IDC School of Design
अभिकल्प विद्यालय

Design Project 2

# Designing an Organ Transportation Drone (Unmanned Aerial Vehicle)


Submitted by:

**Aditya Mahamuni**
22m2287

M.Des Mobility and Vehicle Design
IDC School of Design, IIT Bombay

Guided by:
**Prof. Nishant Sharma**

## DECLARATION

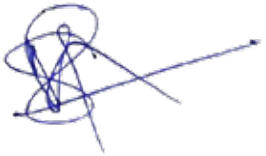
I declare that this written submission represents my ideas in my own words and where others ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated any idea/ data/ fact/ source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited of from whom proper permission has not been taken when needed.

Aditya Mahamuni
22m2287

Mobility and Vehicle Design
IDC School of Design, IIT Bombay

## APPROVAL SHEET

This Mobility & Vehicle Design Project II titled ‘Organ Transportation Drone’ by Aditya Mahamuni is approved in partial fulfillment of the requirements for Master of Design Degree in Mobility & Vehicle Design, IIT Bombay.

Project Guide: Prof. Nishant Sharma 

Chair person: 

Internal Examiner: 

External Examiner: 

## ACKNOWLEDGMENT

My project Design of ‘Organ Transportation Drone’ has been a great experience overall. It has taught me, Contribution of designer to provide better experience to the user, How to look at the problems faced by user and how to design for the people. All these wouldn’t be possible without proper guidance so I would like to sincerely thank my guide, Prof. Nishant Sharma for his valuable guidance throughout this project.

A big thank you to all the people who contributed to my project. Finally a huge thanks to all my classmates for the valuable inputs and feedback throughout the project.

## ABSTRACT

In the world of medical science, organ transplantation is a ray of hope that provides a lifeline to patients dealing with serious medical conditions. The success of organ transplantation hinges not only on the skill of surgical teams but also on the seamless and swift transportation of donated organs from donors to recipients. As the demand for organ transplants continues to surpasses the supply, the critical need for an expedited and reliable organ transportation system becomes increasingly apparent.

Traditional modes of transportation, by road or air, have inherent limitations that can risk the viability of organs and, consequently, the success of transplantation. The race against time, especially for organs with a smaller window of viability, necessitates a model shift in transportation methods. This is where the integration of drone technology emerges as a transformative solution, promising to redefine the landscape of organ transportation and, in turn, enhance the prospects of successful transplantations.

In this project, we delve into the intersection of organ transportation and drone technology, exploring the synergies that can revolutionize the way organs are transported from donors to recipients. By addressing the unique challenges posed by time sensitivity, geographic obstacles, and regulatory frameworks, our attempt seeks to establish a novel and efficient approach—Organ Transportation Drone. This project aims not only to bridge the gap between organ supply and demand but also to contribute to provide better experience in the system.

# CONTENT

# 1. INTRODUCTION

## 1.1 Organ Transportation

Organ transportation refers to the process of moving organs from one location to another, typically for the purpose of transplantation. When an organ donor is identified, and a suitable recipient is found, the organ needs to be transported quickly and carefully to maintain its viability and increase the chances of a successful transplant.

The transportation of organs is a critical aspect of organ transplantation, as organs have a limited window of time during which they can be preserved outside the body. This time frame varies depending on the type of organ. For example, the heart and lungs have a shorter preservation time compared to kidneys or the liver.

Various factors need to be considered during organ transportation, including temperature control, protection from damage, and adherence to strict timelines. Specialized transportation systems, such as organ procurement organizations (OPOs) and transplant coordination networks, play crucial roles in ensuring the safe and timely transport of organs. These organizations work closely with hospitals, transplant teams, and transportation services to coordinate the logistics of organ transportation.

Efficient and well-organized transportation is essential to maximize the number of viable organs available for transplantation and improve the overall success rates of organ transplants. Advances in transportation methods and technologies continue to play a significant role in enhancing the field of organ transplantation.

## 1.2 Organ Transplantation scenario in India

Organ transplantation is a medical procedure in which an organ is removed from one body and replaced in the body of a patient who has damaged or missing organs. The person who donates organ is called donor whereas a patient who receives it, is called the recipient. The donor and recipient may be available in the same location, or organs may be transferred from a donor site to the recipient site by a suitable method.

Successful transplanted organs to date :

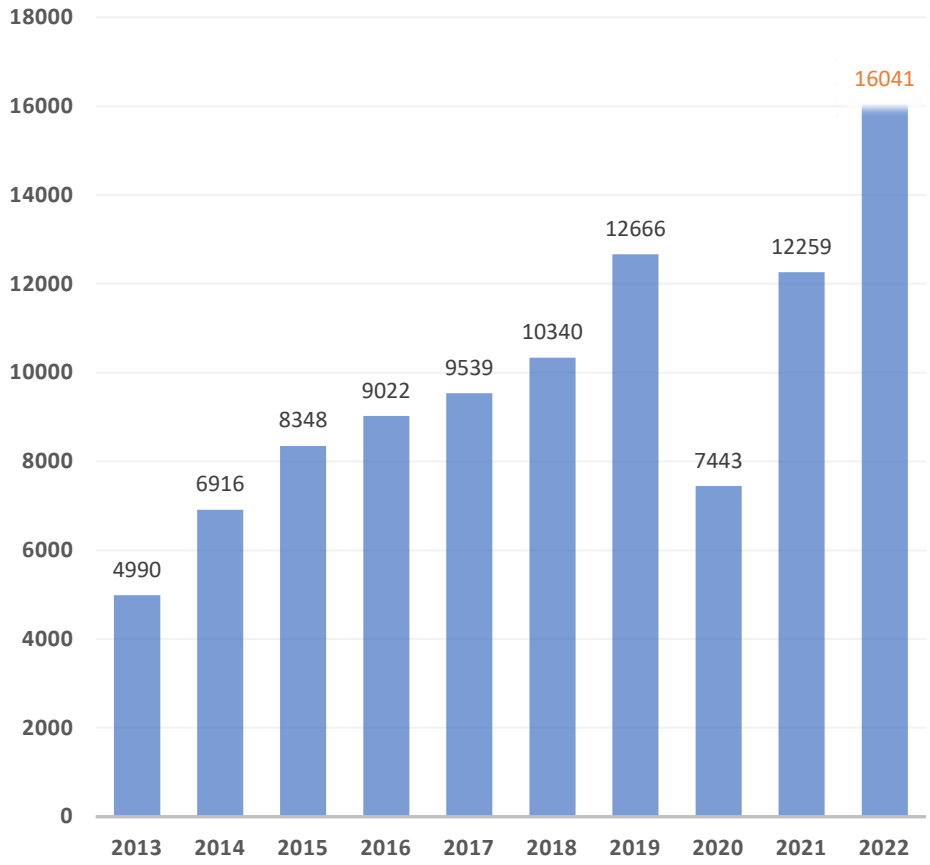
- Kidney
- Lungs
- Intestine
- Pancreas
- Liver
- Heart
- Eyes
- Uterus

Organ donors are living, or brain dead. Cadaver transplantation is the most challenging, complex and risky areas in the field of medical and surgical science. Overall transplantation requires patience, financial planning, ethical consideration, dedication and expertise of the medical team. It involves major risk of patient's life. But it is considered the most miraculous treatment of the century in the field of medical science.

Organ transplantation in India has been steadily growing in recent years, with increasing numbers of successful transplants being performed. According to the National Organ and Tissue Transplant Organization (NOTTO), there were 9,122 organ transplants in India between 2015 and 2020

## 1.3 Statistics of Organ Transplants in India

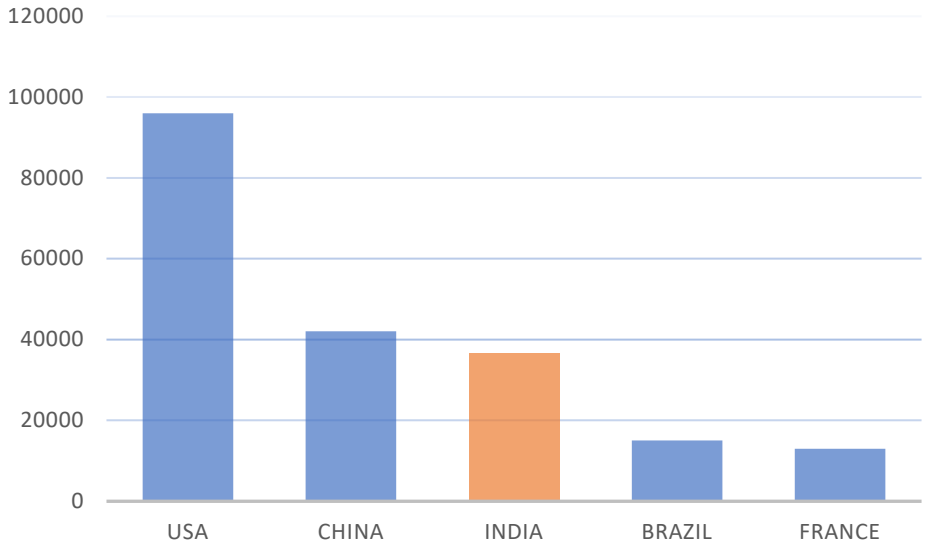
There is significant growth in the numbers of overall transplants in India with every coming year. There was a dip in the year 2020 due to the ongoing pandemic but soon after, the number was recovered and recorded and all time peak in the previous year



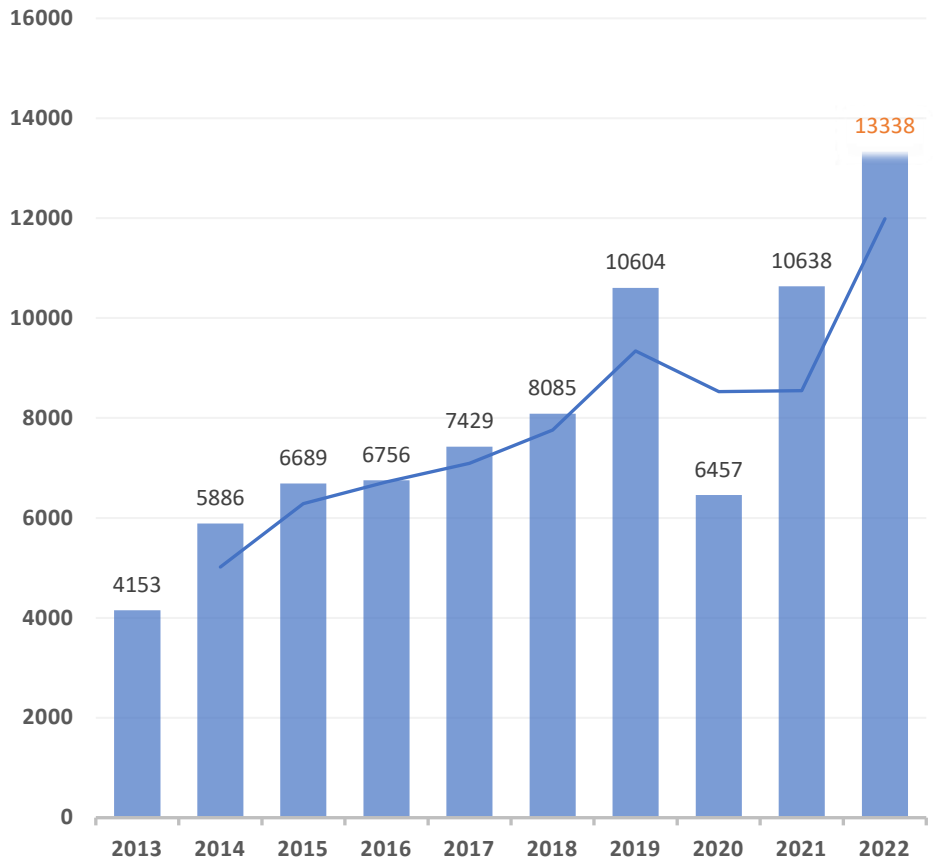

**Total Organ Transplant in India**

In 2022, there were around 16,041 organ donors in India, resulting in approximately 39,718 transplants. India is on third position globally in number of successful organ transplants

Transplant sum : Kidney +Lung+Liver+Heart+Pancreas+Small Bowel (Global.2022)




Number of transplants Globally




**Total Living Donar Transplant**

## 1.4 Living Donar Transplant

Number of transplants are significantly increased in 2022. In the total number of transplants the contribution of living donar transplants is very large.

The number is still pretty low compared to the actual number of patients. Who seek organs every year (approx. 1 lack wait listed patients) whereas the mortality rate is close to 30-40%.

83% of total transplants are performed by the Living organ Donar.

Living Donar are more than Deceased Donar. Due to the lack of awareness in India about Organ Donation. Even if people have awareness about organ transplantation, with current scenario the many people are sharing organs to there relatives and giving them a new life. With this Nature we can assume that people are aware of Deceased Organ Donation. This Potential Donar's organ can not be retrieved in every case because of Viability of Organs and the long distance between Organ Donar and Organ Receiver.

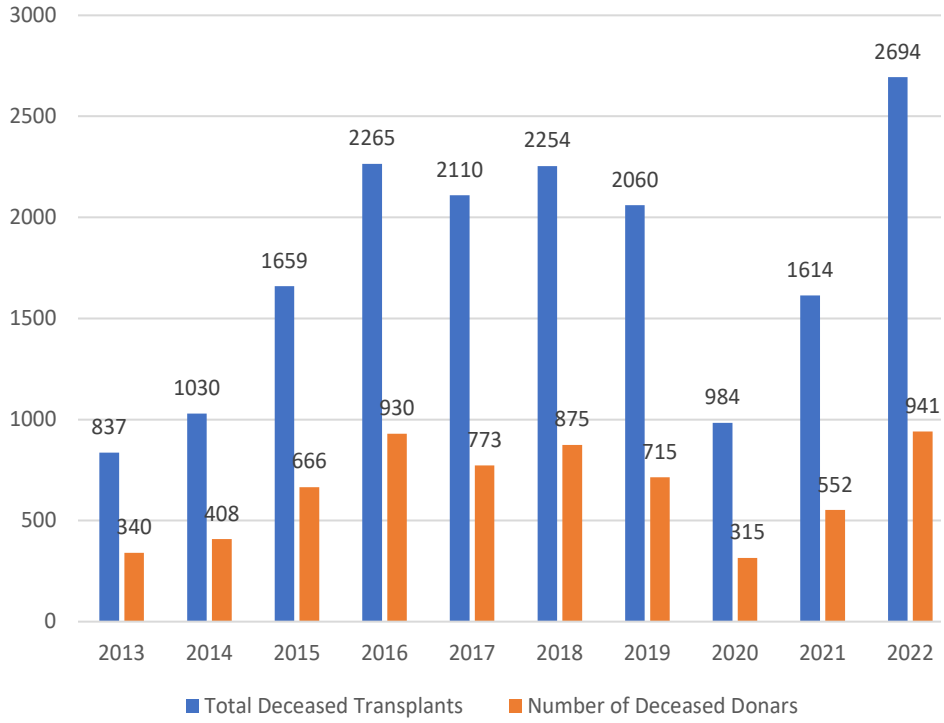
Insight

Number of Living Organ Donar are more than Deceased Organ Donar. Even if there are more potential Deceased Organ Donar.

## 1.5 Deceased Transplants and Deceased Donar

Shown Graph compares the number of deceased donors to the number of deceased organ transplants performed.

| 2016 | 2022 |
|---|---|
| Total Deceased Donors : 930 | Total Deceased Donors : 941 |
| Total deceased Transplants : 2265 | Total deceased Transplants : 2694 |
| Avg. Transplants per donor : 2.43 | Avg. Transplants per donor : 2.86 |

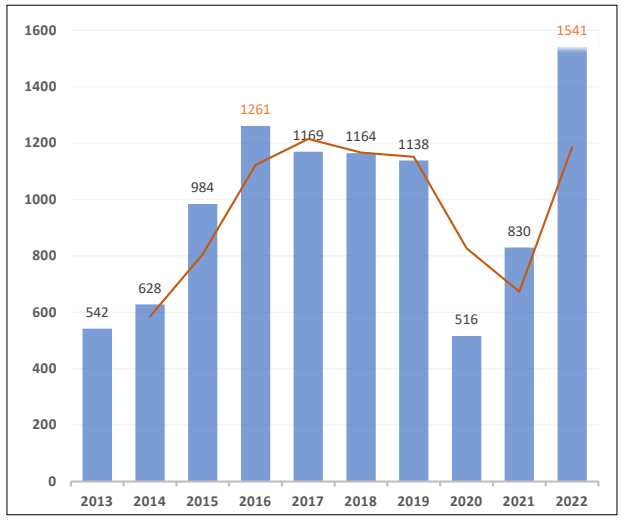



**Total Deceased Transplant**

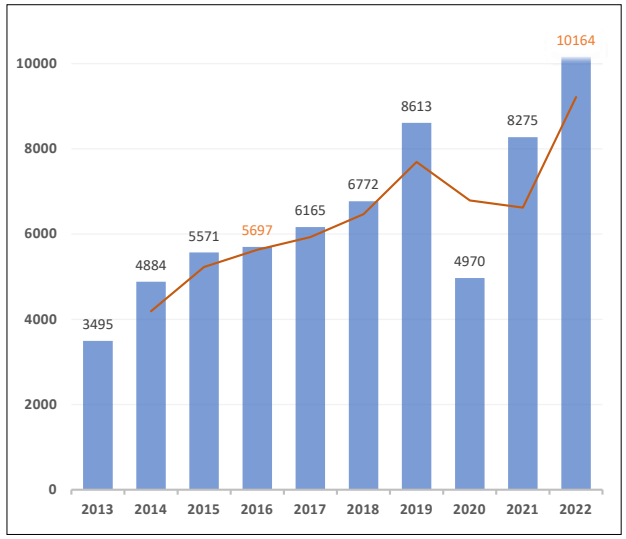
Potential deceased organ donar can save the life of more than two organ receiver patients having serious medical condition. Those Different organ receiver may not be in same hospital or same city, In this case we have to transport organs to different locations. Which requires multiple organ transportation teams and organ retrieval teams.

Insight

Requires multiple organ Transportation Teams when a single deceased organ donar is available.




**Deceased Donar Kidney Transplant**




**Living Donar Kidney Transplant**

## 1.6 Specific Organ Donation Statistics

Following are some facts about the Organ donation scenario in India :

3.17 lacs - Number of men, women, & children on the national transplant waiting list.

Only 3.25% of the total wait-listed patients receive organ.

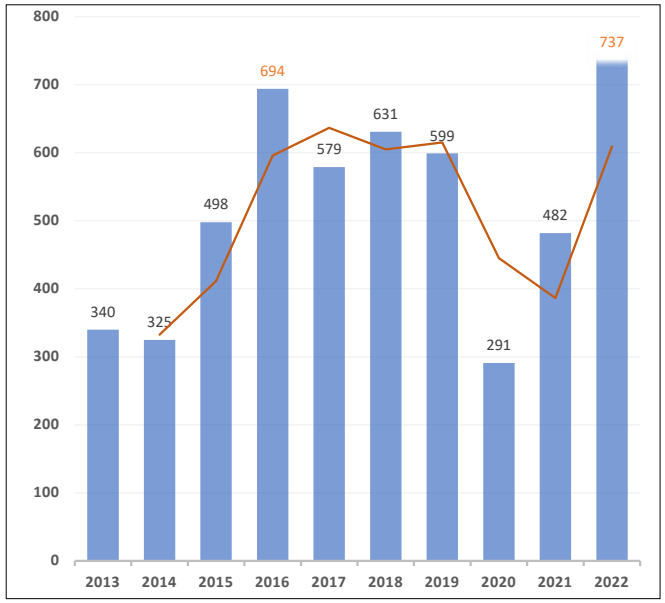
India has an organ donation rate of about 0.52 per million population lowest in the world.

17 people die each day waiting for an organ transplant

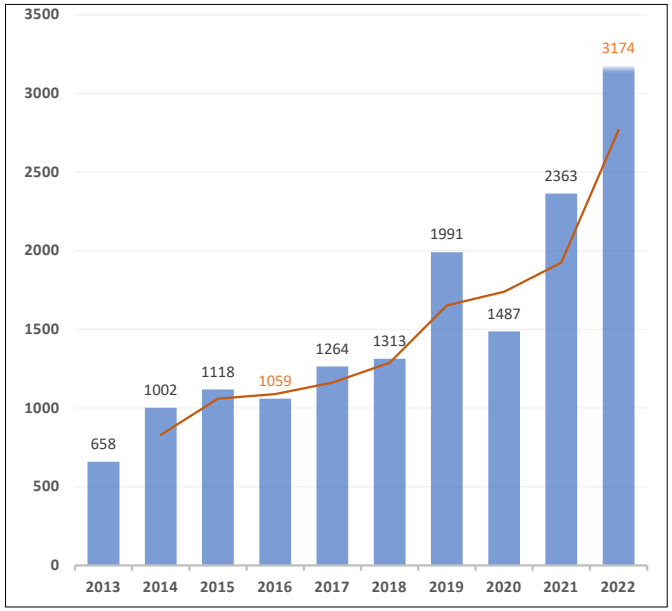
17,000+ Transplants were performed in 2022.

