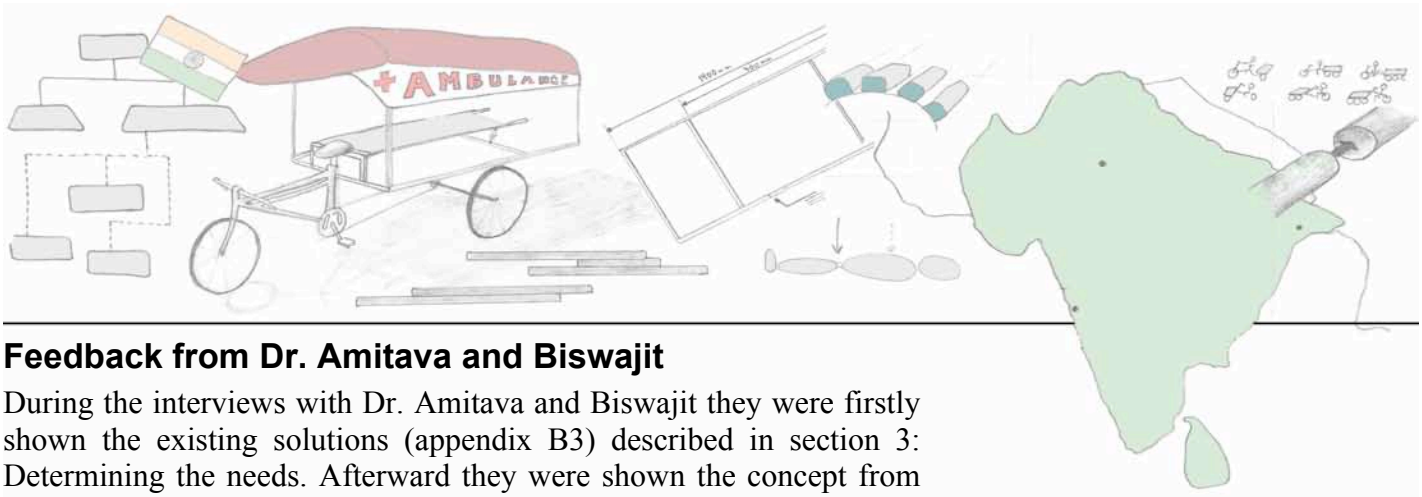


Figure 26. The chosen concept, appendix A15

Design review I

Now that a concept had been chosen it was important to evaluate and get feedback from the main stakeholders. This will be the last step before prototype construction, and it was important to make sure that all functions were included in the design; corrections later on would be significantly more expensive and time consuming. Also it was crucial to look at the remaining sub functions and make sure that the best solutions had been chosen.

Three stakeholders were interviewed for the design review: Dr. Amitava, Biswajit and the Master Blacksmith.



Feedback from Dr. Amitava and Biswajit

During the interviews with Dr. Amitava and Biswajit they were firstly shown the existing solutions (appendix B3) described in section 3: Determining the needs. Afterward they were shown the concept from Figure 26. Both design reviews can be found in full length in appendix B16 and B17.

The existing solutions were all cut into small cardboard cards, which made it easier to lay them on the table and divide them into categories. Generally Dr. Amitava found the existing solutions too heavy and that the patients were situated too low in relation to the ground. He liked the Bambulance, Figure 6 solution the most, and suggested that the most of the ambulance should be made of a fiber material (glass fiber, carbon fiber, etc.) instead of iron. For covers he preferred the Zambulance, Figure 5, because the patient could be totally covered when it rains.

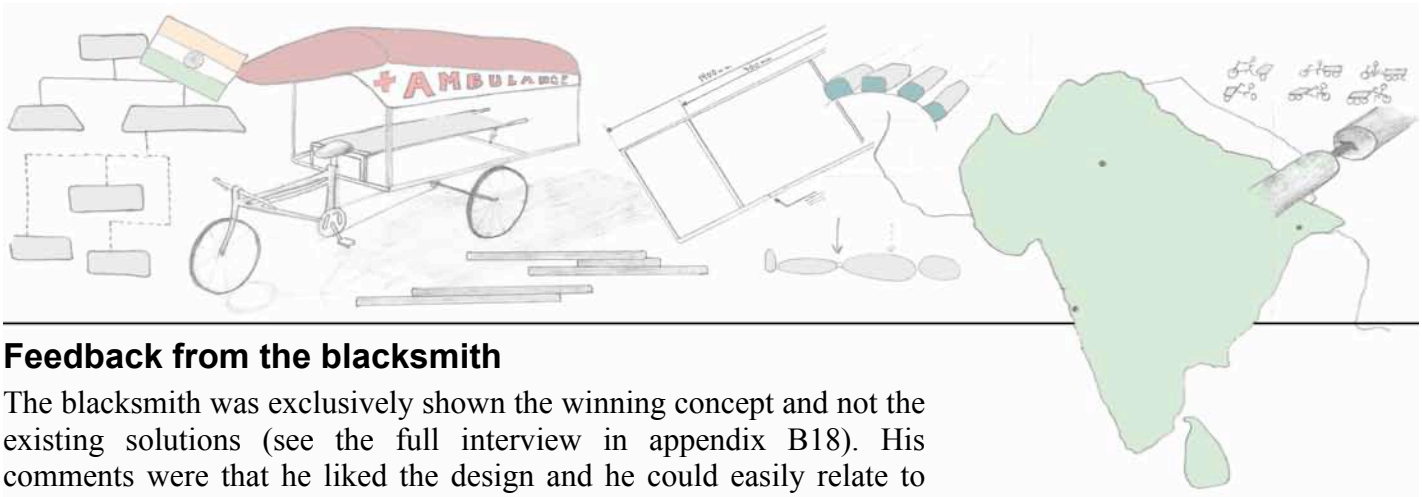
Figure 27. Workshop with Dr. Amitava using e.g. the cardboard cards with existing solutions

Biswajit liked the 3-wheeler solution from the existing solutions worksheet, but he emphasized that it needed a cover and room for relatives to sit. He also liked the motorized solutions because the side wagon design can be strapped onto a moto-rickshaw (the common name used for a motorized rickshaw). He though admits that a moto-rickshaw solution would not be able to travel the mud roads in wet season.

When shown the winning concept from the concept selection Figure 26, both Biswajit and Amitava were quite positive. They found it to be a good idea to use the rickshaw they already know as a base, and from this build the ambulance. Together Biswajit and Amitava though had some additions and specifications to the concept. These were:

- Room for the relatives
- Room for an oxygen tank and a hook for a saline bag
- A shade of some sort for the driver
- Make the stretcher as light as possible
- The patient should be minimum 1 m above the ground at all times
- The oxygen tank should be medium size and vertically installed

Also they both pointed out that the patient should be spared from sudden jerks and be kept stable at all times, which require a good suspension and damping system.



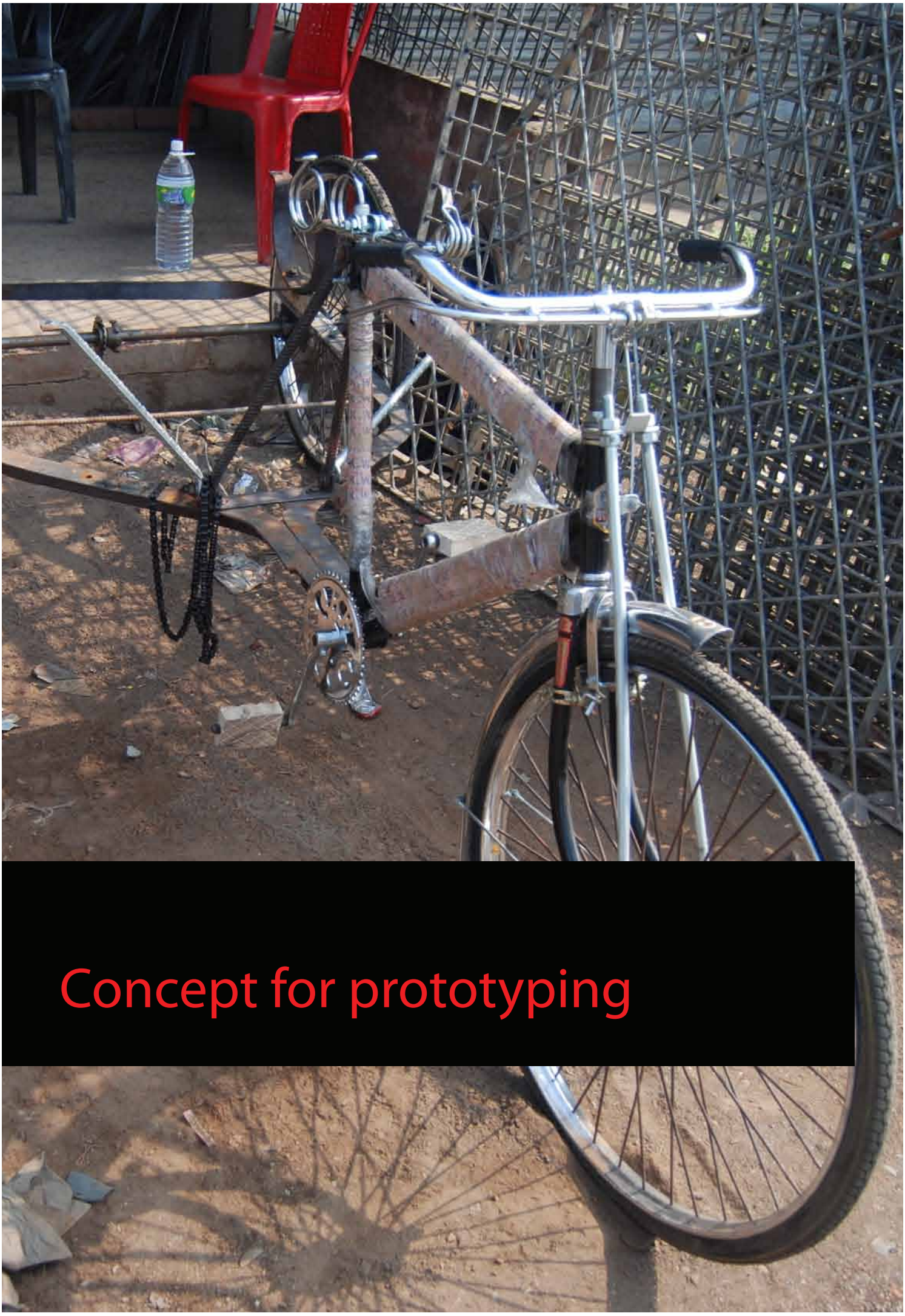
Feedback from the blacksmith

The blacksmith was exclusively shown the winning concept and not the existing solutions (see the full interview in appendix B18). His comments were that he liked the design and he could easily relate to how it should be done, given the familiar rickshaw design. He however suggested that it might be worth looking into the use of coil spring suspension instead of rubber tubes. When he was questioned on the issue of the price, he replied that a set could be acquired for less than 400 rupees (45 DKK.)

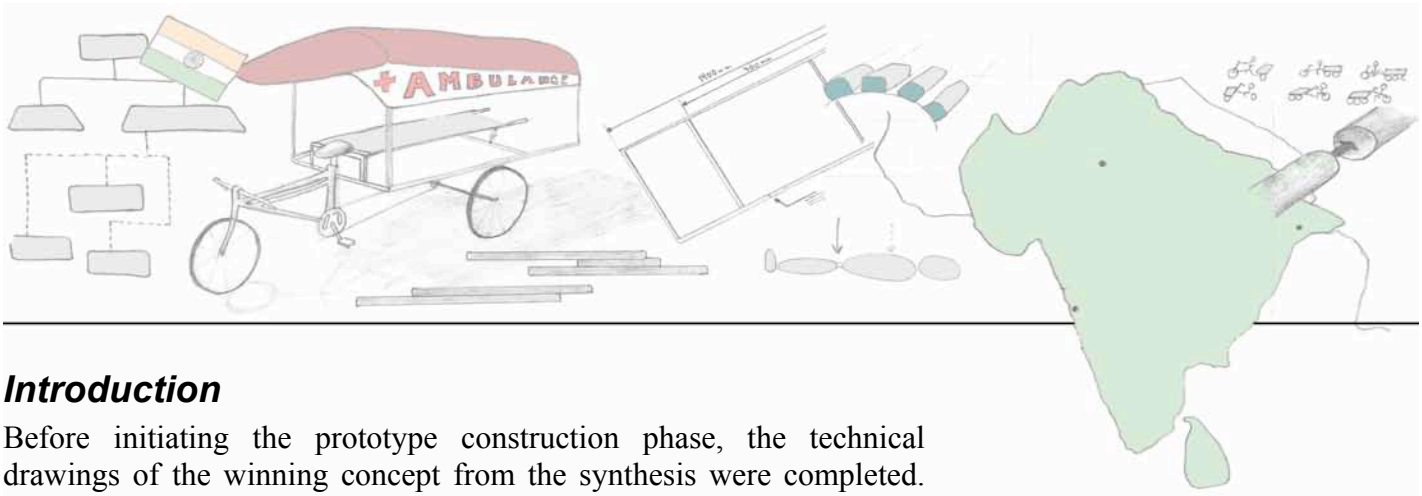
Revised concept

The revised concept can be seen in the next section; Concept for prototyping. The main changes include: a new roof, which covers the driver, a new suspension system and a correct representation of the support for the frame. The coil spring suspension was initially ruled out due to the price, but was assumed to give a much more stable transportation of the patient. When the much lower than expected price was revealed by the blacksmith, the coils spring suspension was a natural choice (Harris, 2005; Nice, 2001).

Other aspects, like room for the oxygen tank and the seat for the relatives to sit was part of the later detailing of the ambulance, and easier to find a room for, when the construction process began. In the next section the chosen design will be thoroughly described.



Concept for prototyping



Introduction

Before initiating the prototype construction phase, the technical drawings of the winning concept from the synthesis were completed. Along with sketched 3D-representations of the concept these drawings sum up the portfolio that was presented to the blacksmith. A 3D sketch was likewise brought to the carpenter for stretcher construction. For detailed drawings see appendices A21 and A23-A26.

Concept description

The drawings were divided into two parts; a lower part and an upper part. The lower part consists of the inner frame (IF), the outer frame (OF) and the stretcher. The two parts are connected by a set of four coil springs, but this was quickly changed to two, when the springs were purchased, and the availability was limited. The upper part consists of the roof and its support beams. All parts are resting on the Rickshaw-Bicycle frame, and the idea is for the stretcher to slide onto the IF. The total form of the design taken to the blacksmith for prototyping can be seen in Figure 28.

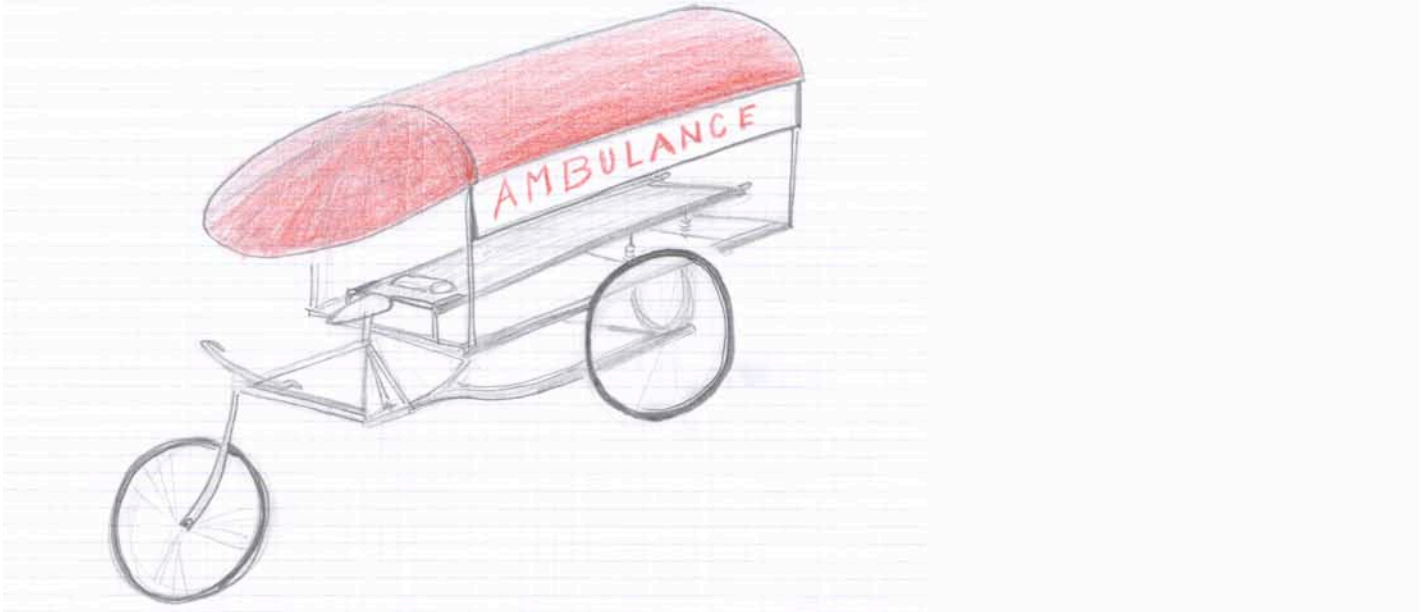
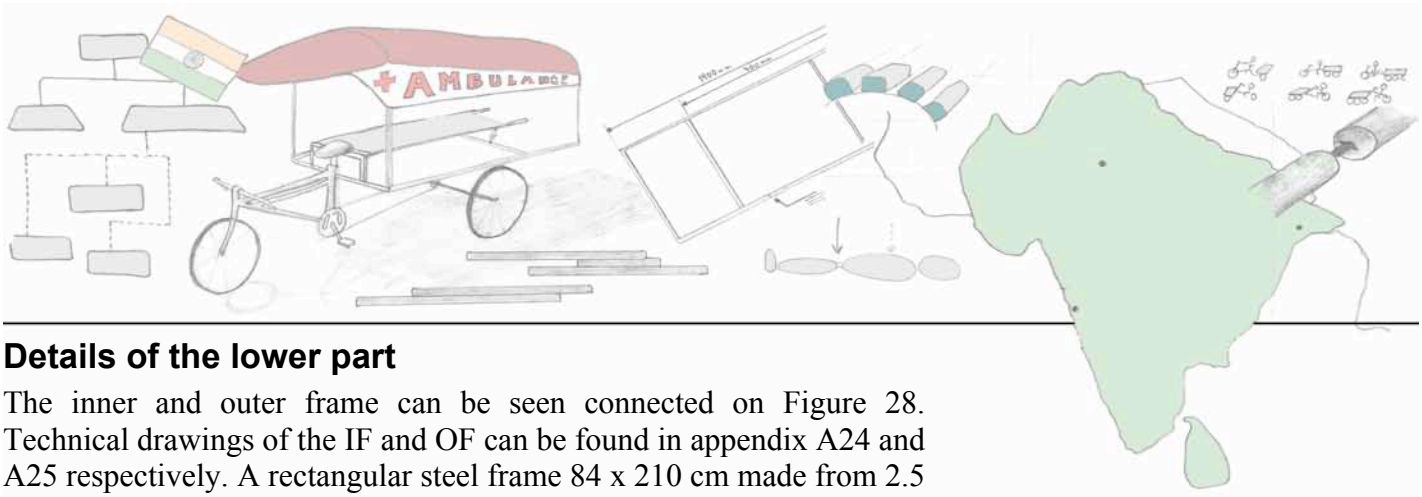


Figure 28. Concept for prototyping, appendix A22



Details of the lower part

The inner and outer frame can be seen connected on Figure 28. Technical drawings of the IF and OF can be found in appendix A24 and A25 respectively. A rectangular steel frame 84 x 210 cm made from 2.5 x 2.5 x 0.3 cm L-profile shaped rods rest on the U-supports. This is the OF. The center of gravity is positioned behind the U support. There are two rods perpendicular to- and connecting the sides. Two small cylindrical steel rods are mounted on the inside of the frame sticking out to support the suspension.
Mounted on the front end of the OF is the support for a rotary joint. The support consists of two vertical L-profile rods. Also there is a horizontal L-profile connecting the vertical rods.

