



P3  
Report

# Designing Scalable Air based Delivery systems.

11th<sup>th</sup> June , 2021

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## Introduction

The DGCA (Director General of Civil Aviation) regulates everything in India Which is related to drones and they are set of regulations which are passed by the DGCA which includes CAR 1.0 and the proposed CAR 2.0.

### In August 2018 , Govt. Of India passed drone regulations

CAR 1.0

VLOS Only,  
Private drones (non- Commercial)  
RPAs Categories

### In 2020, Govt. Of India passed "NEW" drone regulations

CAR 2.0

VLOS & BVLOS  
Commercial drones  
Autonomous Operations  
Drone corridor  
Drone ports  
Payload / Cargo

And they also have NPNT policy which is short for no permission to take off. NPNT technology which is a hardware requirement for the drones.

NPNT essentially means that if an operator doesn't have permit, the drone will not take-off no matter how hard the operator tries.

So the DGCA actually knows when where and which drone is in the air at any given point of time. With the help of custom hardware and software, DGCA has regulated all the major drone manufactures in India. Which allows them to track the drones.

## View: Government needs to stop looking at drones as threat, and focus on the potential

ET CONTRIBUTORS · Last Updated: Oct. 07, 2020, 01:07 PM IST

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### Zomato, Swiggy, Dunzo Get DGCA's Approval for Fly Test Drone Deliveries in India: Report

"We are excited to build the future of aerial food delivery in India," a Zomato spokesperson said in a statement.

By Jagmeet Singh | Updated: 5 June 2020 17:59 IST

### Telangana Seeks to Be First State With Commercial Drone Deliveries

The state government along with private drone industry players have submitted a proposal to the DGCA.

By Indo-Asian News Service | Updated: 5 July 2019 11:12 IST

As mentioned in my earlier Presentation that Drones were a big NO in the past in our little country. But now it is taking a big boom in the recent times. (Image 1)

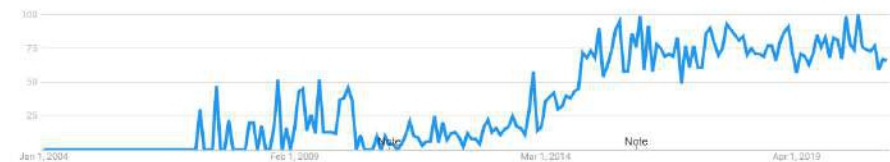


Image 1 : Drone popularity Image source : Google trends

The popularity of the drones has increased in the recent years and people are getting familiar to this brand-new technology.

## Use Case

A successful deployment of delivery drones at scale could radically transform the industry, replacing thousands of drivers, fossil fuel-powered delivery trucks, road traffic, and centralized delivery hubs with drone operators, small aircraft, air traffic, mobile hubs, and point-to-point delivery.

The following sections detail the main applications under consideration.

### Merchandise delivery

Merchandise delivery, one of the best-known use cases for drone delivery, has the potential to significantly reduce the cost and carbon footprint of this enormous industry.

### Humanitarian aid

Providing essential supplies to otherwise inaccessible people in war or disaster areas

### Food delivery

Another industry particularly well suited for drone delivery due to the time sensitivity of its perishable cargo is food delivery

### Courier delivery

Instead of the hub model of merchandise delivery (warehouse to consumers), courier delivery requires point-to-point travel between two private parties.

### Passenger delivery

The most ambitious of all applications and, therefore, the farthest into the future, is passenger delivery by drone.

### Military purposes

Govt. have been using them for a while now.

But the question may arise why commercial companies are looking for drones as an answer, and an answer to what.

## Industry Map

For that we need to understand how an industry functions, whenever a user orders something, the parcel is moved from the seller to a hub, then it is moved to the warehouse for further packaging and all then it is moved

to the nearest hub to the delivery location, than the parcel is transported to user's home in a van. (Image 2)



Image 2 : Industry Map Image source : Author

The most expensive part of the entire process is the last one. Which account to the 55 percent of the entire cost in the process. The last part is called the Last mile Delivery. And companies are targeting this stage of the industry.

According to the business insider, implementing drones in the process could reduce the cost up to 2 times and increase the delivery times by 4.



## What is a Drone ?

Now lets talk about the drone itAuthor, A drone is basically an unmanned vehicle which can be piloted remotely by a human driver or can function autonomously.

The drones itAuthor are categorised in three which are Terrestrial, Ariel and Marines. We will be focusing on Ariel.

Terrestrial



Aerial



Marines



Now the Ariel drones can be further categorised into three based on the types which are, Multi rotor also called VTOL which stand for vertical take-off and landing, Fixed wing and hybrid which is a mixture of both.

Multi - Rotor  
drones



Fixed wing drones



In India , Fixed wing drones are not yet permitted to fly. So we will be focusing on Multi rotor drones

The rotor drones are further categorised based on the number of propellers, like bi copter means two, Quad means four, Hexacopter means six , octa copter means eight and so on.

An arial drone essentially consist of a frame, propeller, a power source, motor all of which is controlled with Electronic speed controller, Flight controller and receivers. (Image 3)



Image 3 : Drone Architecture Image source : Author

According to the DGCA, Ariel drones are classified based on their weight like, Nano, micro, small, medium and large. Out of which only the nano drone which is the lightest required no permission to fly in Indian airspace.

nano:	less than or equal to 250g;
micro:	greater than 250g and less than or equal to 2g;
small:	greater than 2kg and less than or equal to 25kg;
medium:	greater than 25kg and less than or equal to 150kg;
large:	greater than 150kg.

Source :<https://digitalsky.dgca.gov.in>

And as good as the idea of drones delivering stuff is, drones come with a fair set of limitations and challenges.

## Limitations

Now lets imagine, I ordered something from the Hitchki restaurant and wants it delivered by a drone. The drone would need to go to my location deliver the parcel and come back. And because of limited power, it creates a range radius, i.e. the drone can only operate within that radius. (Image 4)

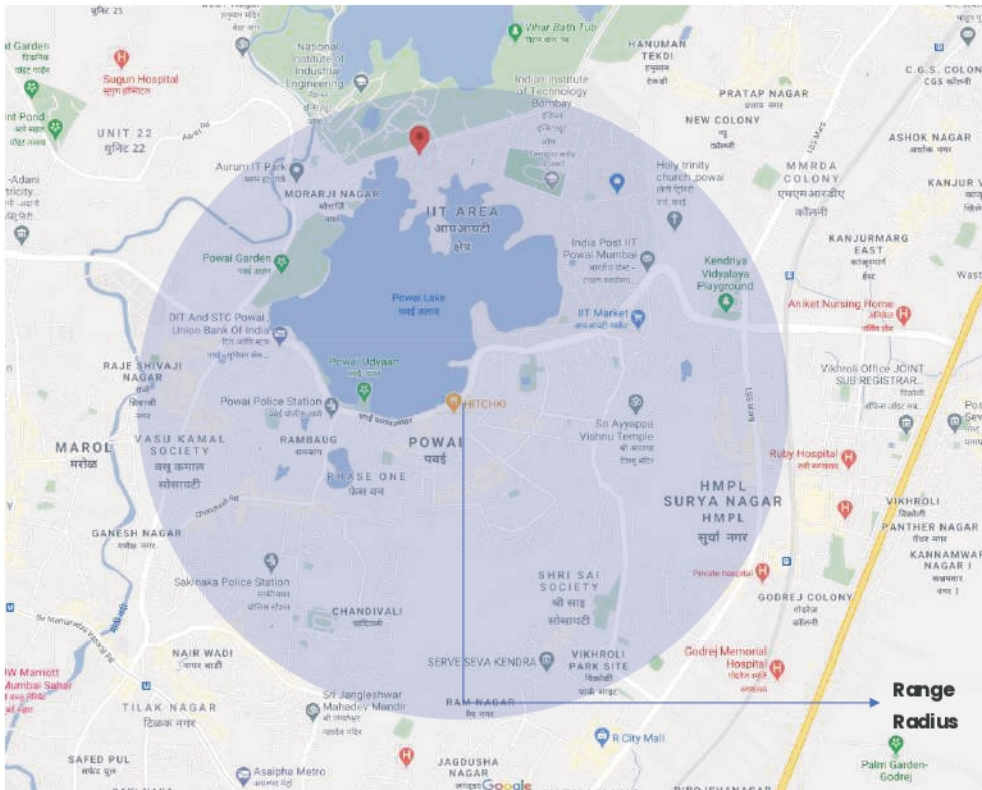
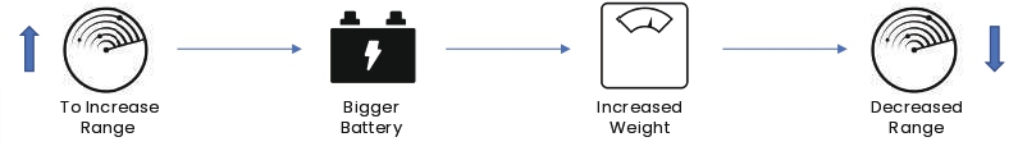


Image 4: Range Radius Image source : Author

The next is weight, Drone in general are designed to be lightweight in prospects of carrying heavier loads, Which ultimately affects the range. Think about it, if we need to increase the range, we would require a bigger battery , a bigger battery would mean there's increased weight, which would ultimately means the range is decreased



So until there are better batteries this would be a problem.



Image 5 : Co-ordination Image source : Giphy.com

Next lets talk about coordination, So when we think about coordination of drones, we imagine aircraft's and drones and other Ariel vehicles tightly passing each other in a choreographed dance so to speak. Jus like in (Image 5)

But this will still be a phenomenon on science fiction in coming years back-seats of various rules and regulations imposed by the DGCA and others all over the world.

But the technology is here and is used in many Ariel vehicles, which is called ADSB auto depended surveillance broadcast.

So ADSB allows aircraft to visualise the location, position and altitude of other aircrafts.

## Synchronic Study

There are currently three types of delivery systems in existence.

One of which is how zip line is using drones to deliver blood samples and medicines using parachutes in Africa. (Image 6)



Image 6 : Zipline Image source : google.com

This kind of system is good as the weight is. Only the parcel since there's no landing there would be minimum damage to the drone itAuthor. But it not accurate and wont work in urban spaces.

Next is the reel system , in which the parcel is lowered down to the user using a string mechanism. (Image 7)



Image 7 : DHL Image source : google.com

but there's increased payload of the reel system, it's fairly accurate and can work in urban spaces limited to roofs and open spaces.



Image 8 : DHL Image source : google.com

Next is landing the drone, DHL has been using this for a while , so the contents are put inside the drone and when the drone lands , the contents are procured. This system is accurate, but increases the chance of the drone getting damaged maybe because of landing errors or some ill intent. (Image 8)

## Landing

Drones are equipped with all kinds of sensors which include GPS and Lidar, Lidars are used by drones, to map out the area for any kind of. Terrain, foliage or a telephone or electric wire, and the system on board can help avoid the drones to not get crash in them.

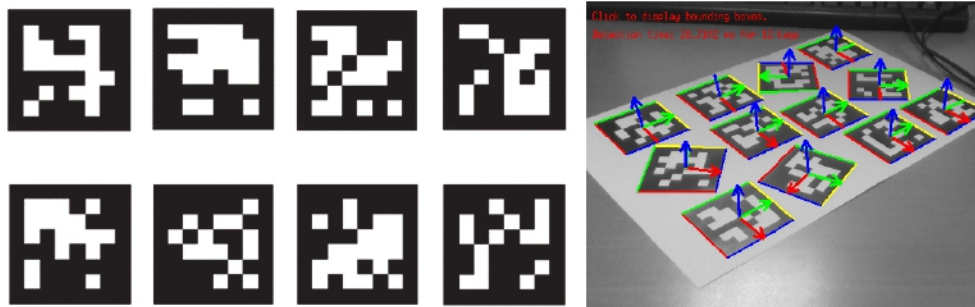


Image 9 : April Tags Image source : visp.inria.fr

the QR code looking rectangles are called April tags (Image 9), and with the help of the camera on the drone, it can visualise the orientation and adjust it Author to land on a pin point location.

## Expert Opinion

But I had a lot of queries and question about the tech, So, I reached out to Prof. Dhvani Shukla. who is a prof. here at IITB and is an expert in drones. A series of question were asked.

Ques : Does drones have a specific dimensions and norms which they must follow ?

Ans : Other than the DGCA's regulation, There are no such limitations to the physicality of any drone. The drones can come in any shape and size. The only thing which is taken in consideration is the payload weight.

Ques : What determines the payload capacity of any drone ?

Ans : So, the payload capacity of any drone entirely depends on how far the drone has to fly for the mission. That of course without changing or charging

the batteries.

Ques : Can a drone land on a pin-point location without using a camera?

Ans : No, not to a pinpoint location. The drone can come to a general vicinity of the landing area with the help of GPS and LIDAR tech. but to land on a specific position. It needs to have a visual awareness of the landing site. We can use QR codes also.

Ques : How much typically a drone would wthey compare to the payload ?

Ans : So, for let's say, a drone must carry a payload of 2 -2.5 kg and a flight time of 20 minutes. The entire drone without the payload would typically weigh 3 – 5 kg. The weight distribution is basically the frame and the battery alone.

Ques : In case of an accident, Do drones have any kind of safety feature like maybe going away from the crowd or a failsafe to not let be any danger to human life.

Ans : Yes, if the altitude if high enough and the drone is heavy. These kind of drones are equipped with all the necessary safety measures like a parachute. And because it has a GPS it becomes easy to procure the drone in that certain event.

Ques : According to you, do you think that we lack in terms of technology ?

Ans : Certainly not. All the required tech is already there, even the drones now can go to a location deliver and come back and that too all autonomously. I think that we lack only in the execution of things like we don't have enough infrastructure, and people also need to be aware that these drones only require cameras for the landing purposes and are not an invasion to privacy.

## Public Perception

Next I wanted to get a better idea of how public perceives drones and drone deliveries, so I create a survey with the help of Instagram. (Image 10)

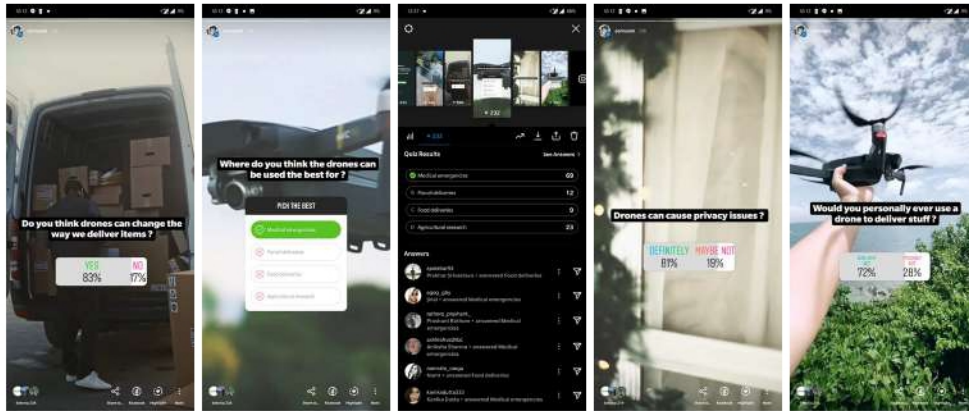


Image 10 : Instagram Image source : Author

- so the majority of peeps agreed that drones could change how we deliver stuff
- majority of the people believed the best use case in for medical emergencies, then it was agricultural research then parcel deliveries and last food deliveries.
- More then 90 percent users believed that drone could cause privacy issues but they also agreed on using the drones to deliver stuff.

## Public Adoption

Now, I had a better understanding of public perception but to understand the adoption rate of this emerging tech I looked into a method devised by the researchers to understand how a new tech is adopted by general public, which is called the Technology adoption curve. (Image 11)

According to which, the population is divided into 5. Different adopter groups

- Innovators which is the people who are smaller in number, first, risk takers and they share experience.
- Early adopters which are small group forward thinking group and they build on innovators experiences,

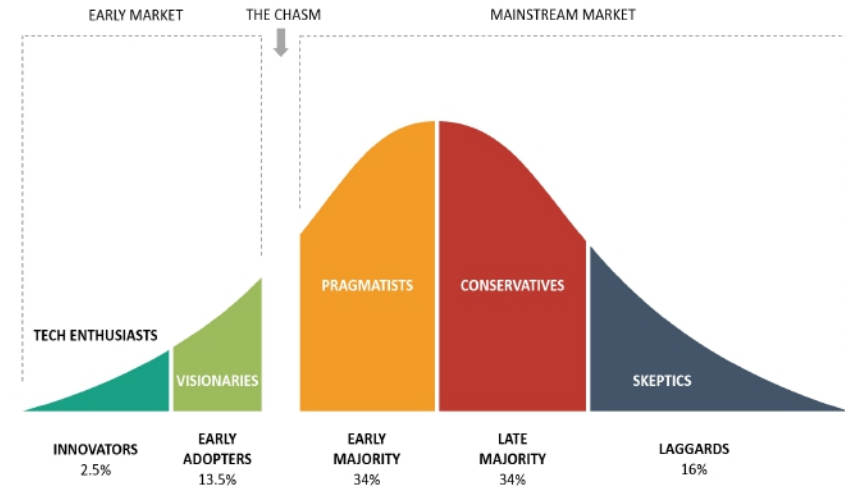


Image 11 : Technology Adoption Curve Image source : Google

- Early majority are the people who use the tech when they are convinced that the tech can be beneficial,
- Late majority are the people who are resistance to change and are responsive to peer pressure,
- The laggards are the people who never use the tech, highly resistance like our grandparents.