Waiting list of organs (January 2023)

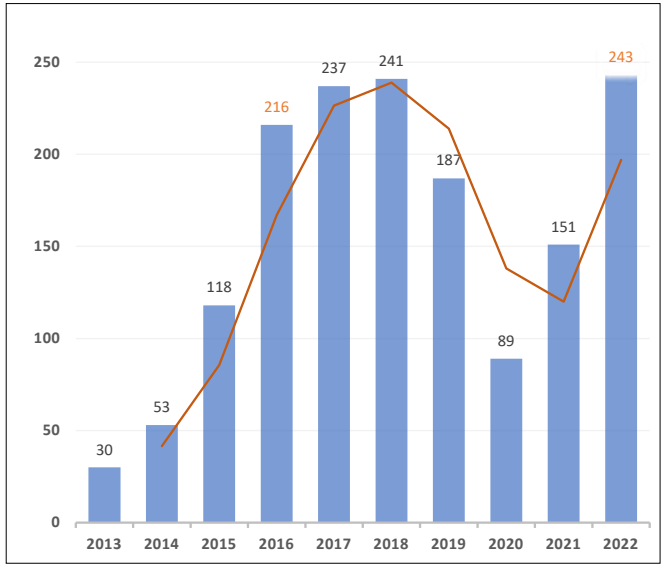
| Organ | Percentage |
|---|---|
| Kidney | 58 % |
| Liver | 16 % |
| Pancreas | 12 % |
| Heart | 6 % |
| Lung | 5 % |
| Other | 3 % |



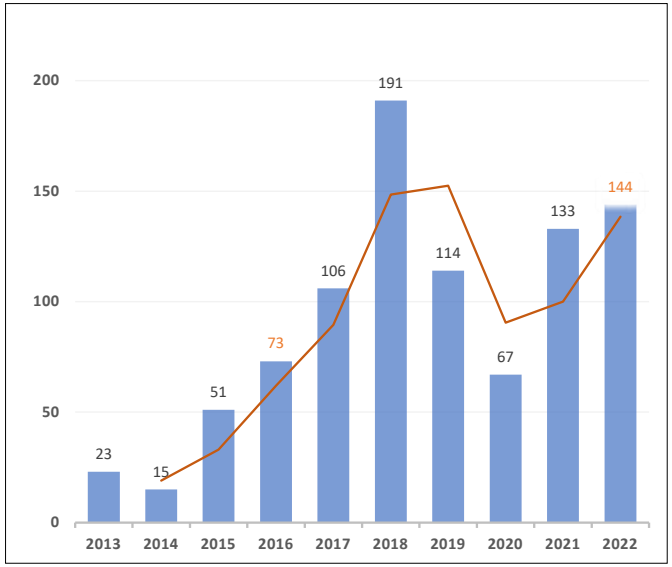

**Deceased Donar Liver Transplant**




**Living Donar Liver Transplant**



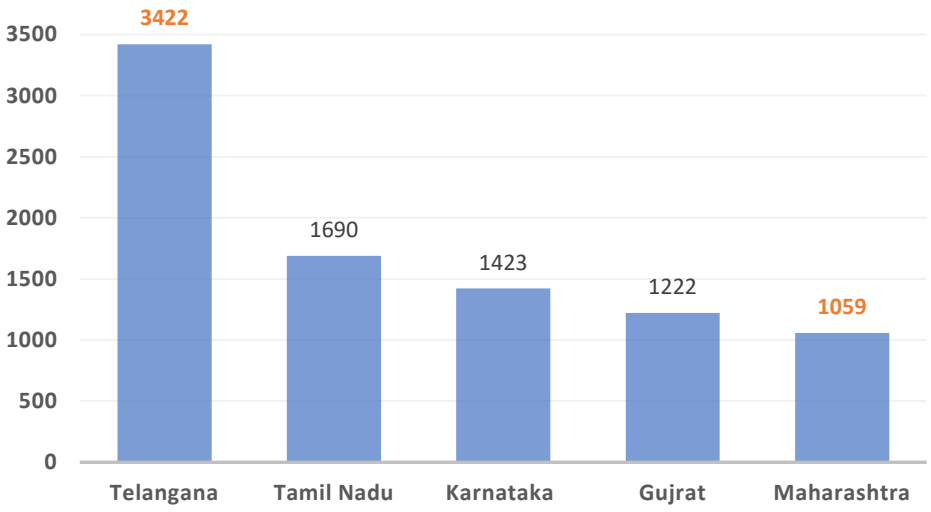

**Heart Transplant**



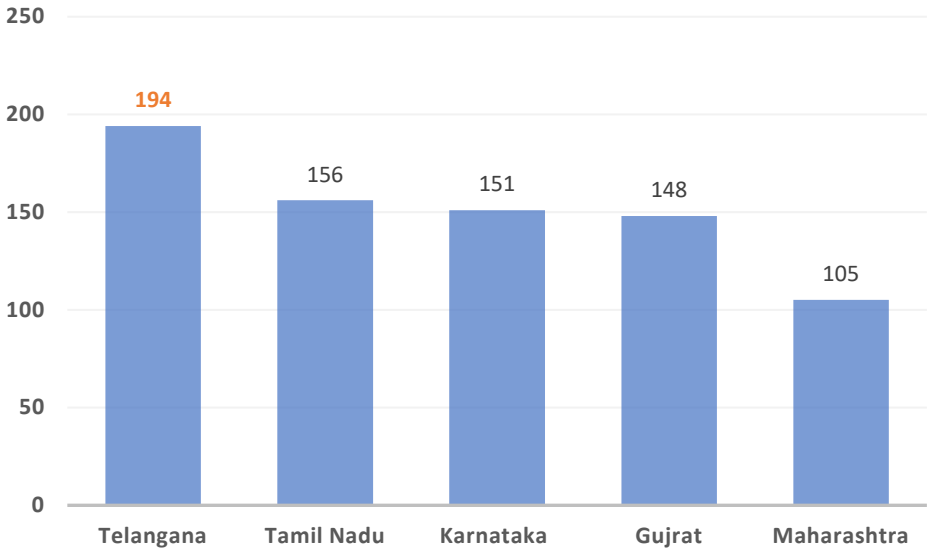

**Lungs Transplant**

## 1.7 Top 5 States of organ Transportation

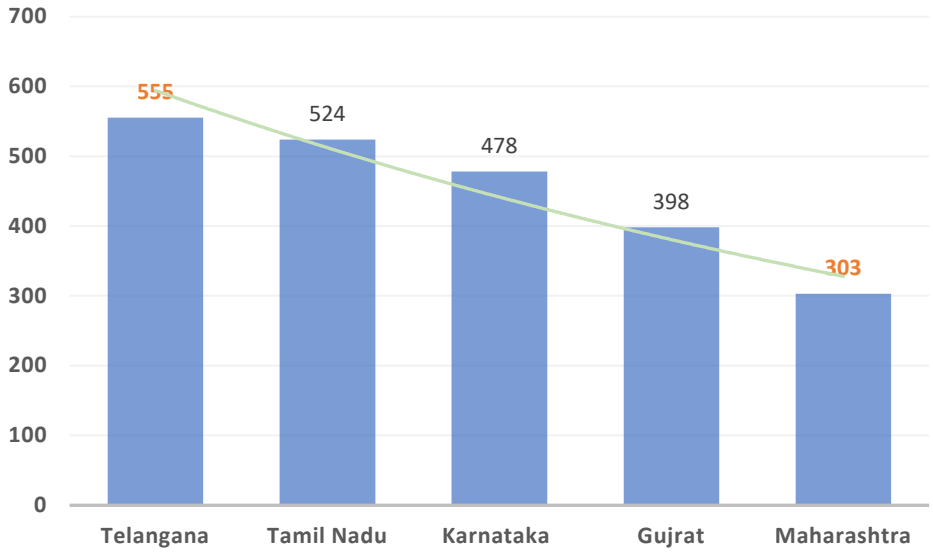
After classifying the statistics of deceased organ transplants according to the states, the resulting graph looked like this. The bulk of the states in the top 5 list of recipients of deceased organ transplants are from the southern part of India: Telangana, TamilNadu, Karnataka, Gujarat, and Maharashtra.




**Number of Living Donar Transplant**




**Number of Deceased Organ Donar 2022**

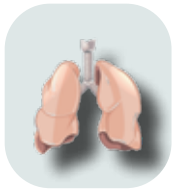
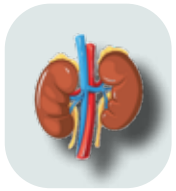



**Number of Deceased Donar Transplant 2022**

# 2. BACKGROUND RESEARCH

## 2.1 Widely Transported Organs

Shown below, Information about the most widely transplanted organs, their vitality time span and also the required temperature range to keep them vital and weight and size.

| Heart | Lungs | Liver | Kidney |
|---|---|---|---|
|  |  |  |  |
| 4 - 6 hr | 6 - 12 hr | 12 - 18 hr | 24 - 36 hr |
| 2 - 4 $^0$C | 2 - 4 $^0$C | 2 - 4 $^0$C | 4 - 8 $^0$C |
| 230 - 300 g | 600 - 750 g | 1300 - 1600 g | 135 - 150 g |
| 12 * 9 * 6 cm | H - 24 cm | H - 14 CM | 11 * 6 * 3 cm |

## 2.2 Impact of Vibrations on organ

To begin with, I gathered information about the most widely transplanted organs, their vitality time span and also the required temperature range to keep them vital. Vibrations during transportation can have a significant impact on organs. It is important to take measures to minimize the impact of vibrations, such as using appropriate padding and securing the organ during transportation, to ensure the best possible outcomes for patients. W

Following are some of the problems that can be caused due to vibrations

1. Stressed or damaged tissued
2. Shearing and tearing of tissues and vessel
3. Improper or less blood flow
4. Detachment of blood vessels

## 2.3 Temperature and moisture

Maintaining proper temperature and moisture levels during the Transportation of organs for transplant is critical to ensure their viability and success in the transplant process. Following are some of the reasons why there is a need to maintain the temperature and moisture level

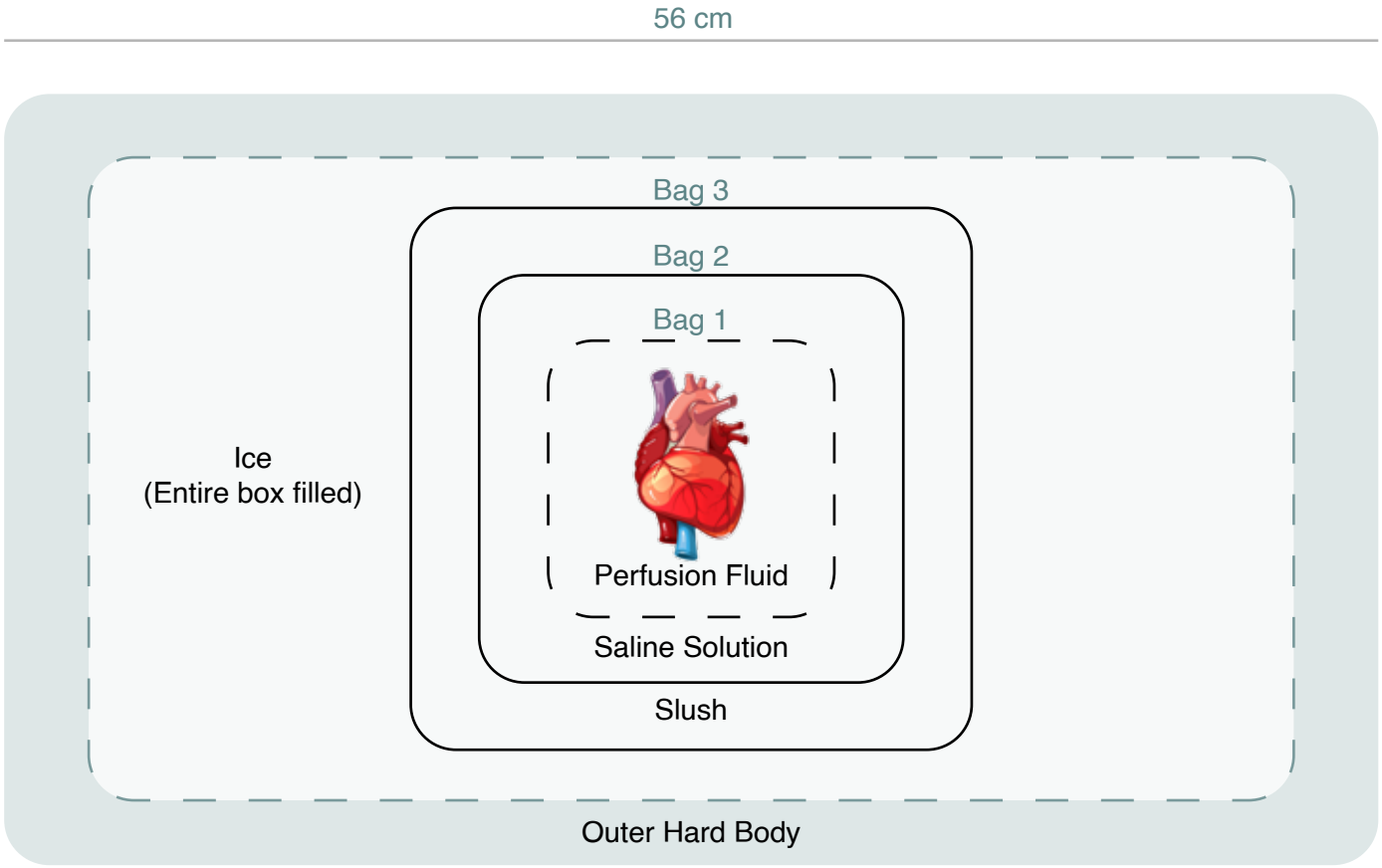
1. Viability of the organ:

Organs are extremely sensitive to changes in temperature and moisture levels, and any deviation from their ideal conditions can cause irreparable damage. Proper temperature and moisture levels help to preserve the organ's cellular structure and function, which is crucial for a successful transplant.

2. Length of transportation:

The longer the transportation time, the more important it becomes to maintain proper temperature and moisture levels. Organs can only survive outside the body for a limited period, and any changes in temperature and moisture levels can significantly decrease their viability during transportation

## 2.4 Organ Transportation Box & Triple Bag Package




Triple bag packaging is a common method of packaging organs for Transportation during organ transplantation. The purpose of triple Bagging is to protect the organ from contamination and to maintain its Viability during transport. To triple bag an organ, three sterile plastic bags are used. The organ is first placed in the innermost bag, which is then sealed. This bag is then placed in a second bag, which is also sealed. Finally, the double-bagged organ is placed in a third bag, which is sealed and labeled with the appropriate information, such as the donor and recipient information

## 2.5 Green Corridors

A green corridor is a special route created to facilitate the fast and safe transportation of organs for transplantation. These corridors are typically used when transporting organs from one city to another, and they can significantly reduce the time it takes for the organs to reach the recipient.

**Process of Green Corridor**

The process of creating a green corridor typically involves the following steps:

- The organ retrieval team contacts the local traffic police and Requests a green corridor.

- The traffic police clear the roads along the route, stopping all Other Traffic to allow the ambulance carrying the organs to Pass-through quickly.

- The ambulance is escorted by police officers to ensure it reaches The transplant center as quickly as possible.

**Benefits of Green Corridor**

Green corridors have several benefits for organ transplantation, Including:

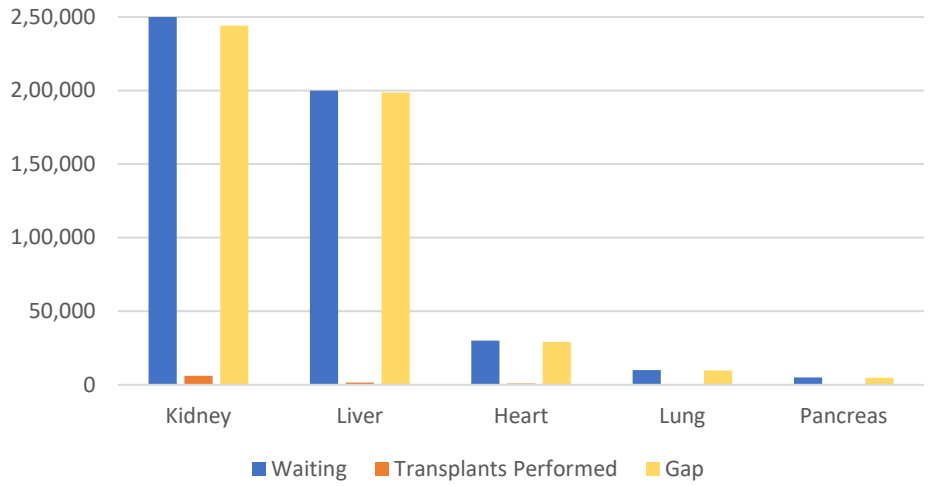
Reduced ischemic time:
The ischemic time is the amount of time an organ can be without Oxygen before it becomes unusable. Green corridors can help to

Reduce ischemic time by minimizing the time spent in traffic.

**Increased organ viability:**
By reducing ischemic time, green corridors can help to increase the viability of organs, making them more likely to be successfully transplanted.

**Improved patient outcomes:**
Shorter ischemic times and increased organ viability can lead to improved patient outcomes, including a shorter length of stay in the hospital and a reduced risk of complications.

If proper provisions are provided, the statistics of organ donation and the saving of people's lives can also be improved. Shown below is the statistics of patients looking for organs to the number of transplants performed (as in 2020)




Route of the hospital where an organ is harvested and the hospital where it is to be transplanted, are green and controlled manually.

Following are the participants of Green Corridor Process

- The organ retrieval team
- Ambulance Driver
- Ambulance service
- Traffic dept.
- Local Police & head
- Airport Authorities

## 2.6 Recent Incidents of green Corridor In India

**Jabalpur to Bhopal**
19-Sept-2023

In a remarkable effort to facilitate organ transportation within the state, Madhya Pradesh traffic police successfully established a green corridor spanning approximately 310 kilometers. This corridor was initiated on a late Thursday evening, connecting Metro Hospital Jabalpur to Bansal Hospital in the state capital, Bhopal. Initially, plans were in place to airlift the vital organ; however, due to unforeseen technical issues, the decision was made to opt for a ground route instead.

The traffic arrangements for this crucial journey were meticulously coordinated. Jabalpur Traffic Police ensured a smooth passage until the border of Jabalpur, while the responsibility for further traffic management fell to the respective district police.

The motivation behind this extraordinary effort was the decision of the family of a 64-year-old man, Rajesh Saraf, a resident of Vijaynagar in Jabalpur. Tragically, Mr. Saraf had been declared brain dead, prompting his relatives to make the noble choice of organ donation.

A dedicated team of surgeons from Bansal Hospital swiftly arrived at Jabalpur to perform the organ retrieval operation. Dr. Gursagar Singh Sahota, a Liver Transplant Surgeon, shared insights into the mission, stating, “We received information from Metro Hospital Jabalpur that there is a patient who has unfortunately become brain dead and his family made a very good decision to donate his organs. As soon as we got the information, we talked here and came to know that the patient’s liver is in good.

**Chandigrah - Delhi**
06-Jan-2022

The Delhi Police created a green corridor on Thursday for transportation of a live heart from Terminal 1 of IGI Airport, officials said. The heart was brought by air from Chandigarh for a patient admitted in AIIMS here.
A distance of about 12 km from Terminal 1 to AIIMS was covered within 11 minutes for transportation of the heart, the officials said.

Joint Commissioner of Police (Traffic) Vivek Kishore said on Thursday at 10 am, a call was received from professor Aarti Vij, head of the institute's Organ Retrieval and Banking Organization (ORBO) for creating a green corridor to facilitate the transportation of live heart ..

THE ECONOMIC TIMES News

Delhi: Green corridor created for transportation of heart

Synopsis

Joint Commissioner of Police (Traffic) Vivek Kishore said on Thursday at 10 am, a call was received from professor Aarti Vij, head of the institute's Organ Retrieval and Banking Organization (ORBO) for creating a green corridor to facilitate the transportation of live heart from Terminal-1 of IGI Airport to AIIMS.

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**Thane - Hyderabad**

A green corridor was operationalized today between Kashimira area of Thane district and Vile Parle in Mumbai to help airlift a critical patient to Hyderabad, a police official said.

The no-obstruction traffic corridor of 23 kilometers was set up after a Request came in from a local hospital at 7 am, and the ambulance Carrying the patient covered the distance in 35 minutes between 9:10 am and 9:45 am, the Mira Bhayander Vasai Virar (MBVV) police official said

"The flight carrying the patient, who needed an urgent liver operation, Off from a Pawan Hans facility in Vile Parle at 10:05 am and it reached Begumpet Airport in Hyderabad in Telangana at 11:40am," he said

**Hyderabad metro Transports Live Heart for Transplant**
09-Feb-2021

Special train covers 16 stations across 21 km from Nagole to Jubilee Hills.

For the first time in Telangana, Metro Rail was used to transport an organ from one hospital to another for transplantation. Hyderabad Metro Rail created a special green corridor between Nagole and Jubilee Hills to facilitate non-stop transport of a heart from Kamineni Hospital, L.B. Nagar, to save a patient admitted at Apollo Hospital, Jubilee Hills, on Tuesday.


Usually, roadways is used to transport organs intra-city. Though traffic on road could be cleared to establish a green channel for transporting organs, surgeons felt the heart, in this case, could be transported faster through Metro Rail.

## 2.7 Existing Concepts and Proposals

Few projects or proposals have received attention and effectively served their intended purpose thus far; the majority of these are covered below:

### 2.7.1 Organ transportation UAV prototype by MGM healthcare.
Tamilnadu

Developed an innovative drone-based solution for transporting organs for transplant. The hospital's initiative, called "Drona," uses a custom-built drone to transport organs such as hearts, lungs, and kidneys between hospitals and airports in a timely and efficient manner. The drone has been designed specifically for organ transportation, with a cargo box capable of maintaining the temperature and humidity during flight time to ensure vitality of organ. The drone is also equipped with GPS, real-time tracking, and a secure communication system to ensure that the organ's location and condition are monitored throughout the journey. Drona has already successfully completed several test flights, and MGM Healthcare is now awaiting regulatory clearance to launch the service commercially. Once operational, the drone-based organ transportation system is expected to significantly reduce transportation time and improve the chances of successful organ transplant surgeries, ultimately saving more lives. Currently the drone is capable of lifting approx. 6kg of payload for a duration of 20+ mins at an altitude of 300ft.

### 2.7.2 School of medicine, University of Maryland

The University of Maryland has developed an Organ Drone Delivery System (ODDS) that can transport a single organ safely and efficiently. The ODDS is a custom-built drone that is equipped with sensors to monitor the temperature and humidity of the organ compartment. It is also equipped with a GPS system that allows it to fly autonomously to the recipient hospital.

The ODDS has been successfully tested in a number of real-world scenarios. In one test, the ODDS was used to transport a kidney from a donor hospital in Baltimore to a recipient hospital in Washington, D.C. The organ was transported in just 45 minutes, which is significantly faster than traditional ground transportation.

The ODDS has the potential to revolutionize the way organs are transported. It can significantly reduce the time it takes to transport organs, which can improve the chances of successful transplantation. It can also reach remote areas that are not accessible by traditional means of transportation.

**Specification of DJIM600**

Hexacopter
Retractable Landing Gear
Payload: 15 Kg

DJIM600 drone

Less Vibrations.
Economical
For short distance.
Comparative low speed.

Fixed wing aircraft


More Vibration.
Expensive.
For Long Distance.
High Speed.

## 2.8 Advancement in Organ Transplantation

### 2.8.1 Organ Care System

Preservation of donor hearts, Lungs and Liver.

System designed to keep a donor heart in **metabolically active state.** It gives **more time** to evaluate and assess the organ suitability for transplant
Heart can be transplanted in **12 hours**

The dimensions of the OCS
- Height: **68.5 cm**
- Width: **56 cm**
- Depth: **43 cm**

The weight of the OCS heart is **45 kg**

### 2.8.2 Paragonix sherpa pak™

**Donar heart preservation and transport**

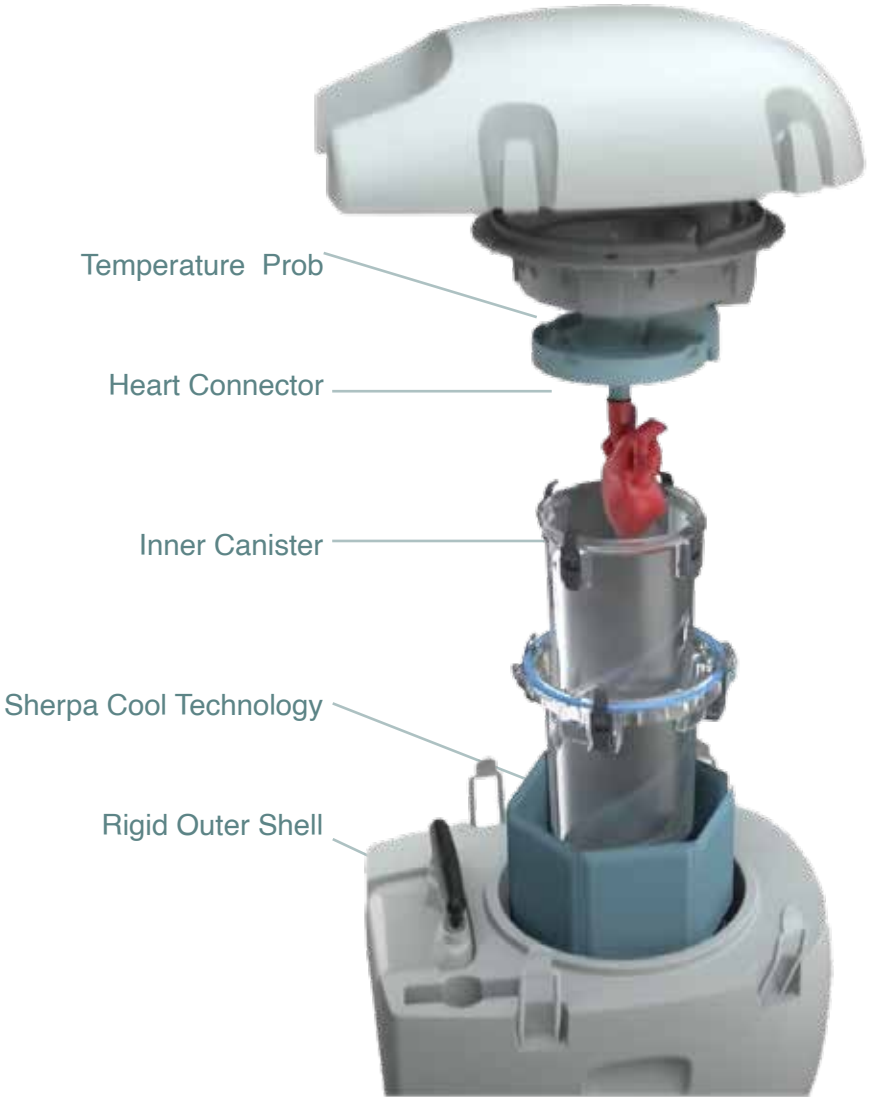
Designed to overcome potential issues associated with the current systems.