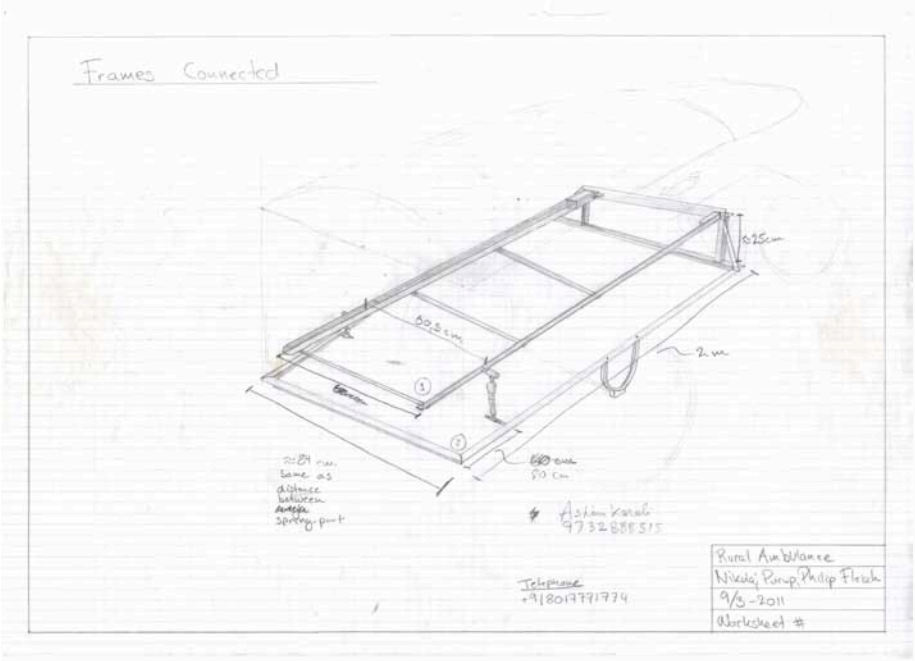


Figure 29. IF and OF assembly drawing, appendix A23

The IF is likewise a rectangular L-profile frame measuring 60.5 x 210 cm. The L-profiles used for the 210 cm sides are 4 x 4 x 0.5 cm. There are L-profile safety rods equally spaced between the L-profile rod in each end. Two small cylindrical rods are mounted on each outer side of the frame 60 cm inwards from the rear end to support the suspension. At the very front of each of the frame sides a 10 cm long encasing is mounted upside-down on the original L profile creates a hole for the stretcher handles to slide into, see Figure 31.
The suspension connects the IF and OF by being mounted on the cylindrical rod support as described earlier.
The stretcher, Figure 30, is a rectangular 60 x 210 cm frame made of 2.0 x 2.5 inch (5.08 x 6.35 cm) hard wood. However the short side of

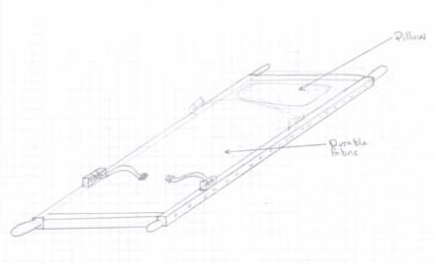
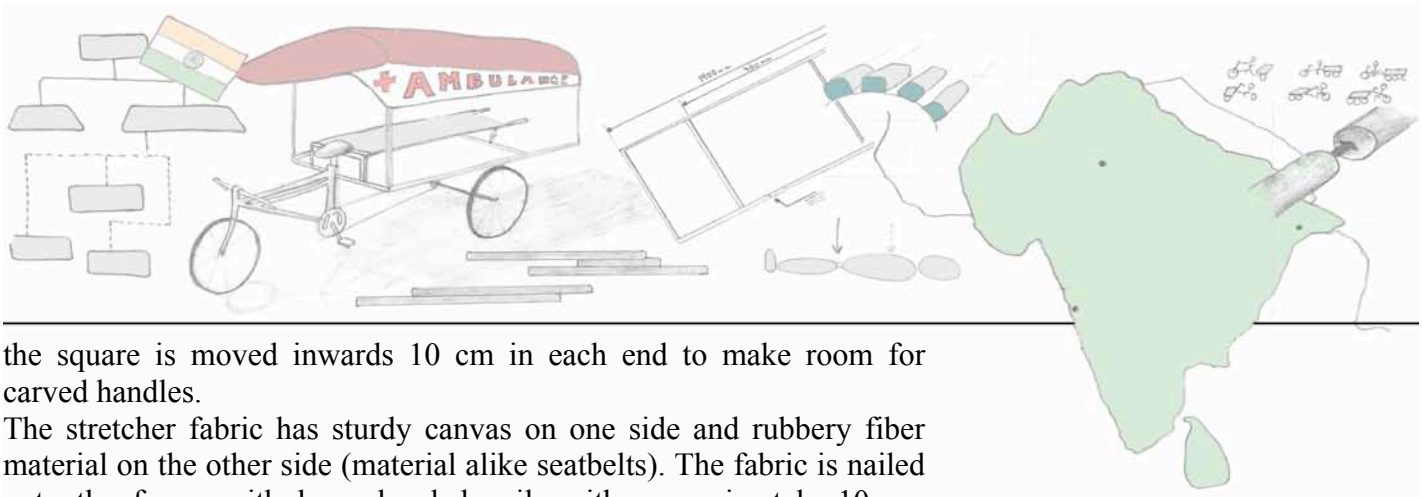


Figure 30. Sketch of the stretcher, appendix A21



the square is moved inwards 10 cm in each end to make room for carved handles.
The stretcher fabric has sturdy canvas on one side and rubbery fiber material on the other side (material alike seatbelts). The fabric is nailed onto the frame with large headed nails with approximately 10 cm spacing between each nail. The idea is that the stretcher slides onto the IF which locks its vertical movement by fixating the handles in the two holes in the end. A split in the back end will ensure that the stretcher does not slide out when driving.

Details of the upper part

The roof is designed like a standard roof similar to the ones on every moto-rickshaw in the area. Four L-profile beams support the roof in each corner and connects with the corners of the OF. Four L-profile rods connect the four corner rods.
The roof itself has five arch supports, which are made up of bend flat steel profiles. At the front there is a shade for the driver, which is made of a single piece of bent flat profile steel, connected to the corner support joints, see Figure 32 and appendix A26.

Figure 31: Handle fixation

The roofing material is a thick leathery plastic sheet fitted to the frame, with the possibility of rolling down the sides, thereby blocking the view of the patient from the sides of the ambulance. The sides are rolled around a bamboo stick, which is slightly longer than the length of the outer frame. The lowest part of the fabric is folded up and sewed onto itself creating a pocket for the bamboo stick. When the sides are rolled up the ends of the bamboo stick are fastened with sturdy rubber bands attached to the corner support rods of the roof. The roof is red and the sides are white in accordance with section 4: What makes an ambulance in Sunderbans.

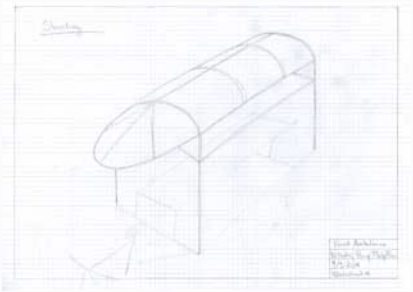
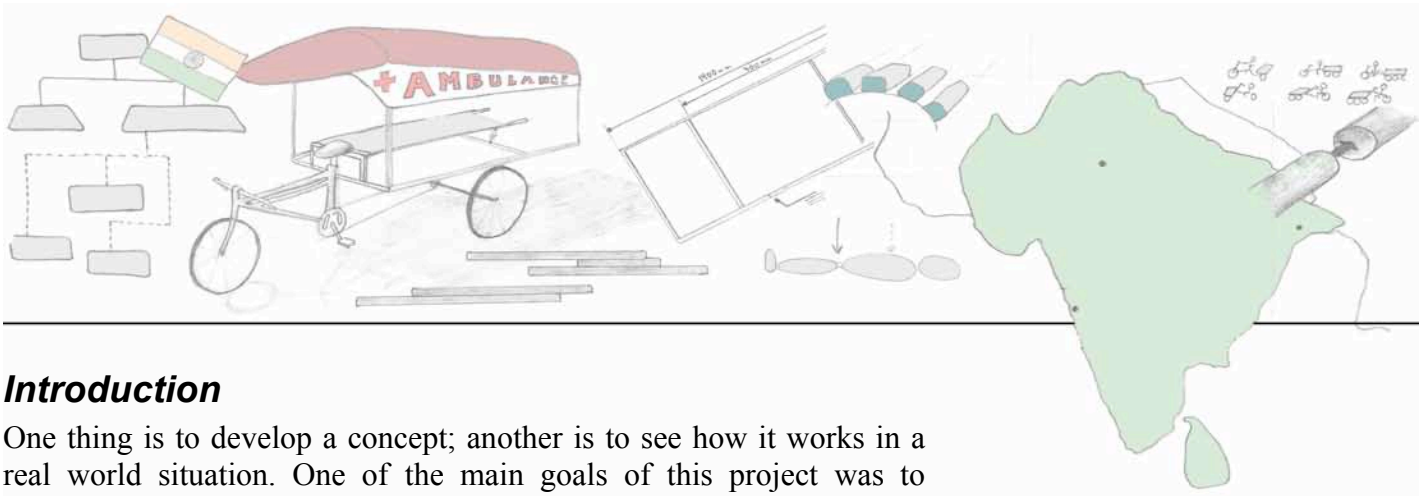


Figure 32: Roof sketch, appendix A26

Accessories

A reflex is mounted onto the front (white) of the bicycle and two at the back (red) on the corner supports for the roof. A horn is attached to the handlebar and a halogen light is mounted on the very front of the roof with a wire connecting it to the dynamo placed at the front wheel.
A rear view mirror is connected to the handlebar and allows the driver to look down the right side of the ambulance (left side drivers). The relative's seat is a single plank of polished wood which passes under the IF and is screwed onto the OF on either side. The relatives can then be situated on either side of the IF in the front end.

Prototyping



Introduction

One thing is to develop a concept; another is to see how it works in a real world situation. One of the main goals of this project was to develop a prototype and test the developed concept under realistic conditions. The prototyping had several purposes but the most important ones were to reveal even more needs and to specify and validate the ones already identified even further. Another purpose of the prototyping is to serve as a proof of concept, i.e. to unveil that it is realistic to produce the concept in the local area, and make sure that the end-users are using the artifact as intended.

Prototype construction

The main part of the prototype construction was conducted at the blacksmith, because the steel structure represented the largest challenge in the project. This structure defines the overall shape and strength of the ambulance and is therefore highly important to the success of the product. Other challenges included the roof fitting and the stretcher construction. The construction is built on a standard rickshaw frame from the local area, with smaller adjustments (e.g. the rear axel moved further backward).

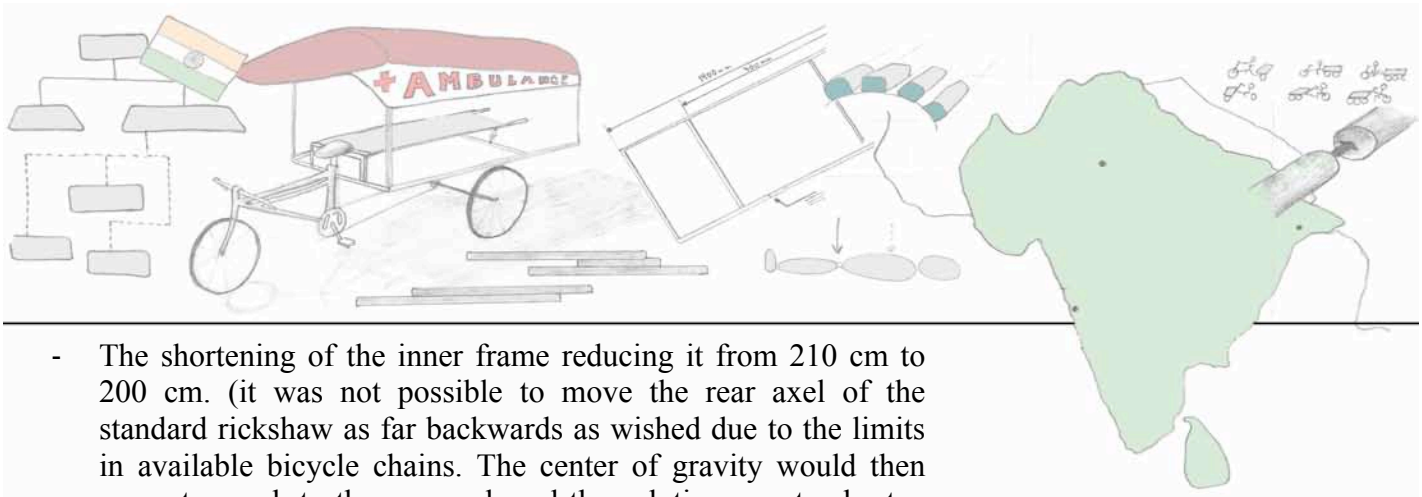
Figure 33. Standard rickshaw frame

Constructing the main frame

In order to ensure the best prototype possible, the project group was present during all steps of the production process at the smithy. This led to several discussions with the blacksmith concerning the design and in the end several changes were made to the original design (see section 3: Context, Avoiding "technology transfer" about designing with the people instead of designing for them). These changes were a result of the professional input from the blacksmith and realizations from the project group while the prototype took shape. To name an example it quickly became apparent when the inner and outer frame were connected, that the full length of the outer frame was unnecessary, and consequently 60 cm were cut of the back end.
A full list of changes to the original design can be found in appendix B27. However the most significant changes were:

Figure 34. The Rickshaw prototype finished from the blacksmith

- The cutting off of approx. 60 cm from the rear end of the outer frame
- The lowering of the rear end roof support, resulting in a downward sloping roof (due to aesthetics, wind resistance and minimizing materials used).



- The shortening of the inner frame reducing it from 210 cm to 200 cm. (it was not possible to move the rear axel of the standard rickshaw as far backwards as wished due to the limits in available bicycle chains. The center of gravity would then move to much to the rear end, and the solution was to shorten the stretcher)
- Switching L-profiles with flat profiles and removing perpendicular rods from the frames to reduce weight.

Fitting the last details

After constructing the main frame, it was time to fit the last details. This included features as the hook for a saline bag, the oxygen tank holder and the wooden relatives seat fastened to the OF. The only things left now was the stretcher, reflexes, horns and the roof materials.

Figure 35. Fitting the stretcher material

For the stretcher it was realized that an additional perpendicular wooden bar was needed in order to stop the sides from bending inwards (deflecting) when weight was applied to the canvas. This was added a little further down on the stretcher than the middle to make it more comfortable. Also a thicker but all cotton canvas was tried out for stretcher material, but was deemed unsuitable.

The project group, in collaboration with a tailor, did the fitting of the roof manually. Because the fabric used for the roof was difficult to sew onto itself, instead of making a pocket for the bamboo stick by sewing the bottom of the fabric onto itself, a similar pocket were made by inserting rivets.

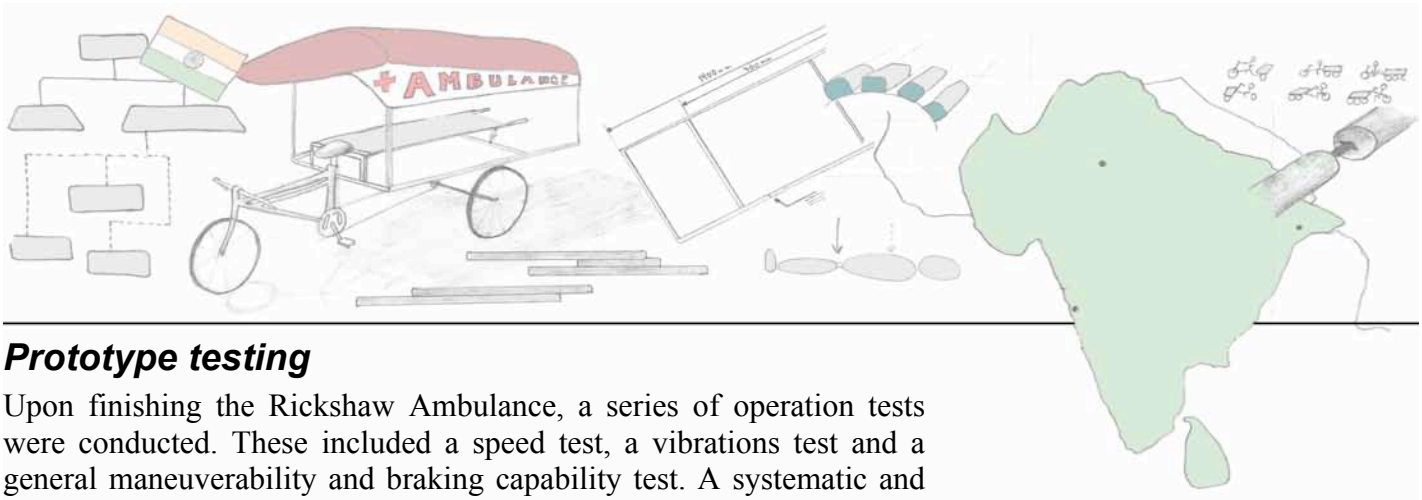
The result of the prototyping process can be seen in Figure 36 and step-by-step pictures of the whole process can be found in appendix B26.