Now according to the Tech, adoption curve we are at the early adopter's stage and to go the next step which is early majority we need to cross the chasm.

And to cross the chasm

- we need to target a very specific market,
- identify a group of individuals that needs the solution to their problems
- use it as a base for broader operations.
- Make things better than the competitors.

## Which sector should we work based on the Adoption curve ?

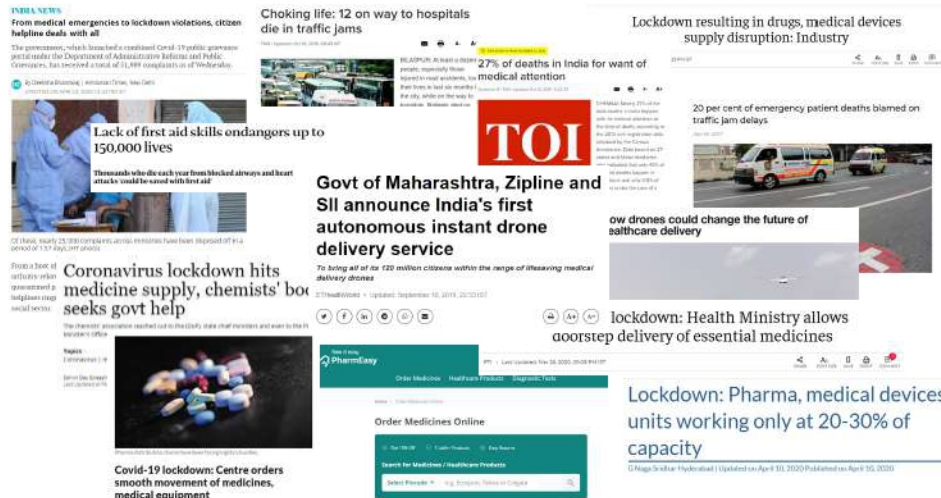


Image 12 : News Clippings Image source : Google.com

So I started looking for that group of people and that market where this can be used and is the need of the hour,

Which came out to be medical health care services. Now we are aware of how covid has effected the market, and even prior to covid due to traffic jams, prolonged time to get the required blood, required organs lead to a lot of deaths. (Image 12)

I started looking at various segments and application where this could be useful for example, (Image 13)

- Medicine deliveries if some one wants medicines urgently or maybe someone has contracted an allergic reaction and would need an epinephrine pen.
- Or for medical emergencies for first aid, roadside accidents,
- Or for blood , blood transportation being a time sensitive operation, or could be used for sending blood samples to labs for testing, and

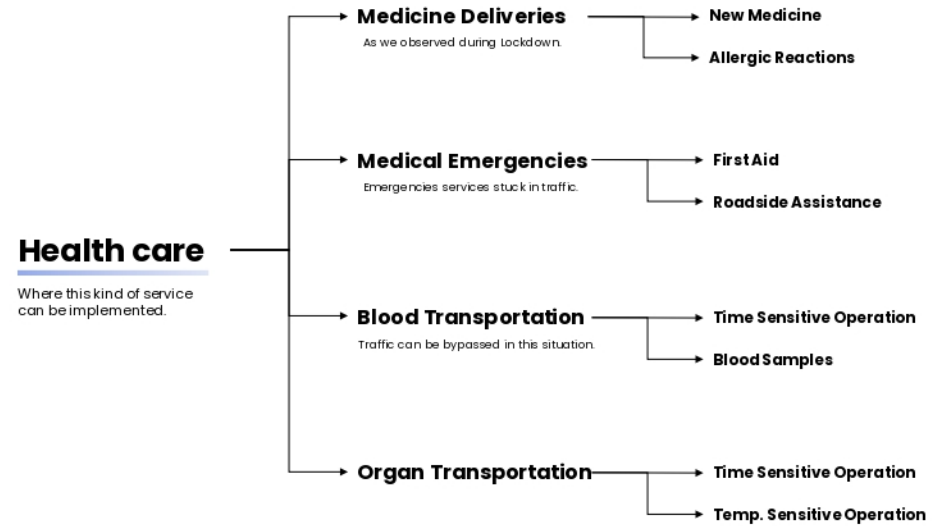


Image 13 : Network Image source : Author

even organ transportation.

So I started to research on how blood is transported, One unit of blood weigh between 350ml to 450ml. If doner is between 50 to 70 kg he can donate 350ml above 70 kg can donate 450ml. Blood is collected at body temperature, i.e. +37 °C. But in order to maintain its vital properties, it must be cooled to below +10 °C to be transported and stored at refrigeration temperatures of around +4 °C until use. Blood samples and blood bags are transported using an insulated box with the help of a cool gel pack which is the cheaper way.

And other with the help of a Peltier module to regulate the temp for longer duration. I also looked at how organs are transported and that won't be possible because you require a doctor to be with the organ at all times.

When transporting Blood, Pre frozen gel packs frozen for 24 hrs. are used as a cooling element.

With the help of Thermocol casing, the temp is stabilized within the container for the duration of the transporting.

## Objective

To design an aerial delivery system for medical supplies in an urban environment with focusing on scalability.

And based on the research I have done, I concluded that we don't lack the technology, but we lack a viable delivery method which can be implemented for the general masses.

## Scope

My scope would be to limited to designing drone ports, Drone ports are proposed to be designated areas dedicated to facilitating take-off and landing of the UAS. However, overtime their capabilities may be enhanced to function as distribution centers (or cargo holds), battery charging stations and/or any other appropriate use.



Image 14 : Range Radius Image source : Author

Making delivery stations that can act as charging stations also can massively improve the range limitation of the drones. (Image 14)

Ultimately making the tech more accessible.

Now lets see how these drone stations can be used,

- Scenario one is that if a drone is carrying a payload and mid-way computer realises that the charge is low, the drone could land on these charging station to replace or charge the batteries and carry on to its mission.
- Scenario two is that drone has no charge but for some reason the drone cannot be charged, the drone could simply leave the parcel on the station and a new drone in the vicinity can come to that location, pick up the

## Design Brief

“ To design a system including drone pods and stations for the aerial drones to deliver and pickup with a maximum payload carrying capacity of up to 3 kilograms with a focus on the urban environment with a prospect of executing broader operations that include transporting blood. ”

The system might include :

- Delivery pods and stations
- Allow delivery and pickup
- Max. payload of 5 kilograms
- Can be set up in an urban environment
- Transporting blood
- Scalable system
- Automated system
- Charging or replacing drone batteries
- For medical professionals
- Usability for consumers and suppliers both
- Contactless execution
- Anti-Theft ( Only the person who ordered can procure the items )
- Easy to use

Limitations of the project :

- Implementing current technological solutions.
- Designing of drones will not be covered.
- Designing of drone hubs i.e. (Origin point of drones) will not be covered.

After coming up with brief and started to map stakeholders, I have classified the users into primary, secondary, and tertiary user groups. (Image 15)

While ideating, I realised that the entire process can be done in phases first crating a robust system for deliveries primality for transporting blood and slowly transitioning to later phase of personal delivery stations that can be used to deliver medicines to public. (Image 16)

And these hubs would be used to transport from hospital to hospital, blood banks to hospitals, blood banks to blood banks, clinics to pathology labs, blood donation camps to blood banks.

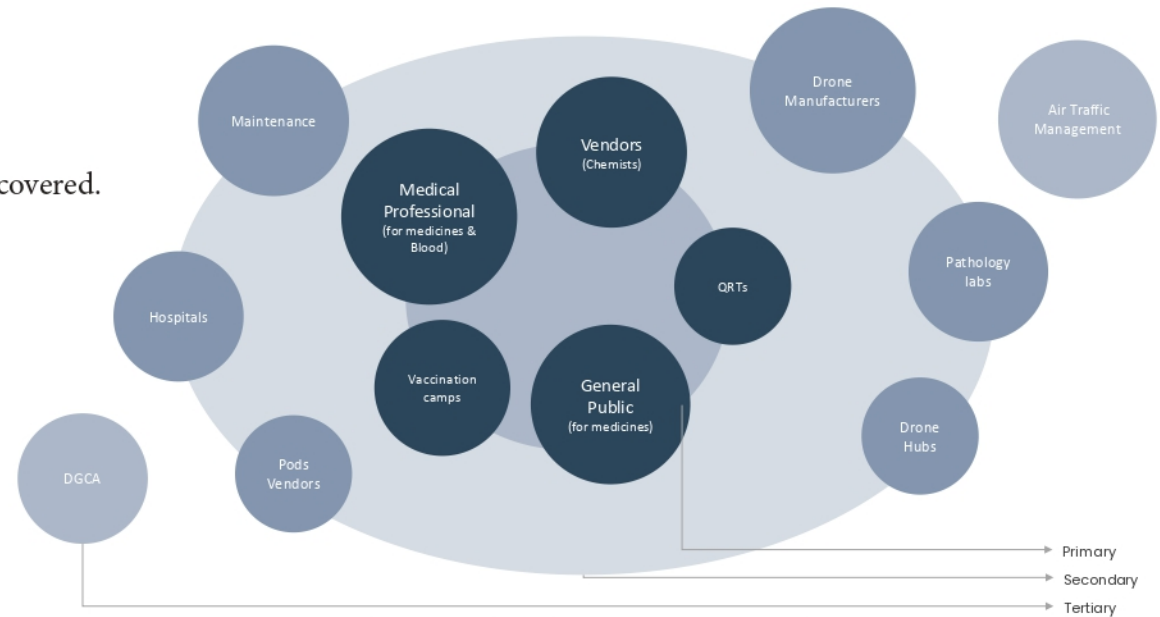


Image 15 : Stakeholders Image source : Author

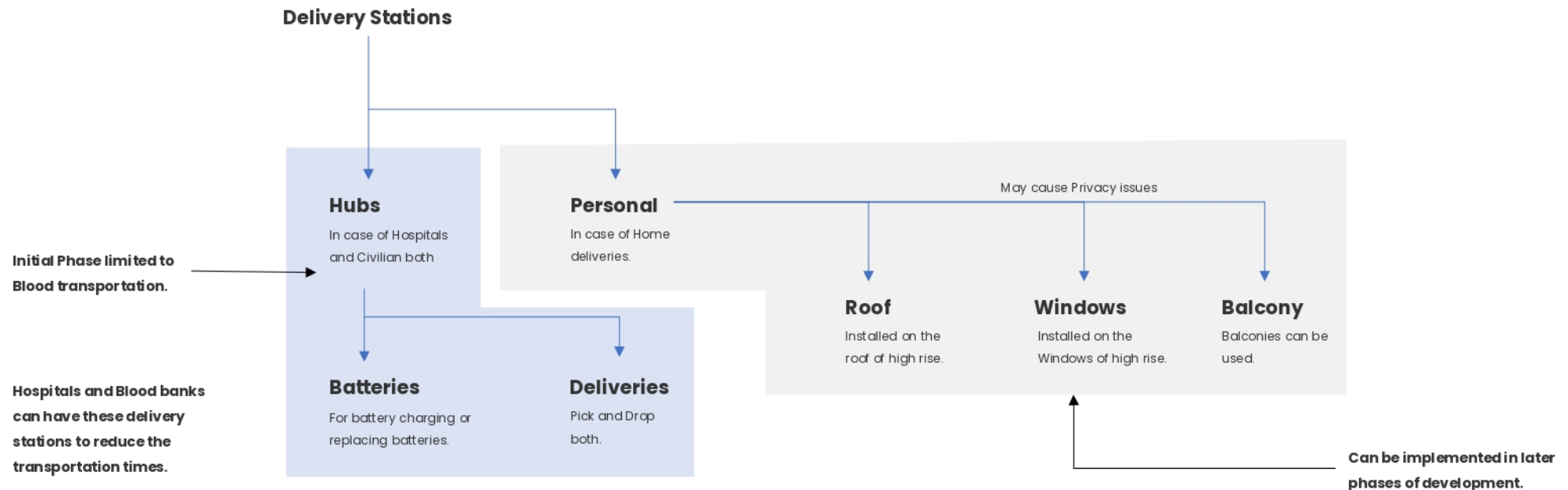


Image 16 : Proposed Phase progression Image source : Author



## Preliminary Ideations

And next I started sketching to come up some tangible solutions. And I clustered them for different systems like for Pods, Stations etc (Image 17).

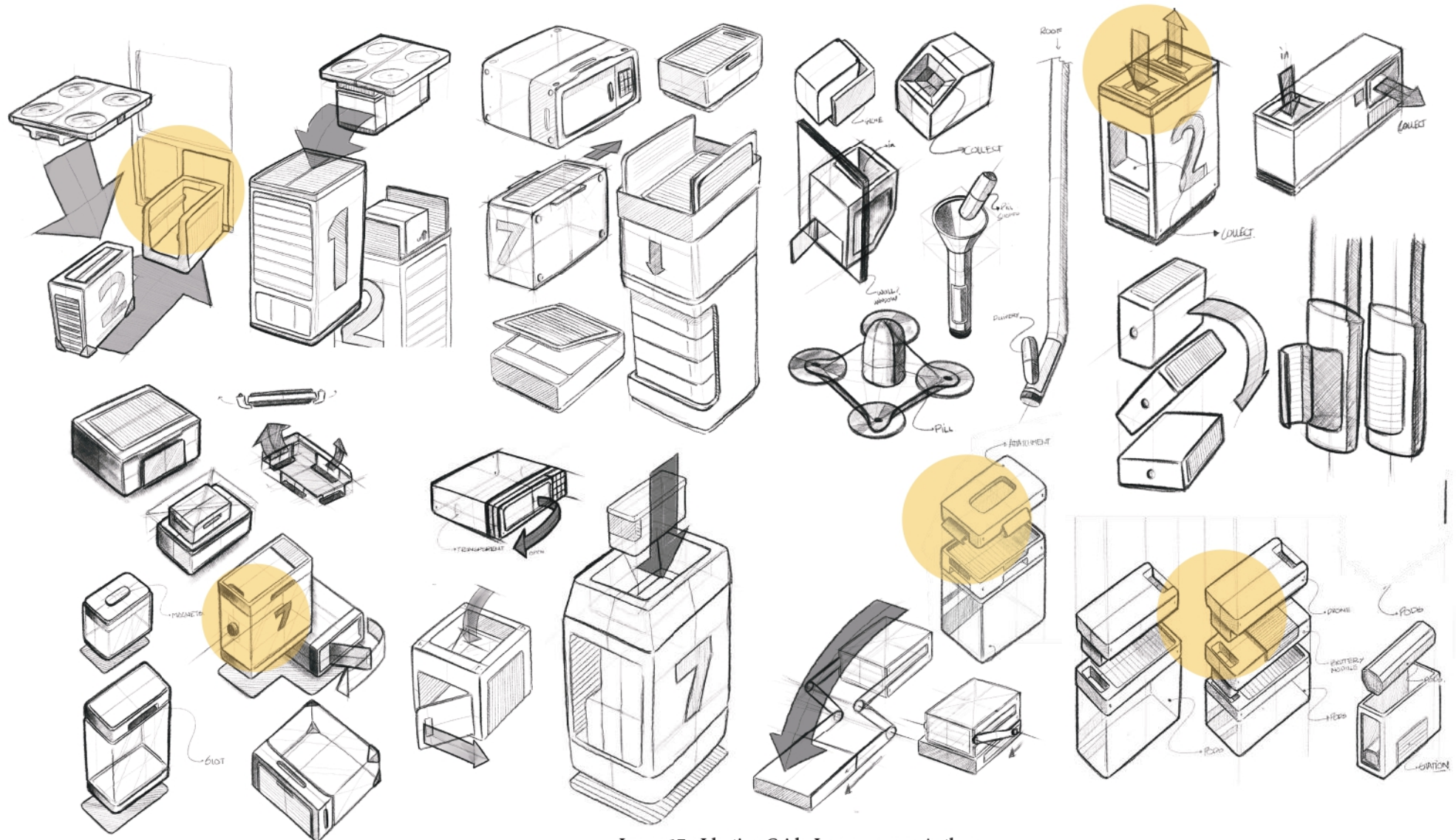
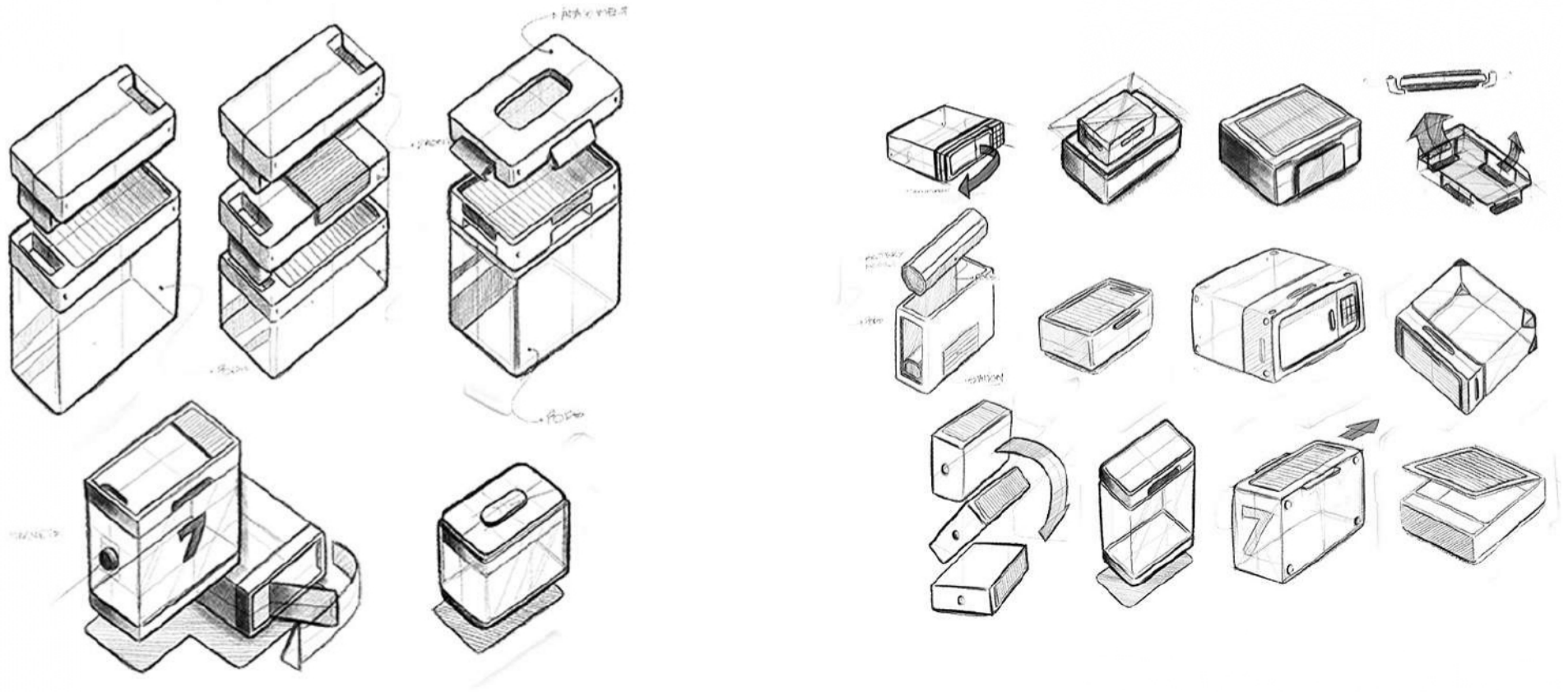