Organ usually gets too cold, That increase the **risk of cold injury** with some proteins denaturing **below 0°C**. Decrease cold injury of donor organs by **even cooling** and **no temperature gradient.** It may decrease **failure after organ transplantation**

The dimensions of the OCS

Height: **56 cm**
Width: **41 cm**
Depth: **33 cm**

The weight of the OCS heart is **27 kg**




https://www.paragonixtechnologies.com/sherpapak

**Paragonix LUNGguard**


Lungs Transportation Box

**Paragonix LIVERguard**


Liver Transportation Box

# 3. PRIMARY RESEARCH

## 3.1 Interview

Reaching out to organ transplant surgeons posed its own set of challenges. Their demanding schedules and the critical nature of their work made it challenging to secure direct engagements. To overcome this hurdle, I optimized available resources, such as recorded interviews, written correspondences, and participation in virtual conferences where surgeons presented their work. In few day received a permission to have short talk with Surgeon. Mainly talked about time taken by organ transportation and Organ transplant system.

**Dr. Swapnil**
Nephrologist, Juslok Hospital

He has Transplanted many kidneys in last two years. Through his experience he was saying that we are ready work hard to save more life. But main reason of Less number of transplant is Organ Donar.

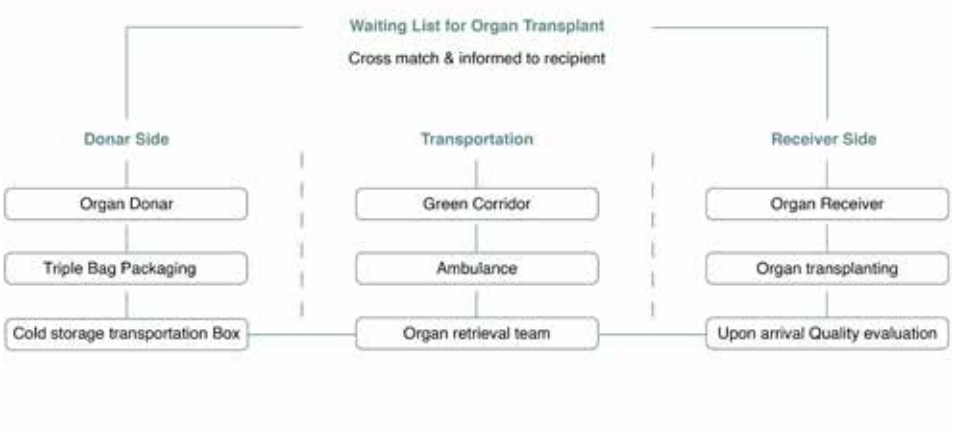
ZTCC - Zonal Transplant Co-ordination Center
Non profit co-ordinating agency for Mumbai and Suburbs.

Organ retrieval team (Doctor, Sister, Ward Boy) from organ receiver hospital goes to donar location to retrieve organ and transport it back to the transplant centers. The numbers of Transplants can be increase if we are able to retrieve organs from suburban and rural areas.

Outside India, Systems are designed to keep a donor heart in metabolically active state to increase the Viability of organ. Ultimately to save more life.

## 3.2 Transplantation Process

Shown below is overall view of Organ Transplantation process.




**Eligibility Criteria for organ Transplant.**

**Medical Evaluation:**

Patients must undergo a comprehensive medical evaluation to determine if they are physically fit to undergo the transplant surgery. This evaluation includes a thorough assessment of the patient's overall health, including their heart, lungs, liver, and kidneys.

**Age:**

There is no specific age limit for organ transplantation, but the patient's overall health and medical history are considered.

**Organ Function:**

The recipient's organ function should be severely impaired, and the transplant should improve the patient's quality of life and lifespan.

**Serious Medical Conditions:**

Patients with serious medical conditions such as active cancer, untreated infections, or active substance abuse may not be eligible for transplantation.

**Psychiatric Evaluation:**

Patients will undergo a psychiatric evaluation to assess their mental health and ability to adhere to the post-transplant care plan.

**Financial Stability:**

Patients must have adequate insurance coverage or financial resources to cover the cost of the transplant surgery and post-transplant care.

**Doctor recommendation for an organ Transplant**

When patient have been through all possible treatments for his medical conditions and there is no other option than organ transplant and patient satisfies the all criteria to under go organ transplant surgery. Then Doctors  suggest for organ transplantation.

**Patients and Family decision**

When decision from the family member and patients convey to the doctors then process starts to list patients name on waiting list of organ receiver.

**Adding data of Organ receiver on the waiting List.**

Different organization on different level for Organ transplants in India

- NOTTO - National Organ & Tissue Transplant Organization
- ROTTO - Regional Organ and Tissue Transplant Organization
- ZTCC - Zonal Transplant Coordination Centre

Here ZTCC is taken to explain the process. Hospital administration add the organ receivers data on the ZTCC Portal. Required organs information  and other medical information which will be used for cross-match with the donar organ

**Become a potential organ donar**

Registration form is illustrated. Donar can select the organs for donation. To become a potential donar permission from family member is required

Donar card will be provide to the donar from ZTCC. Donar has to keep Donar card always with him.

**Death of donar**

Doctors attempts their best to save the life of patient. Somehow they couldn't save the patient. And it is brain dead. Potential donar now. Patient is kept on ventilator. Body can be kept on ventilator for few days.

**Consent from Donar's Family**

Consent from family member is needed for retrieve organs from donar body.

**Receiver in same Hospital**

Donar Hospital have permission to use organ from body in their Hospital without uploading data on ZTCC portal. But they have to submit record of Transplants and upload data of remained organ on ZTCC portal.

**Donar Data on Portal**

Hospital verify the organs are suitable to donate and After perfect results of test. Data is uploaded on ZTCC portal by Hospital Administration.

**Waiting List for Organ receiver**

There is large waiting list for organ receiver as mentioned in statistics its unending with available numbers of organ.

**Distribution of Organs**

As per waiting list and priority organs are distributed

**Cross - Matching of Organ**

According to Perfect Cross match the organ receiver is informed about availability of Donar organ

**Receivers Decision for Transplant**

Hospital forwards the ray of hope to organ receiver patient and family about availability of Donar organ.

**Communication through ZTCC**

Information of hospital and contacts are shared with each others and To arrange green corridor call has be made with Traffic police department and Police department.

**Preparation for Transplant**

In both hospital the donar and receiver is shifted to the operation room simultaneously in respective hospitals. Organ retrieval team is also preparing to leave toward organ donar hospital

**Preparing Organ Transportation Boxs**

As Potential Donar can donate multiple organs. At least 4 organ transportations boxes should be ready.

Cold storage Boxes are Cleaned from inside outside with warm water and 5% sodium Hypochlorite. Check the Seal for Damage. Drainage wall is closed before filling the Ice

Blank Documents are kept inside the Box. Ensure you have sufficient labels, color coded sterile ties and Bags for triple packaging.

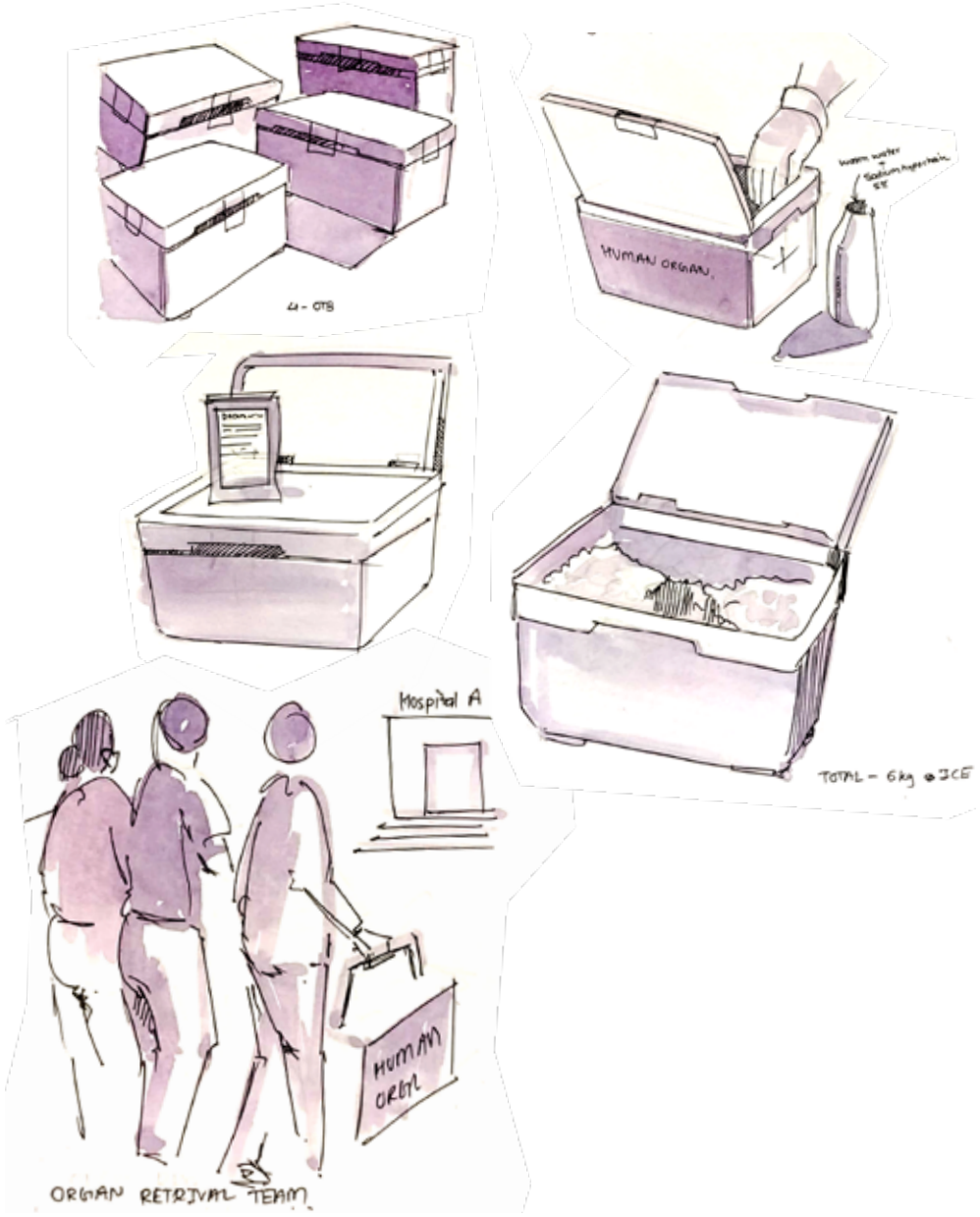
With Filling of melting Ice boxs are ready to use in organ transportation. Required Ice for single box is 6 Kg. Ice Temperature must not be less than 0 degree celcius.

**Organ Retrieval team Reaching.**

Organ Retrieval team is reaching to the donar Hospital. Team has the following members.

- Organ Preservation Practitioner
- Retrieving surgeon
- Scrub Practitioner

Team will perform the operation in organ donar hospital. Verify the condition of organ.



## Green Corridor

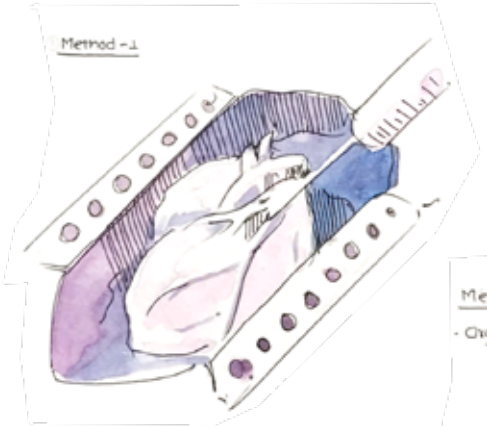
Vehicles and Drivers are ready outside the Hospital to Transport organ to the destination. Traffic and police are at their location to make path clear for organ Transportation.

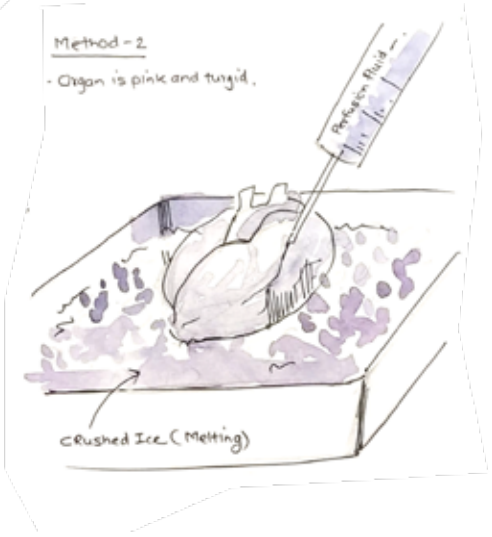

## Surgery to Remove Organ from Donar Body

There are two methods to perfused organ

1. Organ is perfused in Donar's Body with Chilled Perfusion solution. Liquid is forced into organ till it become Pink.

2. Organ is perfused after the organ is removed from donar body. Organ is kept in tray which contains Crushed melting ice and Perfusion solution.




Types of Perfusion Solutions

| | | |
|---|---|---|
| 1.HTK | : Heart + Lungs | (shorter preservation time) |
| 2.UW solution | : Kidney + Liver | (Longer preservation time) |
| 3. Celsior | : Kidney | (Longer preservation time) |
| 4. Custodial | : Heart + Lung | (Protect heart during Transportation) |
| 5. Perfadex | : Lungs | (Minimize the damage of tissue) |

## Triple Bag Packaging

Standard operating procedure. Package has three layers of medical grade plastic bags and perfusion solution.

First Bag : Organ is submerged in sufficient cold preservation solution.

Second Bag : It is filled with at least 250 ml cold saline (Without any Ice)

Third Bag : Small amount of fluid (Sufficient to ensure there is no air in Bags between the second and third bag)

Each Bag is firmly tied after adequate de-airing. Bags are medical grade sterile plastic bags.(LDPE) of two different size (25 * 35) & (55 * 50) cm

## Cold Storage Box

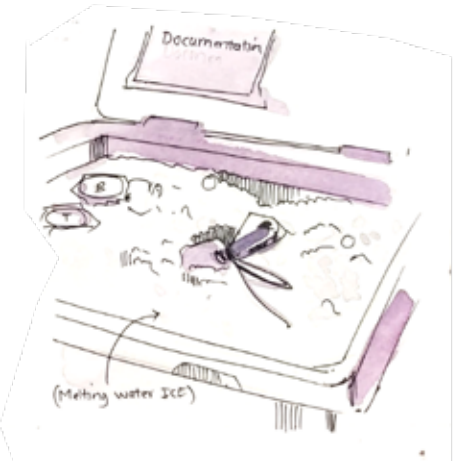
The prepared and packaged organ must be packed immediately inside the organ transport box.

1. The organ must be contained and covered by melting water ice

2. The box should be closed but not sealed until all required blood, tissue Samples and documentation have been placed inside and are ready for Transportation

3. The box must be sealed on both sides with tie wrap straps/cable ties (Where possible) and a note made of the ID number of the box.

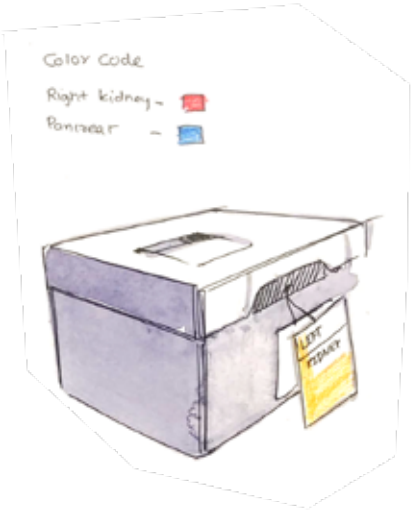




## Identification and labeling of an organ transport box

The organ transport box must be secured. Where applicable, cable ties should be used to ensure that the box remains closed on both sides. The organ transport box must be clearly labeled to show than an organ is being transported. The following must be visible on the box.

1.."Handle With Care"
2. "Organ in Transit"
3. The name of hospital where the retrieval took place
4. Identification of which organ is inside the organ transport box
5. Identification of the destination recipient center, including the address.
6. Specific instructions on the required transport conditions e.g. Keep Upright




## Color code for identification of Organ

Color codes are used as shown below.

Right kidney  left Kidney  Pancreas

## Releasing an organ for transport

a. Confirm the identity of the person collecting the organ.
b. Confirm the type of organ that is being dispatched.
c. Check that the transport box is structurally intact & fastened securely.
d. Must record the date and time of handover to transport personnel, and
Sign, print and date the record

**Communications Network**

1. Transplant Coordinator (LDC and DDC)
2. Recipient Centre Point of Contact (RPoC)
3. Traffic police.
4. Organ Retrieval team

**Transport provider organizations**

a. Ensure a professional code of conduct
b. Provide a timely response to transport requests
c. Maintain appropriate conditions of transit
d. Ensure timely delivery of organs to their destination
e. Manage/report adverse events during transport
f. Monitor the progress of a journey
g. Provide vehicles fitted with mobile communication devices, and with Routing/GPS tracking facilities
h. Ensure the relevant license for all vehicles and drivers

**Successful Organ Transportation**

At organ receiver Hospital. The person receiving the organ must Confirm the identity of delivering the organ. Confirm the type of organ

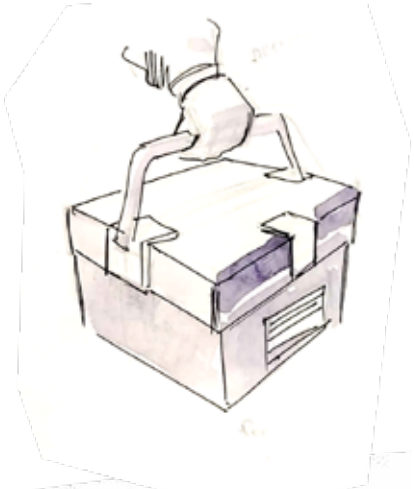
Socially clean the exterior of the organ transportation box.

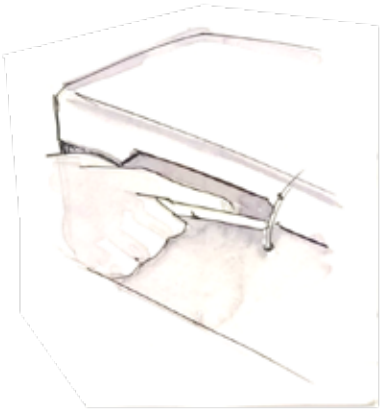
**In Operating Theater**

Externally cleaned organ Transportation Box take into OT and simultaneously the receivers body is opened and made ready for Organ Transplant  Unboxing starts with removing external safety cable ties followed by Locking mechanism .Organ is removed from Triple bag package and kept in melting ice tray and organ transplant surgery beings.

**Successful transplant**

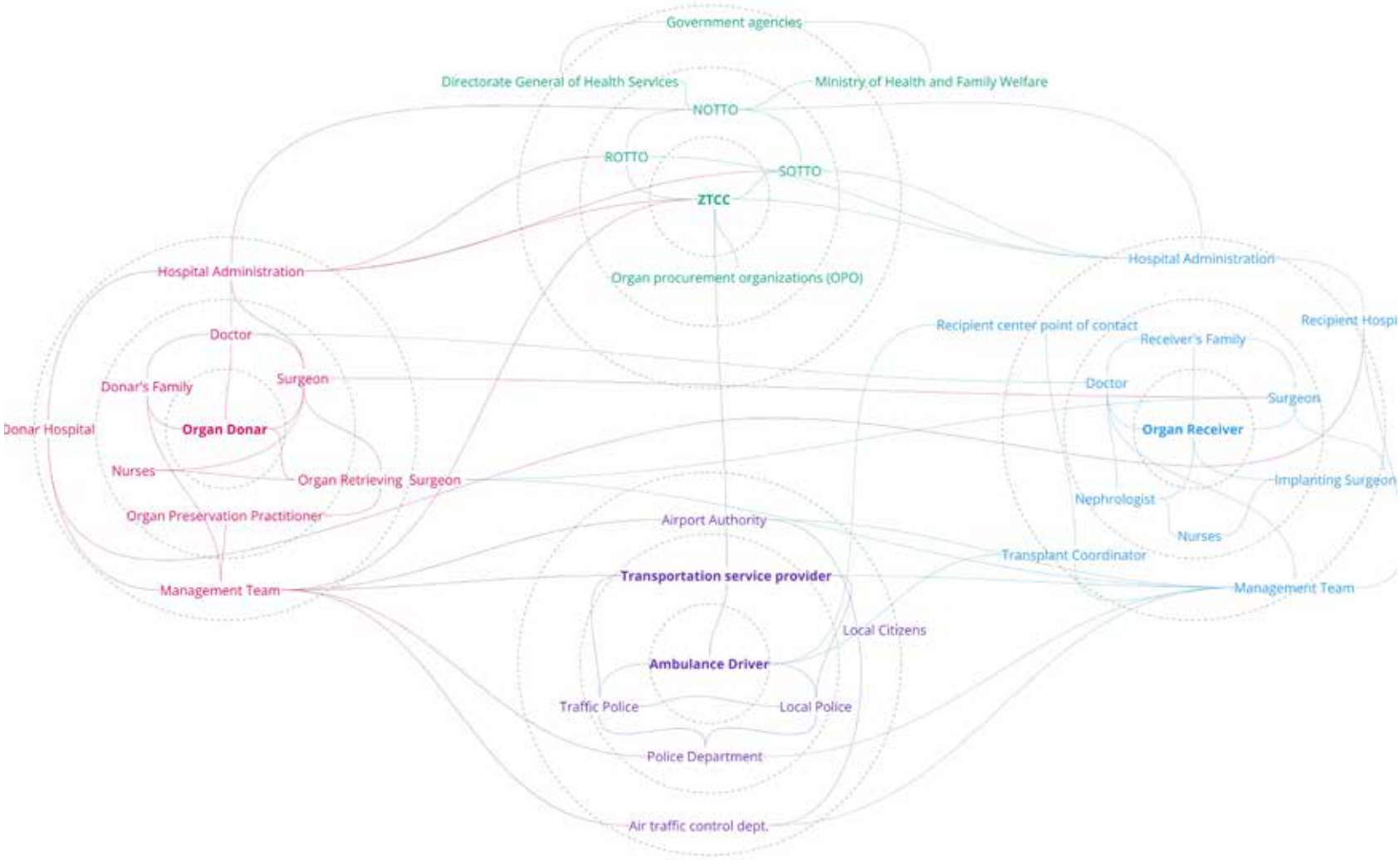
Patient has kept under observation few days and released with  prescription for months that avoids the failure of transplanted organ due rejection from body.