Figure 36. Finished prototype

Cultural aspects of manufacturing the prototype

During the prototype construction a large effort was put into evening out the cultural differences, and to actually make the design in collaboration *with* the people and not just *for* them. This proved to be a challenge, but not as great a challenge as first expected. In the end of every day different situations from the days work were evaluated, and it was discussed how problematic situations from one day could be avoided the next.

The largest problem when producing the prototype was the sharply defined hierarchy as described in the context section under "The Indian caste system". This made it difficult to get feedback on the design from the workers at the smithy. One way of leveling the hierarchy was to be present at all times at the blacksmith and to ask the workers about their opinion on the design, instead of telling them to build it with no questions asked.
Other trust building methods included bringing some Danish candy to the smithy when the workers were working late one day or to take photos of the craftsmen working and showing it to them. The sum of these actions resulted in a more casual and relaxed atmosphere. After the workers at the blacksmith realized that their ideas and opinions were listened to and taken seriously they began suggesting design details, which created an invaluable dialog revealing many new design and construction ideas.



Prototype testing

Upon finishing the Rickshaw Ambulance, a series of operation tests were conducted. These included a speed test, a vibrations test and a general maneuverability and braking capability test. A systematic and formal test description can be found in appendix B28.

Speed test

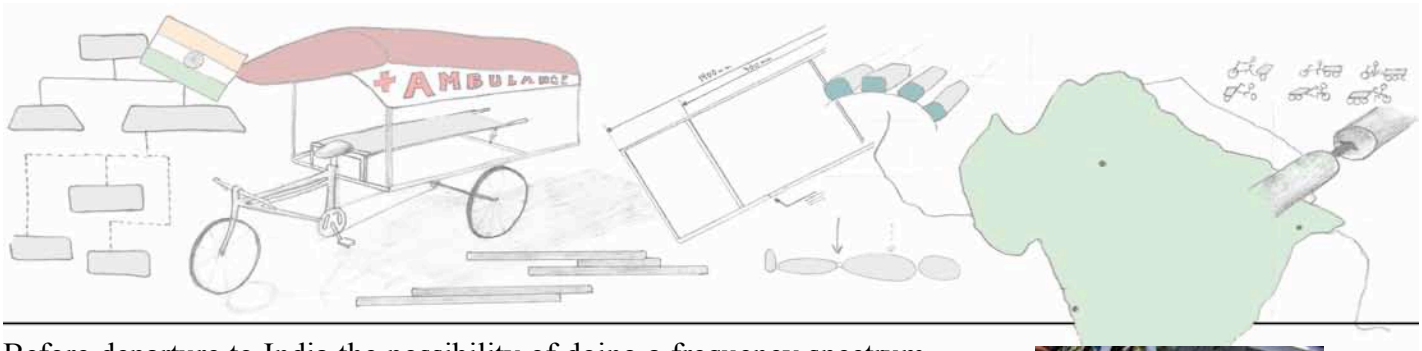
The distance were determined by measuring the outer diameter of the wheel and note down how many times a point on the wheel, marked by marking tape, passed by on a stretch of road. The time was simultaneously taken, and dividing the distance with the time gives the speed.
The speed was measured for two different road stretches and types, namely brick and asphalt road. There were a driver and a "patient" laying on the stretcher for the test. The aim of the test was to determine a realistic pace the ambulance might travel by and the driver consequently did only drive with a pace that could easily be maintained for a longer distance.

For brick roads the average speed was: 2.22 m/s or 8 km/h
For the asphalt road the average speed was: 3.18 m/s or 11.5 km/t

(The velocities stated above are an average of three test runs conducted on each road type.)
These speeds correspond to a steady running pace for a marathoner in good shape, which means that transportation in the Rickshaw Ambulance will be much faster than carrying the patient. It is also evident from previously described route scenarios that the ambulance travel time will rarely surpass 1 hour of operation, which is reasonable for a grown man to endure in one go.

Vibrations test

A vibrations test was conducted to get an idea of the degree of damping of vibrations. The scope of the tests was not to get precise results for scientific use, but just to get an idea of the range of vibrations. This was used to determine how much the suspension system was damping these. The tests were performed using an Iphone, with an accelerometer application installed. The readings were primarily performed with 5 Hz. This was later found to be a little to few and it might have caused some degree of aliasing. Vibrations were measured in the x, y and z direction and plotted in an excel worksheet which can be found in appendix B31.



Before departure to India the possibility of doing a frequency spectrum analysis, which would give a good idea of which frequencies the dampers eliminated, were examined. Upon returning to Denmark a formal interview were conducted with Jon Juhl Thomsen (vibrations specialist at DTU), on how to interpret the data. A full interview can be found in appendix B44.

The problem faced was, that the Iphone application could only do acceleration measurements, and a frequency spectrum analysis needs displacement as an input. The data could be converted to displacement using Simpsons rule or similar approximation methods, but that would have caused the data to be very unreliable, because the vibration "noise" would have been much more dominating after this.

Figure 37. Iphone attached to the ambulance frame.

What was done instead was to plot the different acceleration graphs against each other in the vertical direction. From this image it can be seen how the accelerations have been significantly damped (see Figure 38). It should be noted that the vibrations have been measured in different points on the ambulance, and with different fastening methods, so the data has some degree of uncertainty.

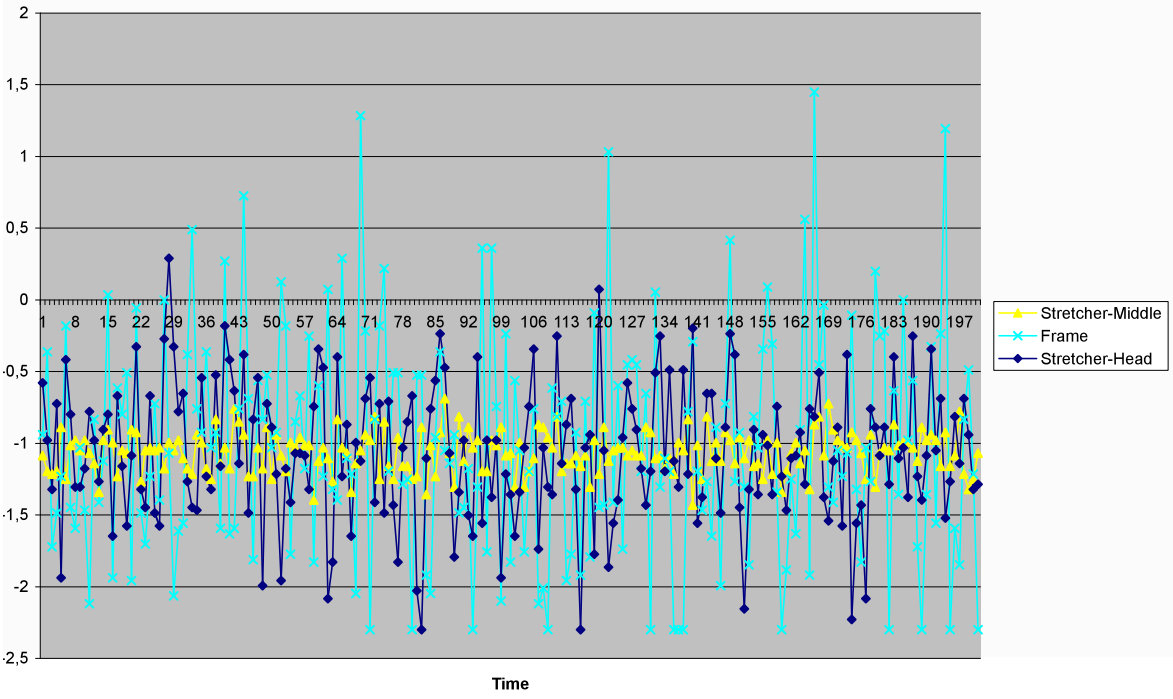
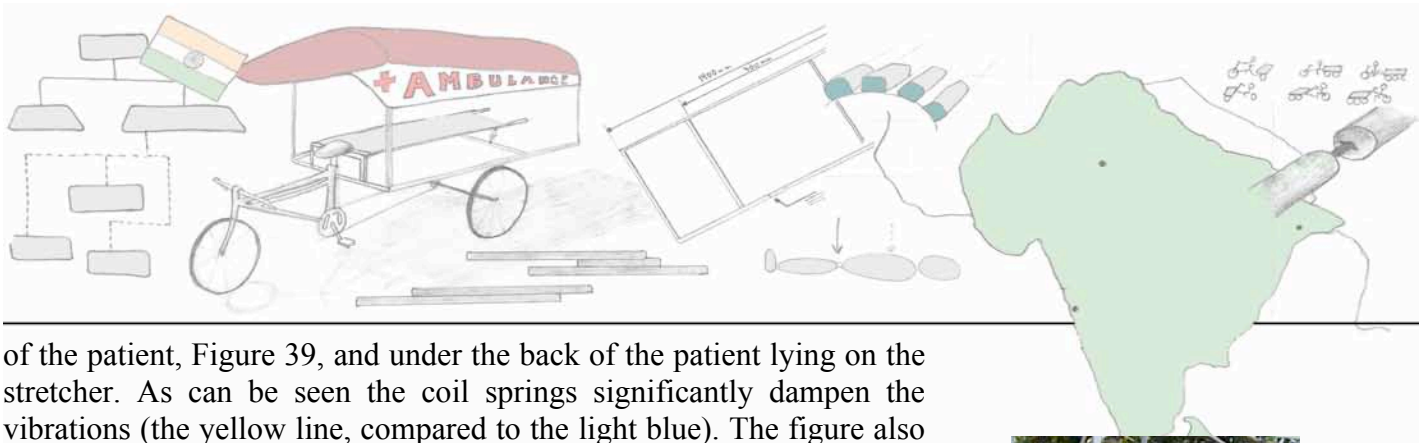


Figure 38. Vibrations, appendix B31

The graph shows vibrations at three different spots on the Ambulance; just under the stretcher attached to the frame, Figure 37, under the head



of the patient, Figure 39, and under the back of the patient lying on the stretcher. As can be seen the coil springs significantly dampen the vibrations (the yellow line, compared to the light blue). The figure also emphasis the need for a pillow for the patient, as the coil spring system inevitably will provide less damping nearer the rotary joint where the head is positioned.

Figure 39: The Iphone is placed just under the head of the patient

To compare the data with other vibration data the Root Means Square (RMS) can be calculated. To compare vibrations like this, the test ride has to be continuous and with no sudden shocks, which in this case holds true. The average RMS values for all the tests were found to be 0.72 m*s^-2 r.m.s, 0.44 m*s^-2 r.m.s and 0.36 m*s^-2 r.m.s for the frame, the head of the stretcher and the middle of the stretcher. Handbook of Human Vibrations states:

*"The vibration encountered within road and rail vehicles varies from about 0.2 m*s^-2 r.m.s for a very smooth ride up to 1 m*s^-2 r.m.s or more for a bad ride. The magnitude of some off-road vehicles may reach 2 m*s^-2 r.m.s. or more"*(Griffin, 1996)

Based on this the vibrations of the Rickshaw Ambulance can be concluded to be acceptable, even for an ill person. Vibration analysis is of course a very complicated field of study, and a whole report could be written about the vibration damping of the ambulance. This is not the scope of this project, but on the basis of practical experiences and the limited analyzes on the collected data it can be concluded that the vibration of the ambulance have been damped sufficiently to transport medically unstable patients.

Other function testing

Maneuverability and braking were continuously tested through out the use of the prototype. No actual braking test was needed due to the low speeds at which the ambulance travel, but it was noticed that the brakes functioned impeccably and that the brake length will never surpass 2 m. Both the maneuverability and the brakes were deemed reasonable for the form and weight of the construction. Illustrations of a turning radius test can be found in appendix B30 and Figure 40.

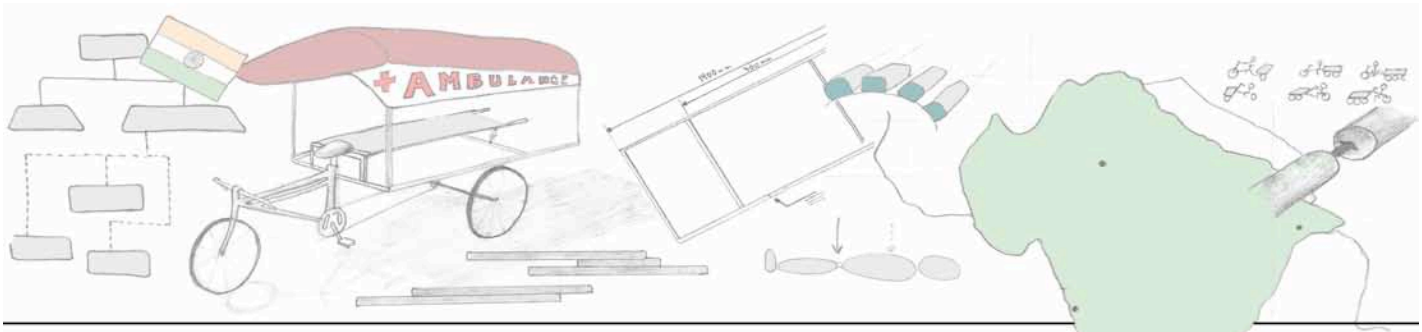


Figure 40. Demonstrating the turning radius, appendix B30

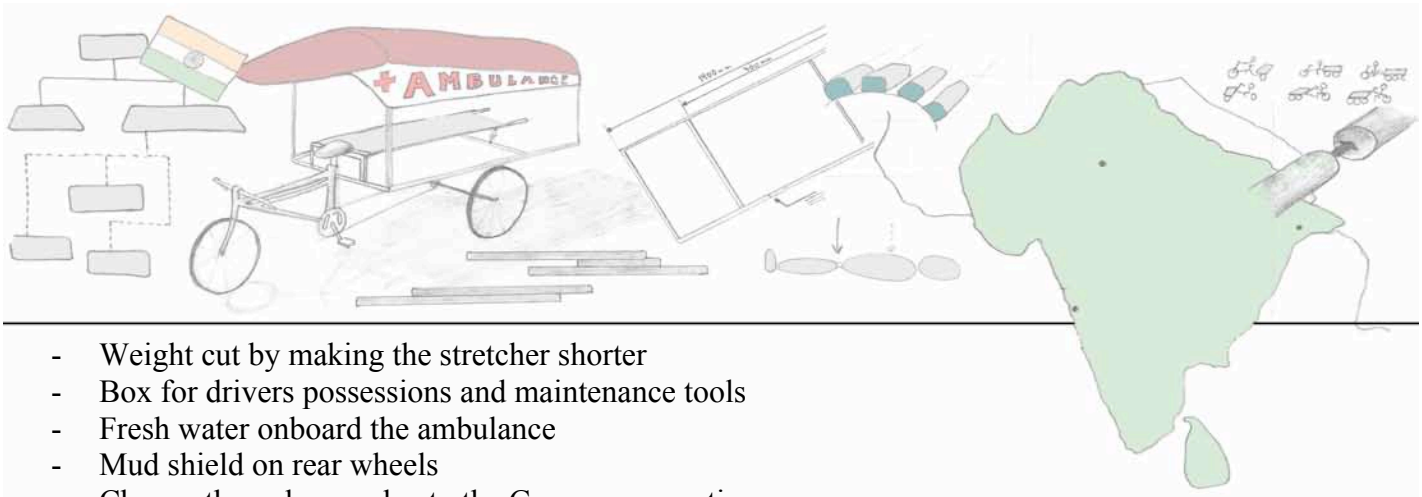
Prototype review

Several people were interviewed and asked to give their feedback on the prototype. Workshops and observations were also conducted, and it was attempted to acquire improvement ideas from someone on all levels in the social hierarchy. In the following the data from these interviews and workshops will be presented, and all ideas will be evaluated in the end.

Feedback from Dr. Amitava and Biswajit

In this second design review Amitava and Biswajit were once again, in their role as main stakeholders, consulted for feedback on the design. This was the last design review before the final concept detailing and it was therefore important to uncover any inexpediency that might still be present in the prototype at this stage. Both of them were shown the actual prototype and were asked to come up with ideas for improvements. The prototype reviews can be found in their full length in appendix B34 (Amitava) and B35 (Biswajit). The combined list of suggested changes from Amitava and Biswajit were as follow:

- New design of relatives seat (move it to the side, fiber seats?)
- Two fasteners for oxygen tank instead of one
- Stretcher needs to be collapsible



- Weight cut by making the stretcher shorter
- Box for drivers possessions and maintenance tools
- Fresh water onboard the ambulance
- Mud shield on rear wheels
- Change the red cross due to the Geneva convention
- Logo of university on the ambulance
- Lower roof to lessen the effects of the wind
- Put JGVK logo on the side of the ambulance
- Put the drivers telephone number on the side of the ambulance

All suggestions were considered and the result can be found in the concept evaluation section.

User feedback

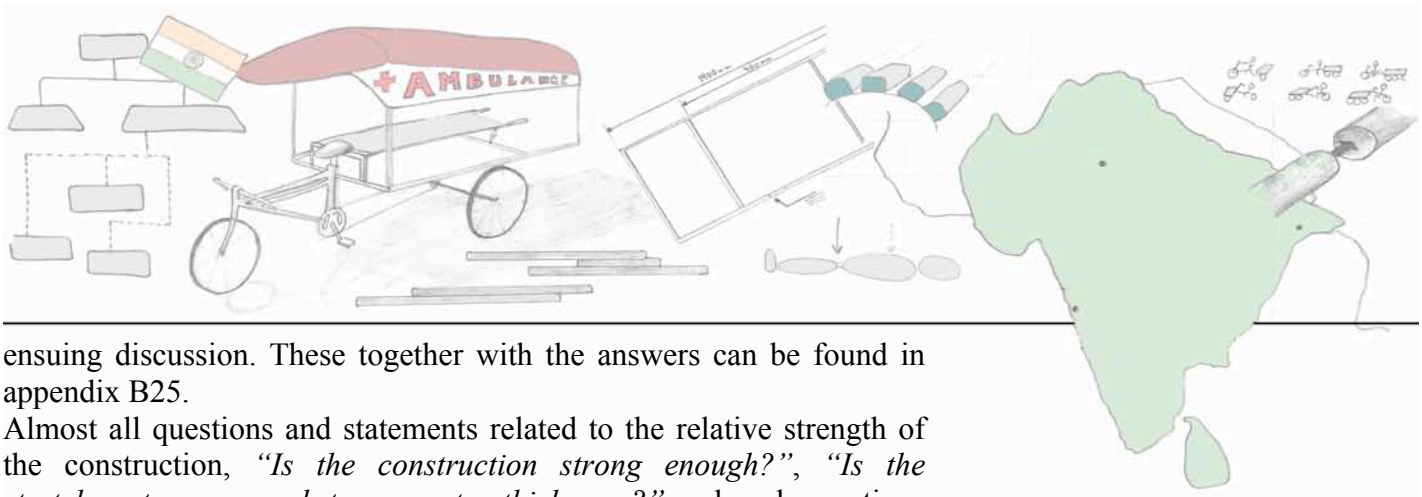
This section consists of data collected from various sources, where most share the common subset of all being the future users of the ambulance. However the section also contains observations from the project group, and a spontaneous discussion brought on by arriving at JGVK HQ with the ambulance fresh from the blacksmith.
The scope has been to indentify new needs in reference to the existing prototype.