Image 17 : Ideation Grid Image source : Author

I really like a modular system where there could be different modules for batteries, for temp. control pods, and regular pods which could drone just pick up and go. (Image 18)

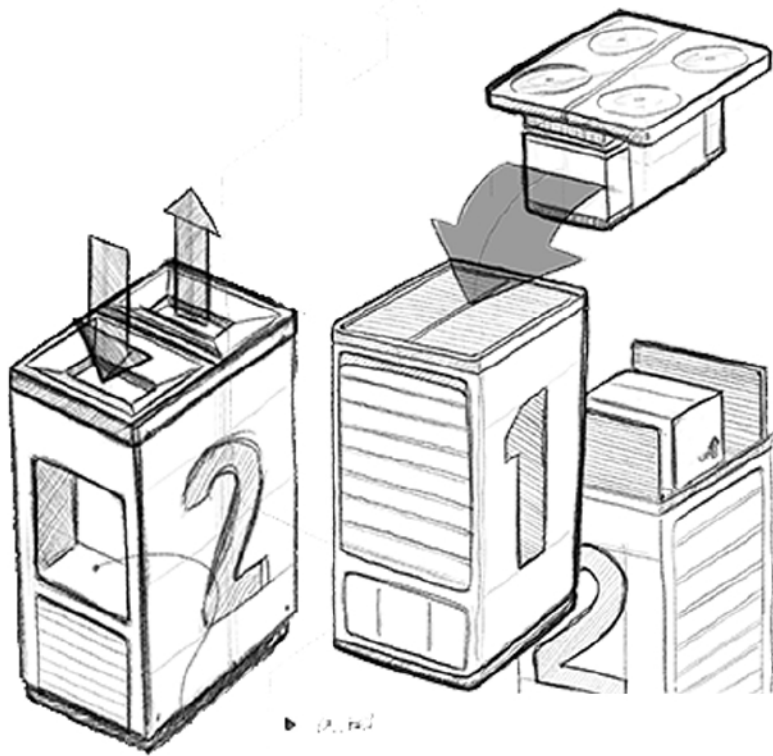


Module system which can work with specially designed pods.  
May include Battery Modules, Pods with Temp. Control for Blood samples.

Image 18 : Pod Ideation Image source : Author

And for hubs, a solution where the user could pick the delivery from the front of the tower and a drone can come and pickup the empty or filled pod from the same unit but from the exit point. (Image 19)

Stations  
(Hubs)



A delivery station which may allow the drones to deliver as well as make pick ups from the same module.

A delivery station which may allow the drones to stay on the station

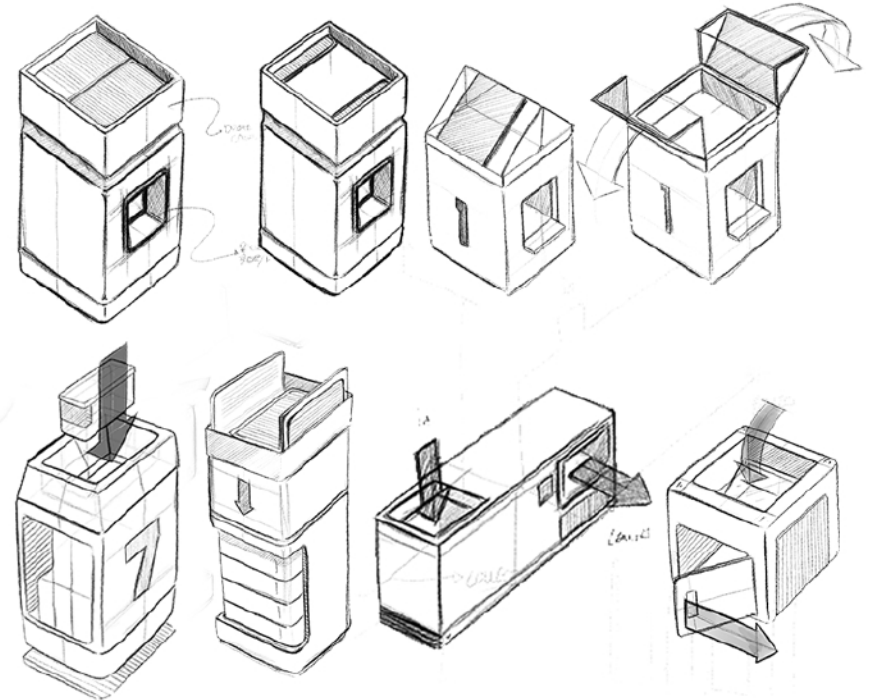
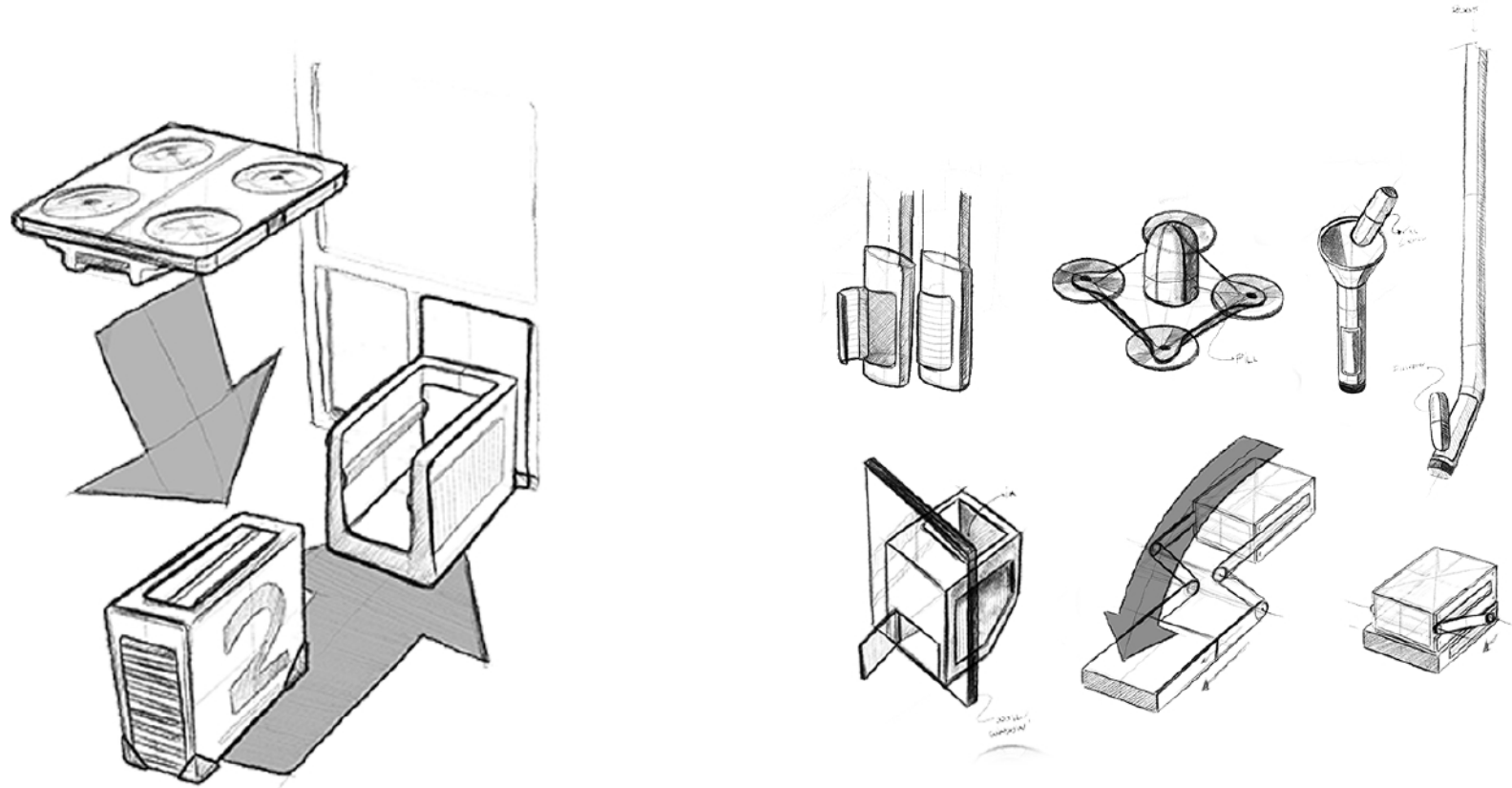


Image 19 : Station Ideation Image source : Author

And for the personal aspect of the system, focused on the users at home, a package that can be fitted on the windows which would allow the drone to deliver to that specific window making it a personal station for make medicine deliveries. (Image 20)

Stations  
(Personal)



A delivery station that can be fixed on windows that will allow medicine deliveries.

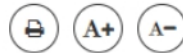
Image 20 : Window Station Ideation Image source : Author

## Context

# “India could bleed itself dry amidst covid-19 crisis owing to blood shortage”

*In India, blood donations have dramatically reduced due to the implementation of social distancing, cancellation of various blood drives and low donor turnout due to fears associated with catching infection from public places such as hospitals and blood banks.*

ETHealthWorld • July 07, 2020, 19:20 IST



## EVERY MINUTE COUNTS: TIME TO DELIVERY OF INITIAL MASSIVE TRANSFUSION COOLER AND ITS IMPACT ON MORTALITY

### Imagining a world without avoidable deaths due to blood shortage

*Given the undeniable importance of blood in our lives, access to adequate blood and safe transfusion of blood should be an integral part of every country's national health policy, regulatory framework, and health infrastructure.*

Suryaprabha Sadasivan • May 07, 2020, 12:50 AM IST



Suryaprabha Sadasivan  
Vice-President and Public Policy Practice Lead - Healthcare, Chase India

Image 21 : Newspaper articles Image source : various news websites.

The context behind that was that there has been a shortage of blood in our country for a while of course because of the pandemic and lockdown but also because the general perception that the people should only donate blood when there's a requirement of it. And hence because of that the blood banks in our country are empty. (Image 21)

There's an online database of all the blood banks in the country. Here's a data for three different blood banks which are in Mumbai and as you can see, there are some blood groups which are available at one bank and some which are available at another. (Image 21)

Blood Bank A	Blood Bank B	Blood Bank C
68. Prince Aly Khan Hospital Blood Bank	74. Sir, J.J. Group Hospital Blood Bank, Byculla	30. V.N. Desai Municipal General Hospital Blood Bank
Stock Details   Camp Details	Stock Details   Camp Details	Stock Details   Camp Details
Stock Details	Stock Details	Stock Details
Whole Blood	Whole Blood	Whole Blood
<b>Stock Availability Details</b>	<b>Stock Availability Details</b>	<b>Stock Availability Details</b>
AB-Ve: Not Available	AB-Ve: Available	AB-Ve: Available
AB+Ve: Not Available	AB+Ve: Available	AB+Ve: Available
A-Ve: Not Available	A-Ve: Not Available	A-Ve: Not Available
A+Ve: Available	A+Ve: Available	A+Ve: Available
B-Ve: Not Available	B-Ve: Not Available	B-Ve: Not Available
B+Ve: Available	B+Ve: Available	B+Ve: Available
O-Ve: Not Available	O-Ve: Available	O-Ve: Not Available
O+Ve: Available	O+Ve: Available	O+Ve: Available

Image 22 : Blood bank availability Image source : E-raktkosh

The unavailability of blood means that the blood must be acquired from the source wherever it is available. The availability of that blood type matters.

**What I want to say is that the proximity of a hospital to a blood bank doesn't really matter but the availability of the blood does.**

## Process of obtaining blood.

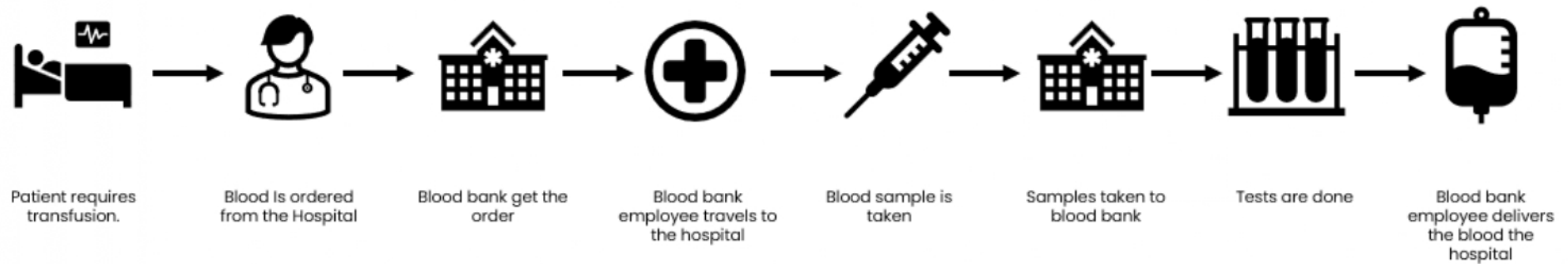


Image 23: Process for obtaining blood Image source : Author

And that's not the only problem, the process of obtaining the blood is far more complex. So whenever a blood is required, the hospital contacts the blood bank, then a blood bank employee comes to the hospital collects the blood sample, travels back to the blood bank, tests the blood, and carry the blood bag to the hospital. So a to and fro motion is seen in this process (Image 23).

For an example let's say IITB hospital required blood and that certain blood type is only available at Blood bank C then the total duration for the entire process is 3 hours. And as you know in blood transfusion time is everything. (Image 24)



Image 24: Time for obtaining blood Image source : Author

Transit from Blood bank to hospital.	42 minutes
Transit from Hospital to Blood Bank	42 minutes
Testing the Blood sample	20 minutes (Average)
Transit from Blood bank to hospital.	42 minutes
<b>Total time for the entire process.</b>	<b>146 minutes (3 hrs.)</b>

## Site Visit



Image 25 : Visitation of several hospitals and blood banks Image source : Author

Source : Self

To understand the process a little better, I visited various blood banks and hospitals. I specifically visited the hospitals who didn't have a blood bank (Image 25)

- The hospitals and blood bank I visited were part of a multi story buildings.
- The drone stations couldn't be set on the ground because of heavy foot traffic and foliage.
- Every hospital and blood bank had the access to the roof via stairs and elevators.
- Going to the roof required no special permission or a key.
- The drone stations can't be set up on the windows because of narrow spaces and because of limited access.