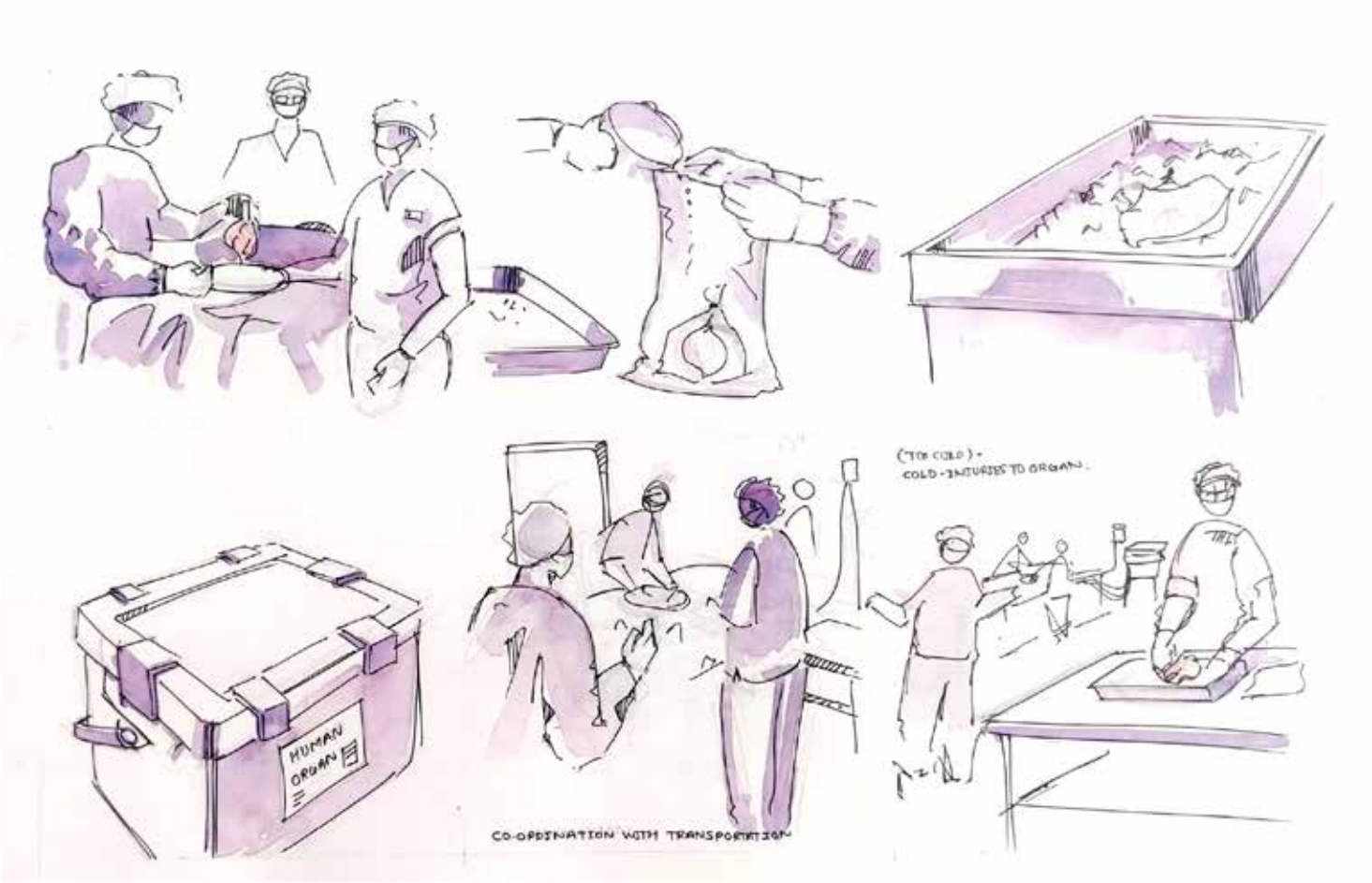
## 3.3 Stakeholder Mapping

As a part of the research, we kept on listing down the stakeholders, mentioned in interviews, heard about in videos and read about in articles and later on listed all of them category wise and this is what we got:



# 4. SCENARIO BUILDING

Various scenarios were sketched out to visualize the problems faced by the Organ transplantation and Transportation system. And key insights were derived from them.




**Scenario 1**

Organ is transported using traditional method, Triple bag Package and Cold storage box.
Melting Ice is used for maintain the suitable temperature.

In this scenario. Temperature is below 0° C. Which caused the cold injuries to the organ. There are very few chance of successful organ transplant.


**Scenario 2a**

Accident happened between Car and Bike, Unfortunately one of bike rider is in serious condition and other is Brain dead.

One who has serious medical condition admitted to Hospital and after trying every treatment he couldn't survive

He is potential Donar similar Brain dead person was potential Organ Donar could have saved someones life.

Due to lack of seamless integration for transportation. His body couldn't reach in Hospital and his new life worth organs are vain.


**Scenario 2b**

Second Part of above scenario that organ has to transported through traffic using green corridor in city while having limited time. Little delay in transportation caused less time for organ transplant surgery.

Mainly delay increases the probability of organ rejection by receiver body.


**Scenario 3**

Special events and Festivals affect on organ Transportation

Show illustration show the Ganpati festival in Mumbai on peddar Road. Organ transplant center is on same road. This road is full of people and Vehicles

Organ is retrieved with standard procedure and Green corridor is arranged but this large crowd is not possible to clear in few hours.

Transport Vehicle has to use longer alternative road to reach transplant center.


**Scenario 4**

Organ is available for transplant in other city. Which caused the family in frugal situation. He has to do anything that can save life of his family member. As suggested the Helicopter arranged for organ transportation.

Illustrations shows the stressful situation for family members and team who is working hard for new life to patient.

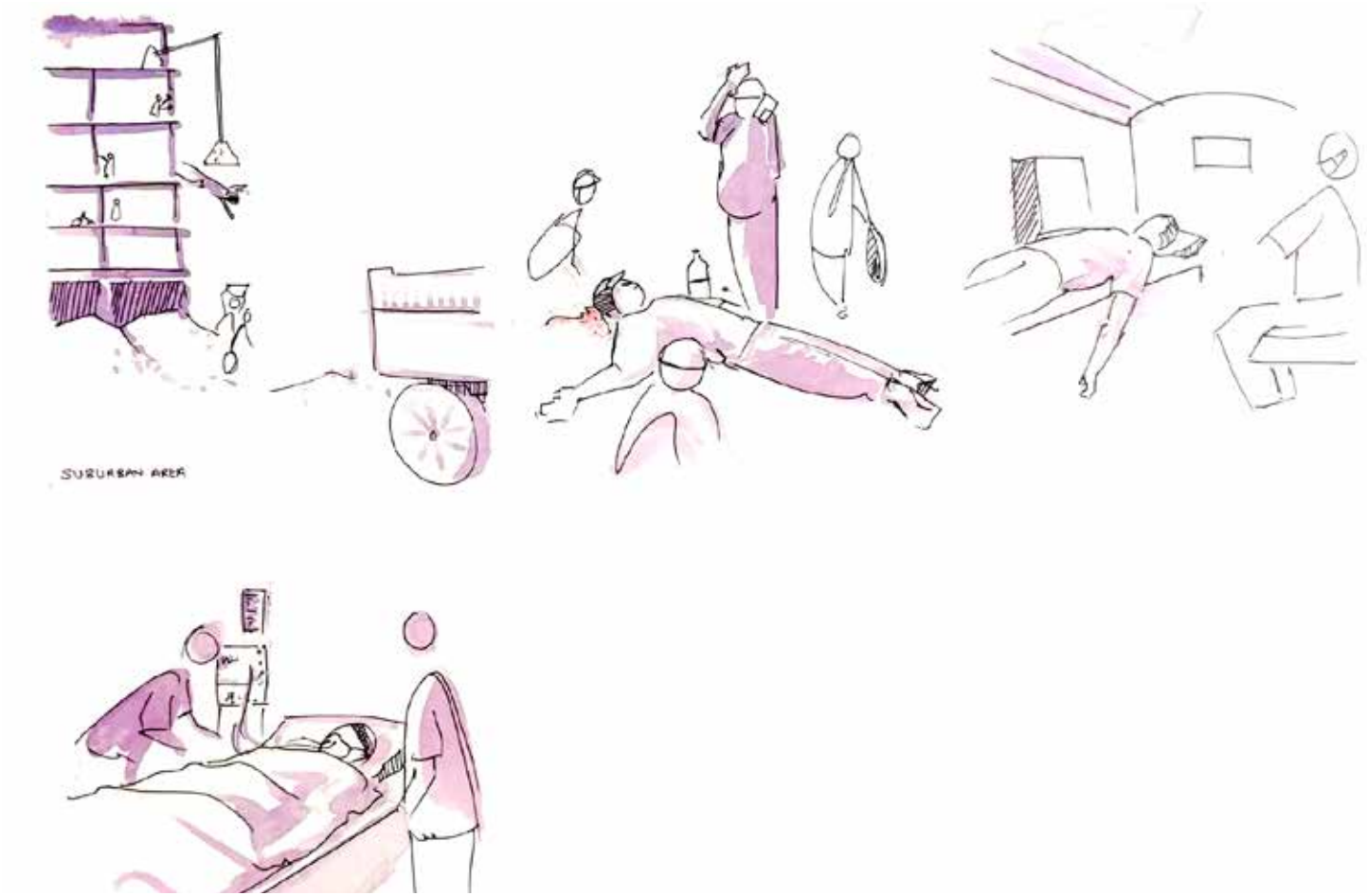

**Scenario 5**

The natural disaster casualty happened in rural area, injured patients are shifted to the rural area hospital for treatment fortunately they couldn't survive the accident Family consent is taken for organ donation.

Rural area has Organ retrieval centers but not organ transplant centers. So they have to transport organs to the city. It takes too much time due to the bad road infrastructure.

Due to viability of organ only eyes and kidneys are transported to the cities for organ transplants

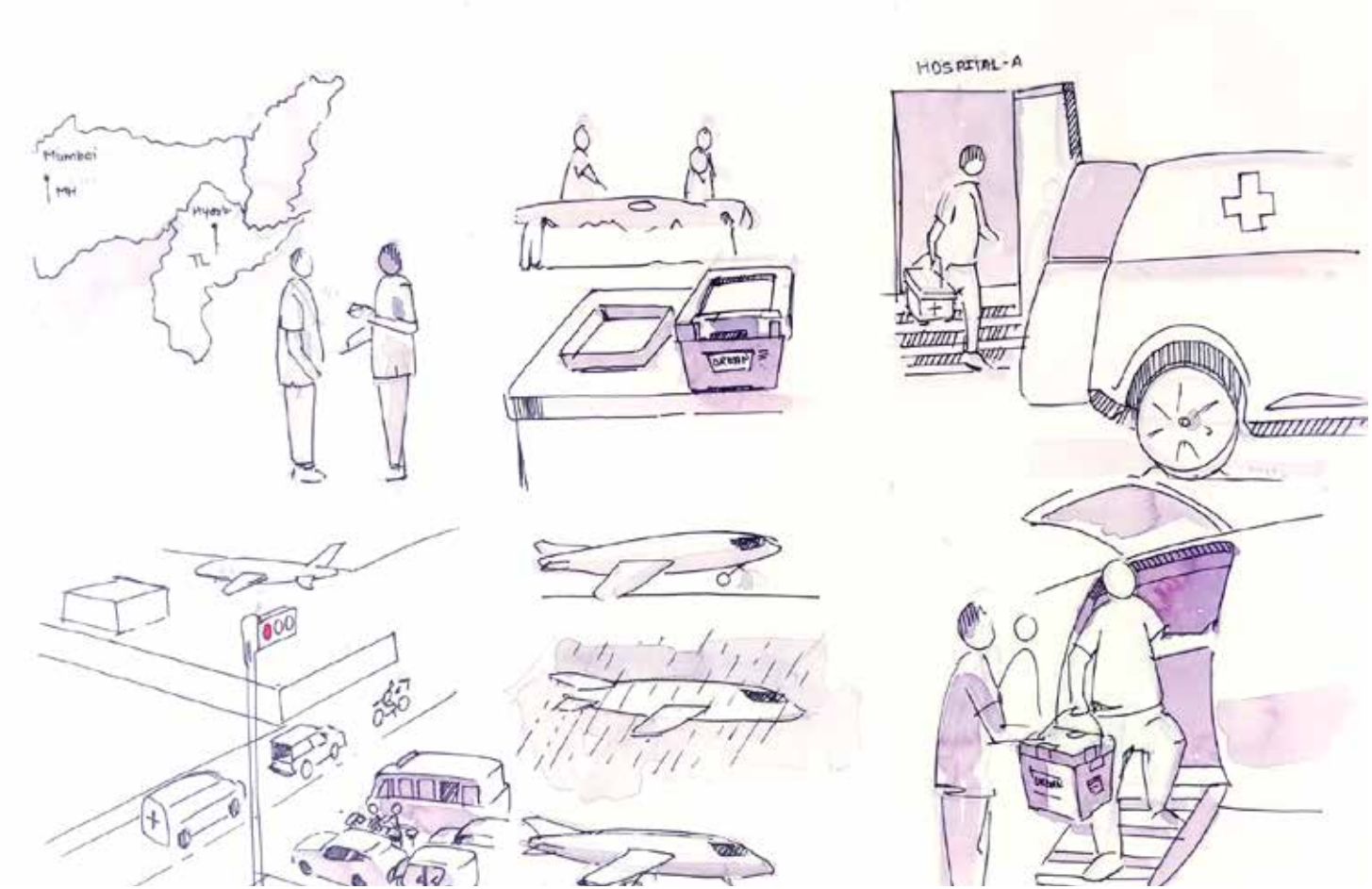
Lack of faster mode of transportation between rural and urban / suburban areas




**Scenario 6**

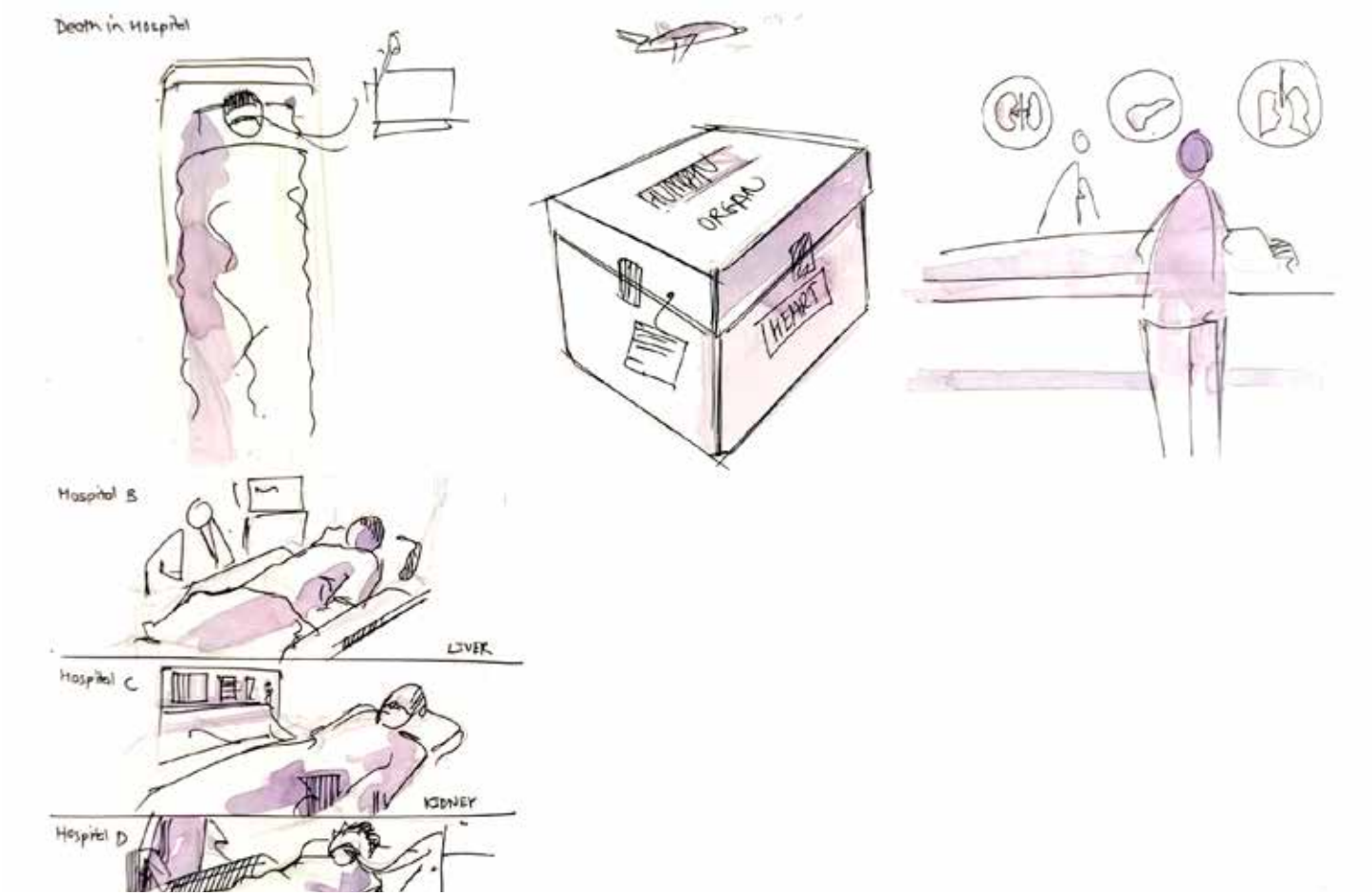
This scenario shows that on construction site worker Has Fallen from the building while working the accident caused injury on head. While taking patient to the hospital he couldn't survive

Unfortunately similar accidents happen in many areas and patient couldn't survive the situation but he is a potential organ donor. We are unable to help them but we can save more lives from their organ.




**Scenario 7**

Organ is transported between Interstate using green corridor and air Mobility. Strong vibration and sudden impacts during landing and taking off damages the organ which will result in failure of Organ Transplants.




**Scenario 8**

Potential donar is capable of saving multiple life. It creates a situation that 3 to 4 organs has to transport and transplant in different locations.

Illustration shows that small miscommunication lead to the loss of patients life


**Scenario 9**

Urgent need of platelets for patient. Required platelets are not in medical Bank. Doctors asked for donation of platelets to family members. They are trying to find donor for platelets.

After so too many calls they found the donars. Who are in different locations and they are reaching the hospital through traffic.


**Scenario 10**

There are possible challenges for drone in Oregon transportation such as payload is at bottom receiver has to bend down and remove the Oregon transportation blocks with moderate difficulty.

Open propellers can cause the failure in the operation due to obstacles in the air. Example tree branches. Electric supply wires, Birds

Position and configuration of propeller causing the receiver difficulty to remove the organ Transportation box

# 5. CHOSEN CONTEXT OF USE

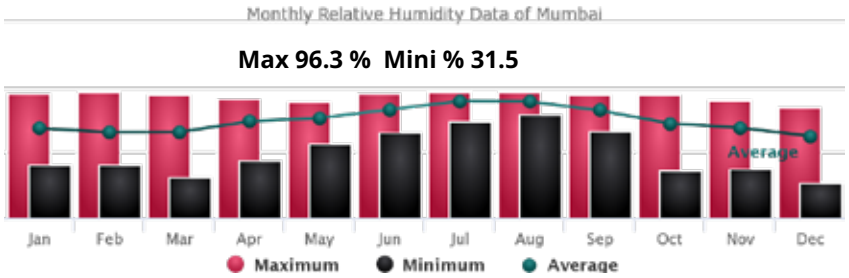
### Challenges in Mumbai

Mumbai has been chosen as context of use ,because it is the bustling metropolis on the coast of western India, faces a multitude of weather challenges that can significantly impact the organ transportation through drone. Goal is to successfully tackle the weather challenges here so we can tackle the most of the challenges from other places of India. Challenges are listed below.

### Moisture and Humidity

Mumbai's tropical climate is characterized by high levels of moisture and humidity throughout the year. This poses a significant challenge for drone operation, as humidity can also lead to condensation on the drone's exterior, affecting its aerodynamics and stability. Also moisture can interfere with electronic components and disrupt communication signals. Reduced flight performance: Condensation on the drone's exterior can increase drag and reduce lift.

1. Aerodynamic and Stability
2. Maneuverability and Range
3. Reduced flight performance




### Heavy Rain

Mumbai is known for its heavy monsoon rains, which can pose further challenges for drone operation. Rainwater can damage the drone's electrical components, sensors, and motors. Additionally, strong winds and turbulence associated with heavy rain can make it difficult for the drone to maintain stable flight. Heavy rain can potentially lead to:

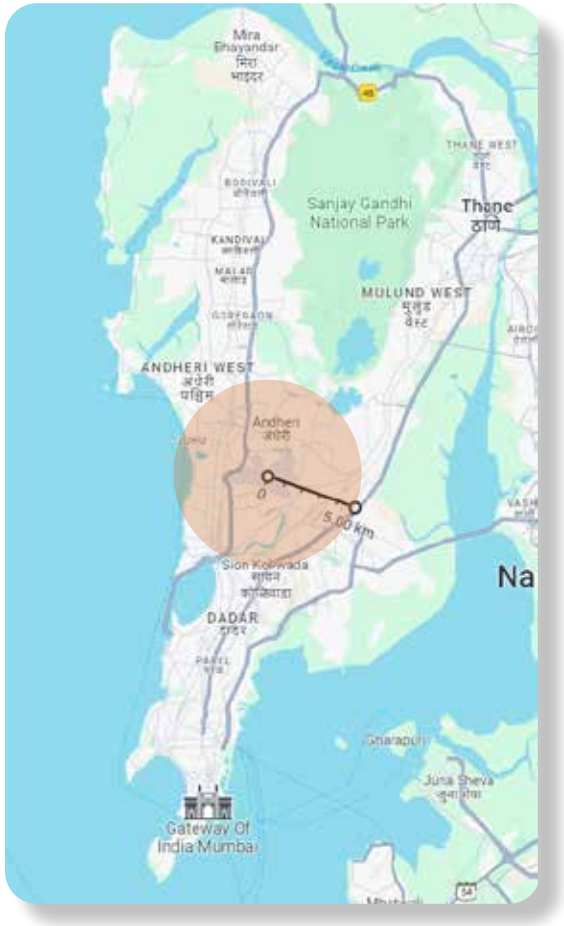
1. Drone Damage
2. Flight Instability
3. Visibility Issue

### No-Fly Zones

Mumbai has several designated no-fly zones, due to security concerns and airspace restrictions. The airport's central location, which divides the city in two, makes it difficult for drones to fly over the no-fly zone

Surrounding the airport. The Directorate General of Civil Aviation (DGCA) has issued a Civil Aviation Requirement (CAR) that states that flying drones is prohibited in the no fly zone, which includes areas surrounding airports within a 5-kilometer radius of airport boundaries.

1. 5 km radius No fly zone around Airport.
2. No fly zones such as private properties




The height of buildings allowed in the no-fly zone of airports in Mumbai depends on their distance from the runway. For buildings located within 150 meters of the runway, no construction is permitted. Beyond 150 meters, the permitted height gradually increases with distance. For instance, a building located 1.2 kilometers from the runway can be up to 100 meters tall.

Distance increase form runways height building increases. Drone is going to fly at 300 feet altitude which is 91.6 meter.

**Insight**

After permission from Aviation Organization. Drones can be used in no fly zone of airport. Outside the 1 Km radius from Runways at 300 feet altitude.

# 6. DRONE RESEARCH

Initially, From the understanding of organ transport and transplant research. Created rough idea about requirements for Drone. Following are some points listed down

- Payload
- Propulsion system
- Flight Time
- Flight Environment
- Target speed to be attained

Drones come in a variety of shapes and sizes each design to suit specific purpose. Following are types of drone depending on Propulsion Configuration

## 7.1 Types of Drones

**Vectored thrust**

Same propulsion system is used for Hovering and Cruising. Mostly used for long range.

**Lift + Cruise**

Two Different propulsion systems are used for Hovering and Cruising

**Fixed Wings**

Wings are added to other configuration

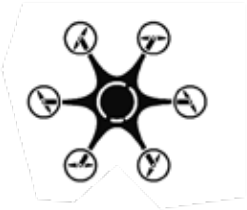
**Multi-Copter Configuration.**

Propulsion system is used for Hovering and for cruising. It is efficient in Hovering

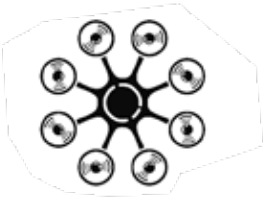
**Types of Multi-Copter Configuration**

Quadcopter

Hexacopter



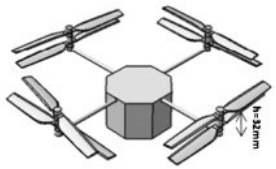
Octacopter



## 6.2 Comparison for selection of Configuration

| Feature | Quadcopter | Hexacopter | Octocopter | Coaxial octocopter |
|---|---|---|---|---|
| Number of propellers | 4 | 6 | 8 | 8 |
| Stability | Good | Very good | Excellent | Excellent |
| Maneuverability | Good | Good | Fair | Fair |
| Payload capacity | Medium | High | Very high | Medium |
| Wind resistance | Good | Very good | Excellent | Excellent |
| Cost | Low | Medium | High | Very high |
| Applications | Aerial photography, videography, racing | Aerial photography, heavy lifting | Heavy lifting, aerial photography, military use | where stability and noise reduction are important |

After comparing the advantages each version of a Drone Co-axial octocopter turned out to be more suitable choice considering the use case. Further the two new shapes are evaluated.



X shape Co-axial Octocopter chosen to move ahead with.

**Insights**

Co-axial octocopter has following advantages

1. Most stable in heavy weather conditions
2. High Payload capacity.
3. Compact in size
4. Maximum redundancy

## 6.3 Circuit Design and Components

Along with designing the exterior and skeleton of a Drone one more crucial part was the circuit design including all the relevant sensors and components and his how it turn out to be

## 6.4 Calculations for Drone.

Calculations are made to find approximate dimensions of technical components. Which are used in Technical Packaging of Drone.