First impressions

The very first test-drive was conducted when the prototype was toed back to JGVK HQ from the blacksmith. The speed of the ambulance reached the maximum speed a single man would possibly be able to pedal (approx. 20km/h) and as such the vibrations and jerks were maximum amplified. One of the project group members was placed on the stretcher to perform an initial comfort test.
The transportation was overall surprisingly comfortable, but some important issues were brought to the attention of the project group; **1)** The head needs to be cushioned, **2)** something should be done to prevent the patient from accidently rolling over the side of the stretcher. These along with other observations were acknowledged and considered in the preceding detailing of the prototype, and they can all be found in appendix B29.

Figure 41: Arriving at JGVK with partly finished prototype

Upon arriving at JGVK with the partly finished prototype, Figure 41, fresh from the blacksmith, approximately 10 people quickly gathered who all wanted to see what was going on and to ask questions about the prototype. Eight main questions and statements were extracted from the



ensuing discussion. These together with the answers can be found in appendix B25.
Almost all questions and statements related to the relative strength of the construction, *"Is the construction strong enough?"*, *"Is the stretcher strong enough to support a thick man?"* and such questions were asked. Other questions were directed at still missing details, such as a seat for relatives and a roof. All in all it was possible to answer all the questions and explain the missing details to the crowd, but the input was important for the understanding of how the naked prototype was perceived by the locals.

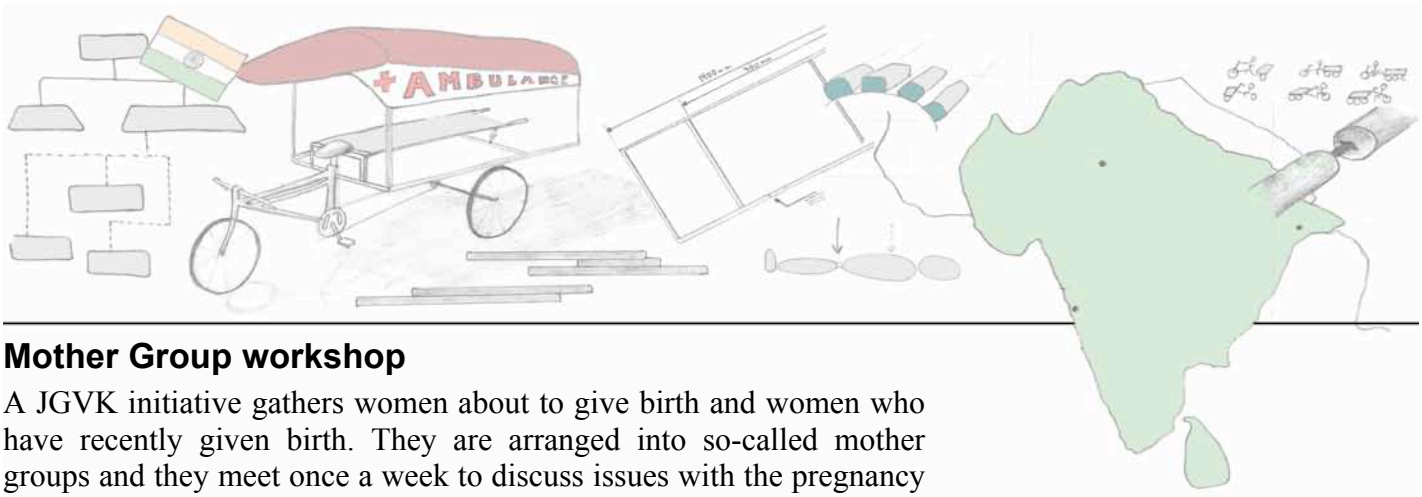
Workshop with the kitchen staff

After the last details were added to the ambulance, a workshop was conducted involving the kitchen staff at JGVK HQ, see appendix B33. A "driver", a "patient" and three "family members" were appointed, and no more instructions were given. The main purpose of the workshop was to see how the participants would react and it was also an attempt to uncover latent needs. The scenario went smoothly and there were no major complications during the exercise. Luckily there were no discrepancies between inscription and description of the artifact. Afterwards the persons involved in the exercise were interviewed and the need for moving as much weight to the front of the frame construction as possible, were identified. Apart from that the "patient" noted that the stretcher were very comfortable.
Also the exercise made the project group aware of the fact that the sliding of the stretcher did not go quite as smooth as intended chiefly due to shredded paint hindering the sliding.

While the workshop was underway Ashim, a health work coordinator at JGVK, observed the whole workshop, and helped translate. After the workshop a short interview was conducted to acquire his thoughts about the ambulance. The full interview can be found in appendix B32. He had some interesting observations in addition to those of the kitchen staff concerning the relative's seat, which he thought were too small. Also he demonstrated how a relative could naturally squat down on the seat instead of sitting in a normal seating position. A sitting position that had not previously been considered in developing the prototype design, but which is very likely to be used, as this is how many people in the area sit.

Figure 42: Workshop with the kitchen staff. Here loading a patient onboard.

Figure 43: Another way of using the relatives' seat was revealed during the interview with Ashim.



Mother Group workshop

A JGVK initiative gathers women about to give birth and women who have recently given birth. They are arranged into so-called mother groups and they meet once a week to discuss issues with the pregnancy and how to care for new born babies. During the user feedback phase the project group met with one of these groups to have an open forum workshop about the Rickshaw Ambulance, which were brought to the workshop as well. There were about 20 mothers present, and the full documented workshop can be found in appendix B36.

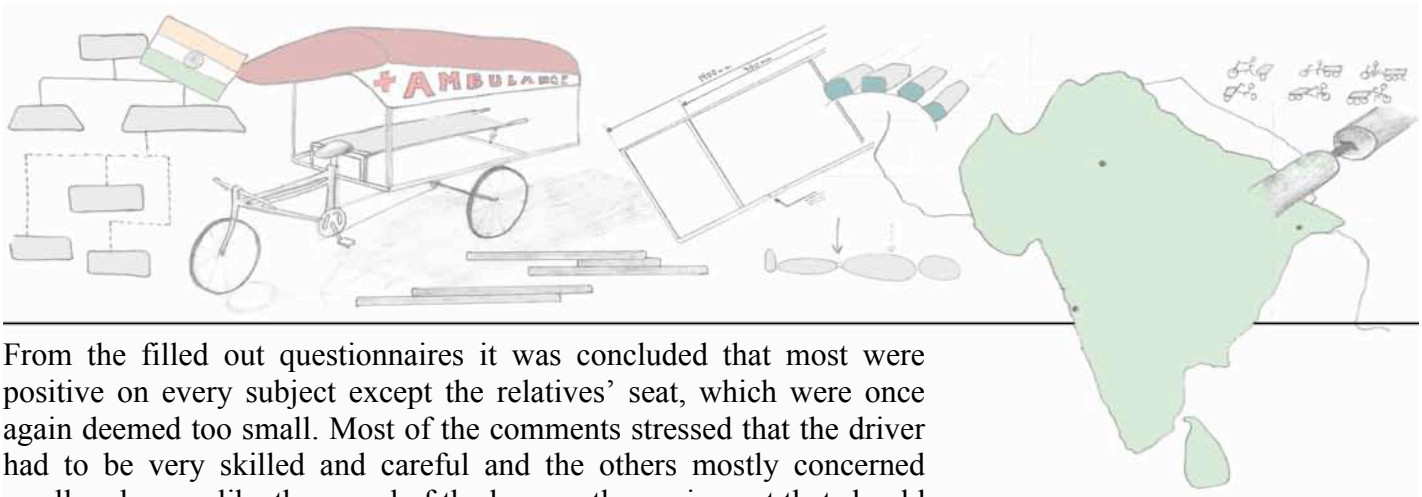
Early in the workshop it was evident that there was a need for transporting pregnant and birth giving women, by another means of transportation than a regular van-rickshaw. When the mothers were later faced with the prototype and tried it out, their single repeated query was the size of the relative's seat, which they thought should be made larger. They furthermore stressed the importance of having two relative's traveling with the birth-giving woman to the hospital. They also suggested the addition of a rope or a bar hanging from the roof of the ambulance to assist the patient in sitting up by his/her own force. Extra equipment on the ambulance if the baby needs to be delivered while driving to the hospital, would also be desirable.

Figure 44: Mother Group workshop

Questionnaire New Market

At the workshop with the kitchen staff it proved to be very difficult to get the average people who are placed low in the social hierarchy to give criticism on the design. It was decided that another indirect way of asking for their feedback was needed and a questionnaire in Bengali (the local language) was the solution. The ambulance was taken to a nearby market called New Market. The market is a natural nerve centre because it is the only market in a 5 km radius, and thus a good place to get in contact with the local population. The questionnaire in English, the returned Bengali questionnaires and a follow-up sheet can be found in appendices B40, B41 and B42 respectively.

Upon arriving at the market a crowd quickly gathered around the ambulance and they were encouraged to try it out, without being given any further instructions. Because of the known van-rickshaw base the people used the Rickshaw Ambulance exactly as it had been intended, with people on the relatives' seat, a patient on the stretcher and a driver easily operating the rickshaw. Only difference between the original intensions and their use of it was an extra person onboard, sitting on the back of the stretcher, see Figure 45.



From the filled out questionnaires it was concluded that most were positive on every subject except the relatives' seat, which were once again deemed too small. Most of the comments stressed that the driver had to be very skilled and careful and the others mostly concerned smaller changes like the sound of the horn or the equipment that should be on the ambulance.

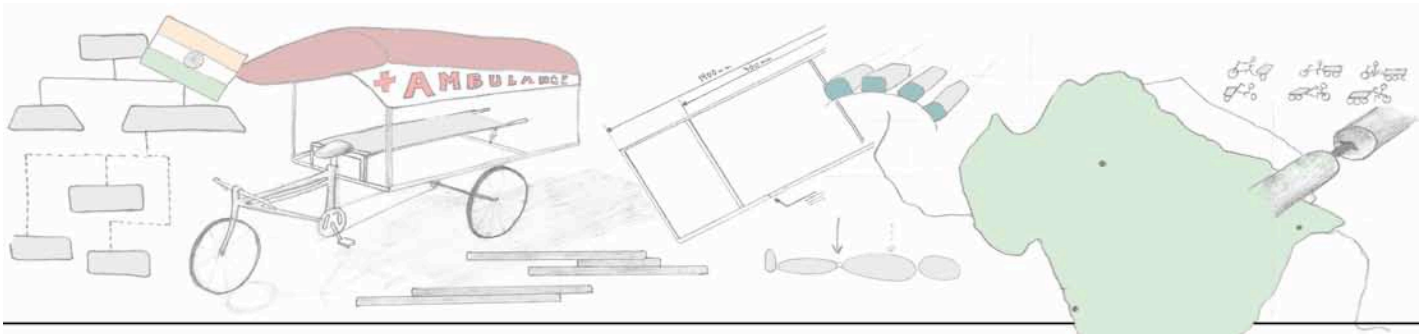
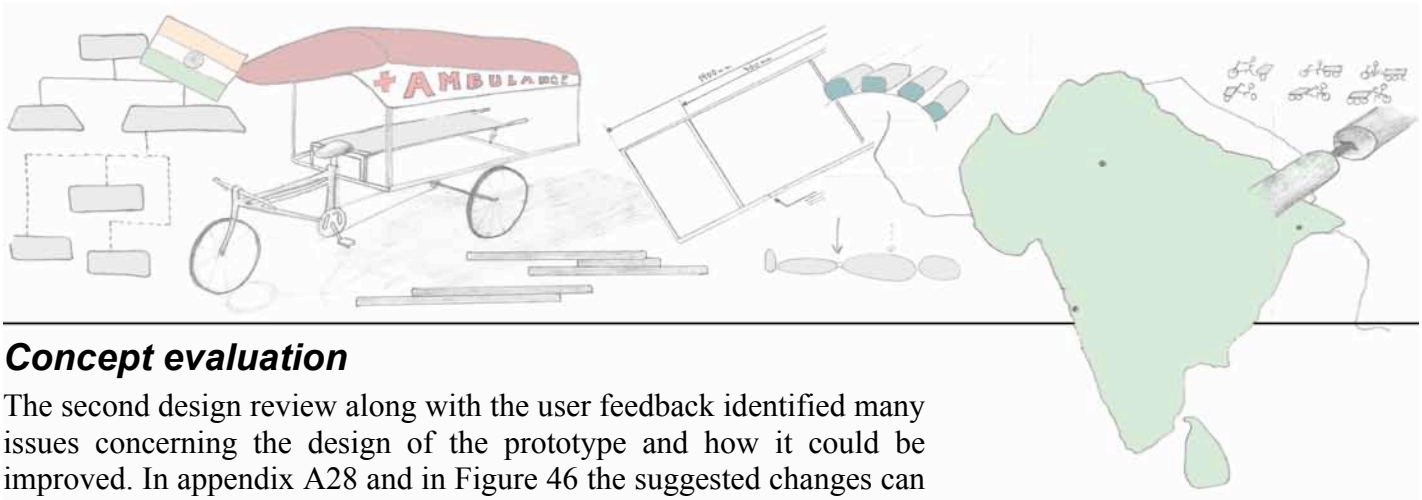


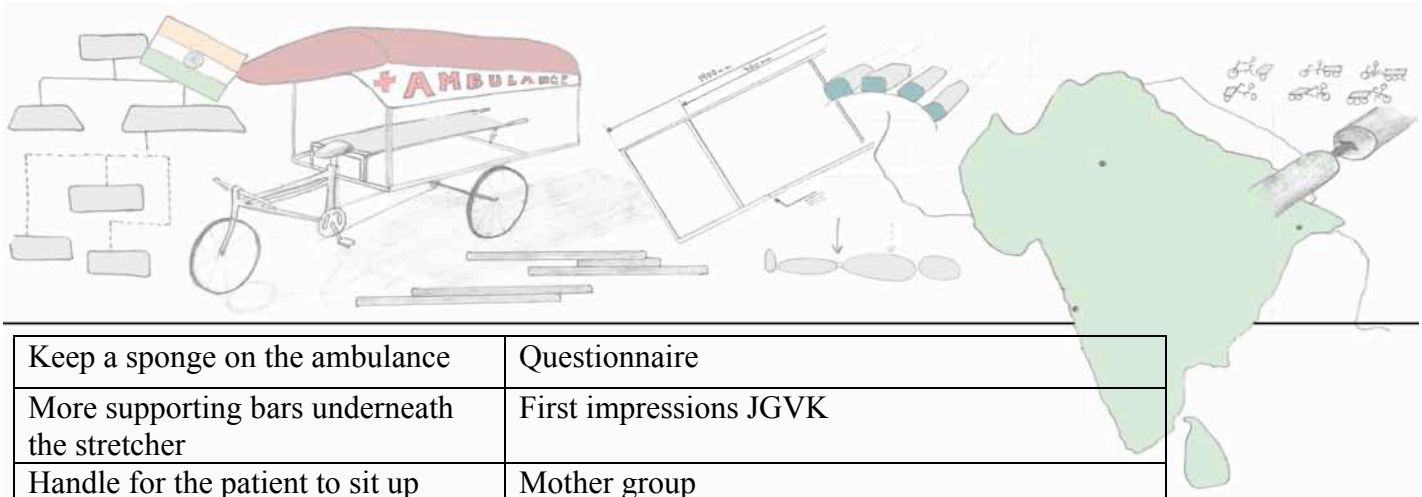
Figure 45: New Market workshop



Concept evaluation

The second design review along with the user feedback identified many issues concerning the design of the prototype and how it could be improved. In appendix A28 and in Figure 46 the suggested changes can be seen:

Suggested change	**Source**
New design of relatives seat	Amitava, questionnaire, mother group workshop, Biswajit, Ashim
Two fasteners for oxygen tank	Amitava
Stretcher needs to be collapsible	Amitava
Weight reduction by reducing stretcher length	Amitava
Box for drivers possessions	Amitava
Water carriage	Amitava
Mud shield on rear wheels	Amitava
Change the red cross to the medical snake logo	Amitava
Logo of university	Amitava
Lower roof to lessen wind resistance	Biswajit
Put JGVK logo on the ambulance	Biswajit
Put the drivers telephone number on the side	Biswajit
Sliding mechanism for the stretcher	Workshop with kitchen staff, Ashim
Move weight forward	Workshop with kitchen staff
Less flexible stretcher material	Workshop with kitchen staff
Equipment for delivering a baby on the ambulance	Workshop mothers group
The horn of the ambulance need another sound	Questionnaire
Wet season arrangements	Questionnaire
Patient should have more space	Questionnaire
The driver has to be good at what he is doing	Questionnaire
The ambulance need to be lighter than it is now	Questionnaire



Keep a sponge on the ambulance	Questionnaire
More supporting bars underneath the stretcher	First impressions JGVK
Handle for the patient to sit up	Mother group
Strap configuration is a cross instead of going straight across the body of the patient.	Rahul

Figure 46: Suggested changes, appendix A28

Each of the suggestions were carefully considered and treated in the next section of the report: Developing the final concept.