Image 26 : Problems for the people Image source : Author

Also, there I met Shri. Samarth Yadav who was at the blood bank to collect blood. He told me that his relative needed blood and the hospital didn't have a blood bank. So, he was asked to go and collect the blood as it would be quicker for him to go on his two-wheeler to the blood bank. (Image 26)

## Landing requirements



Image 27 : Drone pilot interaction Image source : Author

- Clearance

In case of Autonomous drones :

The landing entirely depends on the GPS sensor and GPS sensors comes in various sizes

In case of Piloted drone :

The landing entirely depends pilot's ability to maneuver the craft.

- Visual feedback for pilot  
A for the pilot to see the pad.

- Environment

When landing the area above the landing pad must be clear of any kind of obstruction that includes architectural element or vegetation foliage.

I also talked to Mr. Shardon (Image 27) who is a drone pilot about various aspects related to landing of drone like clearance, environment, visual feedback. So, he told me that if the drone is piloted by a person, then the clearance is all about the pilot's skill and training and to land with precision. But if it's automated then it depends upon the GPS system.



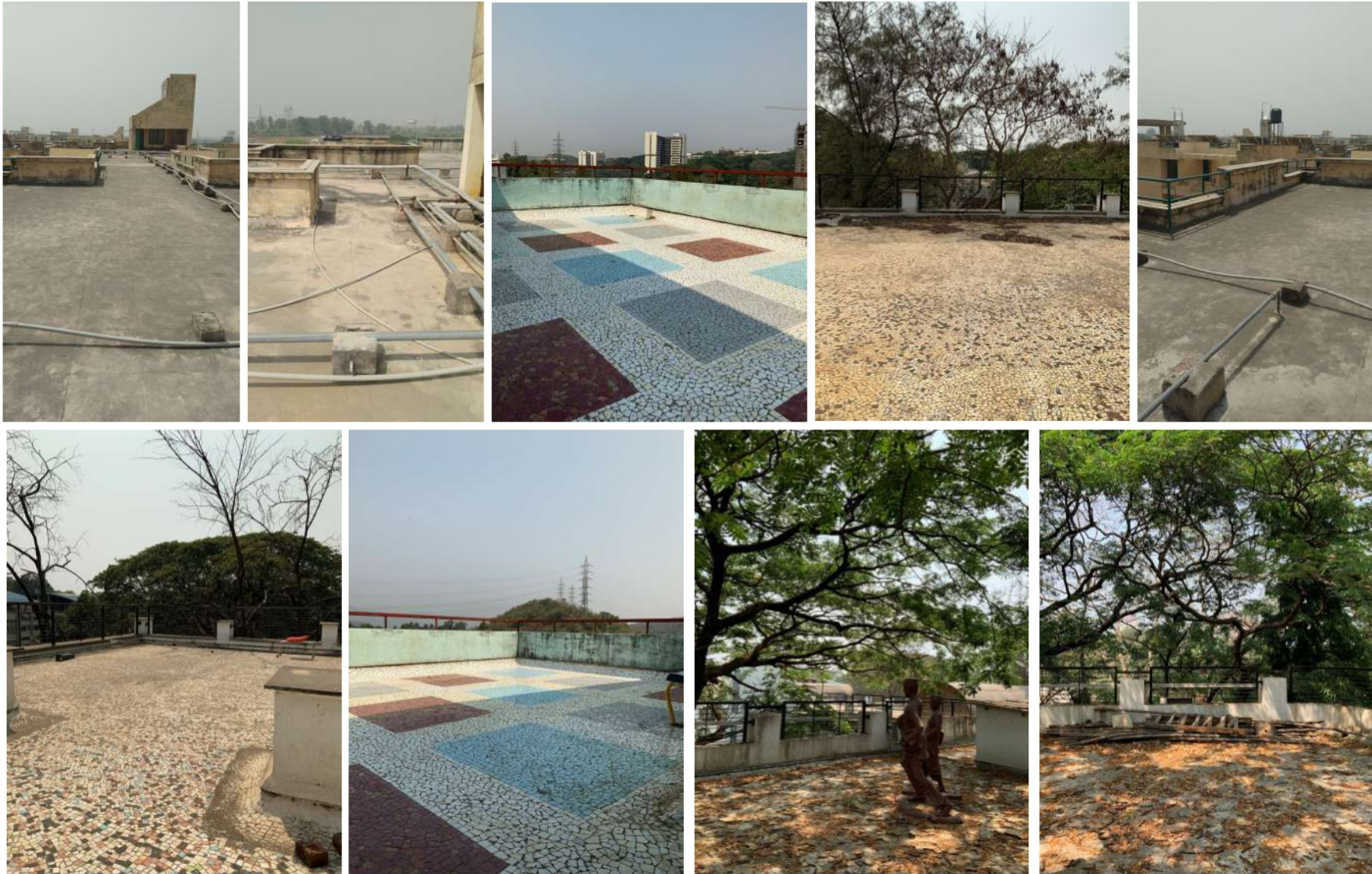


Image 28 : Roof analysis Image source : Author

And for the obstructions I visited few roofs to understand what can be the various obstructions that could be of any hinderance to the drone. The bottom right picture as you can see is filled with foliage so there might be a need to scrutinize the area. (Image 28)

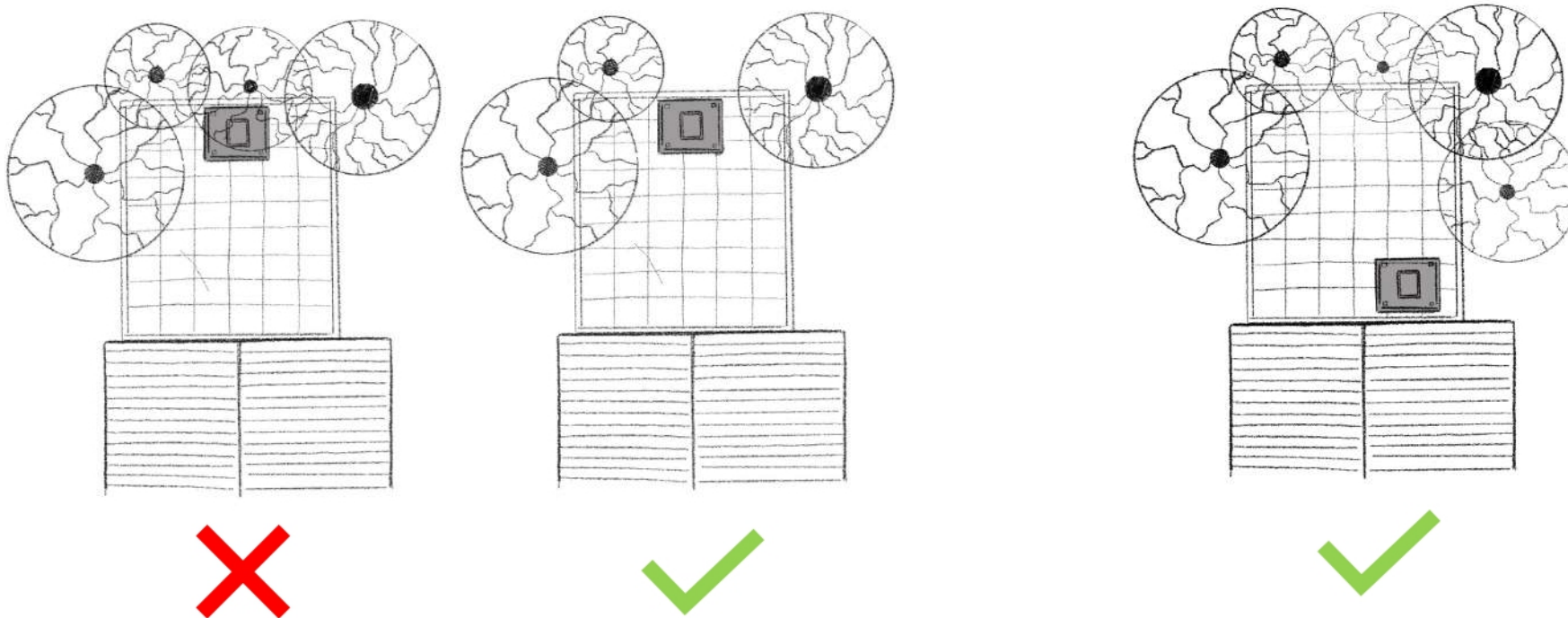


Image 29 : Roof guidelines Image source : Author

Since drones land vertically and not like a plane. The clearance required is only the space above the pad and if the obstruction can't be avoided than the pad needs to be in a strategic location where there's nothing above it. (Image 29)

## Drones companies

I started looking at various drone which could be a part of the system, and I specifically looked for Indian manufacturers and operators like hubblefly, ideaforge , aero 360. (Image 30)

I started looking at various drones that these companies offers in hope of finding the drone which would work for the use case of transporting blood.



Hubble fly Technologies



Idea forge



Aero 360

Image 30 : Drone Companies Image source : Author



Image 31 : Drones in consideration Image source : Author

I narrowed down to two of them out of which one is netra UAV and the other was Aero 360. (Image 31)

And I further narrowed down to Netra pro UAV based on serviceability, weight limit, flight time, operability, flight range and fuel system like whether it is using petrol or electricity.

Criteria for selection -

- Serviceability
- Weight Limit
- Flight Time
- Operability
- Flight Range
- Fuel

Netra Pro UAV having a operational Range of 4km, and flight time of 30 minutes, and take off weight of 6 kg which is well within the limit of the payload for the project.

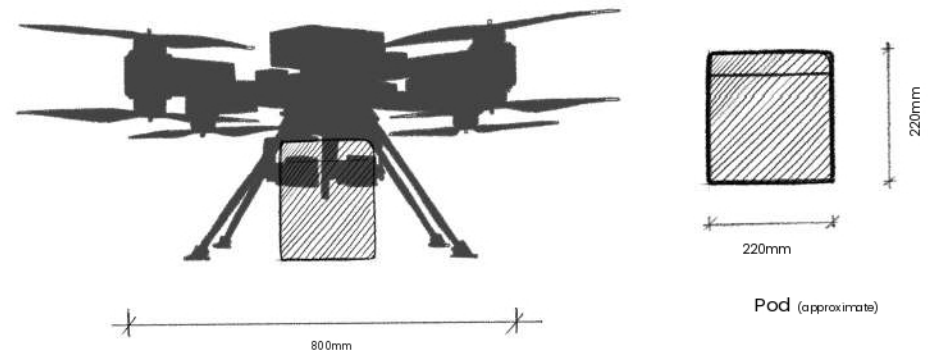


Image 32 : Drones dimensions Image source : Author

Next I started working on the pod and for that I needed the dimension of the drone and the pod space below the drone which was 220 by 220 mm. (Image 32)

The next step was designing the pod, for that there was a requirement of understanding various standards of different elements like vials, bloodbags etc.

## Designing the pod. (Preliminary Stage)

I looked at standard sizes for the blood bags, standard sizes for the vials. (Image 33) And I started creating a checklist -

- The pod must have the capacity to carry 4 blood bags at once
- The pod must carry at least two blood sample vials. As sometimes there are two different sample for different patients are also made as deliveries.
- The pod must have a space for Ice Gel Packs
- The pod must be light weight.
- The pod must not contain any electronics as there's no need.
- Easy to operate – easy to put bags inside and out.
- Must have a mechanism to get attached to the drone.
- Must be user friendly i.e. it must have enough space for the user to put and retrieve the blood easily.

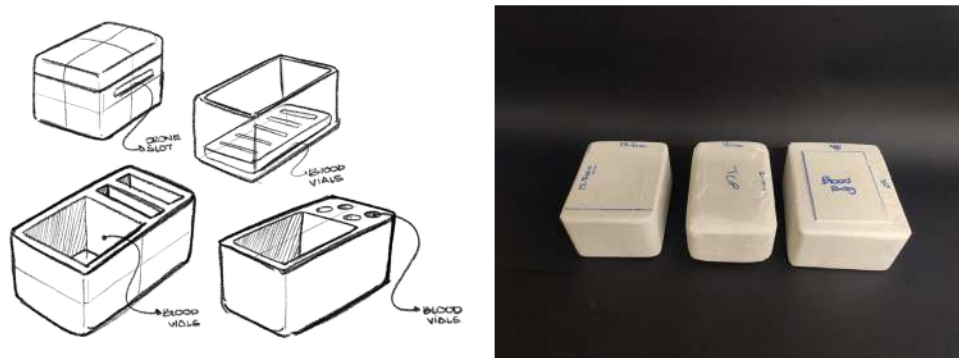


Image 34 : Standard dimensions Image source : Author



### Standard Blood Bag

105 × 105 ±5 mm

### Standard Vial size

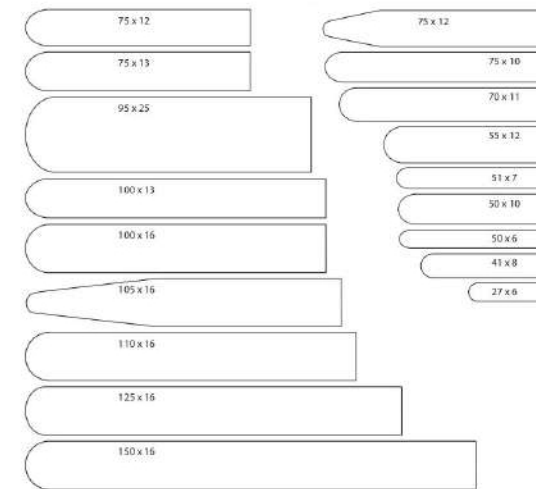


Image 33 : Standard dimensions Image source : [www.naco.gov.in](http://www.naco.gov.in)

So, I started ideating and tried to make physical models to grasp the dimensions of the container, trying to see where the vials could be placed, in what orientation, space required to easily grab the bag. (Image 34)



A groove for the user to easily take out the vials And enough space for the user to put hand inside and retrieve the blood bag.

And I was able to come with a solution where two vials would be kept on the top on both the sides



Image 35 : Blood Pod Image source : Author

So next point was how it will be attached to the drone, I started looking at the systems which are already in place like the carabiner system which is essentially a servo which when pulled releases the payload and the other is a grappler system which hold the payload and release it. (Image 36 , Image 37)

Carabiner system



Image 36 : Carabiner attachment Image source : google.com

Grappler system



Image 37 : Grappler attachment Image source : google.com

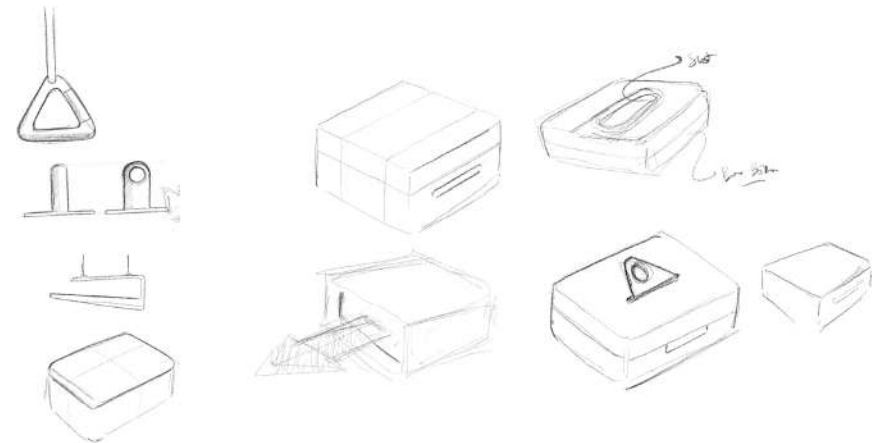
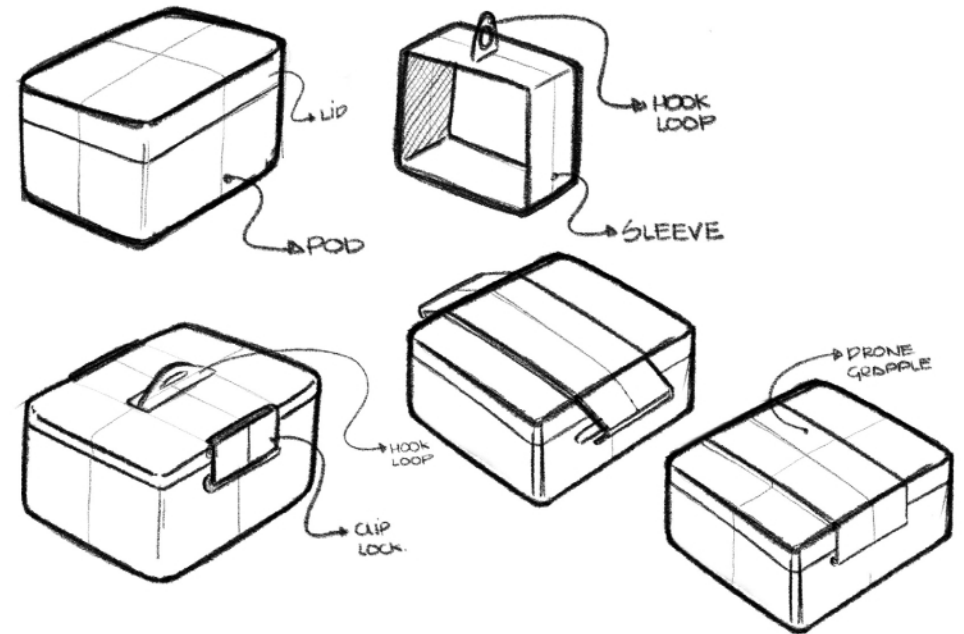


Image 38 : Attachment Ideations Image source : Author

I started ideating on how it can be attached like with magnets or a slider system or a hook or a carabiner and I narrowed down to two. (Image 38)



Image 39 : Carabiner attachment Ideation Image source : Author

## Carabiner

### System

- Will require a carabiner system for the drone.
- A string must be unspun form the drone to connect the pod.
- Can be susceptible to human error.
- Increased number of components
- Increased number of steps.