### Parameters

X-shape Co-axial Octocopter
Payload - 7 kg
Organ - All
Location - Mumbai
Distance Range - 50 km
Flight Time - 50 - 60 min

| Battery chart | % | (kW) |
|---|---|---|
| Capacity Fade | 14% | 0.45206784 |
| Reserve | 20% | 0.6458112 |
| for Cruise | 50% | 1.614528 |
| for Hover | 12% | 0.38748672 |
| Unusable | 4% | 0.12916224 |

| Battery chemical combitions | gy density (Wght (kg) | |
|---|---|---|
| Lithium - ion (Li - ion) | 150 - 250 | |
| Lithium - Polymer (Li - Po) | 150 - 250 | Flexibility in form factor |
| Lithium iron phosphate (LiFePO4) | 90 - 120 | |
| Lithium - sulphur (Li -S) | 350 | Under Develpoment |
| Lithium Air (Li - Air) | 11000 | theorotical |
| Nickel Metal Hybrid (NiMH) | 60 - 120 | |
| Lead Acid (Pb - Acid) | 30 - 50 | |
| Solid State Batteries | | Thermal cooling is not needed |

| Type - Multi Motors | |
|---|---|
| No. of Propellers (Co-axial) | 8 |
| Propeller size (m) | 0.55 |
| Power (kW) | 1.6 |
| Thrust (kg) | 4.5 |
| Weight (P+M) (kg) | 0.486 |
| Thrust / weight Ratio | 8.23 |
| Weight with duct(P+M) (kg) | 0.729 |
| Power with Ducted (kW) | 1.725 |
| Propulsive efficiency | 0.85 |
| L/D ratio | 1 |
| Augumented Coeffient of lift | 1 |

| Calculations | |
|---|---|
| Thrust generated (kg) | 36 |
| Weight (M+ P) (kg) | 3.888 |
| Total Surface weight (kg) | 2.4 |
| Remaining weight (kg) | 11.212 |
| **Available weight for Battery (kg)** | 11.212 |
| Available Energy Capacity (kWh) | 3.229056 |
| **Required Power (kW)** | 12.8 |
| **Rquired weight for Battery (kg)** | 12.916224 |

| | |
|---|---|
| Total weight | 30 |
| Battery power (kWh) | 9.6 |
| Thrust Force (kN) | 0.29 |

| Dimensions | |
|---|---|
| Length (m) | 1.6 |
| Width (m) | 1.6 |
| Heigth (m) | 0.7 |
| Weight (1*1 sq. m) | 0.5 |

| | |
|---|---|
| Net weight (kg) | 30 |
| Payload (kg) | 12.5 |
| Extra(kg) | 0 |
| Range (km) | 50 |
| Endurance (min) | 45 |
| Energy density of Battery (Wh/kg) | 288 |
| Energy density at cell level (Wh/kg) | 250 |
| Total energy consumtion (kWh) | 9.6 |
| Max rated power 8 motors (kW) | 12.8 |
| Ballistic Integrated parachute (Kg) | 2.3 |
| Charging time (min) | 120 |
| Avg. speed (km/h) | 60 |
| Altitude (m) | 400 |
| Take of & landing time (sec) | 40 |

| | |
|---|---|
| Power ratio of (consume / weight) | 0.9910017 |
| Max power required for hover (kWh) | 0.14222222 |
| Endurance (min) | 36.32688 |

### Required Components

Propeller - 22 inch
Swappable Battery - 288 Solid State Li ion Battery
Motor - 1.6 KW
Actual Lift payload - 36
Required lift Payload - 30

# 7. BENCHMARKING

Based on the key insights some products were benchmarked

**Payload Accessibility and Packaging**
Agras T30

**Stability in harsh weather Condition.**
AceCore Neo X8

## Compactness

DJI avta

## Vibration Reduction System

DJI ronin 4D

Octa Core VRS wire

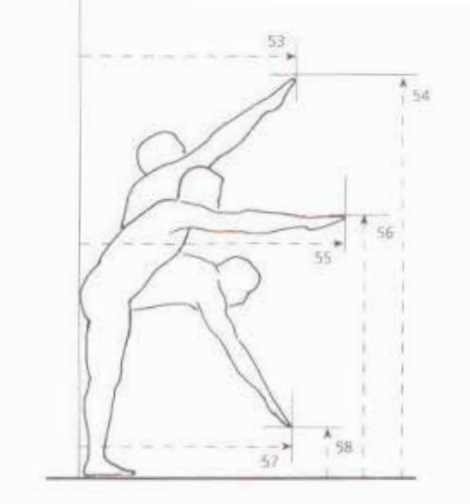
**Attachment and Accessibility**

**Stacking without getting Stuck**

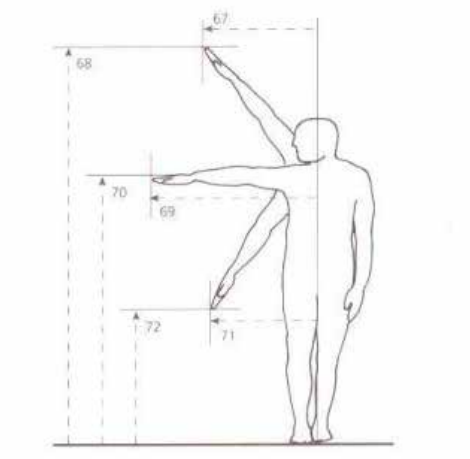
# 8. PACKAGING

## 8.1 Indian Anthropometric Data

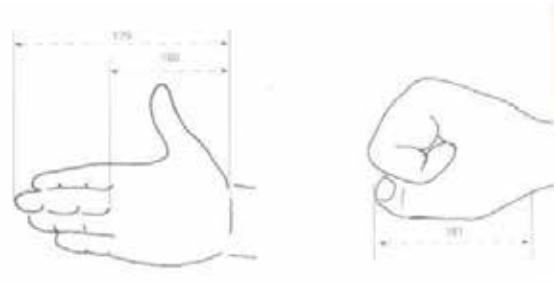
Units are in mm



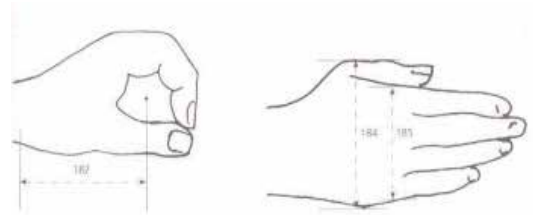

55 - Forward arm Reach 954
56 - Mid Position Height 1399
57 - Lower Position Length 719
58 - Lower Position Height 1139



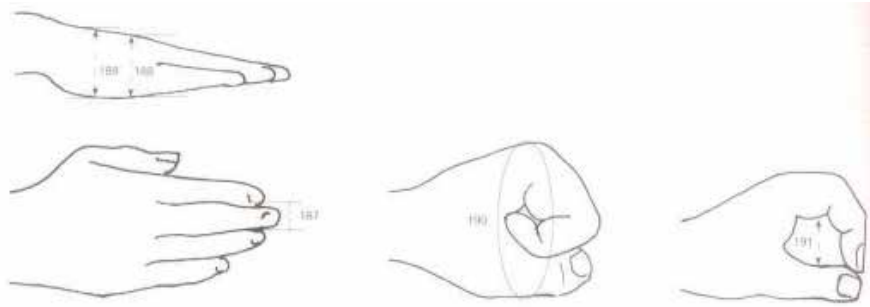

69 - Mid Position Length 739
70 - Mid Position Height 1499
71 - Lower Position Length 409
72 - Lower Position Height 959



179 - Hand Length 198
180 - Palm Length 114
181 - Fist Length 115



182 - Hand Grip, Length 65
183 - Hand Grip Breadth 109
184 - Hand Breadth 111



189 - Hand Depth 50
190 - Fist Circumference 294
191 - Grip Inside Dia 56

## 8.2 User analysis for Handles.

Initial idea is to get dimension for Handel Organ Transportation Bag, To compare the dimension user has grip on grip of Luggage trolley bag. Dimension. Following are pictures.

Over all Required space for hand to grab the handle - 15 * 8 * 6 cm

## 9.3 Dimensions for Components

| Propeller | ESC | Motor | Throttle | Thrust (g) |
|---|---|---|---|---|
| STANDARD22X6.6 PROP | AMPX 60/80A | MAD 6108 EEE/PE KV170 | 50-60% | 2500g / Motor (10S) |
| | AMPX 60/80A | MAD M6 C12 KV150 | 50-60% | 4000g / Motor (12S) |
| | AMPX 60/80A | MAD M6 C12 KV280 | 50-60% | 2800g / Motor (6S) |
| | AMPX 60/80A | MAD M6 C15 KV170 | 50-60% | 4500g / Motor (12S) |

Battery (2) - Size : 19*10*7 cm Weight : 6 kg

Motor (8) - Size : 7.2*7.2*3 cm Weight 0.43 Kg

Propeller (8) - Size : 22 Inch MAD M6 C15 Kv 170

Payload - Size : 61*35*31 cm Weight : 12 Kg

Esc (8) - Size : 7.9*3.6*2.3 cm Weight 0.2 Kg



## 8.4 Locking Mechanism

Initial, Looked for all attachments and Mechanism used in Aircrafts. Few are mentioned below and As per priority selection for Locking Mechanism has been Selected.


Considered Lock and attachments are down Below.

Toggle Lock Mechanism

Over center Latch.

Double Lock Buckle

## 8.5 Packaging 1

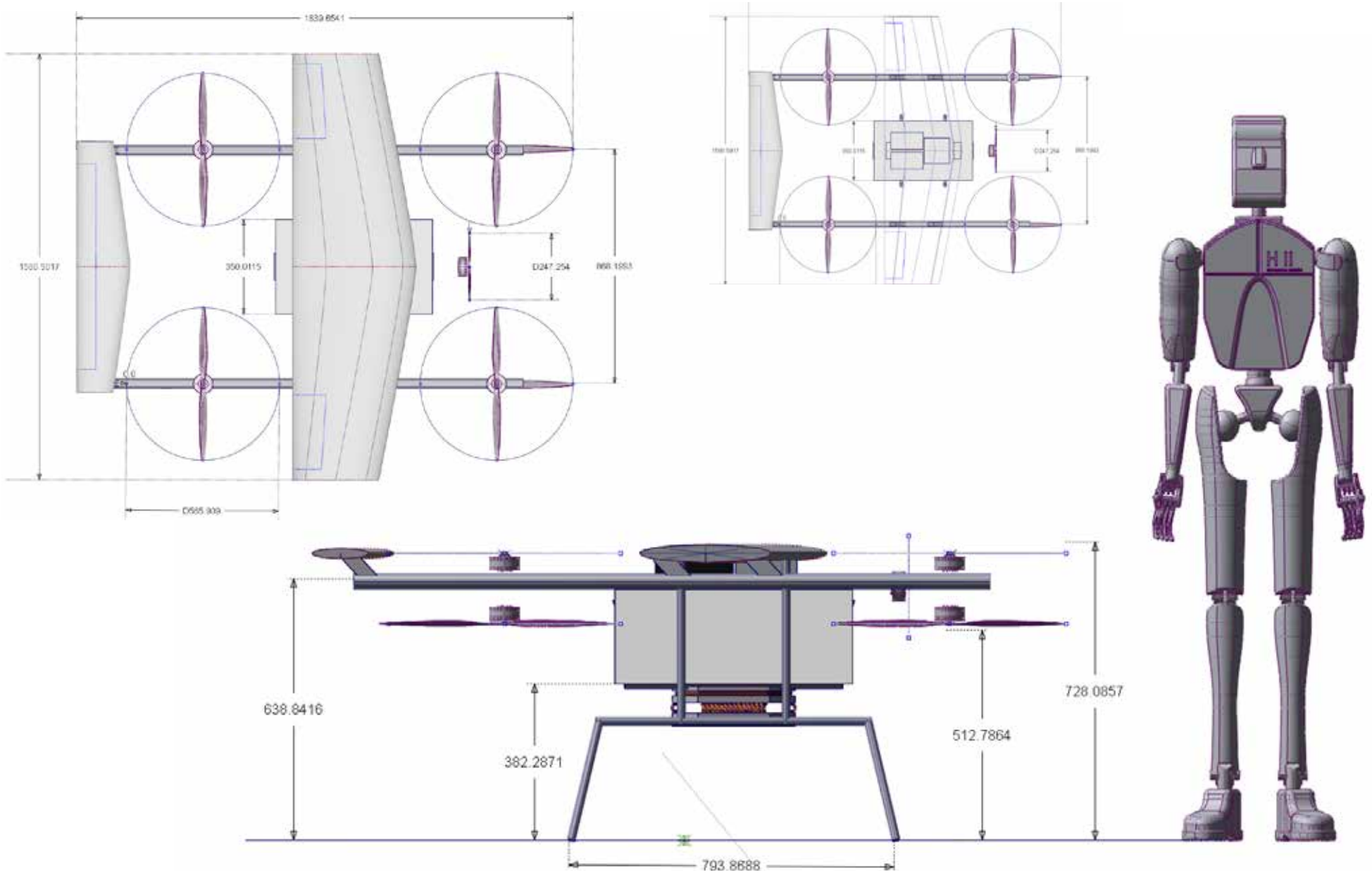
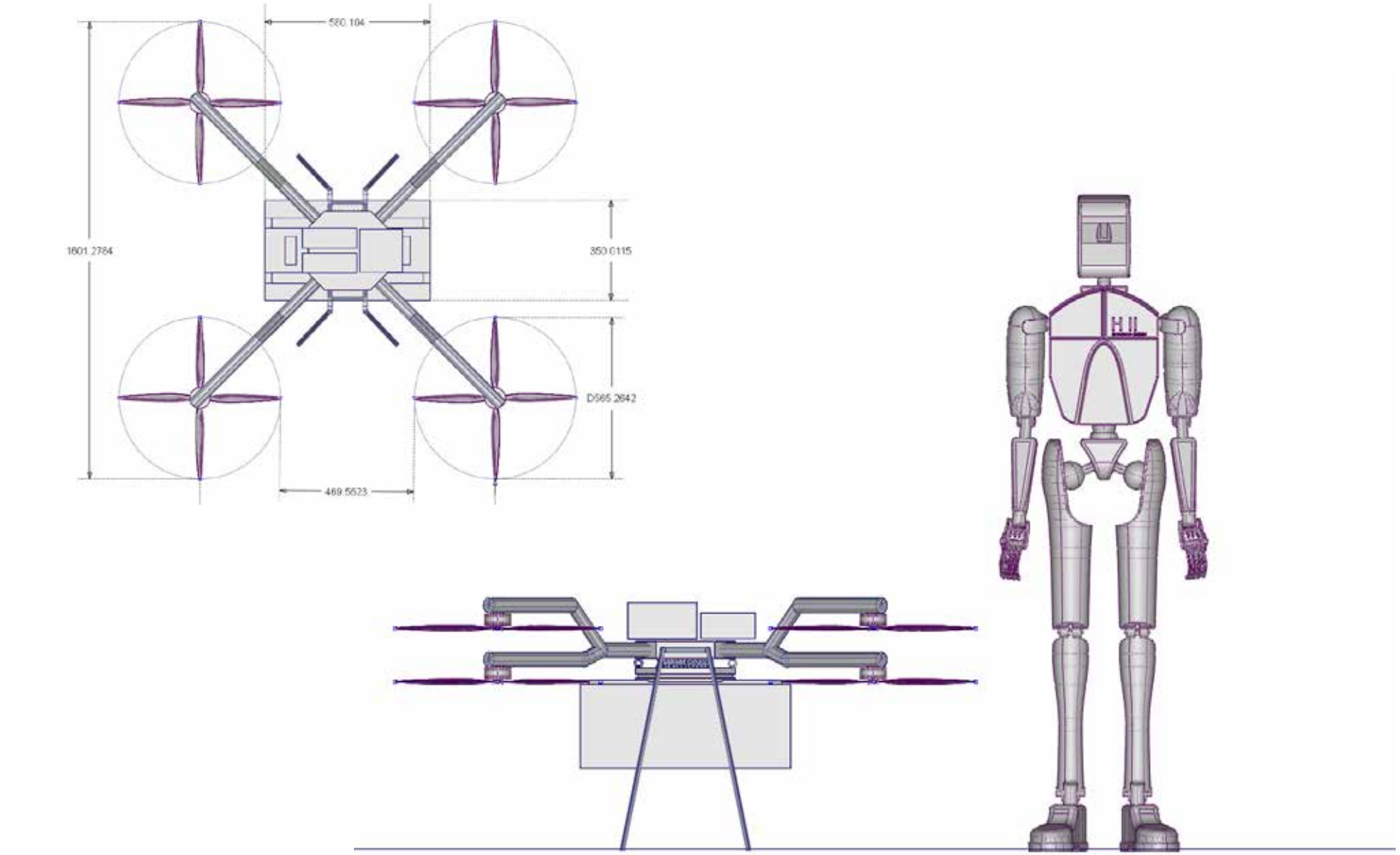
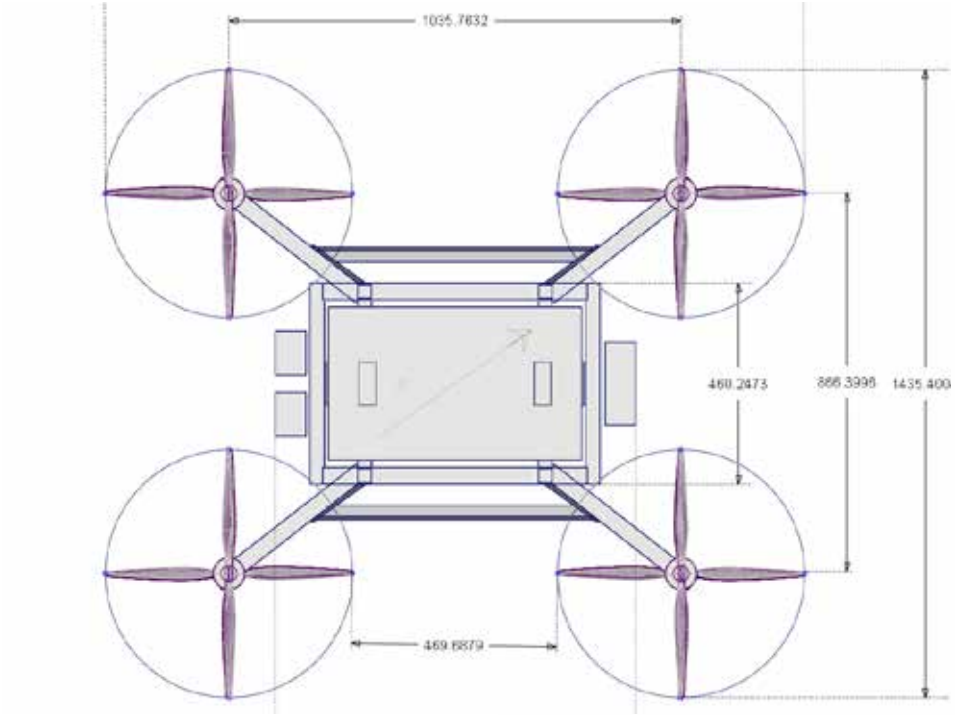


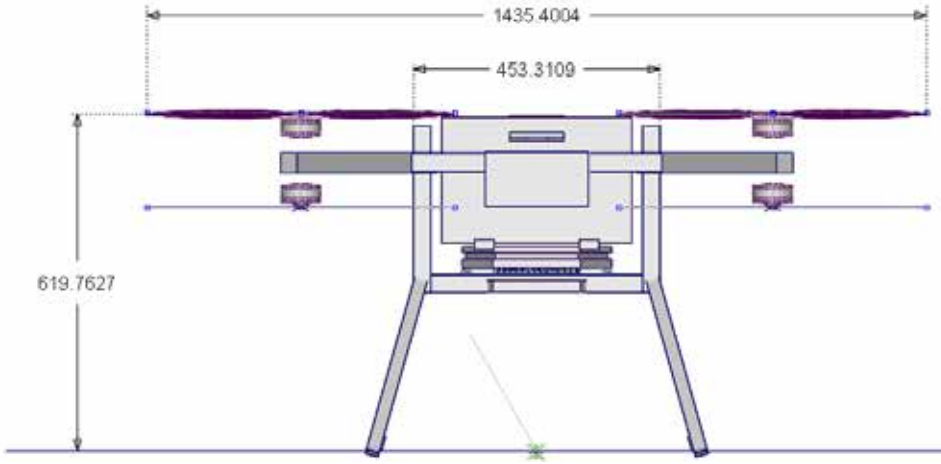

Figure . Digital Human Model based on Indian Anthropometric data

## 8.6 Packaging 2

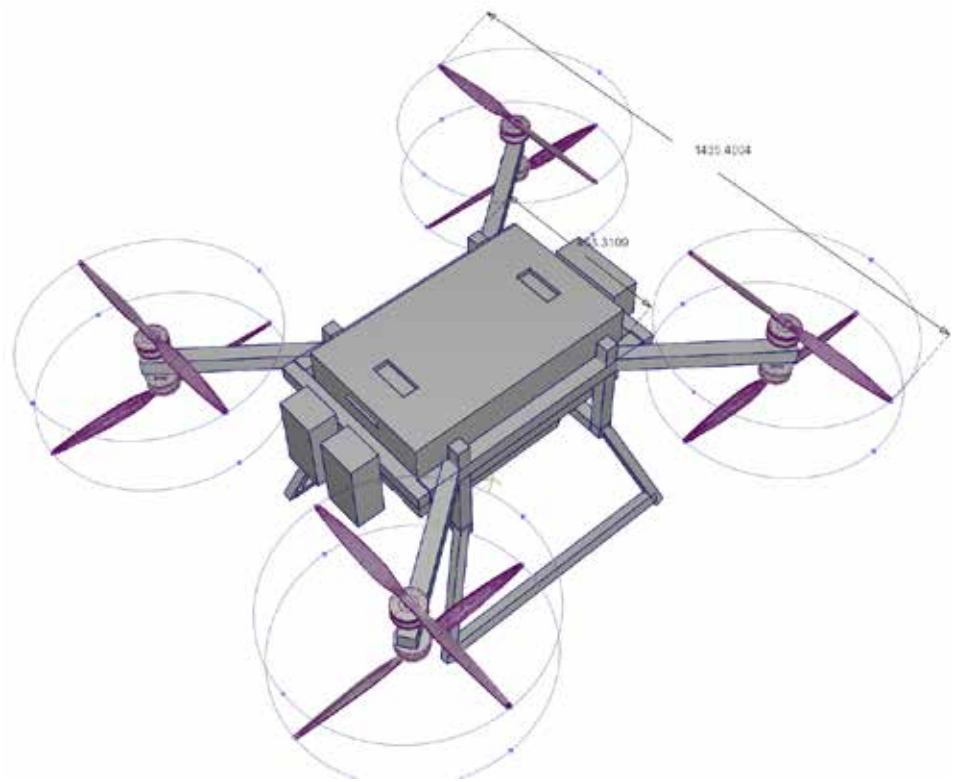


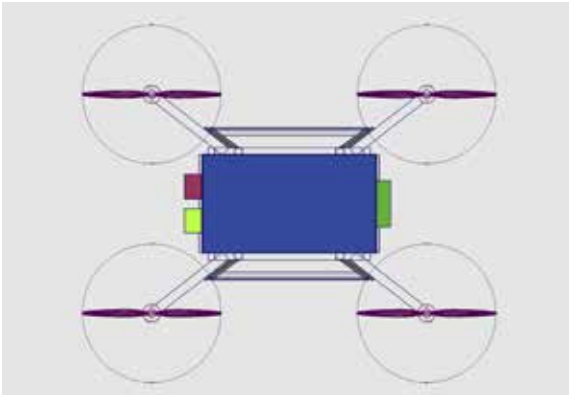
## 8.7 Selected Packaging

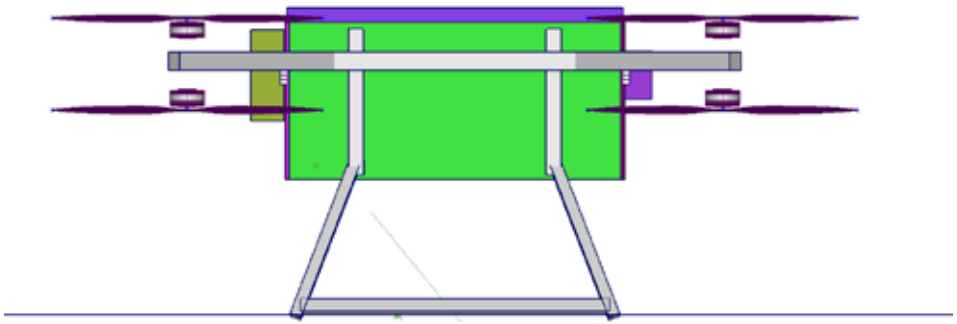


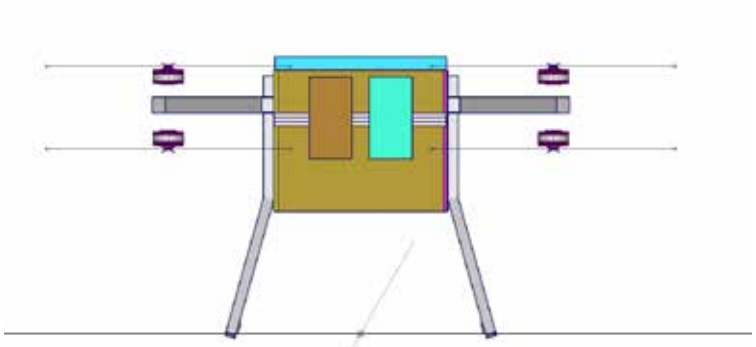




**Components**







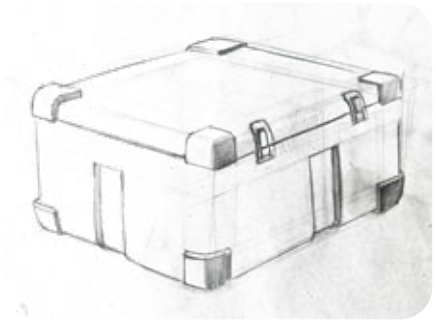


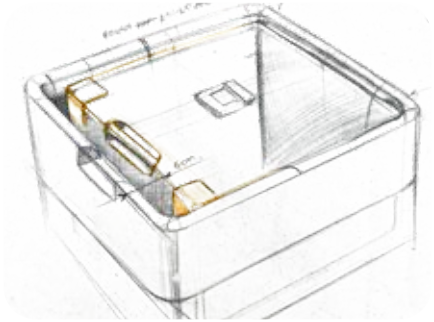
## 8.8 Packaging Mock-up

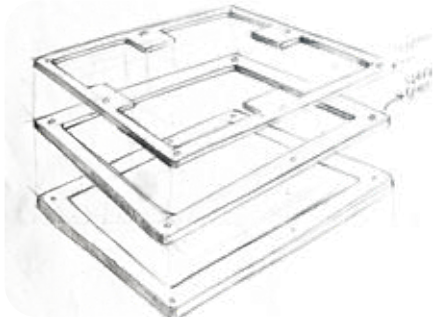
In this section we can see the process of unloading the payload and Human Interaction with Drone. And this mock-up is created for proportions of drone with 95 $^{th}$ Percentile Human manikin. Dimension are approximately accurate Packaging and Manikin. (Scale 1: 6)

Step by step flow of operation is explained below.