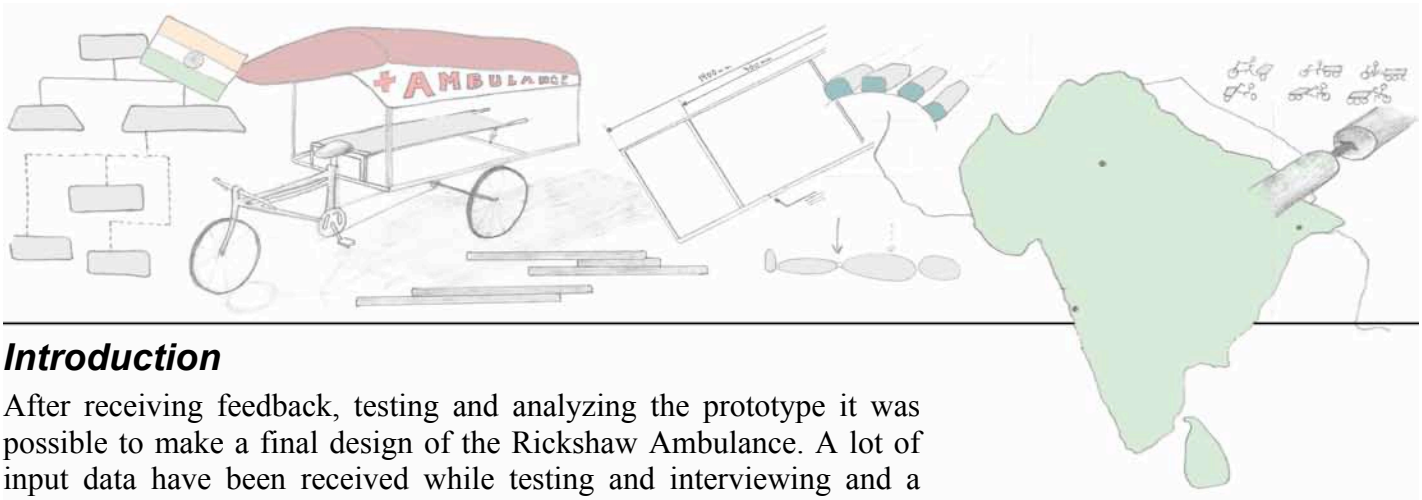
Conclusion on prototyping

Constructing a prototype of the concept proved to be one of the most important steps in the design process. It provided a unique insight in the manufacturing process and revealed many disproportional aspects of the initial design.

The quantitative vibrations and speed tests served as planned as a proof of concept. Patient vibrations showed to be dampened from “bumpy” to “smooth” according to relevant literature. The speed tests revealed that the concept was not too heavy, and that it is possible to ride the ambulance holding a respective pace over a longer distance. The many positive user reactions further added weight to the argument that the design works almost as intended. This leads to a step in the development process where it will be sufficient to make smaller adjustments and add-ons, avoiding any larger changes to the design.

The prototype was tested under near-real circumstances even though it will not stand its real test before after departure where it is donated to a community and tested in real operation.
Both qualitative and quantitative tests were conducted and all layers in the social hierarchy were drawn into the evaluation process. This revealed many new needs and ideas for improvements, which will be processed in the next section.

Developing the final concept



Introduction

After receiving feedback, testing and analyzing the prototype it was possible to make a final design of the Rickshaw Ambulance. A lot of input data have been received while testing and interviewing and a systematic approach was important in order not to forget any of the suggested adjustments. For this a third version of the design specifications was used.

Design specification version 3

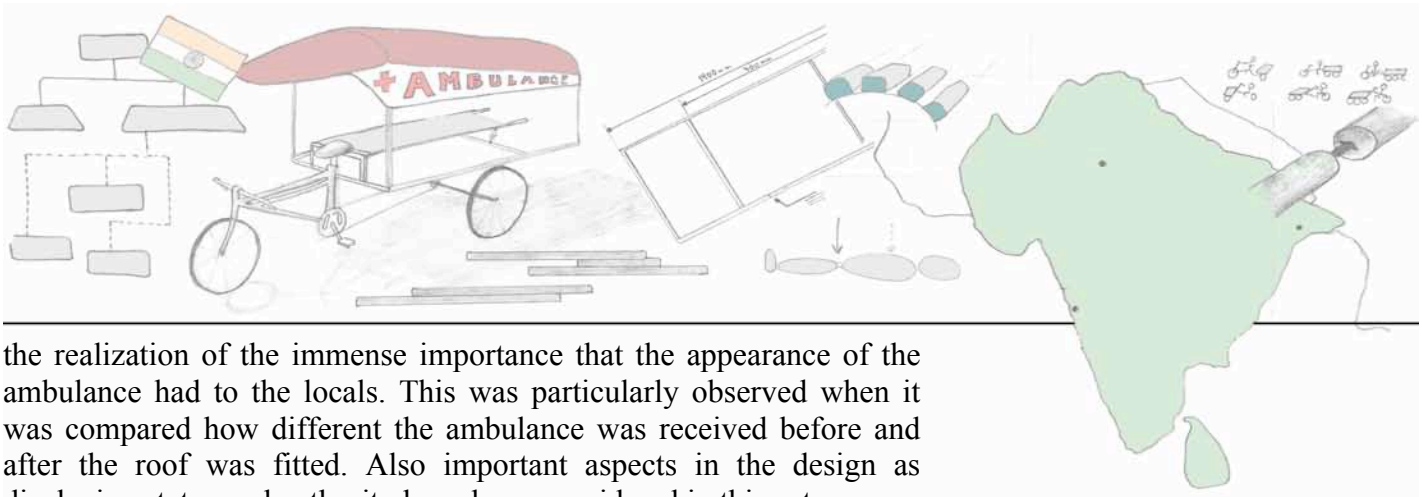
To analyze the above-mentioned results in a systematic way, a third and final set of design specifications was created. A full list of specifications can be found in appendix A6 and the first few can be found in Figure 47. This is the result of all observations, research and feedback obtained during the project and it thus reflects the requirements and criteria for the ambulance as perceived by the project group.

Design specification version 3.0 (Final specification)

	Requirements	Criteria	Comments
Construction			
Stability		Vibrations are kept at a minimum	Damping and shock absorption implementation
Usability	The AMB can be used both day and night	A lamp lights the road in front of the AMB.	The driver is able to orientate himself at all times.
	The AMB is operated by a single man.		
	The AMB carries a load of 100 kg.		
	The AMB fits two additional passengers.		Count: patient, driver, two relatives.
	There are two handles hanging from the roof.		Enabling the patient to sit up by his/her own force.
Visibility		The AMB is	A bright color

Figure 47: Design specifications V3, appendix A6

The largest change in the specifications is the addition of the new overall category named "*Appearance*". This category was added due to



the realization of the immense importance that the appearance of the ambulance had to the locals. This was particularly observed when it was compared how different the ambulance was received before and after the roof was fitted. Also important aspects in the design as displaying status and authority have been considered in this category.

Other than the new category three new requirements were added. Two take into account the large pregnant women patient segment, by adding handles for the patient to sit up by herself along with emergency equipment for delivering a baby in transit, stated in the mother group workshop, appendix B36. The last requirement are mudguards added to the design for use in the rainy season. Apart from these new specifications a number of smaller alterations were likewise made, mainly to ease the general understanding of the specification.

Detailing

The detailing section addresses the suggested changes found in appendix A28, and decides how and why to implement them. The detailing solemnly addresses changes related to the development of the concept and e.g. finding a good driver to operate the ambulance is therefore not the scope of this section.

Relatives seat

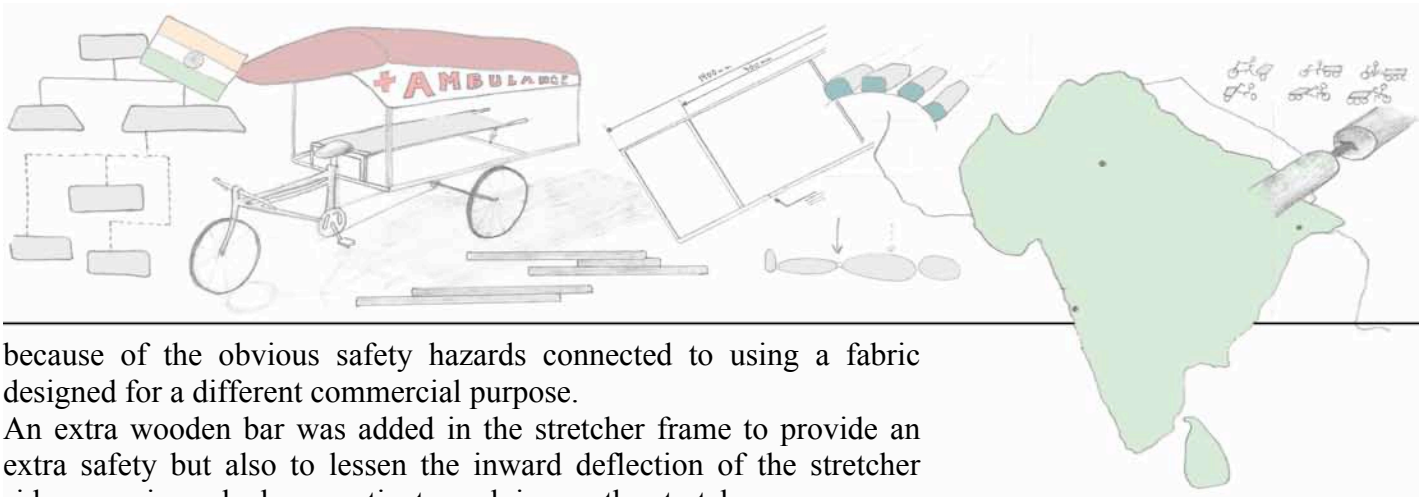
Objections with the relatives' seat were encountered countless times, and were mentioned by almost all actors. From this it was evident that a revised solution had to be thought out to comply with the users needs.

The main point made was that the seat was simply not large enough for a person to sit comfortably, but the overall design was fine. To accommodate this need the seat was enlarged 5 cm in width on each side and 5 cm in depth. To reduce the weight added the depth of the middle section of the seat was reduced.

Stretcher

Many improvements were suggested to the stretcher, mainly in relation to the fabric used. The changes on the second version of the stretcher therefore include the application of a sturdier stretcher material, the addition of an extra wooden bar, perpendicular to the longitudinal direction and cross straps instead of straight straps to fasten the patient onto the stretcher.

The stretcher material was chosen to be a heavy cotton duck canvas (Olsen, 2011; Eastex, 2011), with a synthetic fabric on one of the sides to prevent ripping of the material. A sturdier material was implemented



because of the obvious safety hazards connected to using a fabric designed for a different commercial purpose.
An extra wooden bar was added in the stretcher frame to provide an extra safety but also to lessen the inward deflection of the stretcher sides experienced when a patient was lying on the stretcher.
The cross straps were implemented after meeting with Falck's leading physician in India, Rahul Kalia. In his experience they tend to work better than the straight ones, because they also fix the patient in the longitudinal direction (see interview in appendix B43). Rahul also suggested the use of a prefabricated, commercially available stretcher, but after researching on this it was found that this would not be economically possible.

The suggested changes which were not implemented were; the idea of a collapsible stretcher, the shortening of the stretcher and more room for the patient.
The collapsible stretcher idea was posed by Dr. Amitava, but it was not implemented due to added complexity and because the practical application of it is uncertain. The idea was to make it possible to get through a narrow doorway with the stretcher to get a patient.

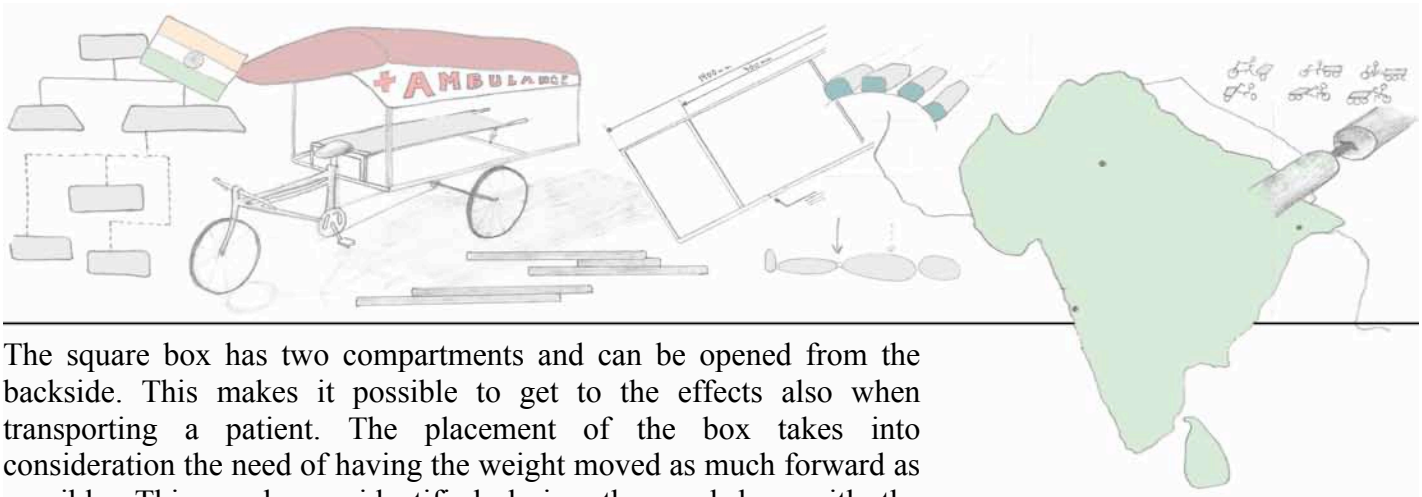
"Some houses it will be hard for the stretcher to get into if the stretcher is not expandable" (From appendix B34, prototype review with Dr. Amitava)

However if the stretcher in its full width cannot pass through the doorway on the way in it certainly cannot get out with the patient either, making the use for the collapsibility redundant.
It was also suggested by Dr. Amitava to shorten the stretcher because the average Indian is not so tall.

"Oh they [the patients] *can just bend their legs. Or the bottom of the legs can be outside the ambulance"* (From appendix B34, prototype review with Dr. Amitava)

This change was discarded because the design has to accommodate everyone.
No more room were added for the patient, because 0.6 m across is a standard stretcher measurement (Callahan, 2010) and more room would make it more difficult to fit the relatives.

Storage box
To hold all of the suggested medical and maintenance effects, it was decided to construct a storage box and situate it on the middle piece of the relatives' seat, underneath the head of the patient.



The square box has two compartments and can be opened from the backside. This makes it possible to get to the effects also when transporting a patient. The placement of the box takes into consideration the need of having the weight moved as much forward as possible. This need was identified during the workshop with the kitchen-staff (appendix B33).

Mudguard

The need for installing mudguards on the rear wheels in the wet season were expressed by Amitava, and due to the relatively low complexity and price this adds to the design, it was decided to implement it.

Aesthetics

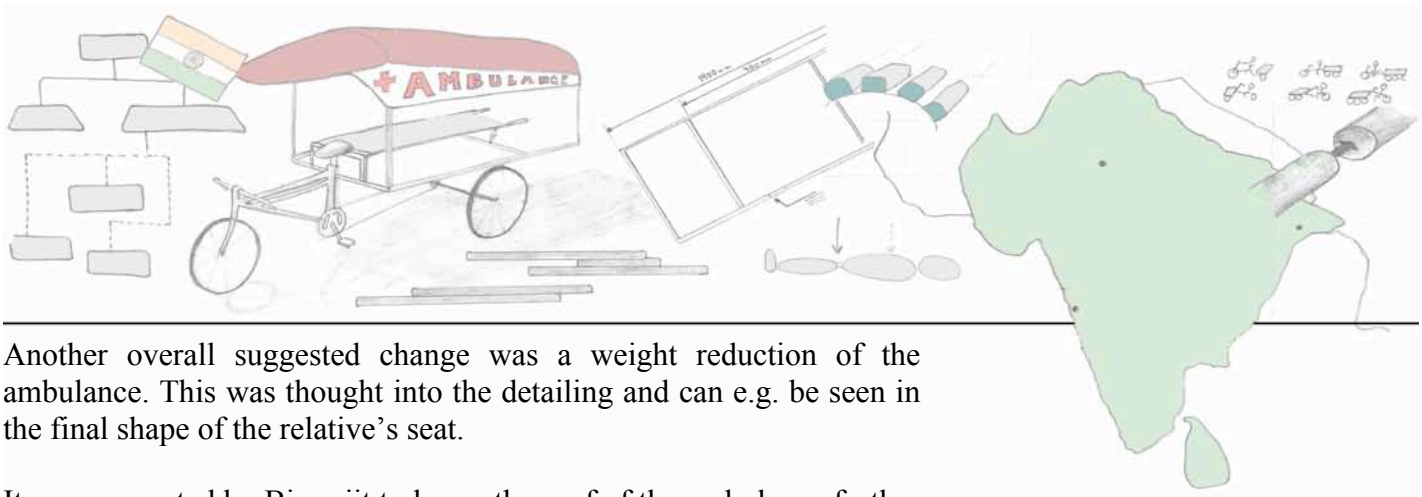
Biswajit and several other actors suggested that practical details and information in the form of placing the phone number of the ambulance and the logo of JGVK on the side were added. Both of these details make sense. The phone number should be there to inform the surroundings of the availability of the ambulance, and the logo creates a sense of ownership. The logo will hopefully ease the acceptance of the ambulance in the local area, as JGVK is a much appreciated and respected organization there.

It was also suggested that the logo of DTU and Falck were put on the side alongside JGVK, but it was decided not to implement this change. It could create unwanted attention and reduce the sense of ownership for the central actors.

Overall frame changes

When performing the workshop with the kitchen staff the need for smoother sliding of the stretcher into the inner frame was identified. Also the kitchen staff pointed out that moving the larger part of the weight closer to the driver would make the ambulance easier to handle for the driver. The mother group expressed a desire to have a secondary handle to hang from the roof to aid the patient in sitting up.

All of these suggested changes were implemented in the final concept by various means. Firstly the large L-profiles where the stretcher rests were honed with sandpaper to remove the paint and make the surface smooth and even. Second the relatives' seat was kept at the current position to move as much weight forward as possible. Third a thick cotton string was added, hanging from the roof and enabling the patient to sit up more easily. The string is fastened to the roof hanging down from one side to the other straight above the chest of the patient. When there is no need for it, it can be tucked away under the arches supporting the roof.



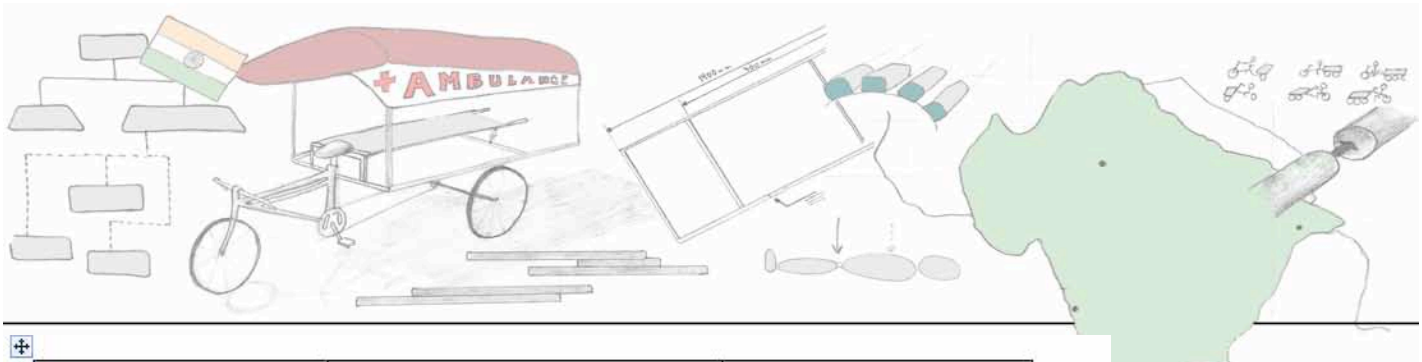
Another overall suggested change was a weight reduction of the ambulance. This was thought into the detailing and can e.g. be seen in the final shape of the relative's seat.