### Pod

- Entire weight of the pod is concentrated on a single point.
- The outer packaging will contain the blood group, order number, address of the delivery.
- Has the tendency to spun around the wire.



Image 40 : Grappler Attachment Ideations Image source : Author

## Grappler

### Systemv

- Will require a grappler for the drone.
- A string must be unspun form the drone to connect the pod.
- Cannot be susceptible to human error.
- Number of steps for the user to execute reduced.

### Pod

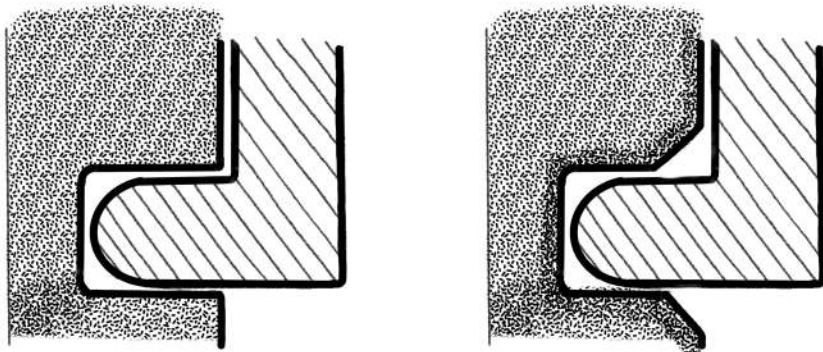
- Entire weight of the pod distributed throughout
- The outer packaging will contain the blood group, order number, address of the delivery.



Image 41 : Grappler Attachment working Image source : Author

The grapple would be slip into the grooves and lock into the place, this would distribute the weight .But since this operation required a lot of precision, in a real-world scenario there can be some problems of aligning.

But I observed some pinpoints like the EPS is not very reusable once it breaks , and what if an accident happens and the pod fall and breaks.



Without self centering geometry.

With self centering geometry.

Image 42 : Author Centering Geometry Image source : Author

There was a need of a self centering mechanism which could work in real world. So I ran some simulation. the pods were intentionally misaligned. the left image is without any self centering geometry and the right is with the geometry and the right pod was wobbling less than the other. (Image 42)

## Designing the Station (Preliminary Stage)

For designing the pad, several pain points were identified that included the technical elements as well as the usability elements.

### Location

- Roof or ground

### Authorization

- Who will have the access to the roof



### Avoid Human error

- Errors in loading the pods
- Errors in placing the items in the pods
- Errors in operating the departure pads.

### Backup in case of accident

- Backup scenario in an emergency case.

### Safety for the user.

- Drone must not cause any harm while landing and take-off.

### Attachments for the drone.

- Hook system
- Grapple system

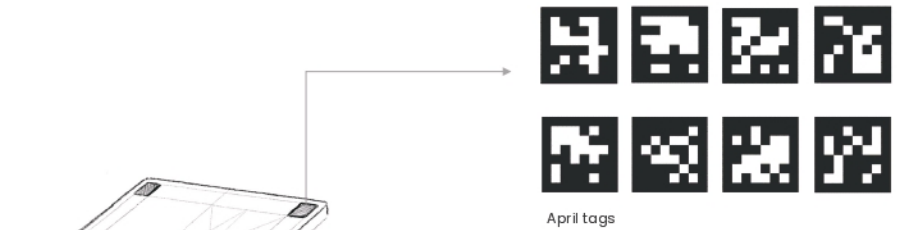
### Pod Design

- Compatible with the selected drone
- Space for blood vials to be included
- Easy to use with minimum extra components
- Light weight

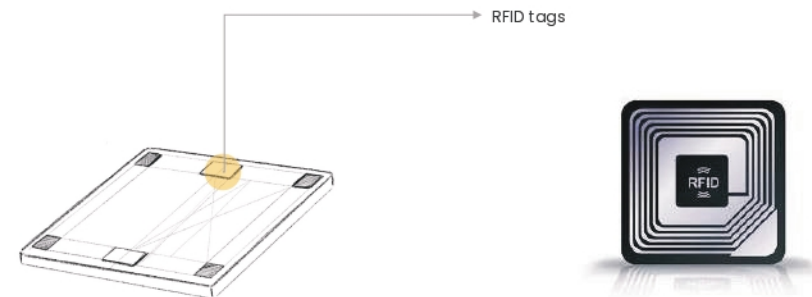
### Compliant Drone

- Take- off weight must be taken into consideration
- Landing footprint must be taken into consideration for landing pad dimensions.

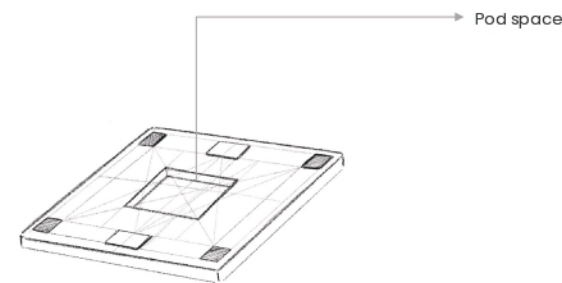
The basic necessities for the stations were identified first ,which were -



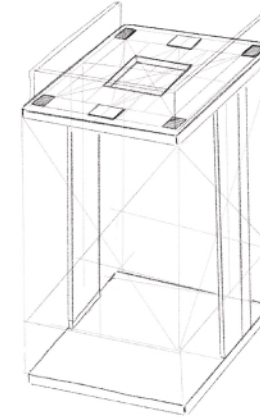
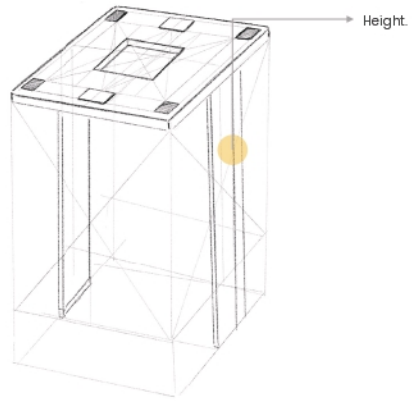
- The pad must have April tags to help orient the drone In the correct way while landing.



- The base must also have RFIDs or some kind of sensor to identify which drone is on which pad.

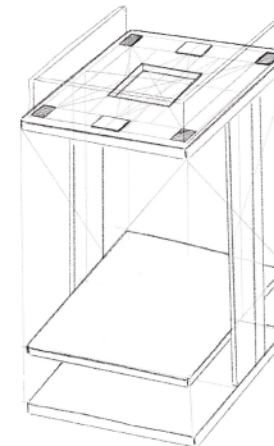
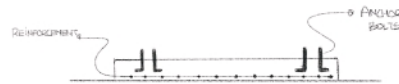
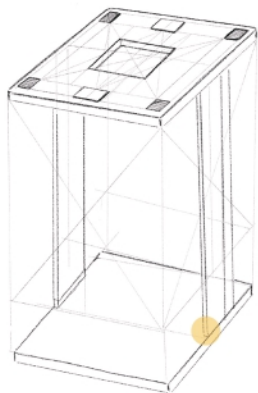


- The base must also have a space to let the delivery pod set in place.



- The entire landing pad must be at a height so that the user could not temper with the drone.

- The landing pad should have some safety measures like protection screens in case of fails to land properly.



- The base of the pad must be reinforced by scrutinizing the roof.

- To make the package attach at the pod, a platform must be added which can lower or raise the package.

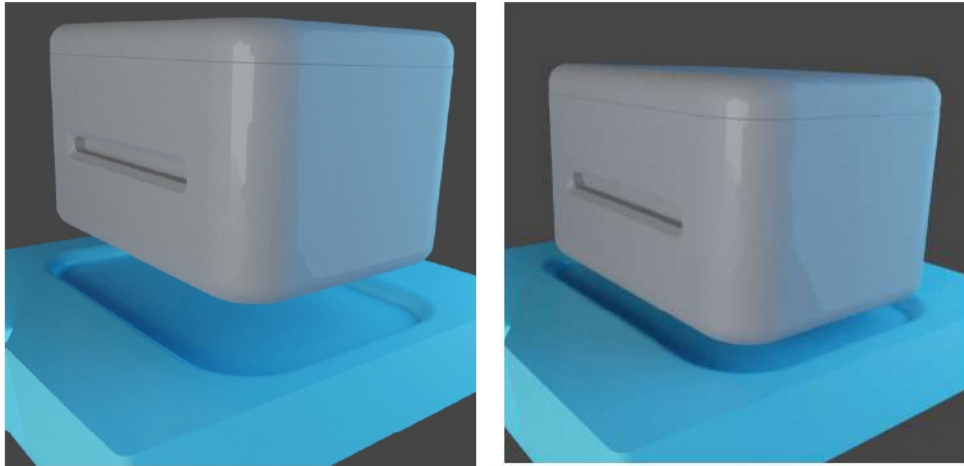


Image 43 : Author Centering Base for pod Image source : Author

- To make the package align perfectly and to avoid human error, there must be a self centering slot for placing the pod.

### Types of delivery system

- Manual System

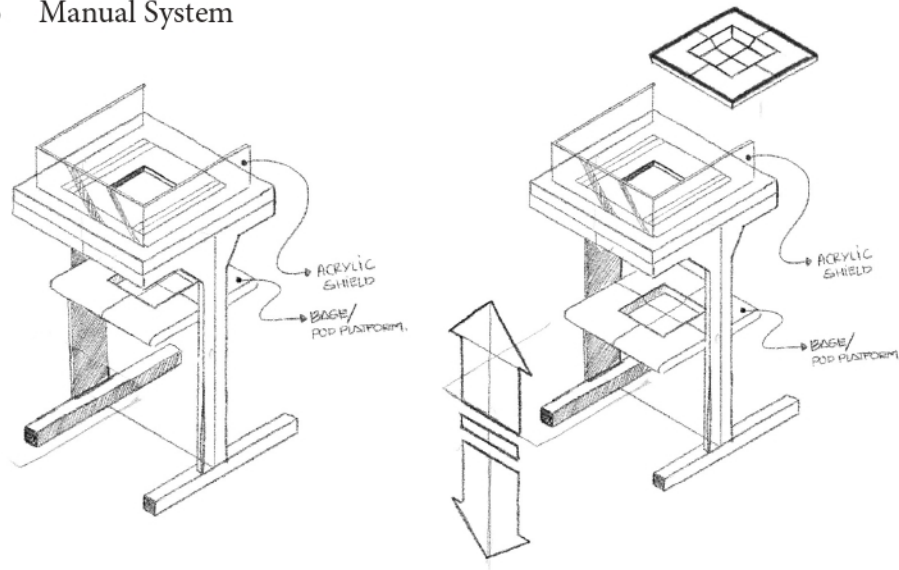


Image 44 : Manual Delivery Station Ideation Image source : Author

These kind of systems can be manual systems where the authorized person can lower and raise the pod to collect and place the pod.(Image 44) **This system is easy to operate , is cost effective, easily manufacturable, and have a low operational cost.**

- Automatic System

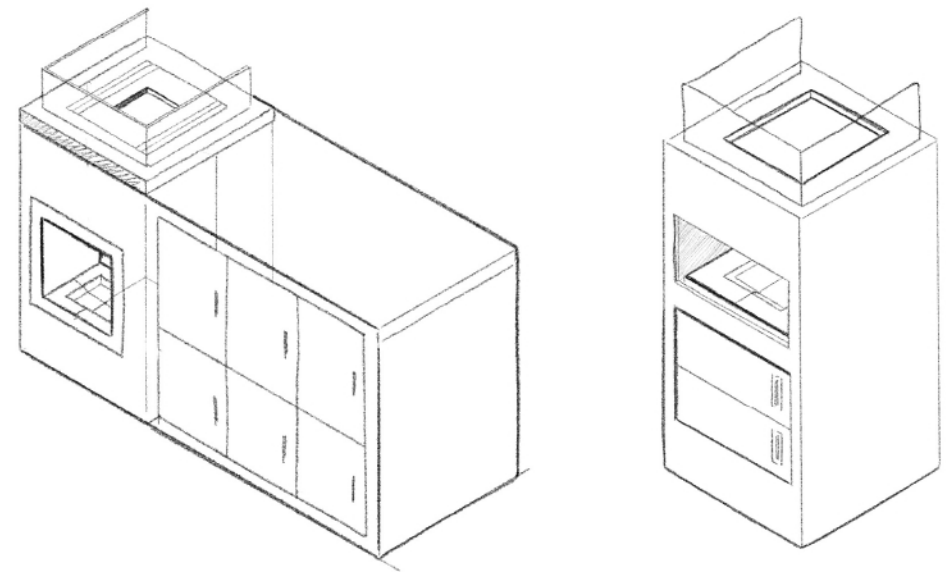


Image 45 : Automatic Delivery Station Ideation Image source : Author

The other system could be which is completely automated where the user just needs to place the pod and the rest is automated function.(Image 45) **This kind of system would be expensive, would require a lot of components, would have a high operational cost, but will be user friendly.**

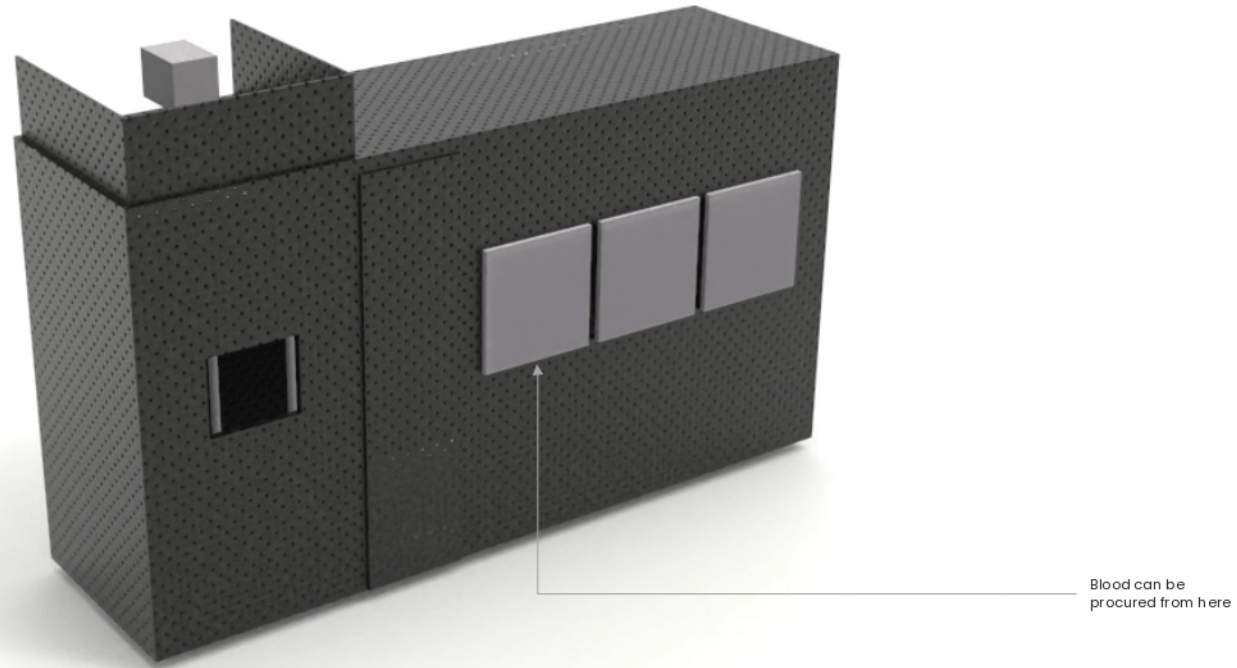


Image 46 : Automatic Delivery Station Ideation Image source : Author

## Designing the System

For designing of the system there is a need to take a few assumptions.