Inside the Organ Transportation Box Standard Triple Bag Packaging is Used for Organ Safety. Keeping Box attached with Drone without Vibration impact because of VRS.







Receiver is reached to the Drone from wide space from side of Drone. Propellers electronically can Positioned such a way that . they will not disturb the operation

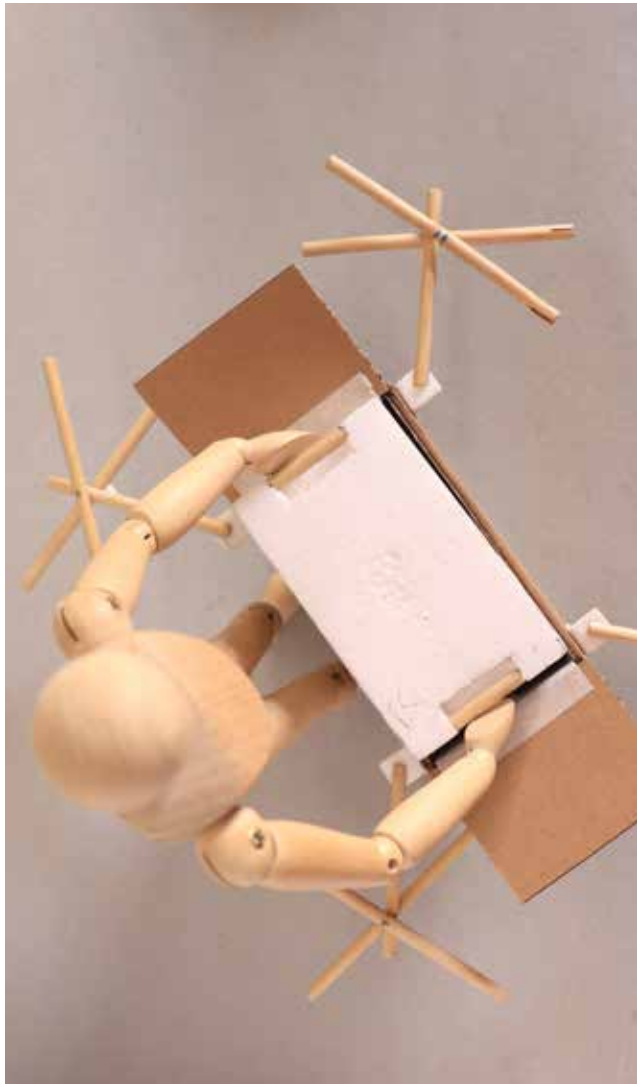
Hand is reaching to open the lead which is positioned at yellow pin shown in image Pin represents a lock mechanism position

Receiver can open the lead from both sides of the drone to complement the operation opening of longitudinal

With simple one step receiver is able to pick organ transportation box which has handles on both sides

As per anthropometric data 8 cm of GAP is provided for hands to reach handle of organ transportation box

By simple vertical lift box is detached from Drone attachments. Which are explained in further process

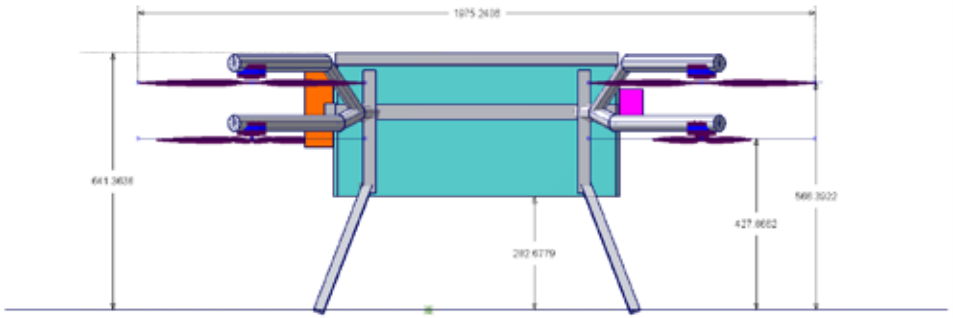


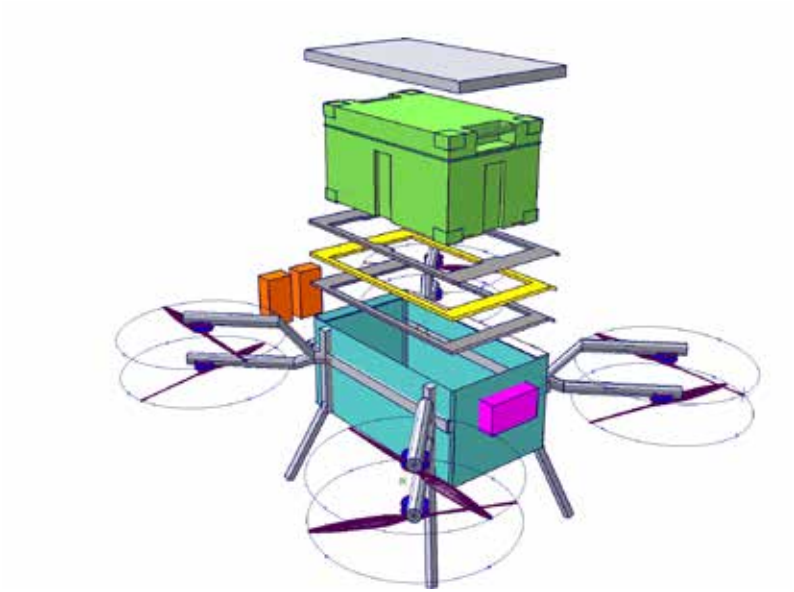
Easily, receiver is able to lift the organ transportation box with his hands.

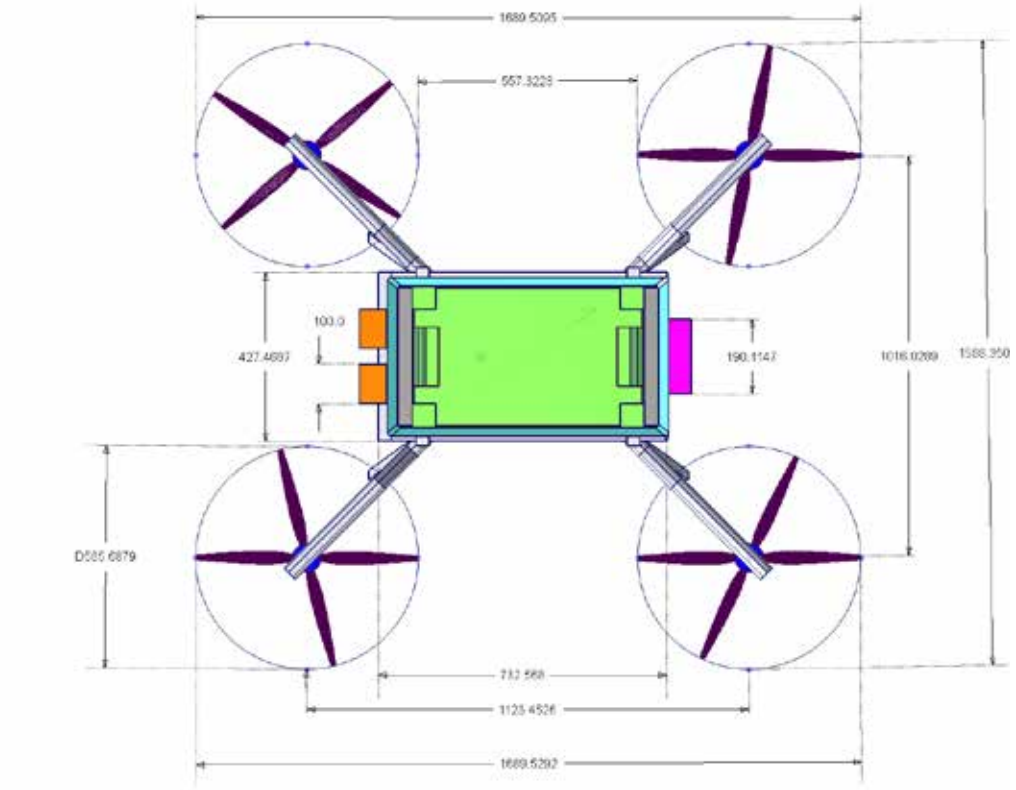
Vertical height to remove 12 kg payload decided from experiment. Users are told to lift 10 kg payload and Payload can be easily lifted till Waist. For 95$^{th}$ percentile is 100 cm

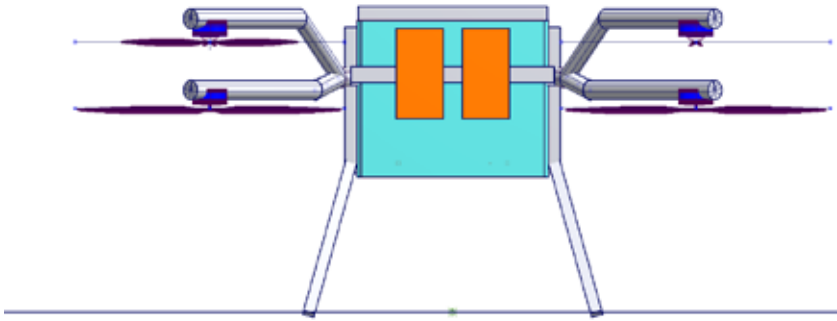
Organ transportation box is carried by 2 persons to the operation theatre

## 8.9 Final Packaging





# 9 DESIGN BRIEF

To design an Octocoptor Drone (Unmanned aerial vehicle) with an organ transportation Box which will be used for carrying human organs for transplants between two medical facilities. Drone is capable of transporting human organs - Heart, Liver, Lungs, Kidney within shortest possible time while ensuring the safety and viability of the organs. Designed Organ transportation Box which will be attached externally to the drone while transporting. Drone caters through heavy weather conditions of Mumbai such as rain, wind, humidity. Attachments between drone and Organ Transportation Box should be designed such that box can be removed with less effort and time considering safety of Organ.

Dimensions of drone

Length - 1.68 m
Width - 1.6 m
Height - 0.65 m

Dimensions of Payload

Length - 61 cm
Width - 35 cm
Height - 31 cm

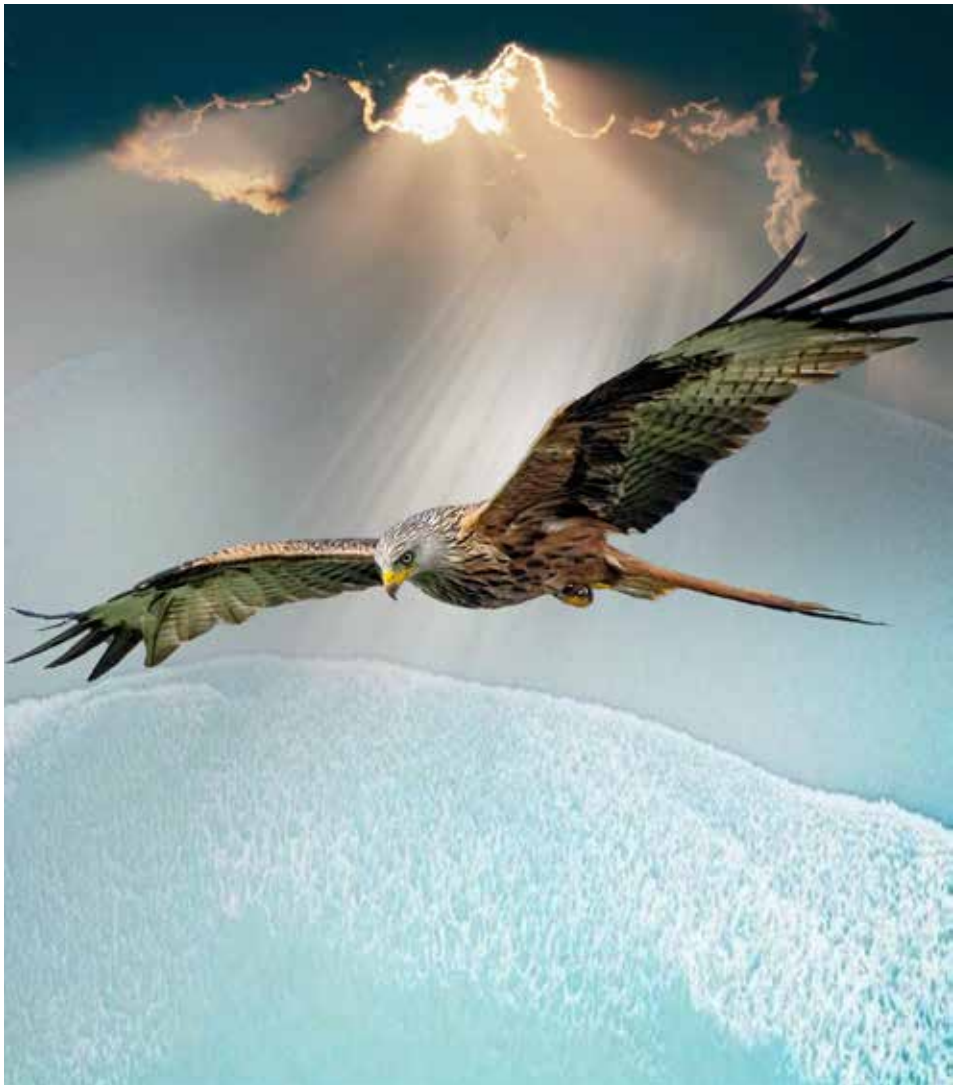
**Features**

- X 8 co-axial configuration of propellers (Most stable, Max-payload, Tandem )
- Use of Swappable Batteries to reduce the idle time
- Vibration reduction system (Gimbal mechanism and Material damping)
- Ballistic parachute the organ and Drone safety in emergency failure.
- Use of wings to increases the flight distance.
- Carbon Fiber Hollow structure for propeller arms.

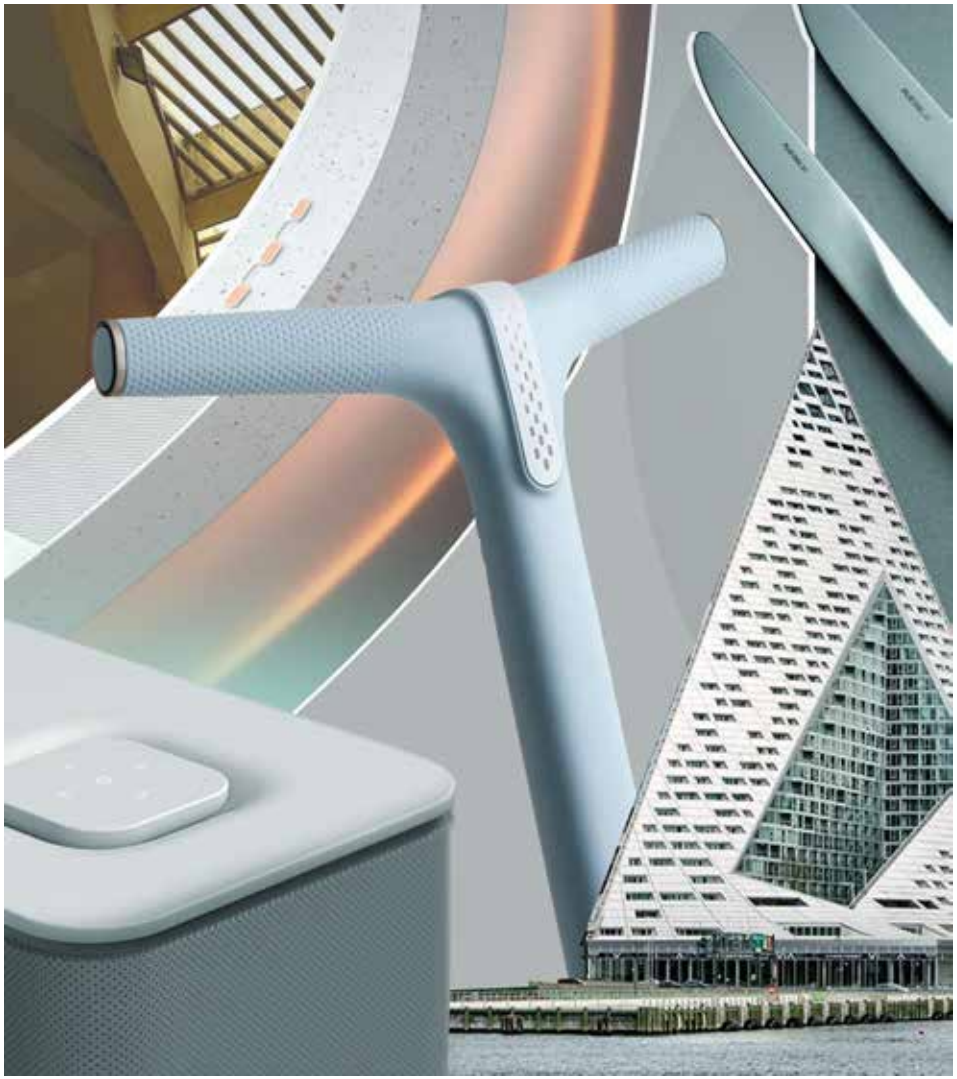
**Technical Specifications**

Range 50 km
Payload Capacity 12.5 kg
Gross weight 36 Kg
8 Co-axial propellers - 22 inch