It was suggested by Biswajit to lower the roof of the ambulance further to reduce wind resistance when the ambulance is driving. This change was not implemented for more than one reason; First of all lowering the roof further would make it more difficult to load and unload the stretcher with the patient, because the back end would block the vision of the people carrying the stretcher. Second of all the relatives would have a hard time fitting underneath the roof when sitting and caring for the patient. Lastly the roof needed to be high enough for the driver to sit under, consequently making the gained wind resistance reduction by lowering the rear larger.
However since it is hard to estimate the effects of wind resistance, from changing weather conditions and such, another solution was discussed. Should the need arise it was decided to cut holes in the back-end roof cover along the last arch. This would enable wind to flow freely through the ambulance thus not creating any notable drag or opposite force to the direction of the ambulance movement.

Project group realization
After operating the ambulance at several occasions and during a number of tests the project group realized some changes that would make the usability of the ambulance better.

A small hook on the outside of the roof supports were added to hold the side covers when they are rolled up. Likewise a rubber band attached to the roof support was added to hold the side covers when they are rolled down. The length of the chain holding the split that secures the stretcher was reduced and the thickness of the split was enlarged to make it a tighter fit.

In order to ease the overview of the changes made and the changes that were discarded a third column was added to the suggested changes overview, appendix A28, where the status of implementation has been described. The principle of the result can be seen in Figure 48.

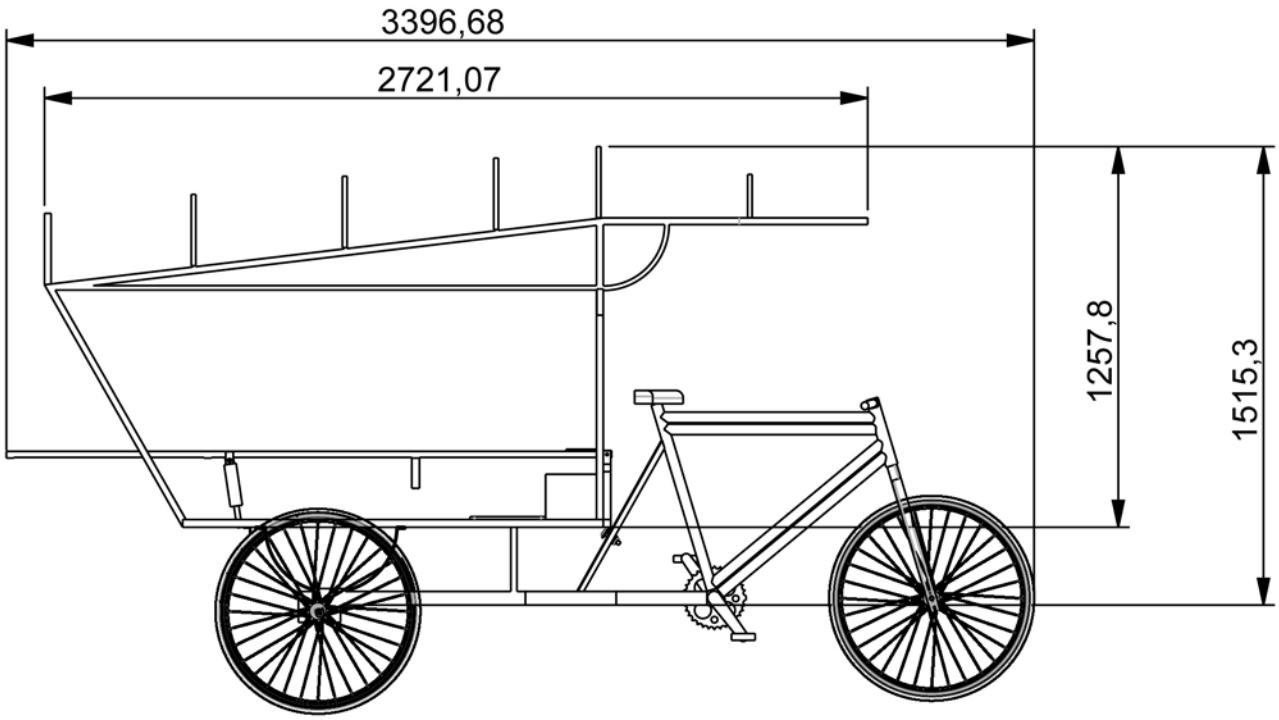


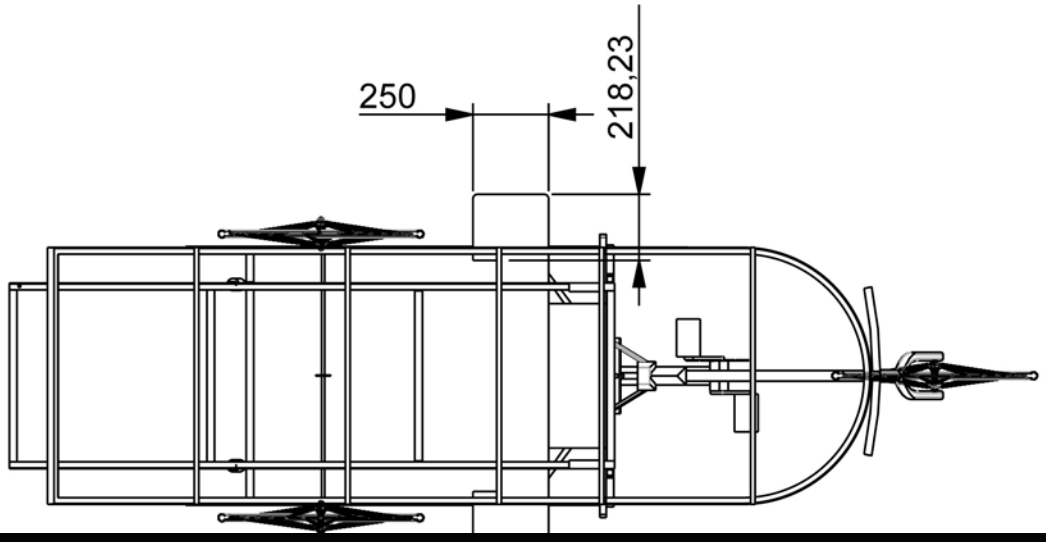
Suggested change	Source	Status
New design of relatives seat	Amitava, questionnaire, mother group workshop, Biswajit, Ashim	Implemented
Two fasteners for oxygen tank	Amitava	Implemented in first design
Stretcher needs to be collapsible	Amitava	Not implemented due to higher complexity, price
Weight reduction by reducing stretcher length	Amitava	Not implemented due to the fact that we need to design for everyone in the area
Box for drivers possessions	Amitava	Implemented

Figure 48: Added column, appendix A28

Conclusion

All feedback and test results have been considered, and necessary adjustments have been made. The conclusion on the prototyping was that only smaller corrections were necessary, and these have now been implemented. The main changes included the redesign of the relatives' seat and the addition of details as a better roll-up system for the ambulance sides. The next section will give a description of the result and serve as a final concept description.





The Rickshaw Ambulance

SCALE 1:25

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DB-name:	CONNECTED	Matr: 1	Mas
Title:	Rickshaw Ambulance		
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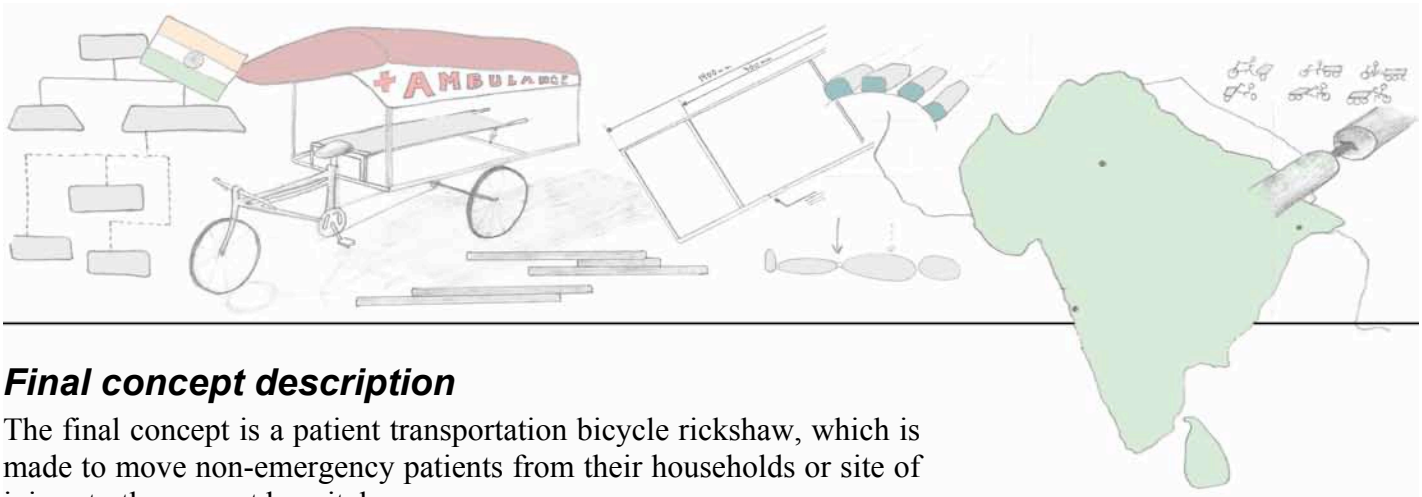


Final concept description

The final concept is a patient transportation bicycle rickshaw, which is made to move non-emergency patients from their households or site of injury to the nearest hospital.

The Rickshaw Ambulance will be outfitted with equipment to do first aid and basic pre hospital treatment. This includes water, sheets, bandages, a razorblade (if a baby is delivered under transportation), saline bags, disinfection fluids, latex gloves and basic medicine as painkillers and antihistamine. The equipment will be placed in a box just between the drivers'- and relatives' seat.

The ambulance is designed to operate in a harsh and varying climate with temperatures as high as 50 degrees Celsius in the dry season and large flooded areas in the rainy season. This means that the driver and patient are covered by a roof to protect them against sun and rain. The stretcher is placed more than one meter above the ground, which enables the ambulance to drive through flooded areas without harming the patient.

The stretcher can easily slide in and out of the two L-profile rails from the back and a lock-split system similar to the one on the prototype ensures that the stretcher is safely locked in all directions during transportation. The stretcher rests on a frame, which is suspended in a swing arm suspension system using two scooter coil springs.

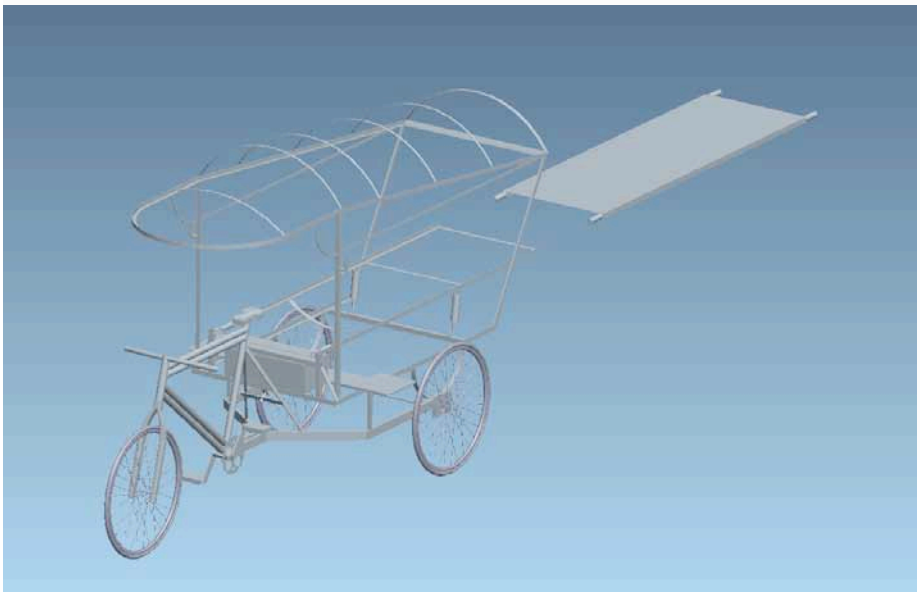
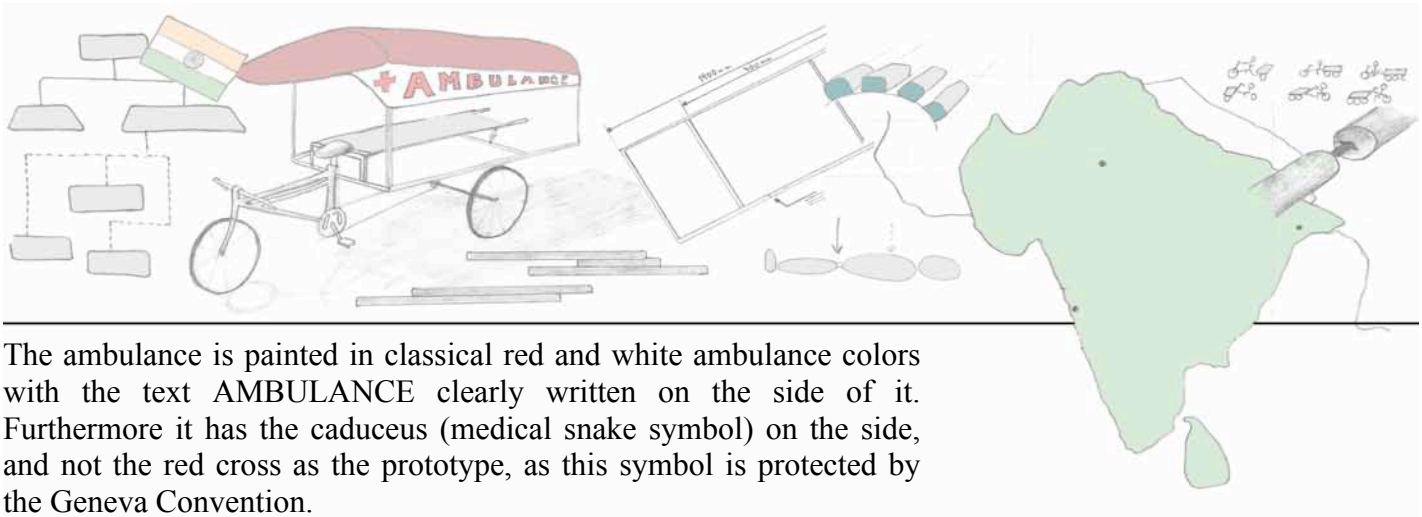


Figure 49: Final concept construction drawing



The ambulance is painted in classical red and white ambulance colors with the text AMBULANCE clearly written on the side of it. Furthermore it has the caduceus (medical snake symbol) on the side, and not the red cross as the prototype, as this symbol is protected by the Geneva Convention.

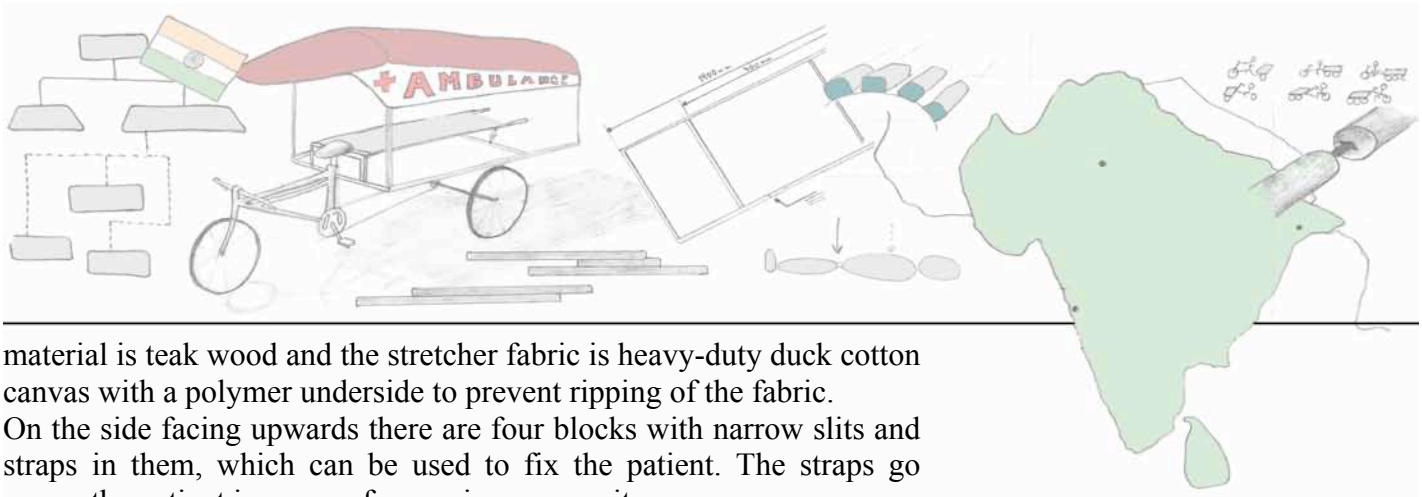
All materials on the ambulance are locally available and it has been ensured that all manufacturing processes used to manufacture it are offered in the local area.

Technical description of the lower part

The outer frame (OF) rests on the U-supports, which rests on the naves of the wheel. The front of the frame, closest to the driver furthermore rests on a sturdy V-support made of a flat 5 x 0.5 cm steel profile. There are three rods connecting the two sides.
Supporting the rotary joint are besides the two vertical L-profiles two angled flat steel profiles that connect to the corners of the OF. The horizontal L-profile that connects the vertical ones is positioned approximately 10 cm below the top of the vertical rods, where screws connect to the inner frame, allows free rotation.
A flat fastening joint connects the front of the OF to the two angled cylindrical steel rods from the bicycle frame.
The new relatives' seat is mounted on the outer frame with screws, and is made of a single piece of wood that passes under the head of the patient. In the middle there is a utility box, which can be opened from either side and holds necessary medical equipment and birth giving utensils.
The suspension is slightly backwards angled and rotates on screws that connects to two square steel pieces, which are welded onto the OF.