### Assuming that everything is according to the regulations.

- The pilot operating the drone is licensed and is following proper rules.
- The Proper UTM – Unmanned traffic Management is functioning.
- The drone in question is compliant to all the regulations imposed by the DGCA.
- The drone port is registered in the DGCA database system.

### The Proposed system would require :

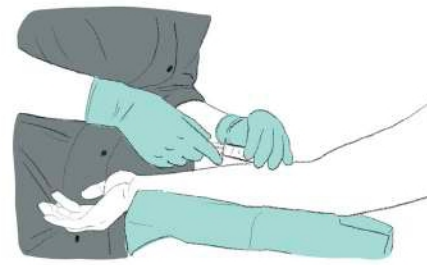
- A third-party service provider who will be owning the drones and landing pads
- A computer/ Mobile Application for managing deliveries
- Stations for picking up and delivering.
- Pods that can carry 2kg blood with the ability to get attached to drones.
- A licensed pilot for operating BVLOS Drones.
- Authorized personal responsible for taking the pods to stations.
- Separate Charging/Battery Changing stations



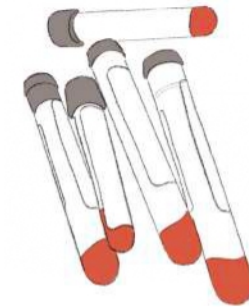
Blood required



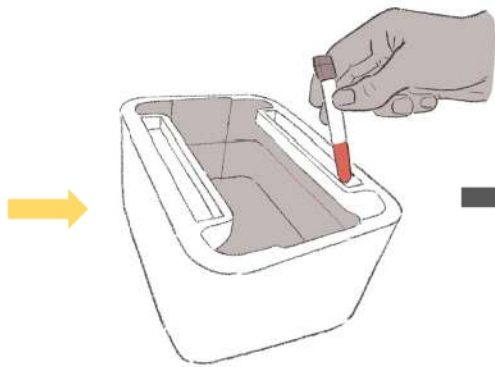
Order is made via app, website etc.



Blood sample is taken



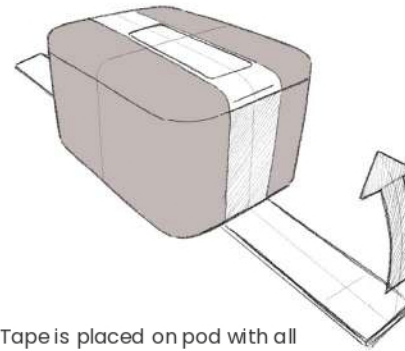
Collected blood sample



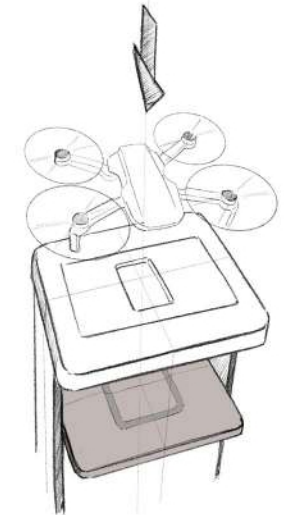
Vials are placed in the pod



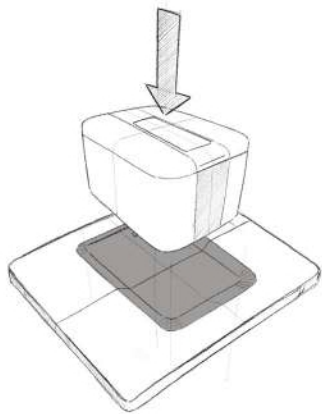
Pod is closed



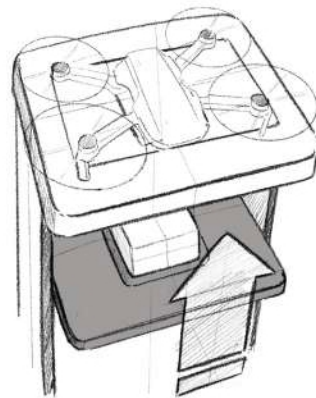
Tape is placed on pod with all the details of the delivery



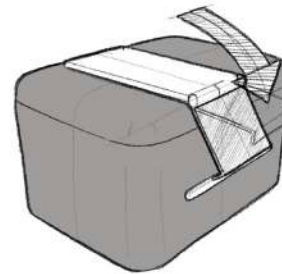
Drone arrives at the hospital



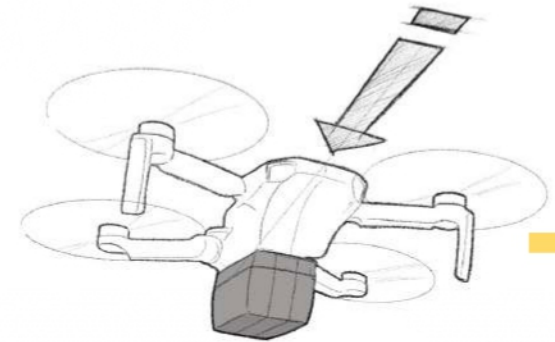
Drone is placed on the platform



Platform is raised

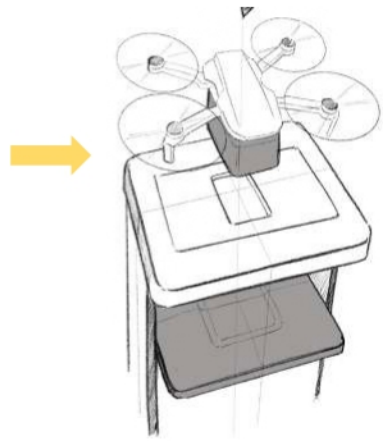


Pod is attached to the drone.

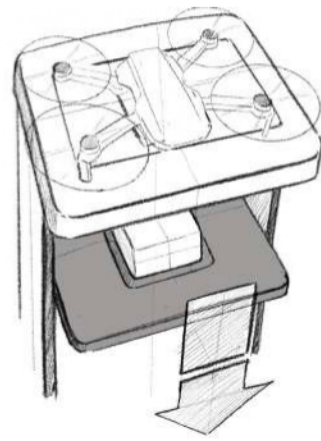


Drone leaves

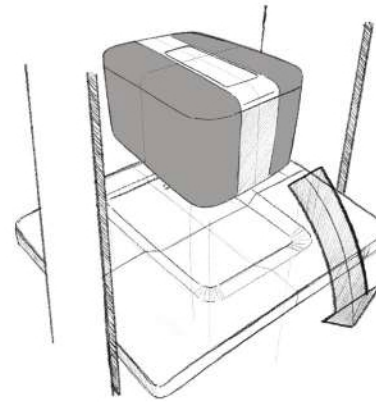




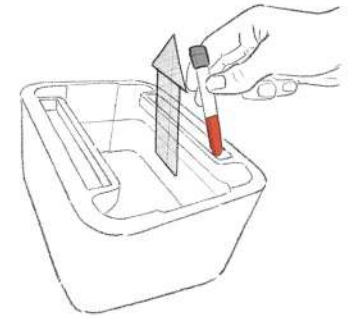
Drone arrives at Blood bank



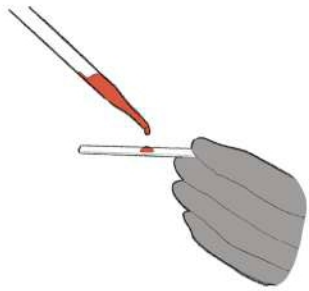
Platform is lowered.



Pod is collected from the platform.



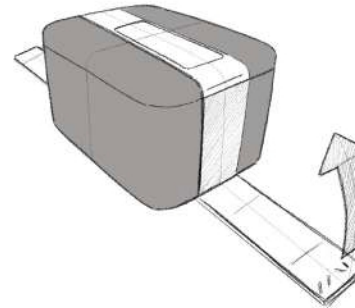
Blood vial is procured from the pod.



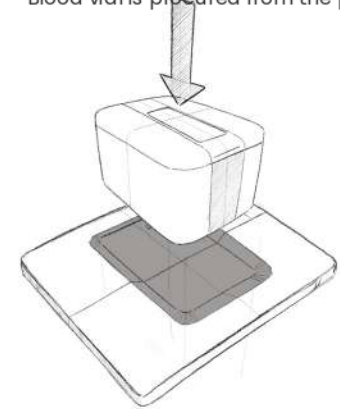
Blood is tested at Blood bank



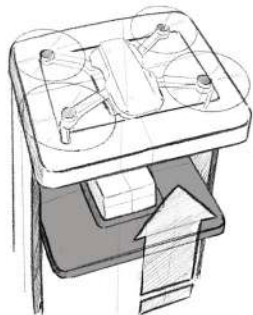
Blood bag is placed inside the pod



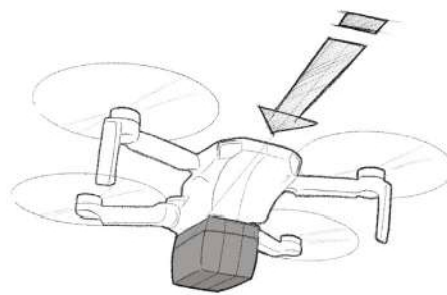
Pod is packed again with the details of blood printed on the labels.



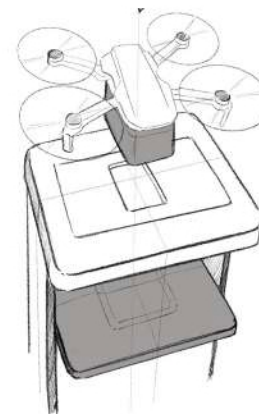
Pod is placed on the platform



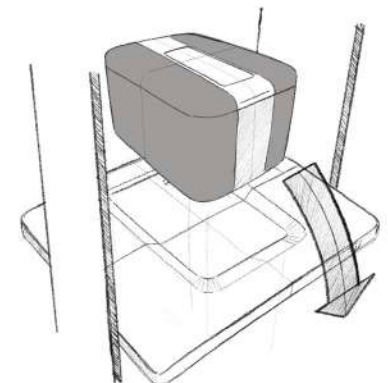
Platform is raised.



Drone leaves the blood bank.



Drone arrives at the hospital.



Pod is procured.

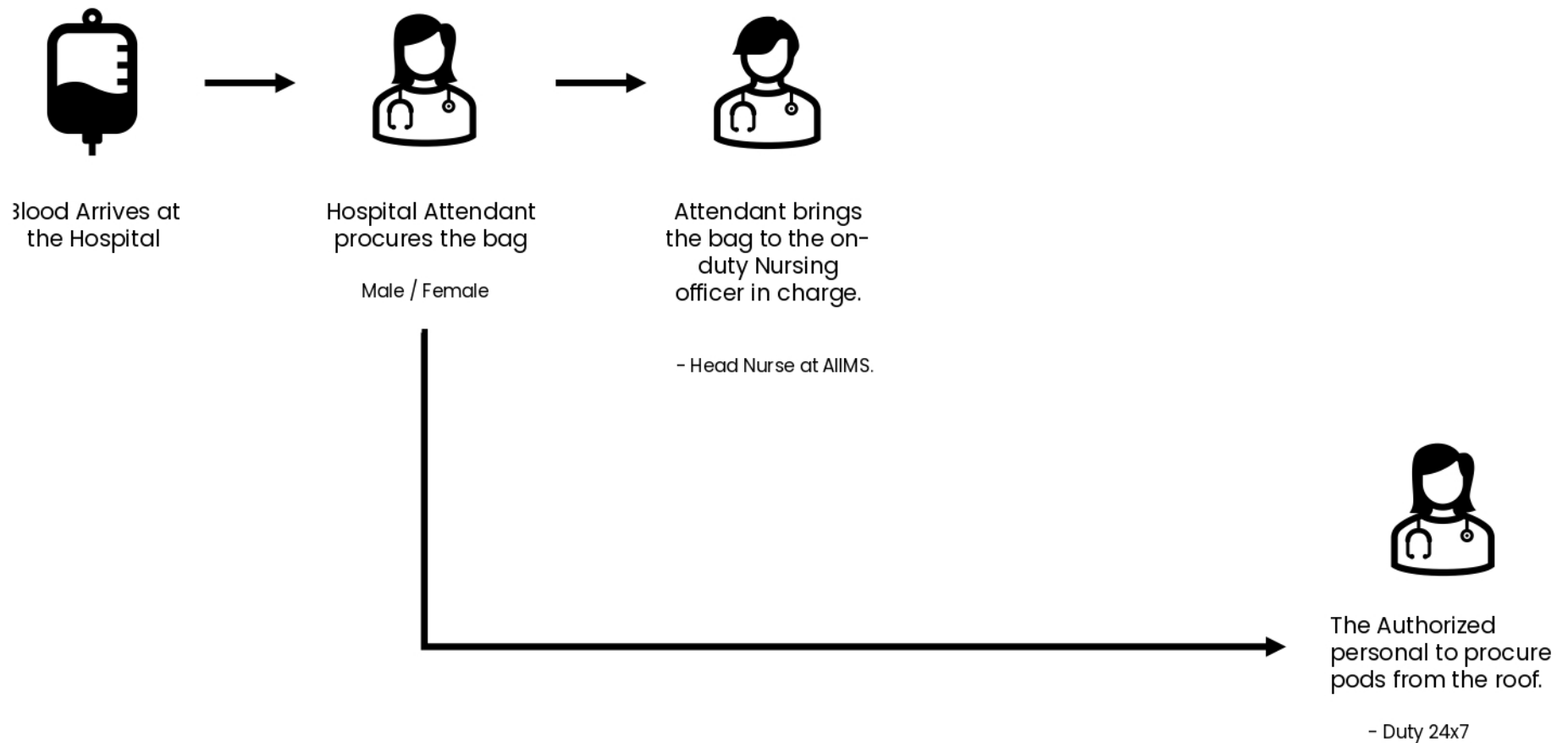


Image 47 :The Authorized personal Image source : Author

And once the blood reaches the hospital, the person responsible for handling the pods from the stations to the hospitals would be hospital attendants who are currently responsible for the exchange between the blood bank employees and the hospital. After the blood is collected, it is transferred to the on-duty officer in charge. (Image 47)

Color coded for easy identification



From Hospital to Blood bank



From Blood bank to hospital

Image 48 : Visual identification for Delivery pods. Image source : Author

Since the tapes are changed twice in the process, both the hospitals and blood banks would have different color coding to minimize the confusion while transporting or sorting the pods.

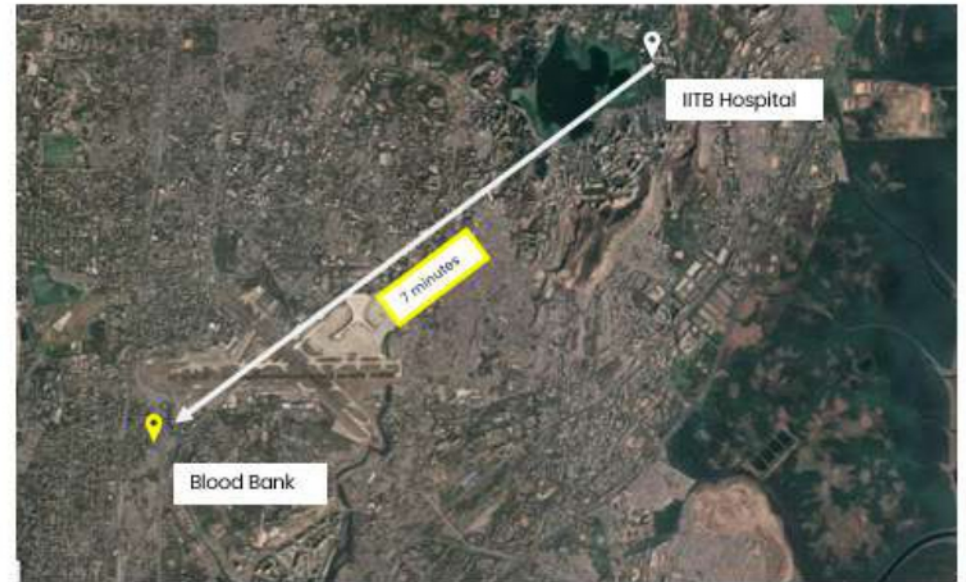




**Existing**

- 1 Transit form Blood bank to hospital. — 42 minutes
- 2 Transit from Hospital to Blood Bank — 42 minutes
- 3 Testing the Blood sample — 20 minutes (Average)
- 4 Transit from Blood bank to hospital. — 42 minutes

Total time for the entire process. — 146 minutes (3 hrs.)