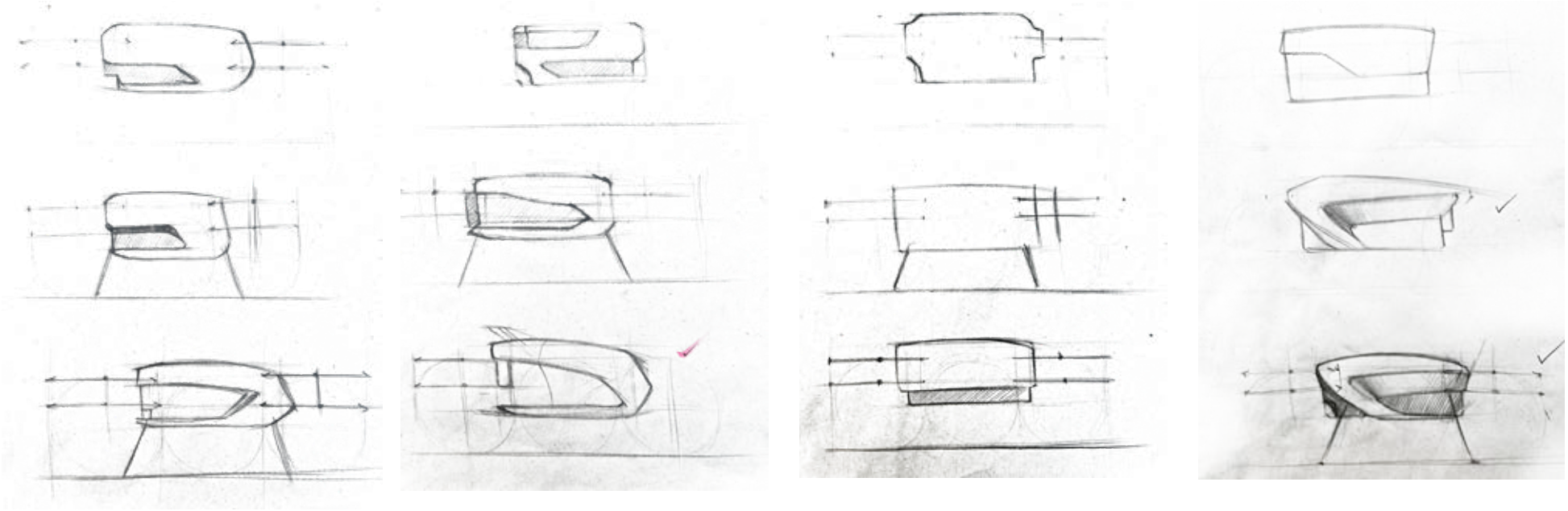
## 10 MOOD BOARD

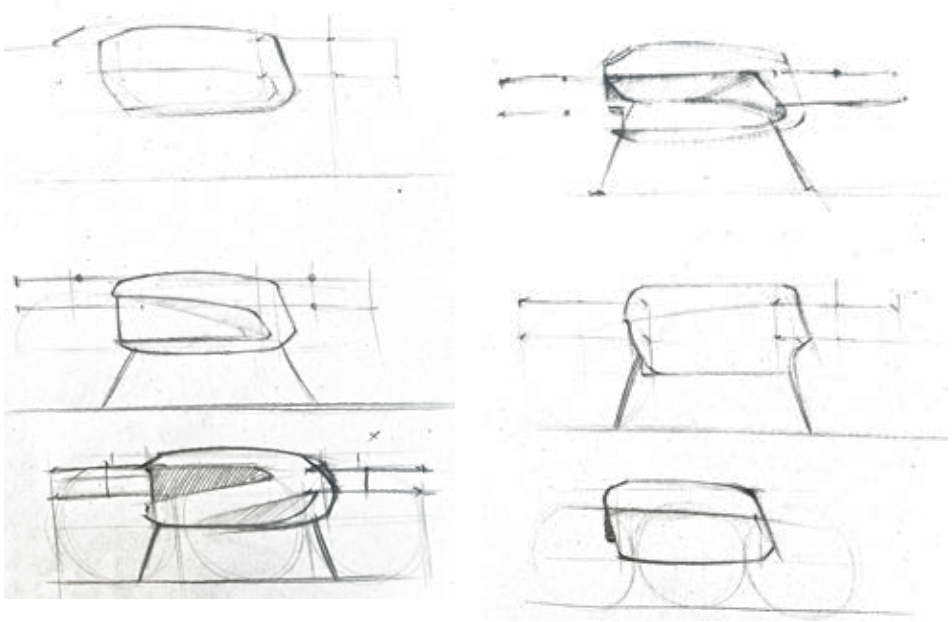


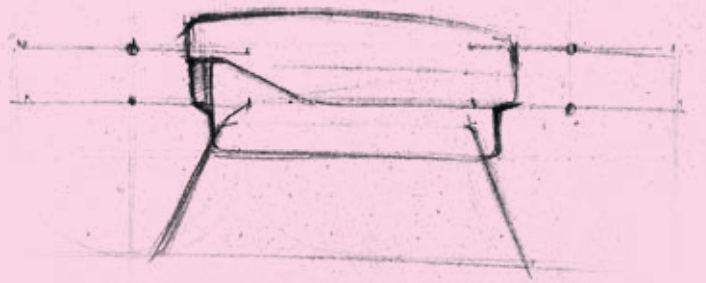
# 11 THEME BOARD



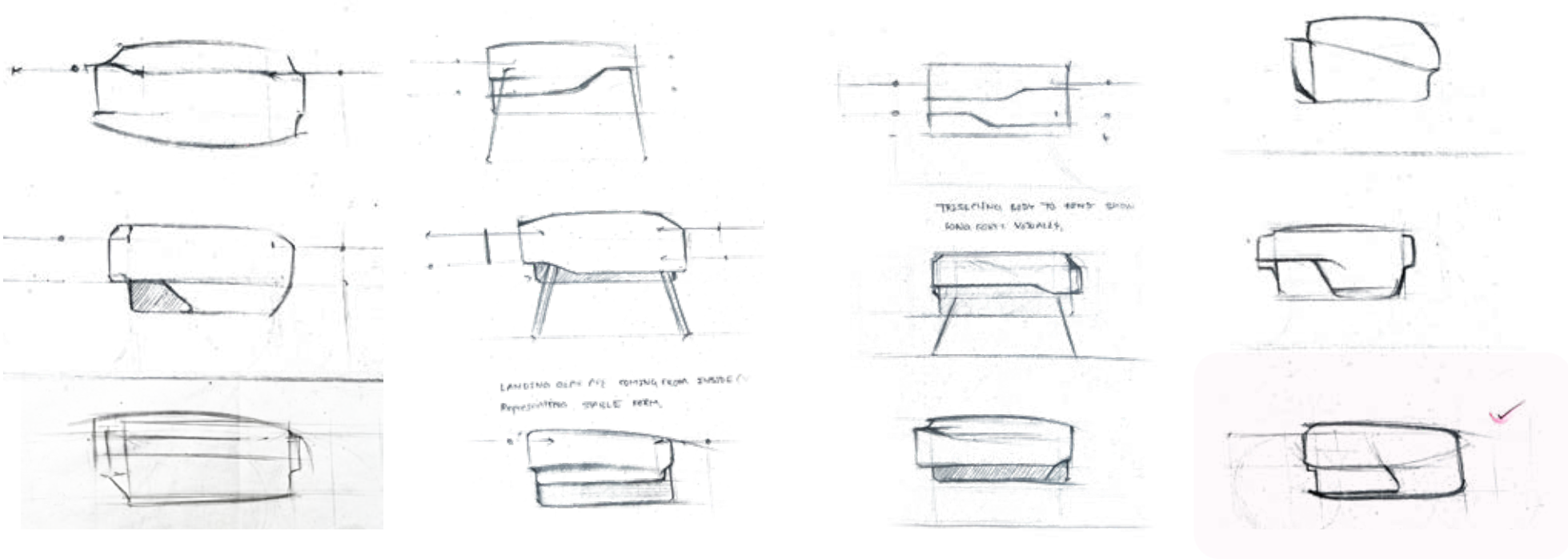
## 12 IDEATION SKETCHES



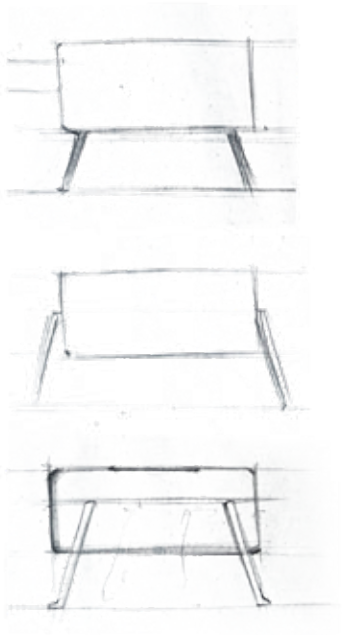


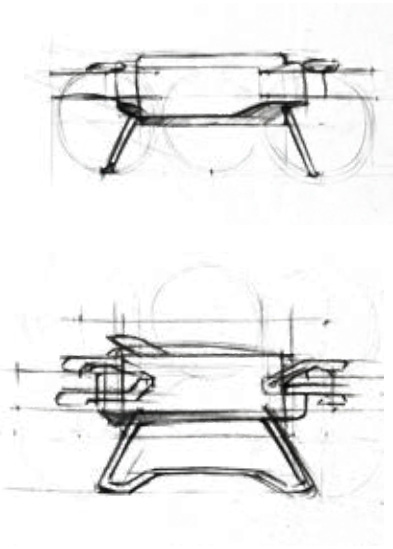


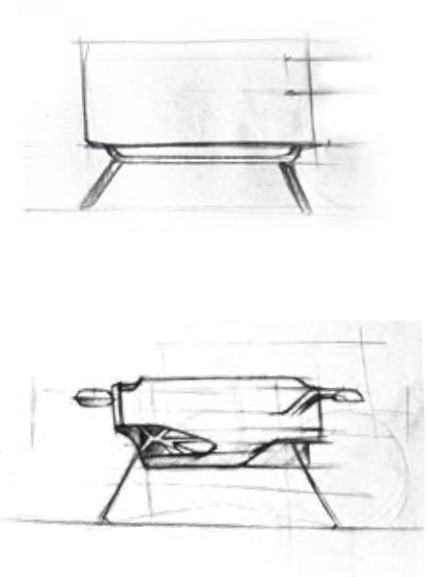
Key Sketch

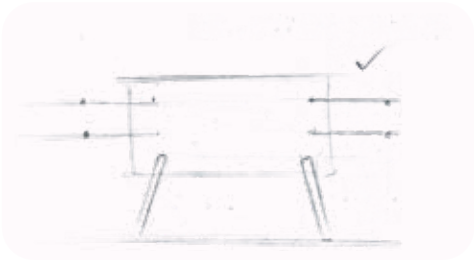


Landing Gear Positions

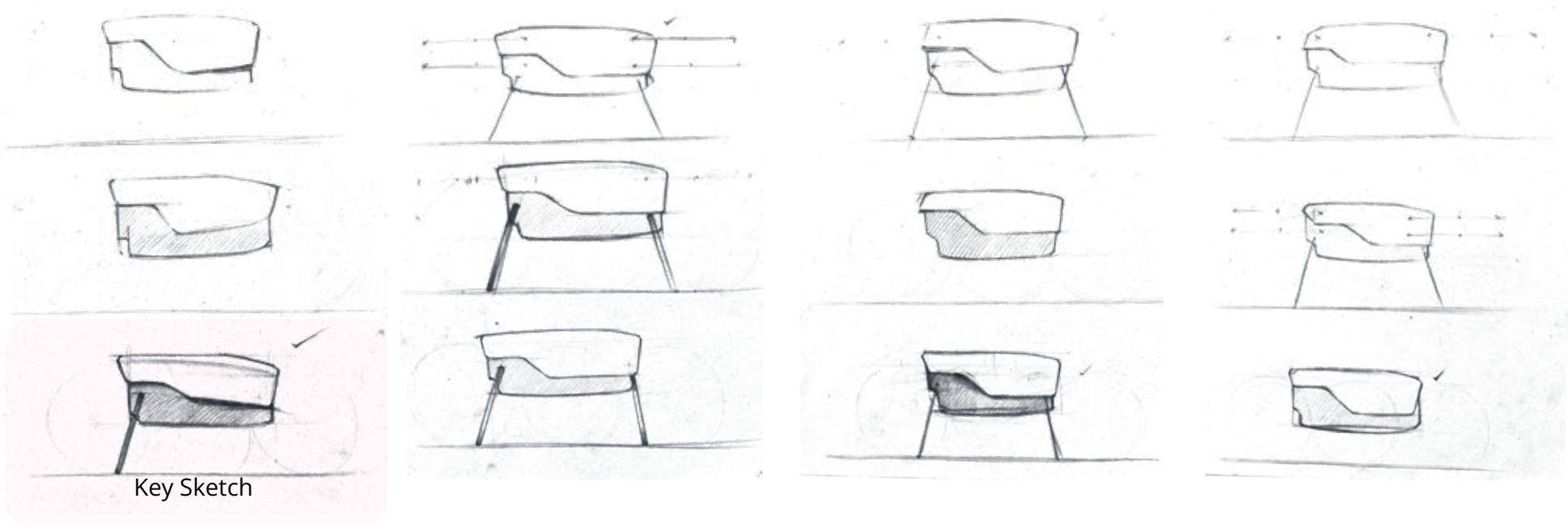




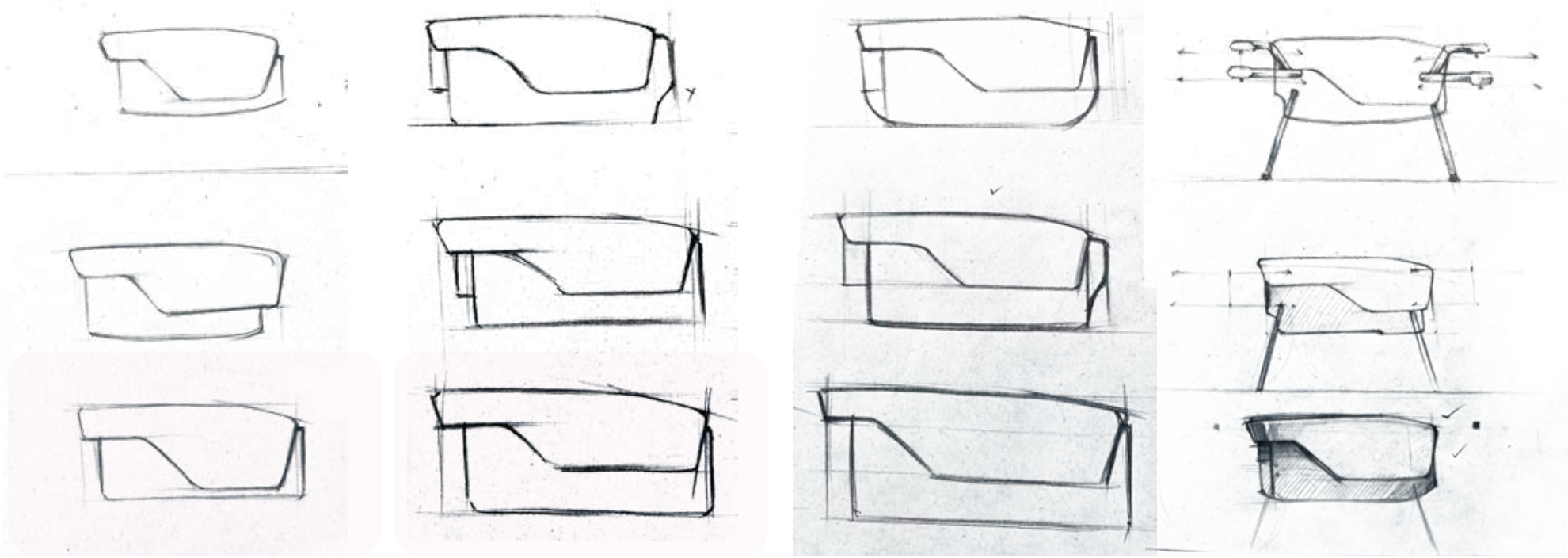


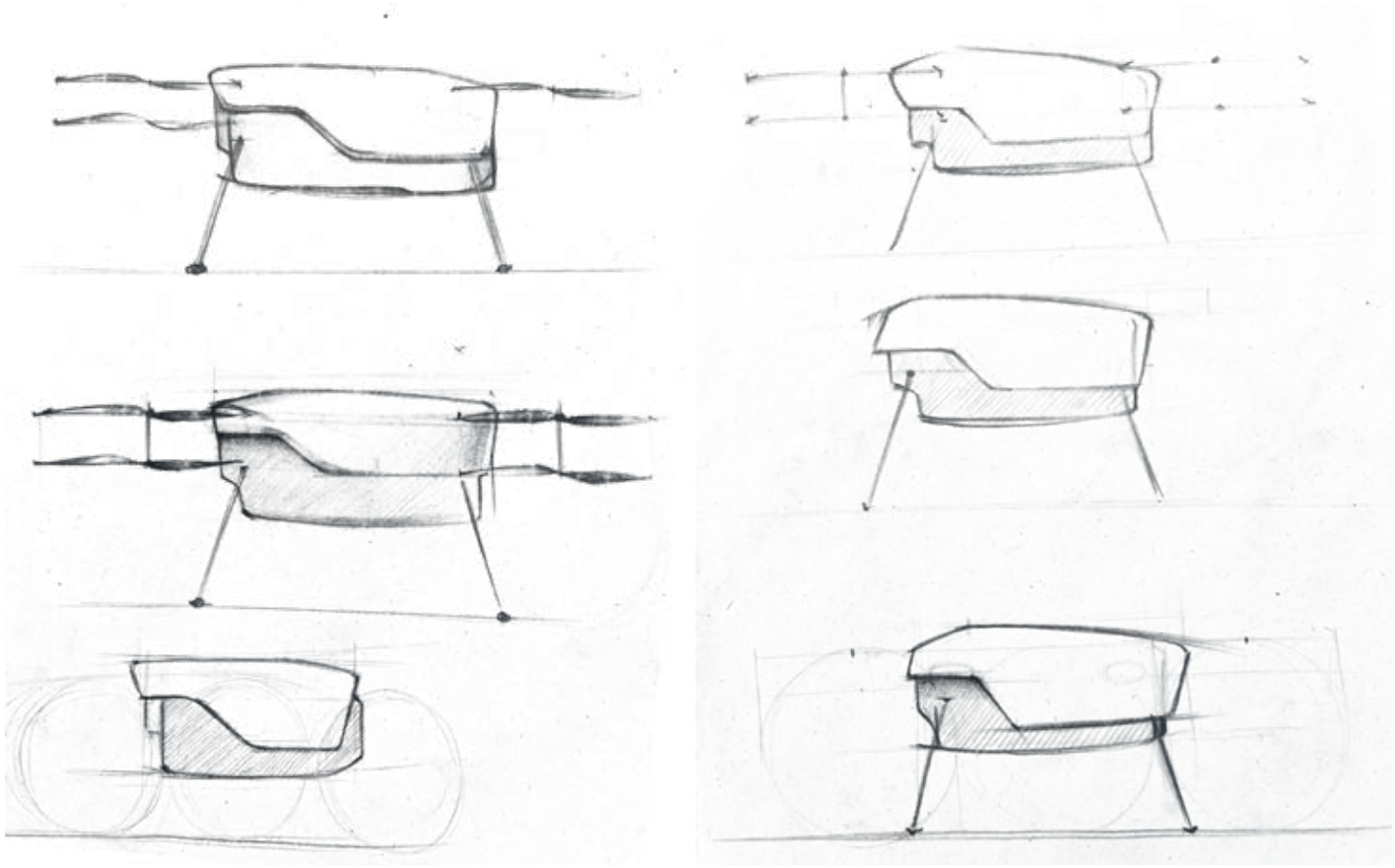


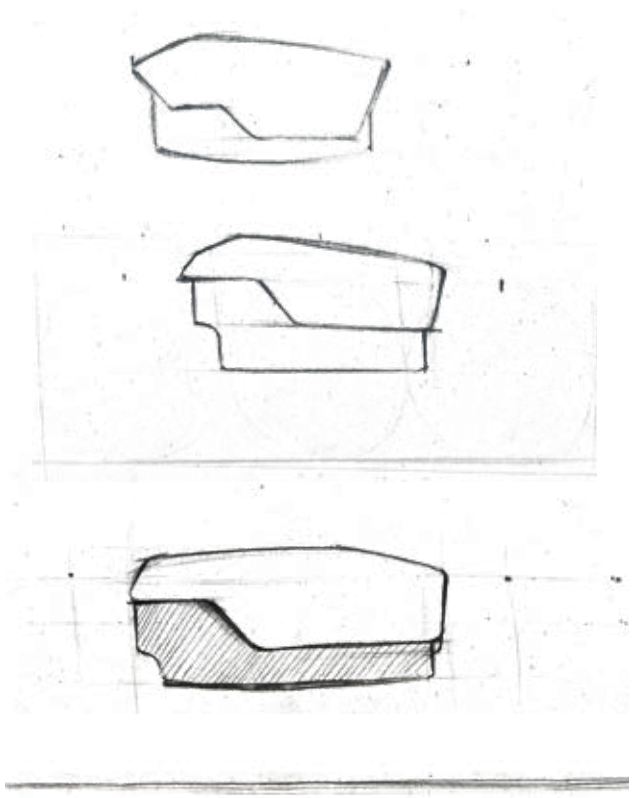
Direction 1

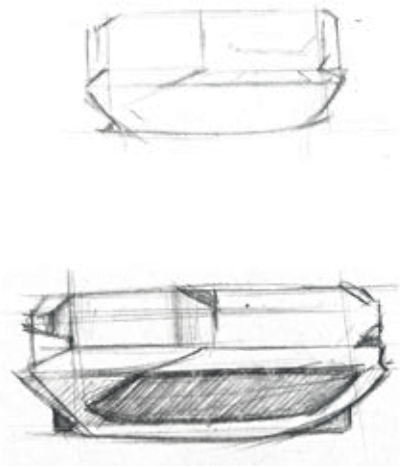


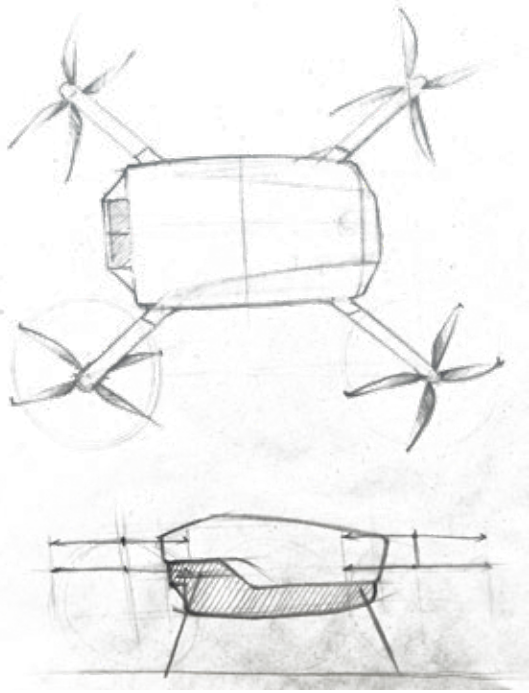
Key Sketch

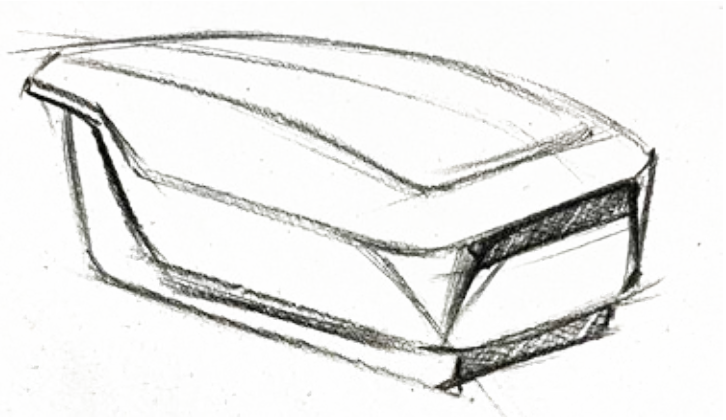


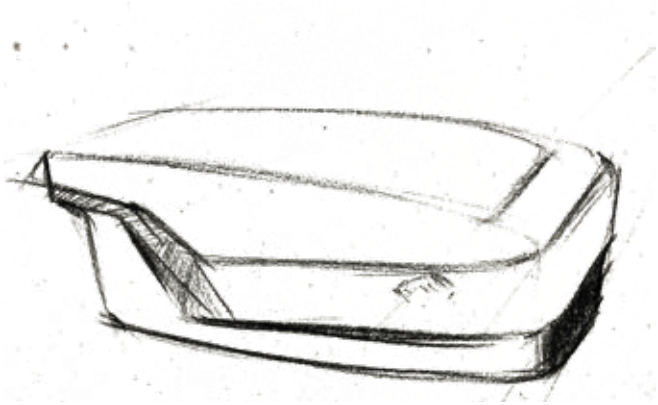


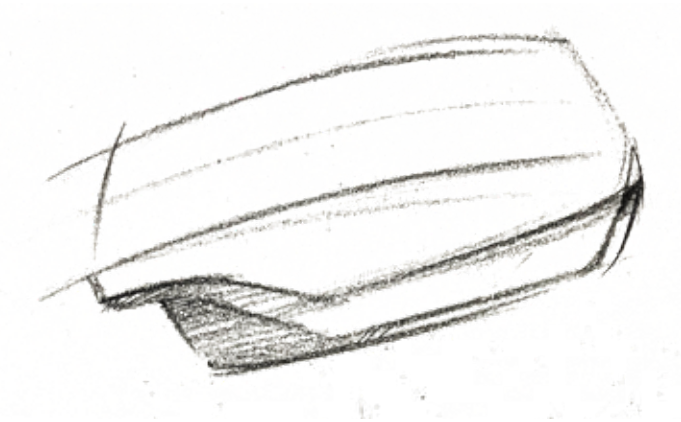