The inner frame (IF) consists of two large L-profile sides connected by three rods where one, straight beneath the back of the patient is downwards sloping. At the front two round encasings can fix the handles when the stretcher is slid onto the frame. At the back end a small vertical hole in the L-profile, indicates the position of the split, which hangs from the side in a short chain that is welded onto the profile.
The sliding surface of the stretcher has been honed with sandpaper to make the sliding smoother.

The stretcher is a new version of the old stretcher design. It consists of a rectangular frame and a single supporting bar that is situated approximately 2/5 of the way from the bottom of the stretcher. The



material is teak wood and the stretcher fabric is heavy-duty duck cotton canvas with a polymer underside to prevent ripping of the fabric.
On the side facing upwards there are four blocks with narrow slits and straps in them, which can be used to fix the patient. The straps go across the patient in a cross for maximum security.

Technical description of the upper part

The roof is almost unaltered using the same design as for the prototype. That means a downward sloping arched roof with a shade for the driver. In the front the roof is supported by two vertical support, which connects to the corners of the OF. The back end is supported by angled supports also connected to the corners of the shortened OF.
The colors are red for the roof and text and white for the sides. The red cross is substituted with the caduceus (medical snake logo) and the logo of JGVK can be found on the side. The words “AMBULANCE” and the number of the driver are likewise printed on both sides of the ambulance.

Production manual

The Production manual is what the name implies; a guide for craftsmen on how to produce and reproduce the Rickshaw Ambulance. Complete with illustrations and short and precise directions the manual provides an easy overview of the manufacturing processes. The manual can be found in the booklet provided along with this report titled “Production Manual – Rickshaw Ambulance”.

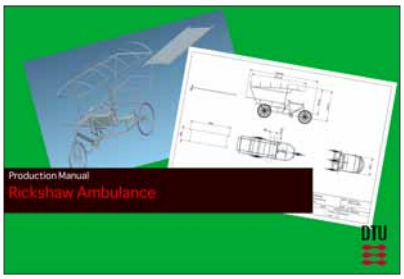


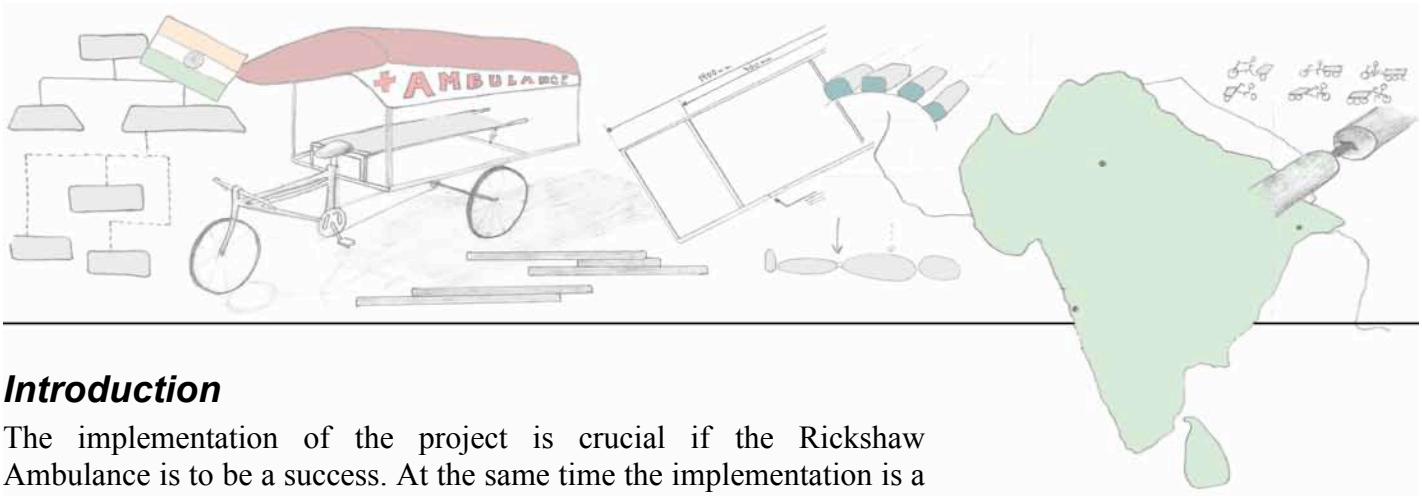
Figure 50: Production manual front page

Conclusion

The product development phase of the project is now complete and no further alterations to the design will be made in this project. It is expected that the need for new adjustments will arise when the Rickshaw Ambulance is taken into actual use, but it can be concluded that the current design serves the users very well, as all design specifications have been met.

In the following section the implementation of the Rickshaw Ambulance from an organizational and economical point of view is looked into, in order to justify the sustainability of the Rickshaw Ambulance-project.

Implementation



Introduction

The implementation of the project is crucial if the Rickshaw Ambulance is to be a success. At the same time the implementation is a very complicated problem, involving socio-technical, cultural and economical aspects, and a complete analysis of how the ambulance should be implemented is not the scope of this report. This section will however work as a justification of the economical sustainability of the ambulance and will try to provide a short description of how the infrastructure of the Rickshaw Ambulance network could be set up.

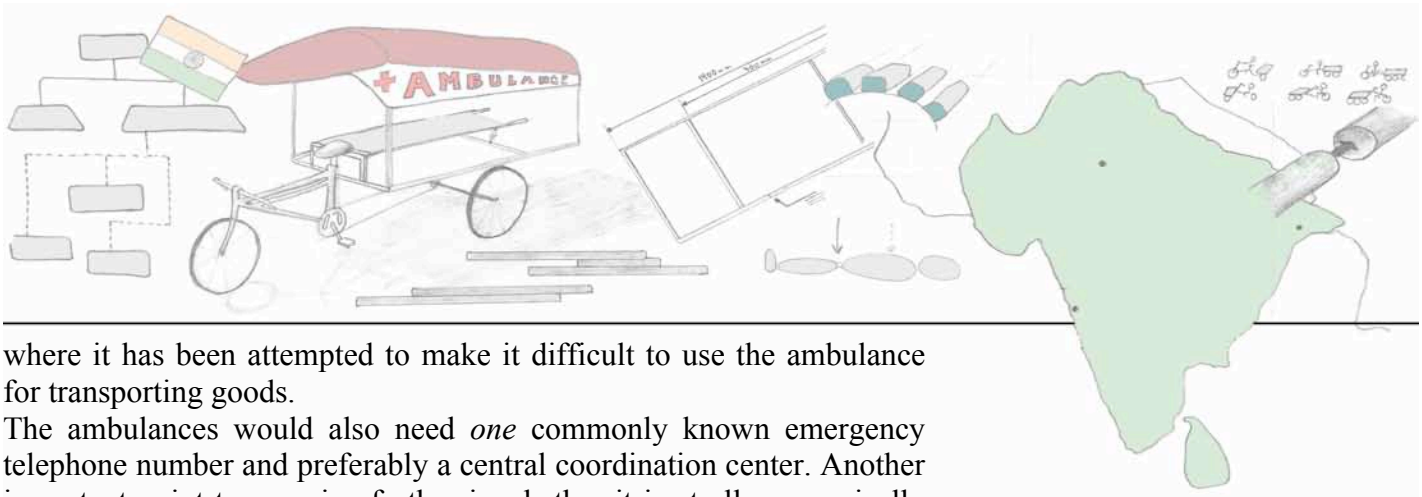
The infrastructure

In West Bengal, India there is no public ambulance system, and if a villager in Sunderbans needs to go to the hospital (for a medical check or in an emergency situation) this person would have to pay for transportation himself. In the area a number of NGO sponsored car-ambulances are operating (see section 4: What makes an ambulance in India), but to use them the patient will need to pay a fee of about 1500 Rp. This is way more than the average family, estimated to earn only 40 Rp a day, can afford. The main users of the Rickshaw Ambulance were therefore identified as the locals who cannot afford the fee for the car-ambulance service, and the ones living in areas where the car-ambulance cannot go due to bad road conditions (see appendix B10, B11 and B12).

Figure 51. Service area.
Blue: Ambulance center
Red: Hospital
Green: JGVK Center
© Google maps

The average speed of the ambulance (brick roads) has been tested to be 8km/h and the service area is at most 15 km south from the hospital (see Figure 51). This gives a response time of approximately 2 hours if there were only one ambulance situated at the hospital. This calls for another solution. One could place several ambulance centers on the island an idea, which was also suggested by Amitava and backed up by Biswajit at other occasions (appendix B13). Figure 51 shows an example of how this could be done, where the blue dots symbolize six ambulances operating from six different village communities. The red and green dots symbolize the hospital and the JGVK center respectively. This would give a response time of about 10 minutes for most areas on the island. The question is now whether there is enough business for this system to be sustainable, but that would have to be analyzed further before a conclusion can be reached.

If this should however have any chance of success it is very important to hire reliable drivers, who will not use the ambulances for other services than ambulance driving. This is also included in the design,



where it has been attempted to make it difficult to use the ambulance for transporting goods.
The ambulances would also need *one* commonly known emergency telephone number and preferably a central coordination center. Another important point to examine further is whether it is at all economically feasible, and this is considered in the subsequent section.

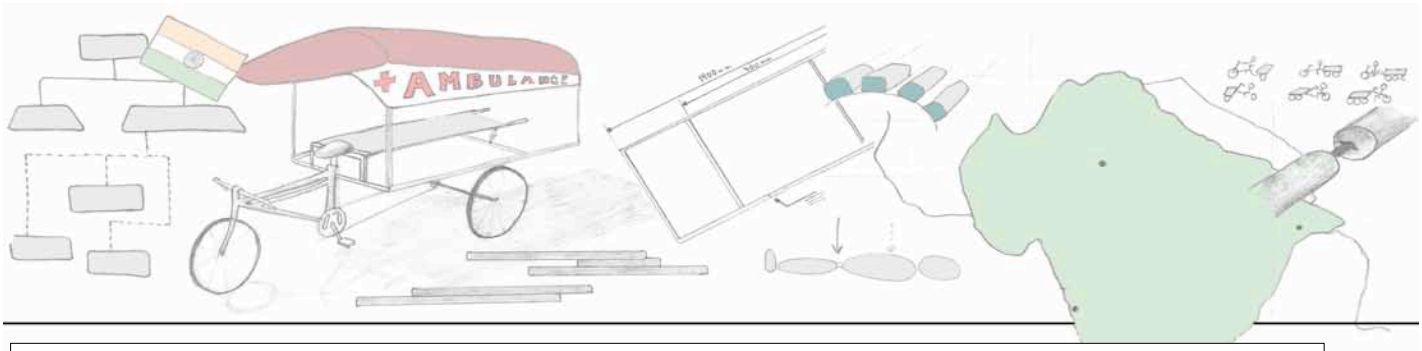
Due to political instability in the area the implementation of the ambulance was delayed. This unfortunately caused a lack of information about implementation and operation of the prototype in actual emergency situations.

Economy

The far most important part of the implementation is to make the ambulance economically sustainable. A way of financing it could be by issuing micro loans, but if the village communities should concede to this they would have to be certain that the ambulance is capable of earning enough money to pay the bills to the bank every month.

A calculation of the payback period (Hedegaard and Hedegaard, 2009) has been conducted assuming the following: The driver will get a fixed wage of 30 Rp a day, even if there are no emergencies, and he will furthermore receive 50% of the income from response calls. The average price is 80 Rp per response call and the price for night transportation is set to 200 Rp. The calculations take into account 300 Rp in maintenance cost every 6^{th} month.

The price of the ambulance is calculated to be 13.000 Rp. The prototype cost was approximately 16.400 Rp, but several of the expenses will decrease if an actual production of the ambulance is to be initiated, see appendix A27 for calculations of prototype and projected expenses.



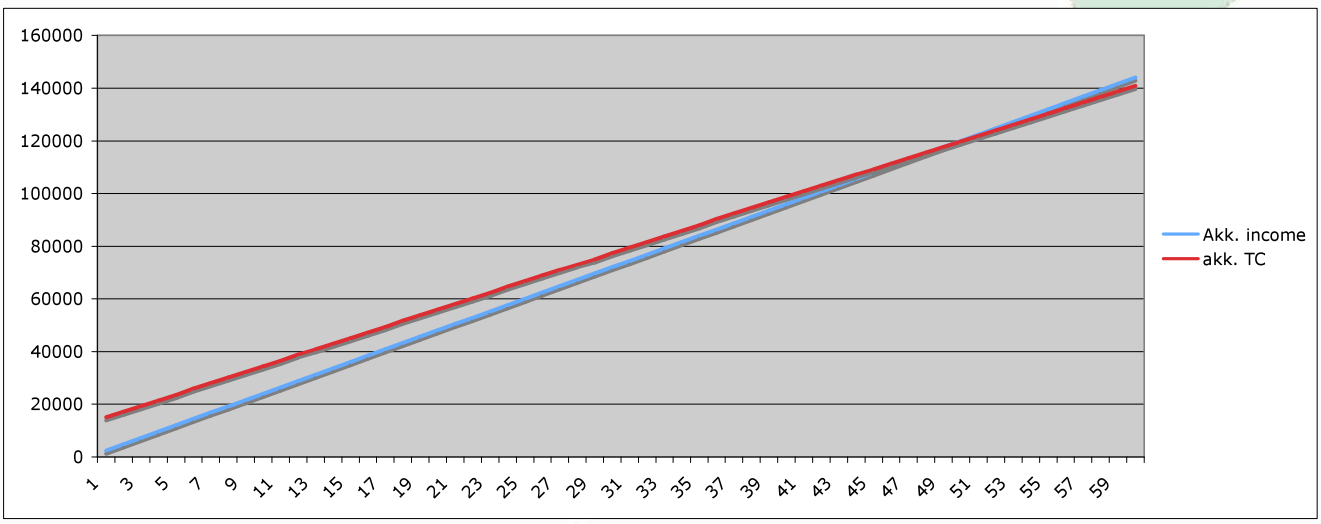


Figure 52: Payback period, Model 1, appendix A29

As seen in Figure 52 the ambulance will have a payback period of 50 months, assuming the above-mentioned factors. This corresponds to 4 years and 4 months. Since the estimated lifetime of the ambulance without any larger maintenance costs is approximated to 5 years the ambulance actually ends up making money in the last 8 months. The calculation assumptions are set at a low level, and the village community will very likely be able to put more money aside every month for unforeseen repair costs.

Another model was likewise considered. This model is based on the idea that the driver should be rewarded for staying in his job throughout the lifetime of the Ambulance. This would ensure competent and dedicated drivers.
Model 2 assumes the same income values as Model 1, but has another driver salary system. The driver earns 20% of the income from response calls the first year, 50% the second and third year and 70% from the fourth year and all subsequent years.

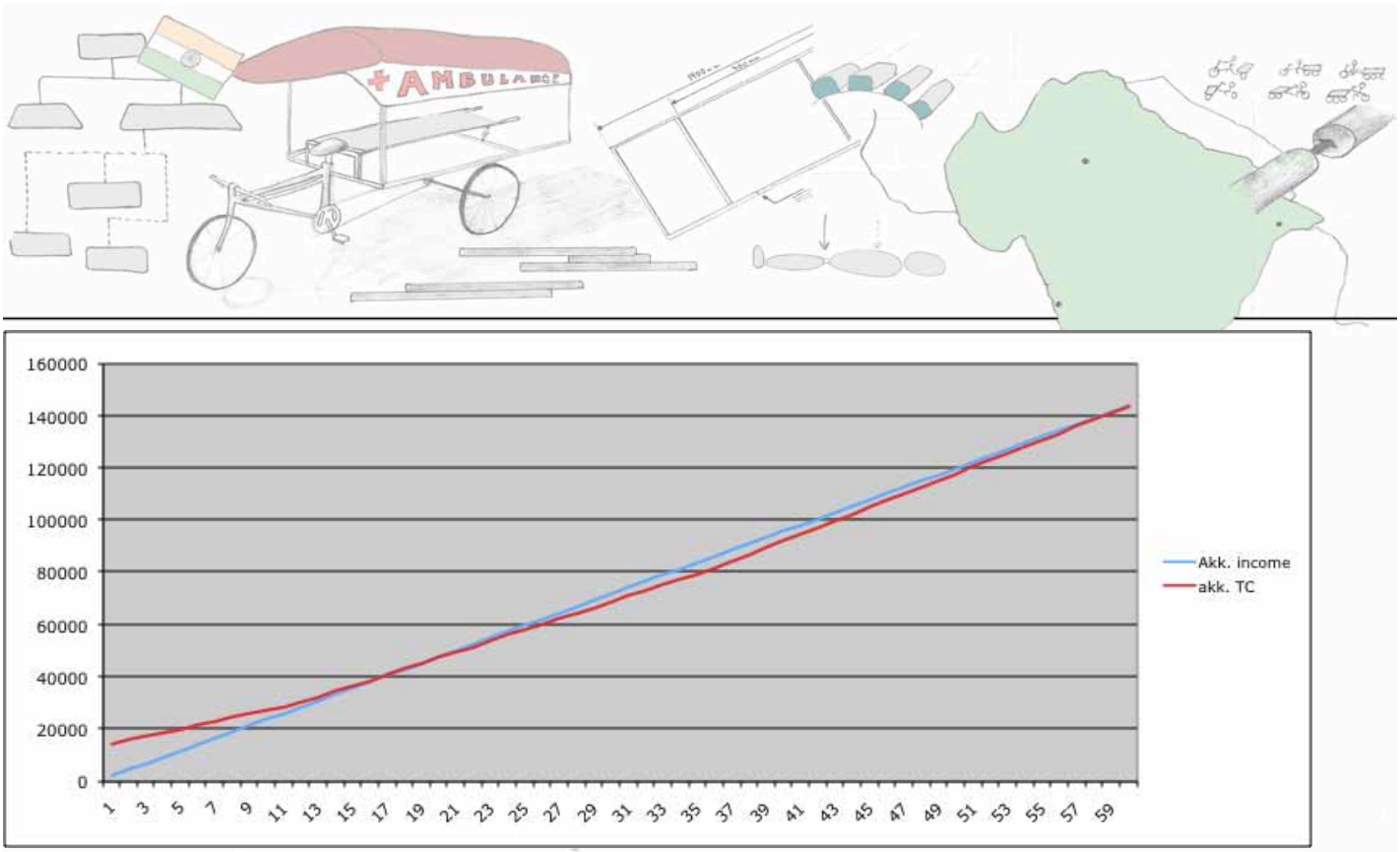


Figure 53: Payback period, Model 2, appendix A29

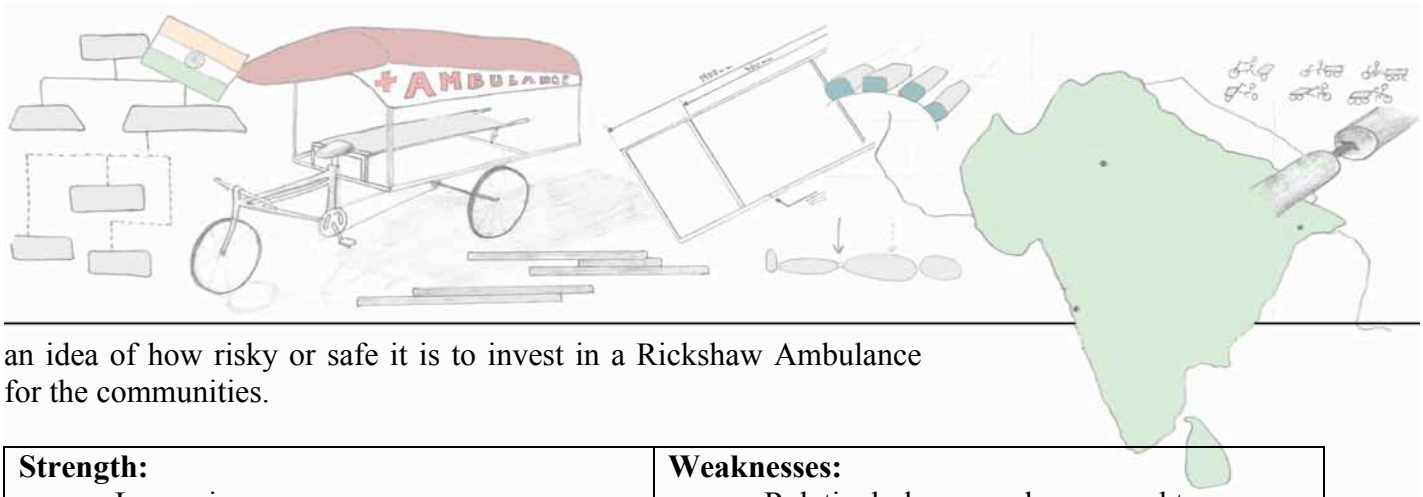
Using this model it can be seen that the payback period is a measly 17 months, which is considerably less than for Model 1. Also the ambulance actually generates profit from the 17th month to the 62nd month. Should the ambulance however last for longer than 62 months the accumulated total cost will surpass the accumulated income and the ambulance will begin to loose money. However the ambulance lifetime is estimated to be 5 years so for this assumption the community only makes money, with this model.