**Proposed**

- Transit from Hospital to Blood Bank — 7 minutes
- Testing the Blood sample — 20 minutes (Average)
- Transit from Blood bank to hospital. — 7 minutes

Total time for the entire process. — 35 minutes

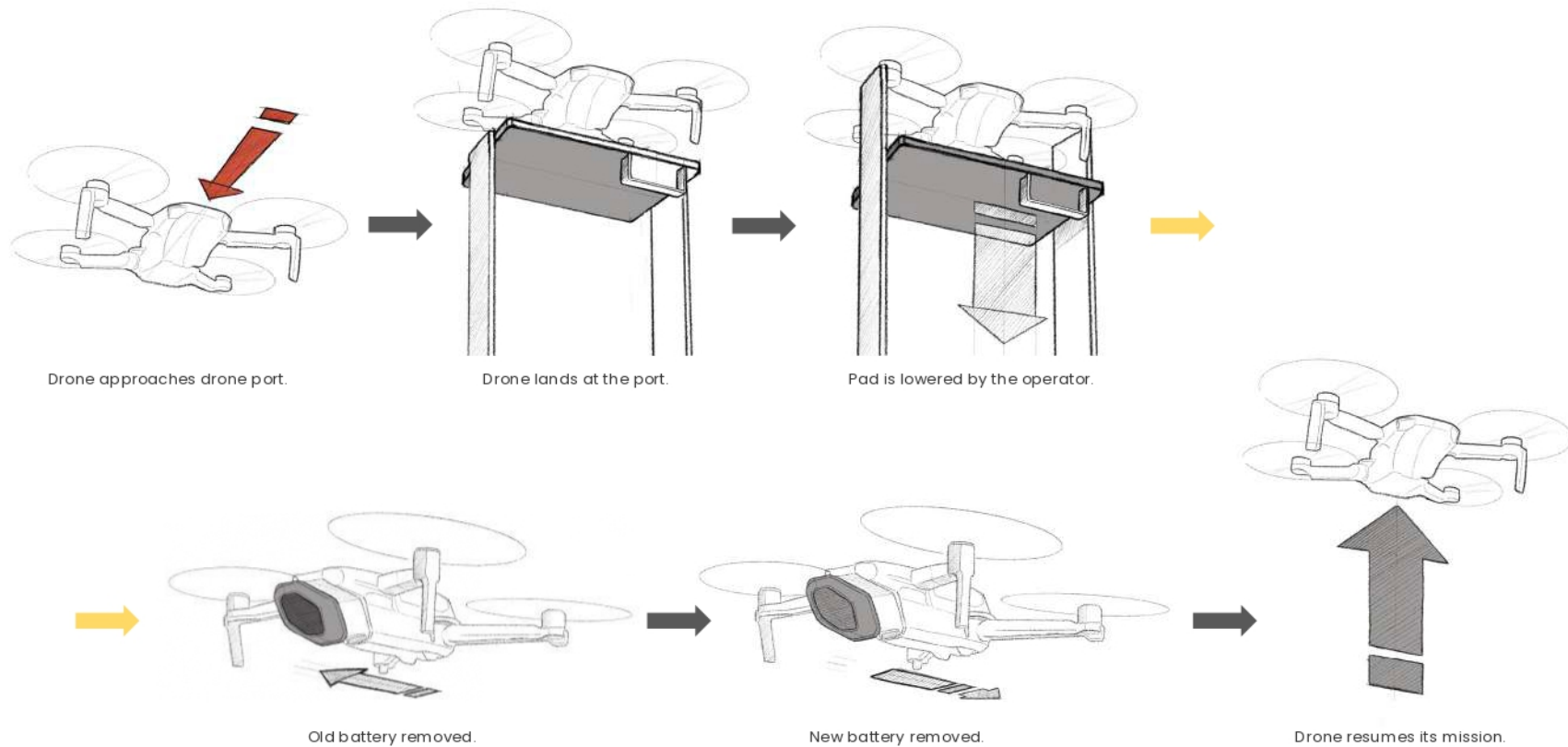
The proposed system will be able to deliver the blood in only in 35 minutes when compared to the old system which took 3 hrs to do the same process.

## Next I want to talk about the charging station,

So the idea of wireless charging is great but its not very practical, because charging takes time and we don't have the tech yet to fasten up the process. so instead of charging , changing the batteries would be a probable solution for that we would require charging pads where the drone would be landing specifically for battery refueling. An authorized person will be responsible for changing the batteries . The station will be placed on the top of the roof.

### The Proposed charging system would require :

- Charging pads where the drones will be landing specifically for refueling.
- An authorized person who will be responsible for changing the batteries of the drones thus creating jobs.
- The charging stations may also act as departure points for the drones to carry out a mission.
- These station will also be placed on roof tops away from any foliage or architectural elements.



The battery changing stations would look something like this, (Image 49)

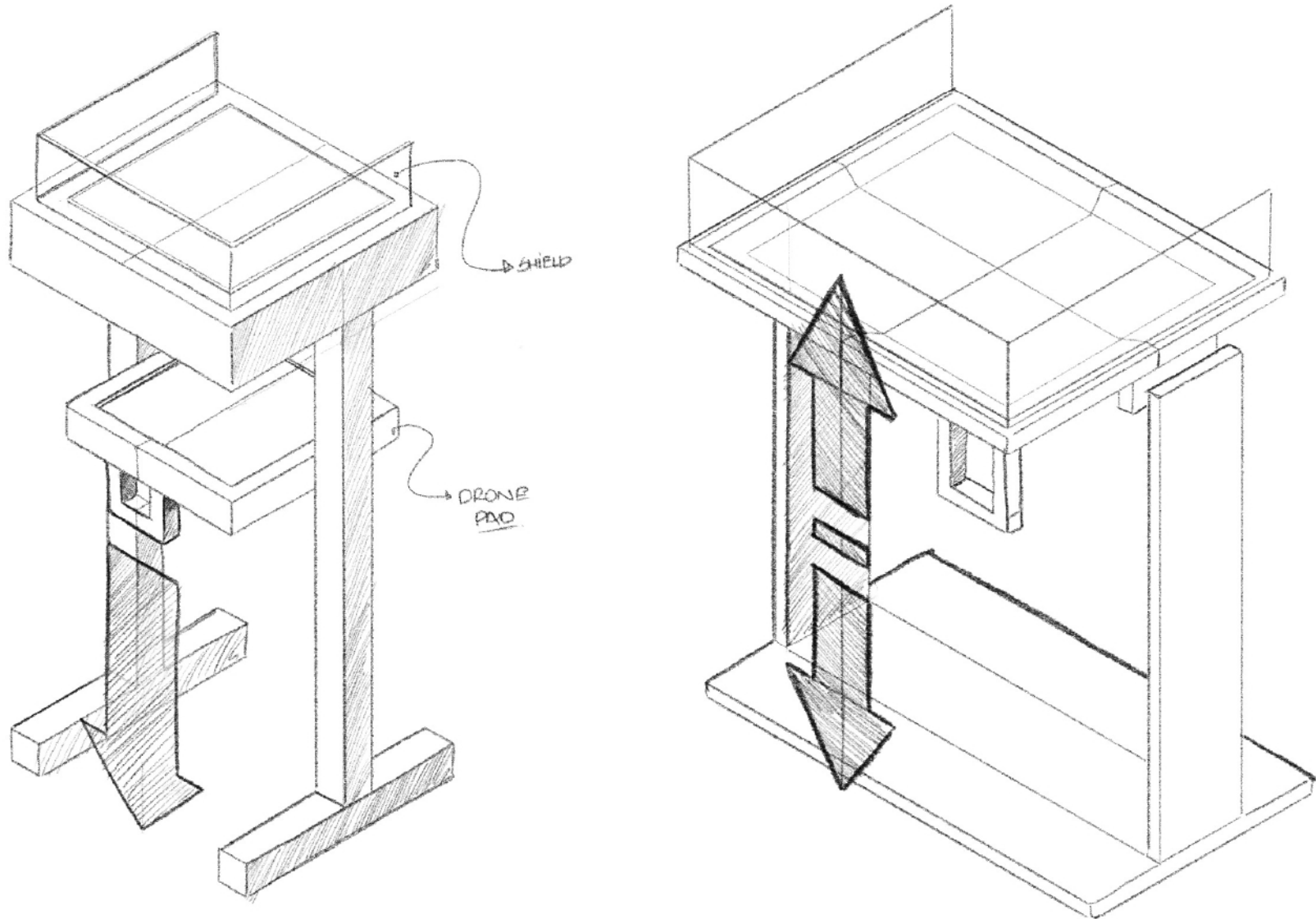
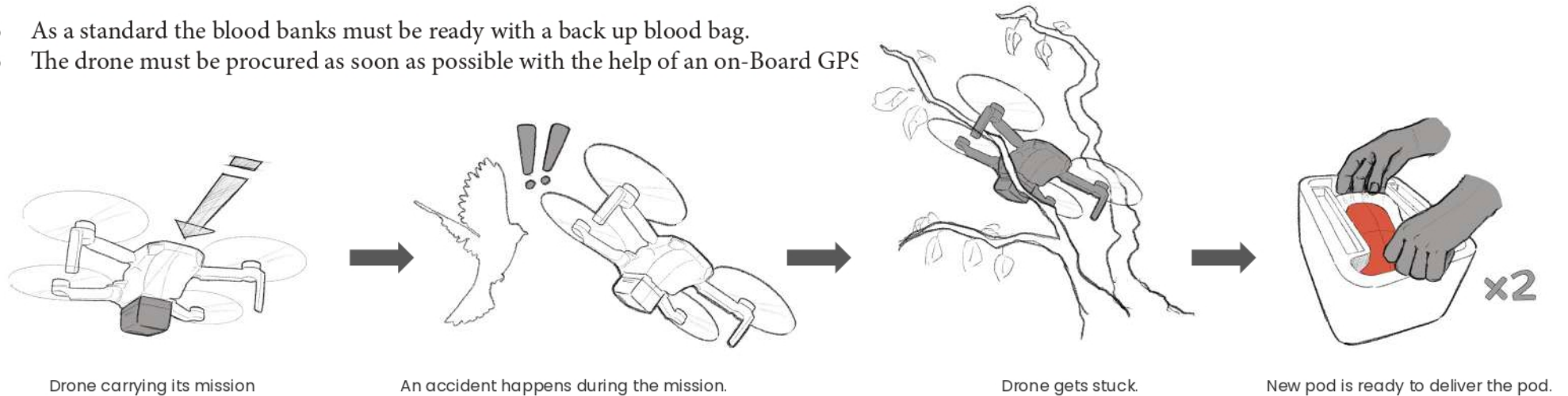


Image 49 :Ideations for charging stations Image source : Author

## Accident

Acc. To DGCA, the drones must have a recovery system that will balance the drone mid air in case of any imbalance but ,  
**In case of an emergency delivery, if any accident happens then -**

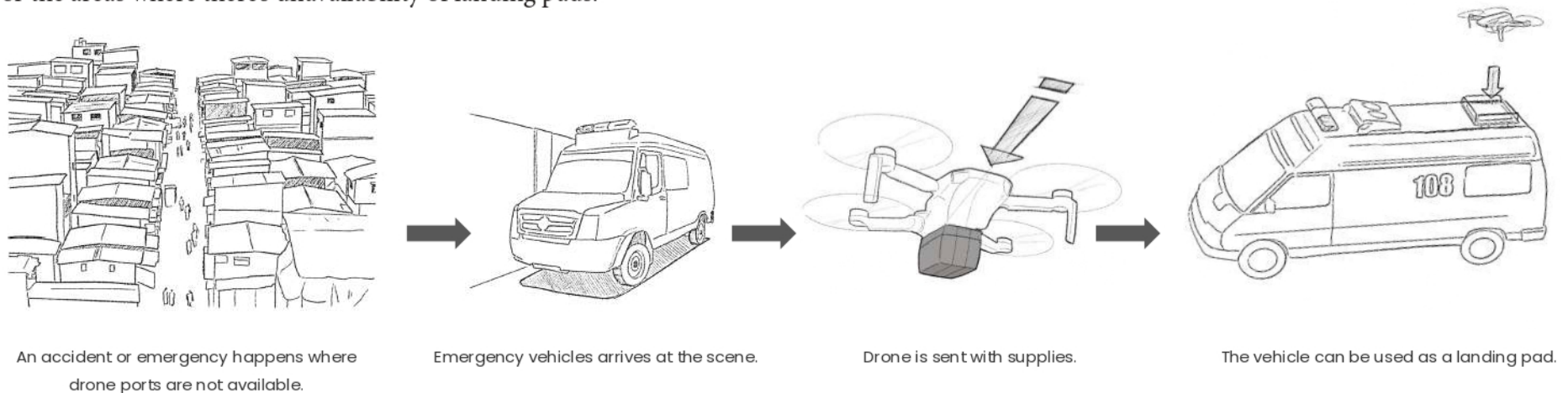
- As a standard the blood banks must be ready with a back up blood bag.
- The drone must be procured as soon as possible with the help of an on-Board GPS



## Remote Area

**In case of remote areas where the stations aren't present or in case of a natural disaster,**

- The on-site emergency vehicles can be used as a landing pad for emergency deliveries.
- For the areas where there's unavailability of landing pads.



Earlier I was able to paint a picture of the system and how the system would function on different scenarios. This time I want to step further into the micro details of the entire system. (Image 50)

So, the third parties will be acquiring drone and stations from the manufacturers, and will be responsible for setting up the infrastructure that included Connection towers, stations, batteries, the application for the user and the charging stations which can be acquired on lease/contract basis that may include shops, malls markets, high rise buildings etc.

The man force will also be handled by the tps including Pilots, engineers, maintenance staff, installation staff.

And the hospitals and blood bank will only be using these services for acquiring blood. And to do that, according to the need the pods will be required, and to make orders, an application computer or mobile which will be integrated with the e rakt kosh database will be used.

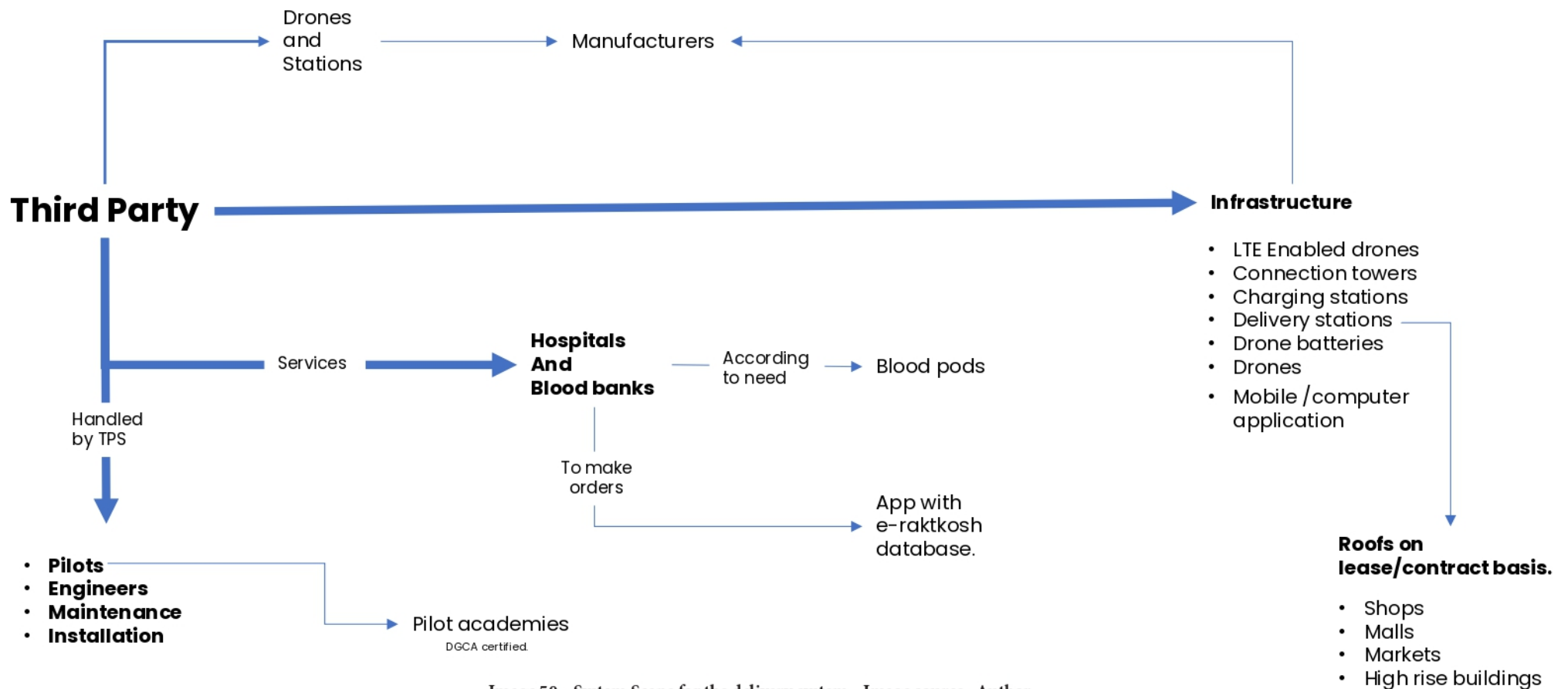


Image 50 : System Scope for the delivery system Image source : Author

I started mapping out all the hospital and blood banks throughout Mumbai. I did this because I wanted to see the ratio as well as the location of these buildings. Whether they are concentrated on one region or distributed throughout the space.