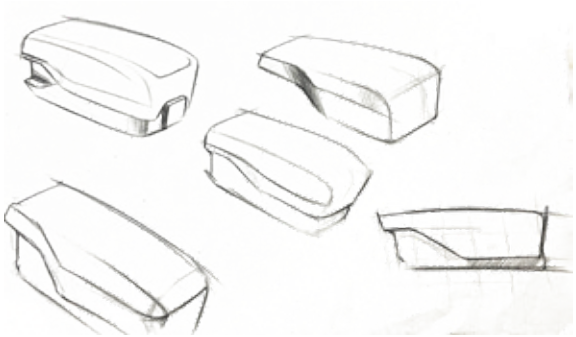


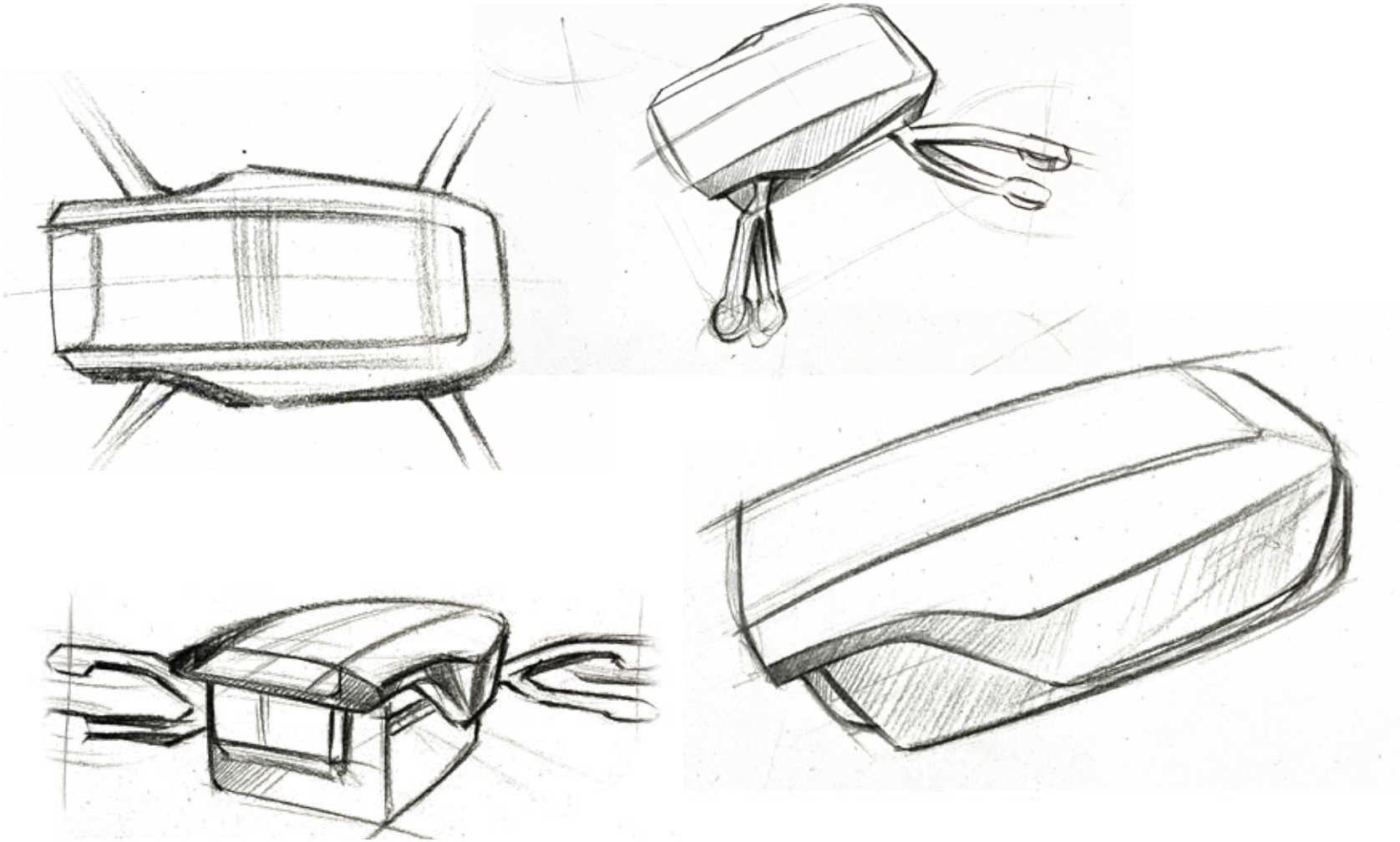


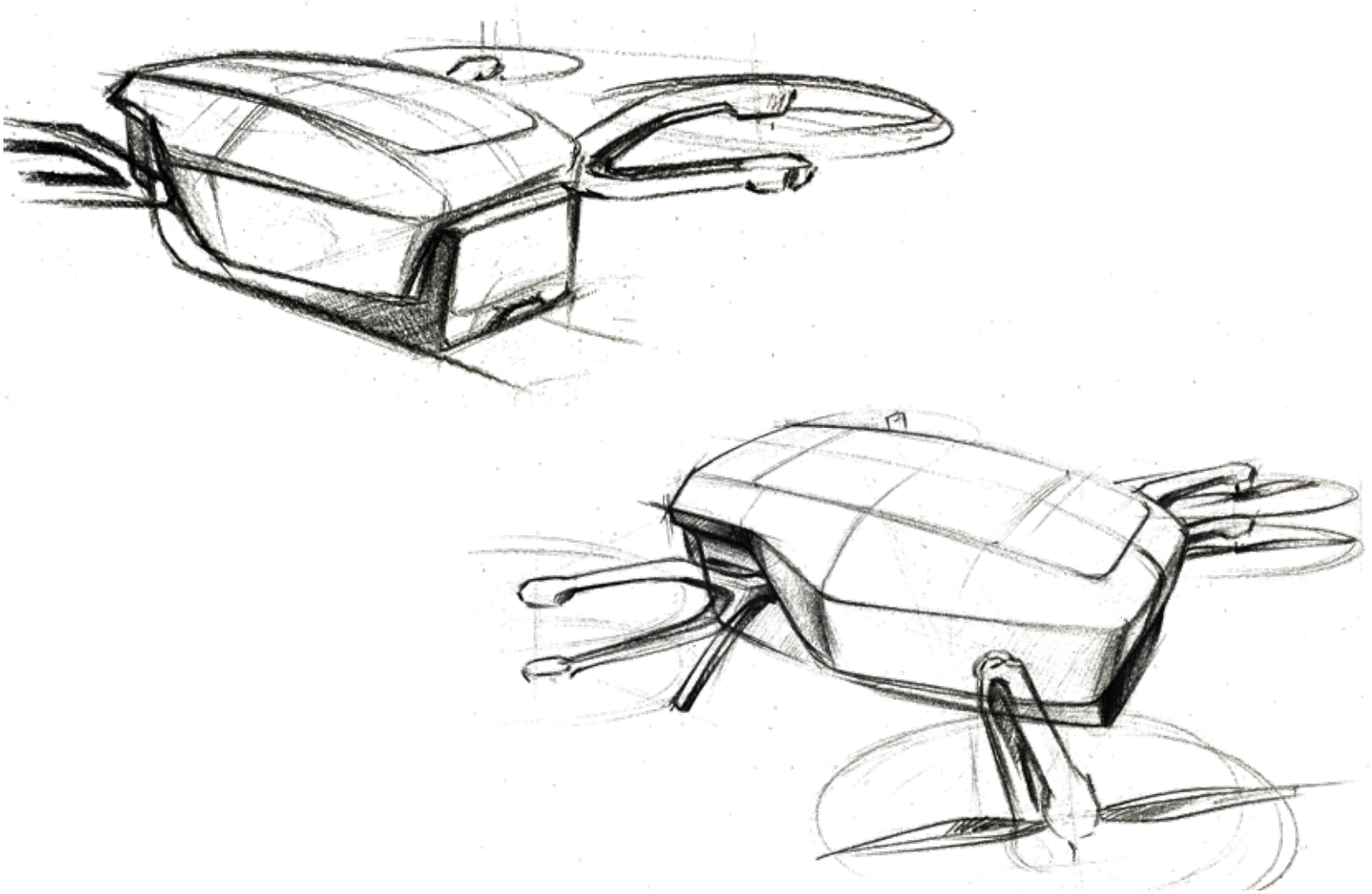




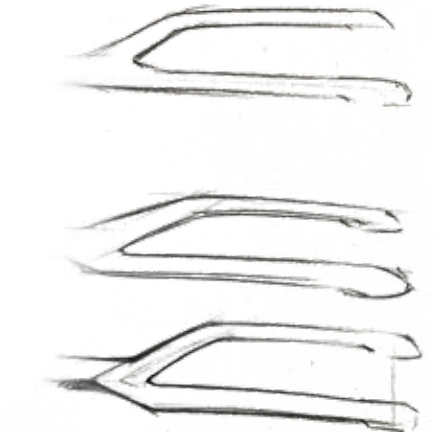


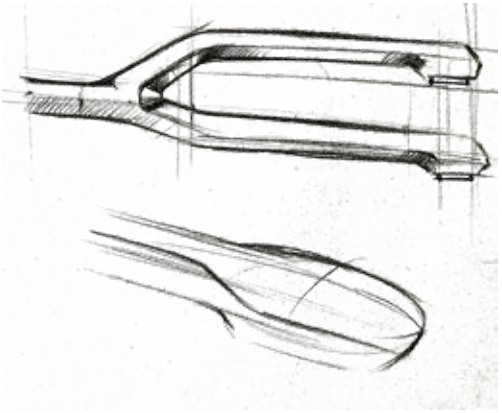


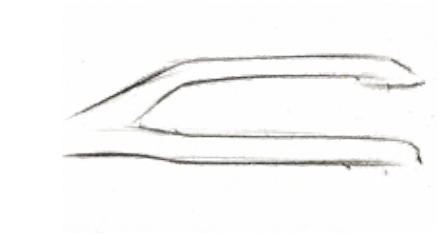


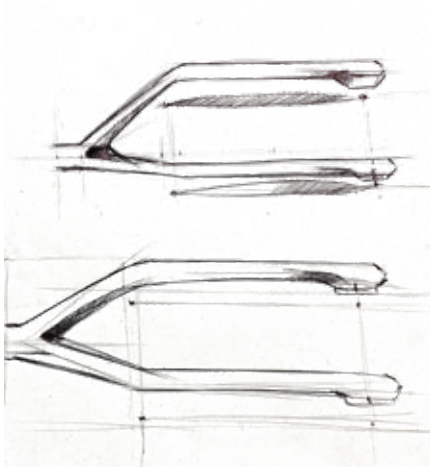


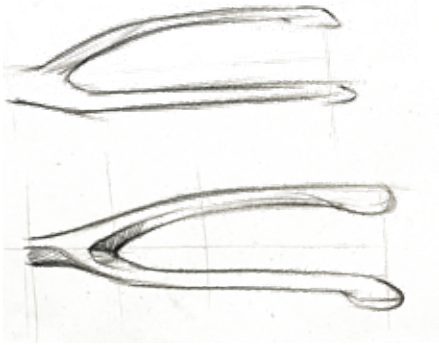
Propeller Arm Design

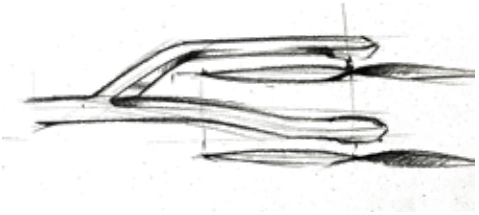


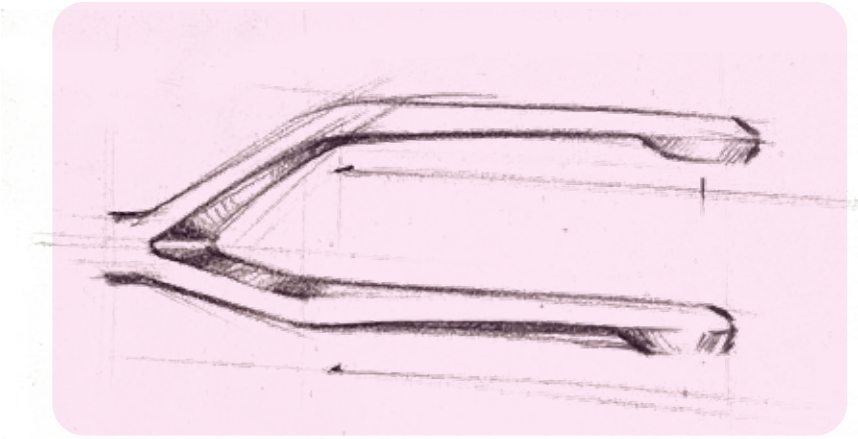


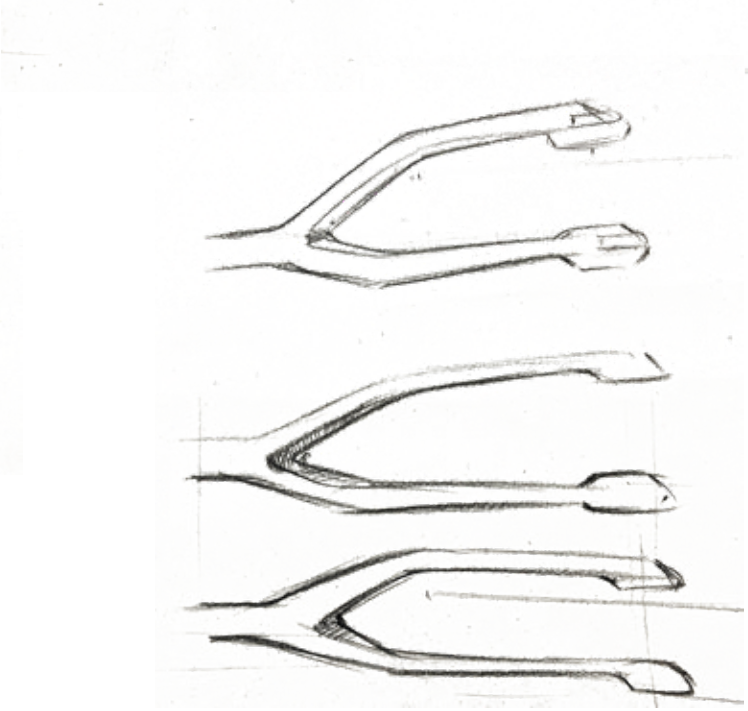




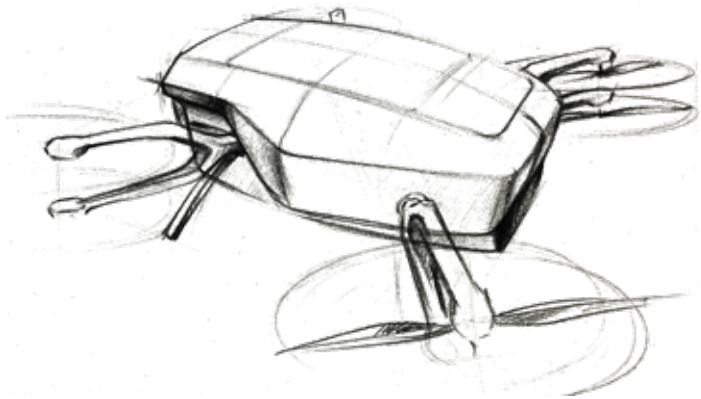






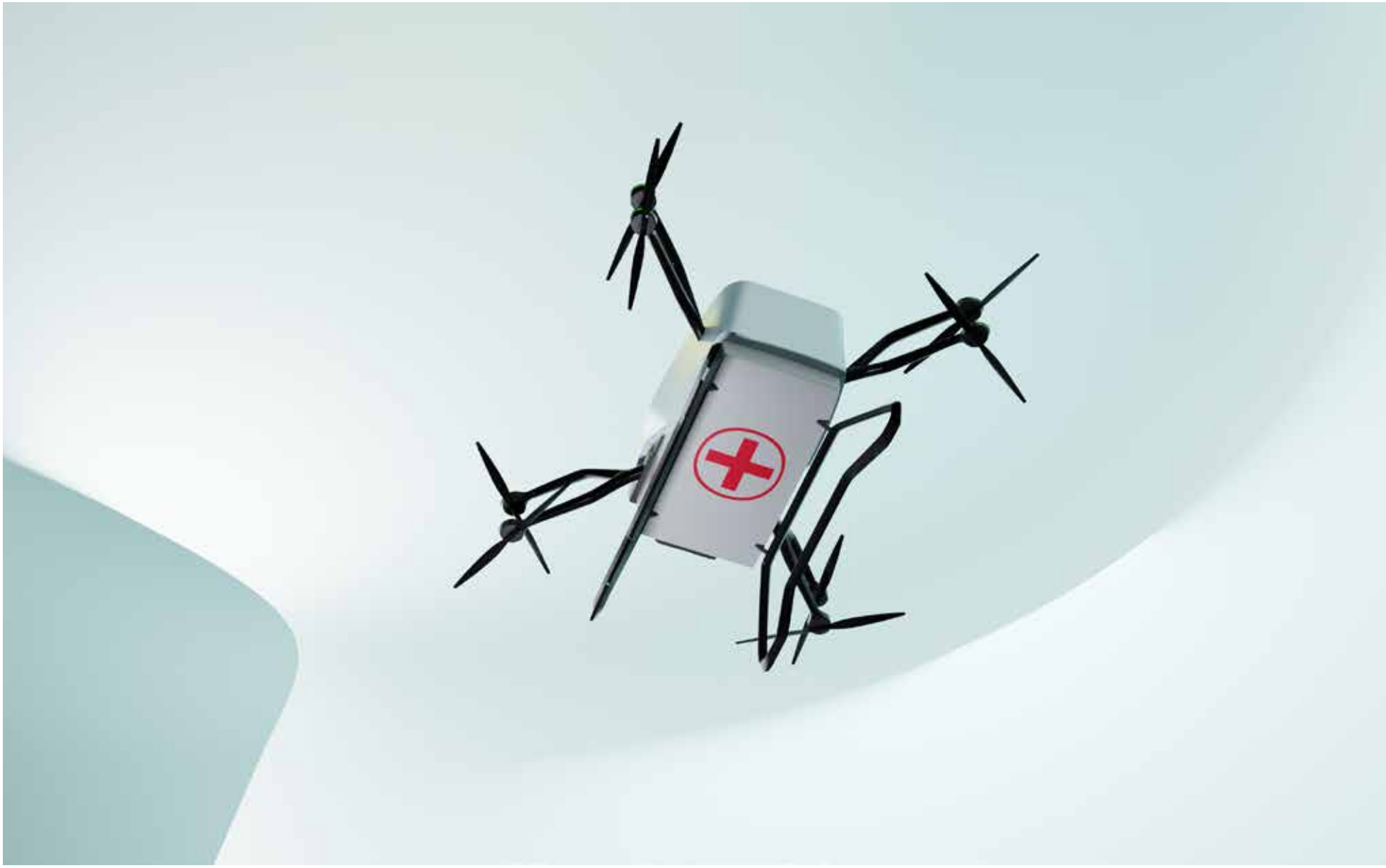


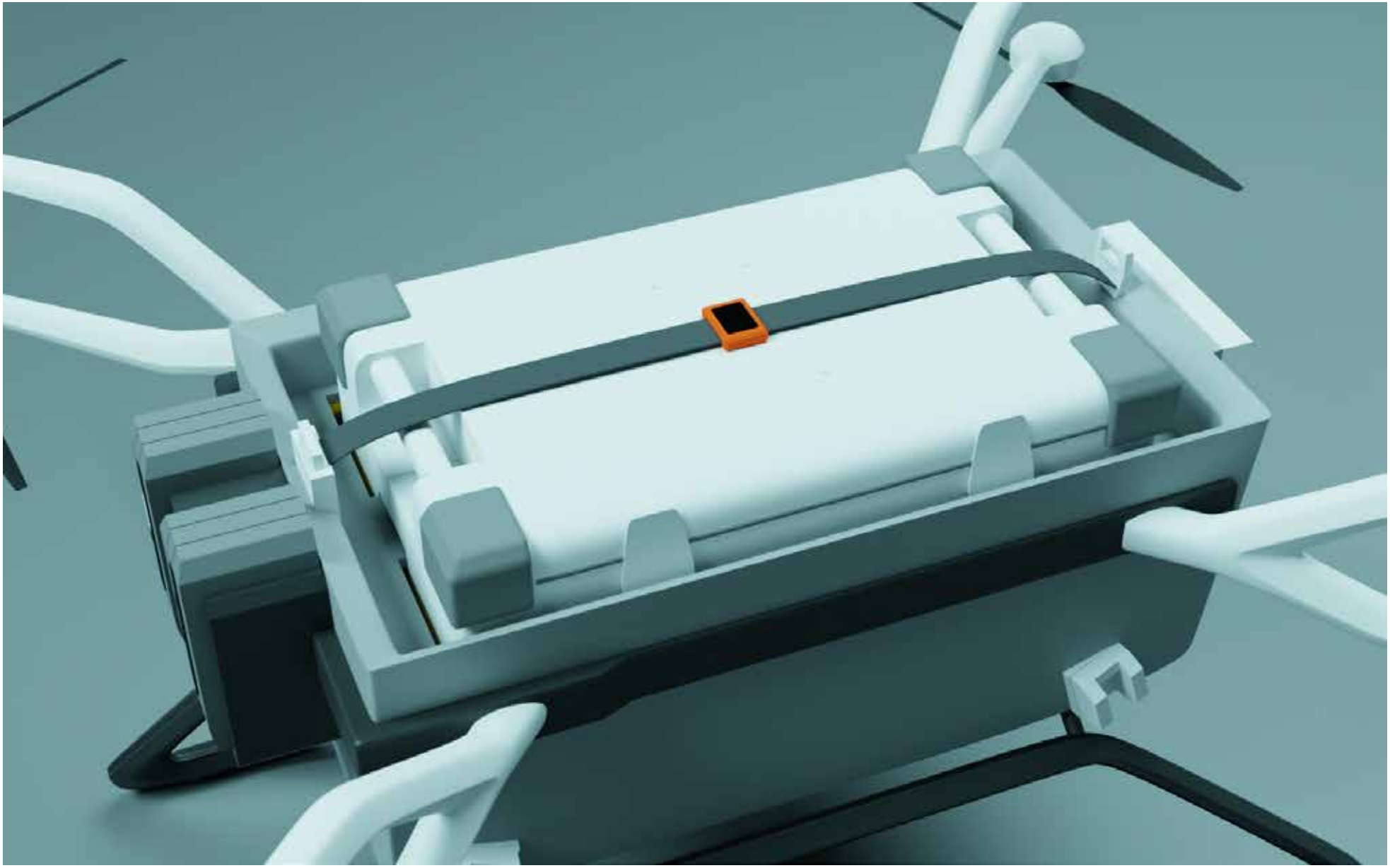
## 13 DESIGN

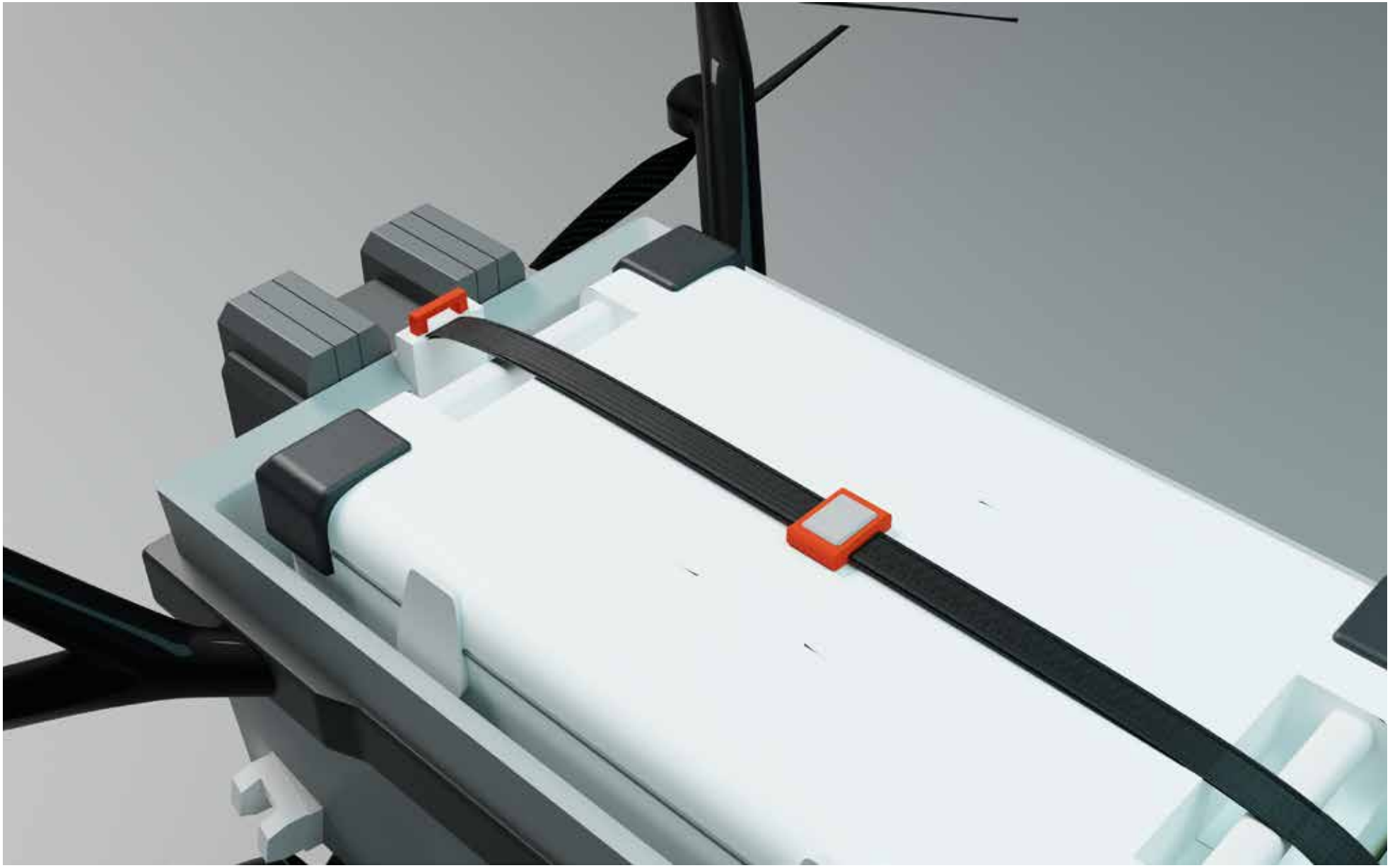


## 14 MODEL RENDERS


HUMAN ORGAN IN TRANSIT








HUMAN ORGAN IN TRANSIT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## 15 SCALE MODEL

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