Each of the models has their strengths and weaknesses. If the community could convince a driver to accept the second model this would greatly reduce the risk of investing in the ambulance for the community. The risk is then moved to the driver who has to gamble on whether he will be able to operate the ambulance for the total 5 years. The strength of Model 1 is that it is easier to understand, and fits better with the mentality of the local farming population who are generally not used to thinking in long term economical plans.

The estimated income factors are set relatively low in both models, and assuming that the communities will accept the idea of the Rickshaw Ambulance it can be concluded that the project is economically sustainable.

SWOT analysis

To formulate a systematic evaluation of the ambulance a SWOT analysis is performed (Andersson et.al, 2005). A SWOT analysis gives



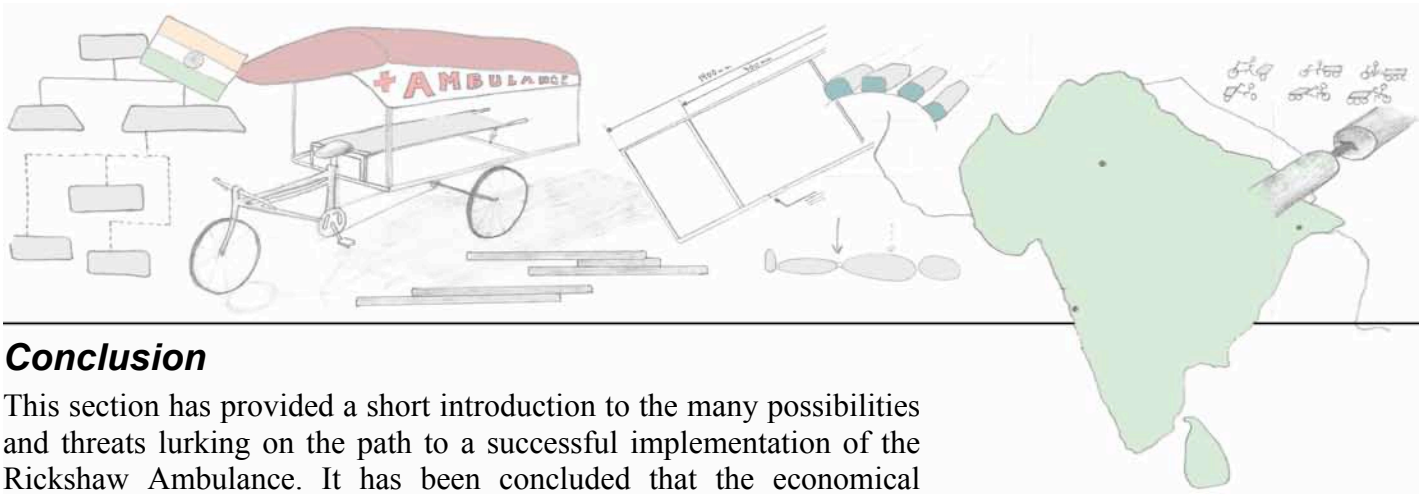
an idea of how risky or safe it is to invest in a Rickshaw Ambulance for the communities.

Strength: - Low price - Can enter areas where motorbikes or car-ambulances would get stuck. - More comfortable than a van-rickshaw or motorbike. (Cover for rain/sun and fixation of the patient will prevent symptoms as e.g. shock in a emergency situation) - Medical equipment onboard, which allows basic treatment of the patient at pickup.	**Weaknesses:** - Relatively low speed compared to car or motorbike - Does not protect the patient from rain and wind as well as a car.
Opportunity: - The local people discover the benefits of the public health care system and more people begin using the ambulance. - Creates a kind of unity in the village communities. - Creates jobs in the local area (ambulance drivers, mechanics, administrative staff, medical staff…)	**Threats:** - Implementation problems in the first phases resulting from a bad perception of the Rickshaw Ambulance in the communities. - Quack doctors telling the villagers not to use it because it takes business from them. - Bad drivers, charging over prices or not answering their phones, causing people not to use the ambulance. - The driver using the ambulance for goods carriage or other business causing the ambulance to be unavailable when patients need it.

Figure 54: SWOT analysis

As can be seen in Figure 54 the ambulance, and especially the implementation of the ambulance, faces a fair amount of threats. On the other hand the Rickshaw Ambulance has a lot of strengths making it superior, and in some cases the only option, compared to motorbikes, van-rickshaws or car-ambulances.

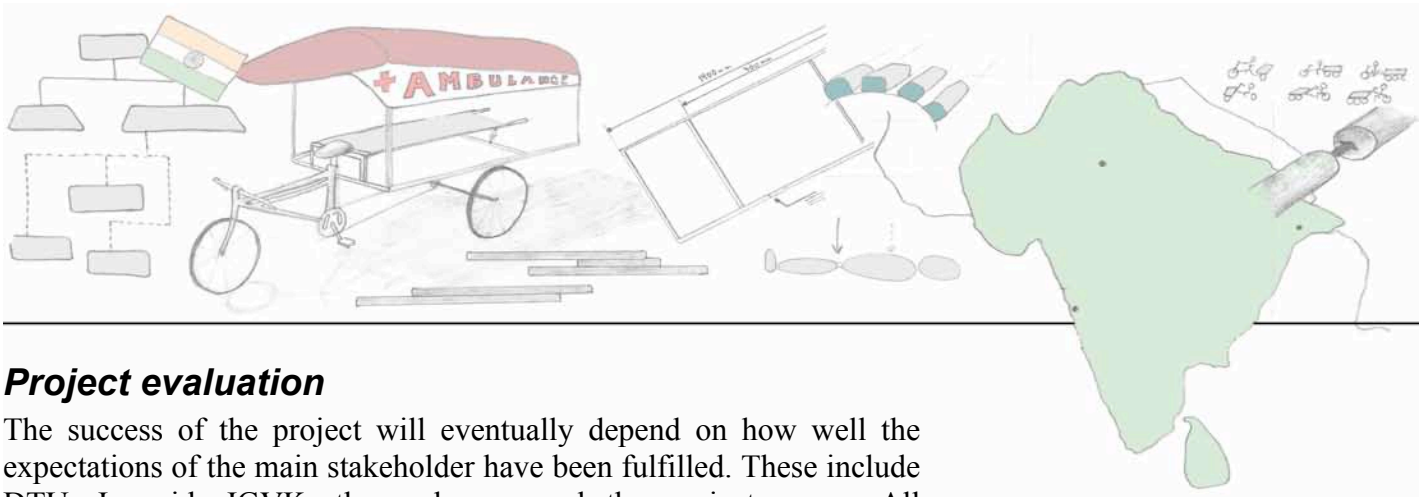
Being aware of the threats and adjusting the implementation plan accordingly will significantly reduce the risk of buying an ambulance. Information campaigns, proper drivers and lobbying in the implementation area will eliminate most of the threats and give the ambulance a great advantage in the form of its strengths and opportunities.



Conclusion

This section has provided a short introduction to the many possibilities and threats lurking on the path to a successful implementation of the Rickshaw Ambulance. It has been concluded that the economical perspectives of the system looks promising. Several implementation systems should be considered to motivate the driver and convince the village communities to invest in the ambulance. It is important to set up the economical system in close collaboration with the local communities. Designing this system in collaboration with the locals is just as important as doing the technical design with them.

Conclusion and Project evaluation



Project evaluation

The success of the project will eventually depend on how well the expectations of the main stakeholder have been fulfilled. These include DTU, Innoaid, JGVK, the end-users and the project group. All stakeholders had different interests in the project, and in the following the project will be evaluated from their individual perspectives.

The interest in the project from the point of view of the project group and DTU has been focused on the academic perspective and before the project was initiated a number of learning objectives were formulated. These can be found in appendix A2. When reviewing these it can be concluded that all of them have been achieved in a satisfactory manner.

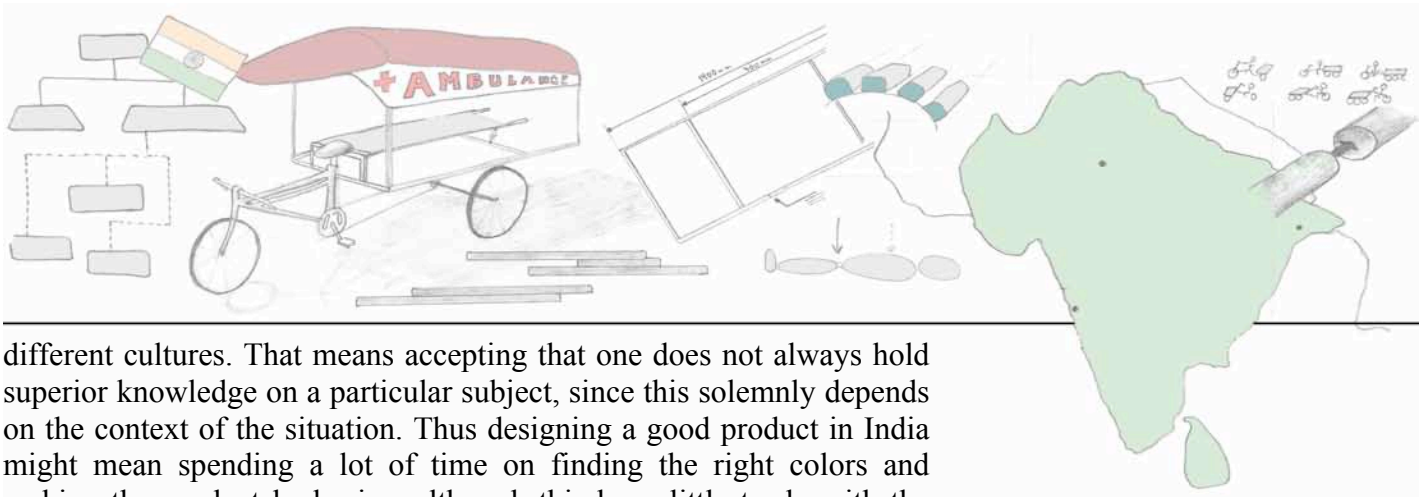
The interests of project owners, JGVK and InnoAid, have been focused on the more physical perspectives of the project. This was especially experienced during the stay in India where many resources were allocated to the project, to allow for the prototype to be finished within the limited time period. From this follows that the expectation of JGVK and InnoAid have been met, since a successful prototype was delivered to the local community. Furthermore a production manual and a full report, documenting the product development process was delivered to JGVK and InnoAid respectively.

It is too early to say if the local communities have gained anything from the project. This will however not show before the actual implementation of the prototype is finished and can be evaluated. It can however be concluded that a new idea have been planted in the community and hopefully this will inspire them to do similar projects in the future.

Final Conclusion

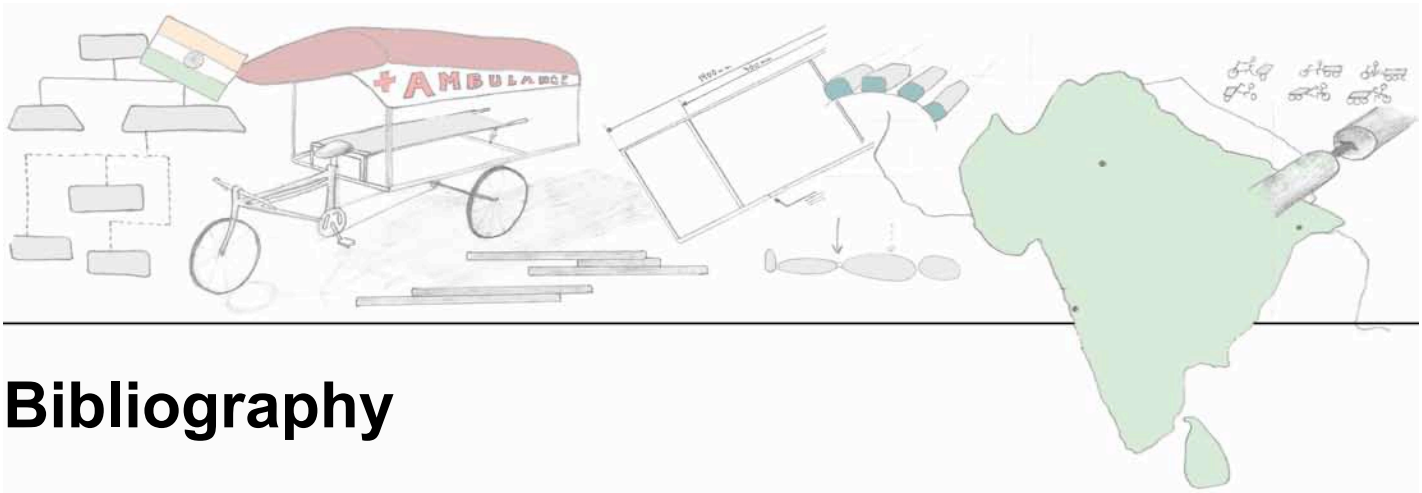
When working on the Rickshaw Ambulance the importance of working with the locals to create the product became evident. Being in India presented an invaluable first hand insight into the system in which the Rickshaw Ambulance had to operate. To identify the needs of the user is fundamental in developing a good product, and several important aspects came to the attention of the project group during the stay in the area. Especially interaction with the locals presented a great challenge, but the gain of overcoming it made it a challenge worth accepting.

Designing for the base of the pyramid is not as hard as it might seem. The key to success lies within the willingness to accept and take in



different cultures. That means accepting that one does not always hold superior knowledge on a particular subject, since this solemnly depends on the context of the situation. Thus designing a good product in India might mean spending a lot of time on finding the right colors and making the product look nice, although this have little to do with the performance of the object. Although this might seem irrational to the analytic western mind ("why sacrifice performance for appearance?"), it matters a great deal to the end users, which is argument enough to justify it. One always has to remember whom the design is meant for or else the whole process will simply be wasted.

This point was thought into the design of the prototype, which was received with overwhelming positive feedback. This leads the project group to believe that the current implementation of the prototype in an actual village community will have a similar successful outcome. If this is the case the actual production and implementation of the ambulance can commence and hopefully in a few years it will be a little easier to go to the hospital in Sunderbans.



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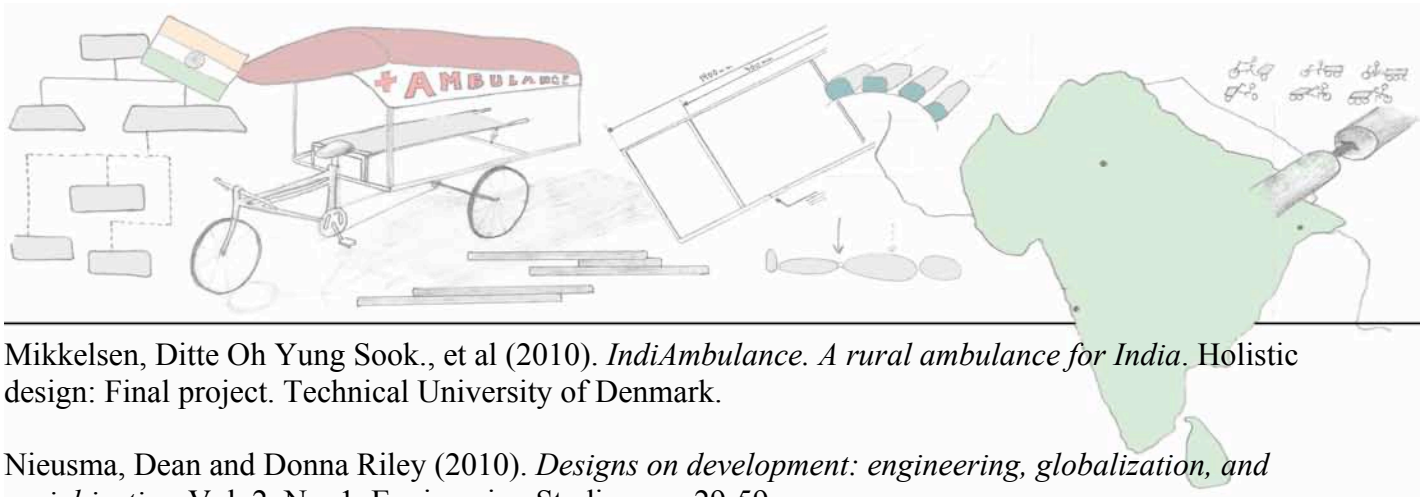

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