So, by doing that I saw that the hospitals and blood banks are distributed through out and the connection towers will be needed. (Image 51)

- Approximately 40 hospitals.
- Approximately 20 Independent Blood banks



Image 51 : Mapping Hospitals and Blood banks Image source : Author

The State's daily requirement is about 4,500 to 5,000 blood units while Mumbai requires an average of 1,000 units. "However, the requirement is currently low as many elective surgeries have been postponed and there are not as many accidents because of the lockdown," said Vinay Shetty from the NGO Think Foundation.

On an average, every day in Mumbai 1000 unit of blood is needed and assuming that one patient required 2 unit of blood, That's approx. 20 deliveries every hour. 20 drone making deliveries per hour.

Since the drones having a flight time of 30 min, on a full charge they can travel upto 12 kms, then the charging stations must be kept at 6 km apart.



Image 52 : Distribution of connection towers Image source : Author

## How can we increase the range of Commercial drones.

Considering the towers have a 4 km range. The towers can be placed such that it can cover the entire state. And I also stumbled upon an interesting article which says that we can increase the drone's range with the help of dual channel antennas that can work as a network, or we can use the existing network of LTE and make LTE enabled drones. Which means now the only limitation of the drone becomes the Battery.

The range of a wireless link can be increased by:

- increasing the transmit amplifier power.
- Increase the sensitivity of the receiver by using low noise figure low noise amplifier.
- Increase the band width keeping the bit rate constant. This can be accomplished by using FSK and increase the frequency deviation.
- One can use forward error correction techniques such as the RS coding or the convolutional coding
- using multiple antennas in form of diversity.

Source : Zekry, Abdelhalim. (2017). Re: How can we Increase the communication range of a commercial drone/UAV?. Retrieved from: <https://www.researchgate.net/post/How-can-we-Increase-the-communication-range-of-a-commercial-drone-UAV/598d6c8648954c2e86056ddc/citation/download>.

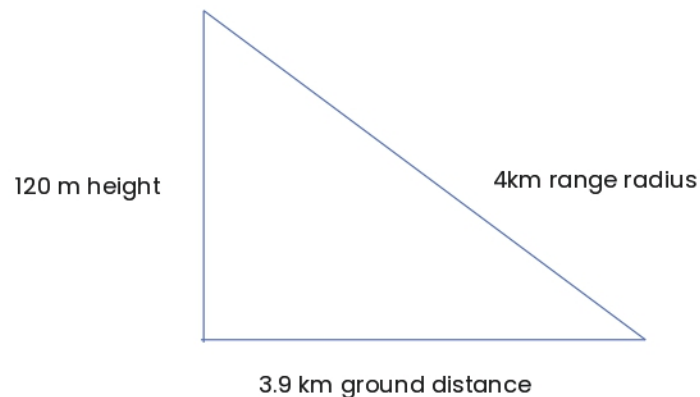


Image 53 : Range analysis Image source : Author

## Implication of this technology

The real-world benefit of using Network or LTE enabled tech is that in a conventional system if there have to be 20 drones flying, we require 20 pilots on different locations. Because without the network, there's a range limitation.



Image 54 : Proposed connection Image source : Author

But if the network is there, all the drones can be controlled from under one roof. Because there's no range limitation. This kind of system would allow the drone pilots to fly the drones from a centralized location rather than from segregated locations.

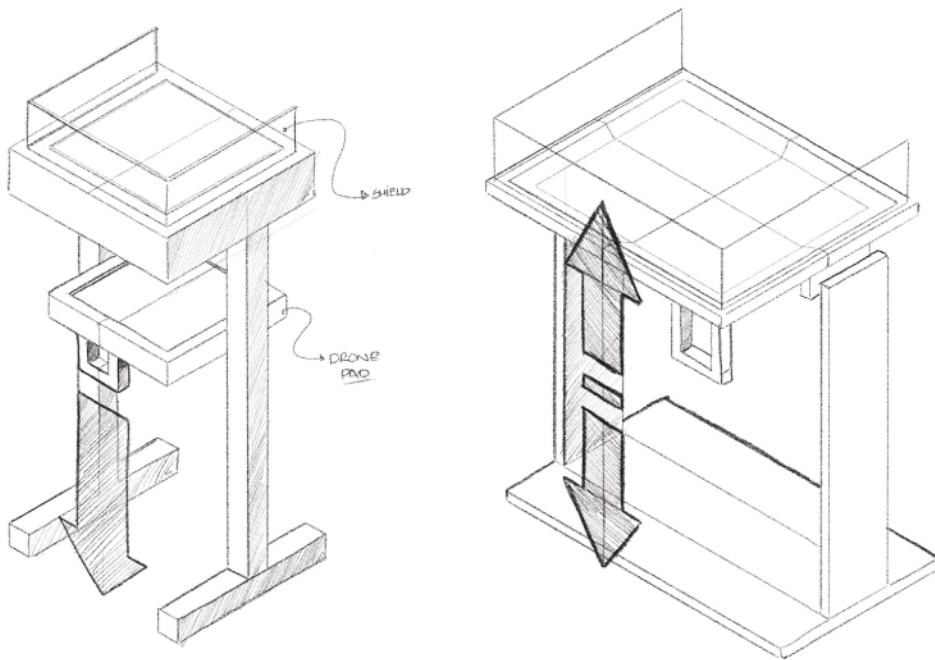


Image 55 : Proposed Delivery Station Image source : Author

These were the probable charging stations. But there is also a requirement of a departure station. Where the journey of the drone will begin from will end.

## Designing Departure Stations

### Departure cum Battery changing stations

The same locations for the connection towers can be used for battery changing stations and the point of departure and return for the drones that would cover the entire area of operation.

- Drones will begin mission from these points.
- Drones will be landing at these points for changing batteries.
- Drones will be ending their mission here.



Image 56 : Proposed Connection towers Image source : Author

### Activity flow chart

An activity flowchart for understanding what's going to happen in the system . Whenever the delivery is required, engineer or technician at the departure points will get updated about the mission. They will place the drones on the pads. The system will get update, and the pilot will take control of the drone and leave for the mission.

And for the arrival the drone will land on the pad once it has been given the permission to do so. The pad sensors will recognize the drone. Pilot will lose control and engineer / technician will remove the drone from the pad and put it in storage.



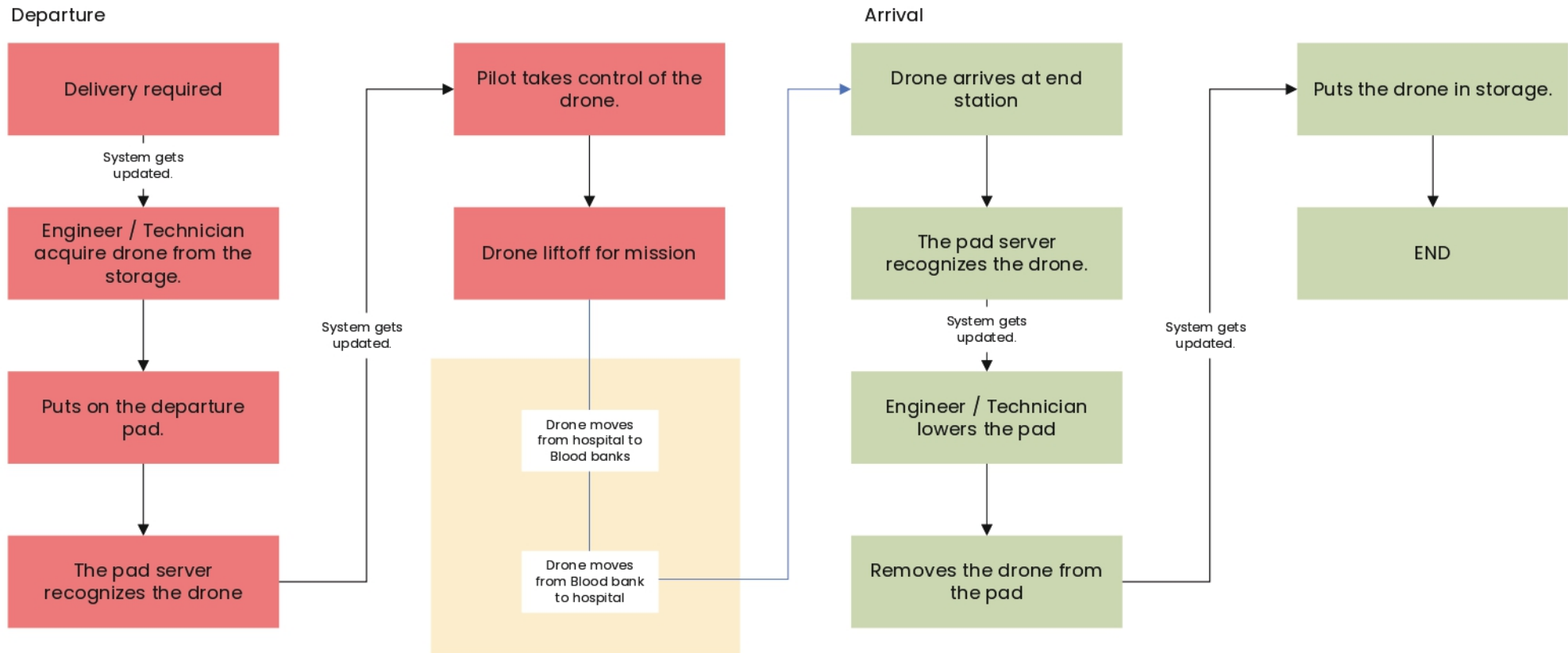


Image 57 : Activity Flowchart Image source : Author

I mapped out the potential pain point like what if it rains does the pad need to be cleaned or cleared of the water, how will the connections be done on the roof, it might require open space for the task.

- Storage
- Pads
- Connectivity
- Open Space for the podsv
- Weather

I mapped out the potential pain point like what if it rains does the pad need to be cleaned or cleared of the water, how will the connections be done on the roof, it might require open space for the task.

- Storage
- Pads
- Connectivity
- Open Space for the pods
- Weather

As the activity requires the technician to place the pad whenever required, the space will require a storage for the drones (Image 58) and a computer for the technician to get notification about the deliveries.

The probable layout will be like this where there are two pads which are open to sky and a room besides it where the technician will be operating from. Which includes the storage as well. (Image 59)

Two pads because one could still be used for landing if the other is being used for departure.



Image 58 : Drone Storage Image source :Google.com

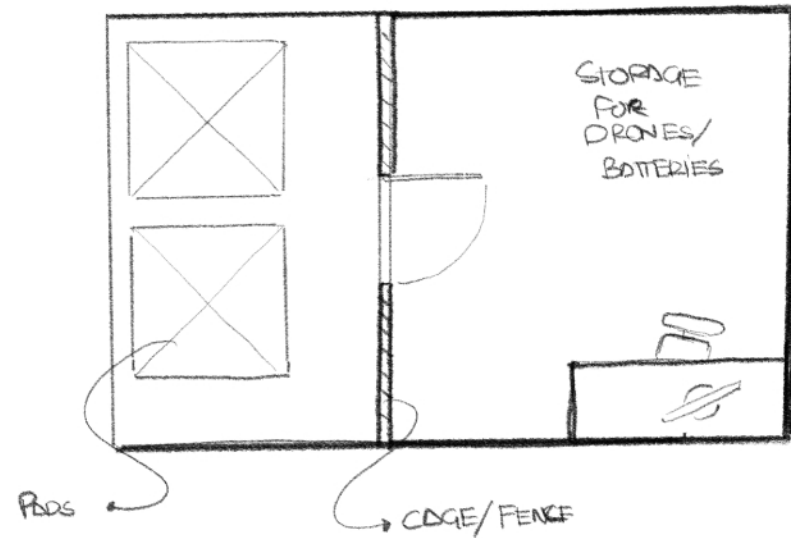


Image 59 : Probable Layout for the departure station Image source : Author

I started ideating by making very crude sketches for the charging stations and

As the system has evolved, There's no need for the drones to be lifted.

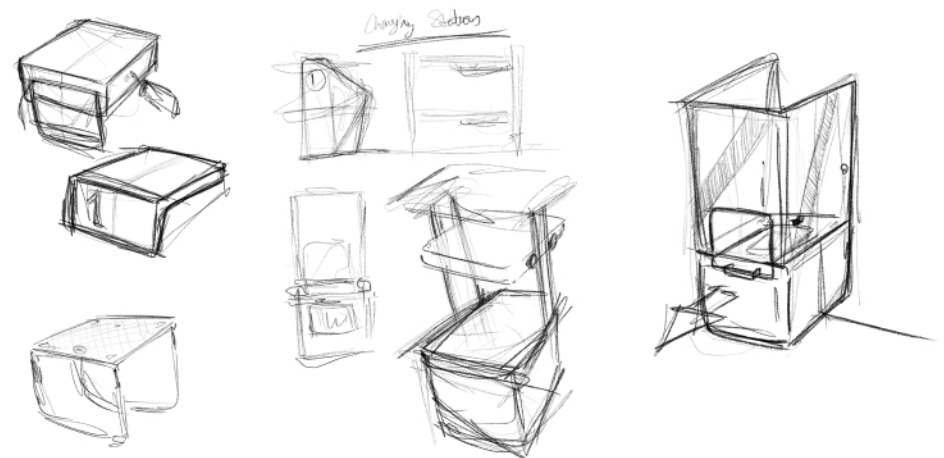
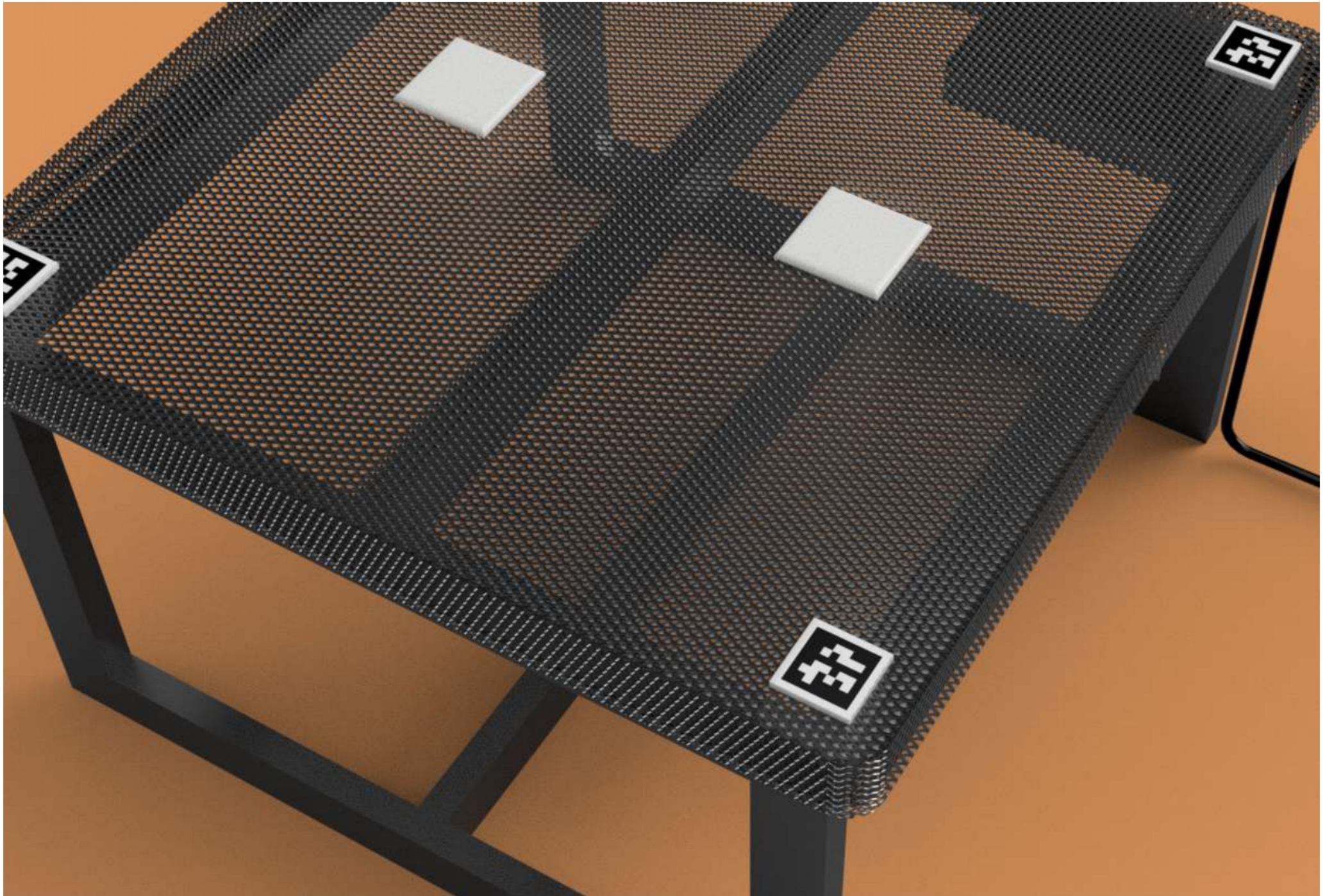
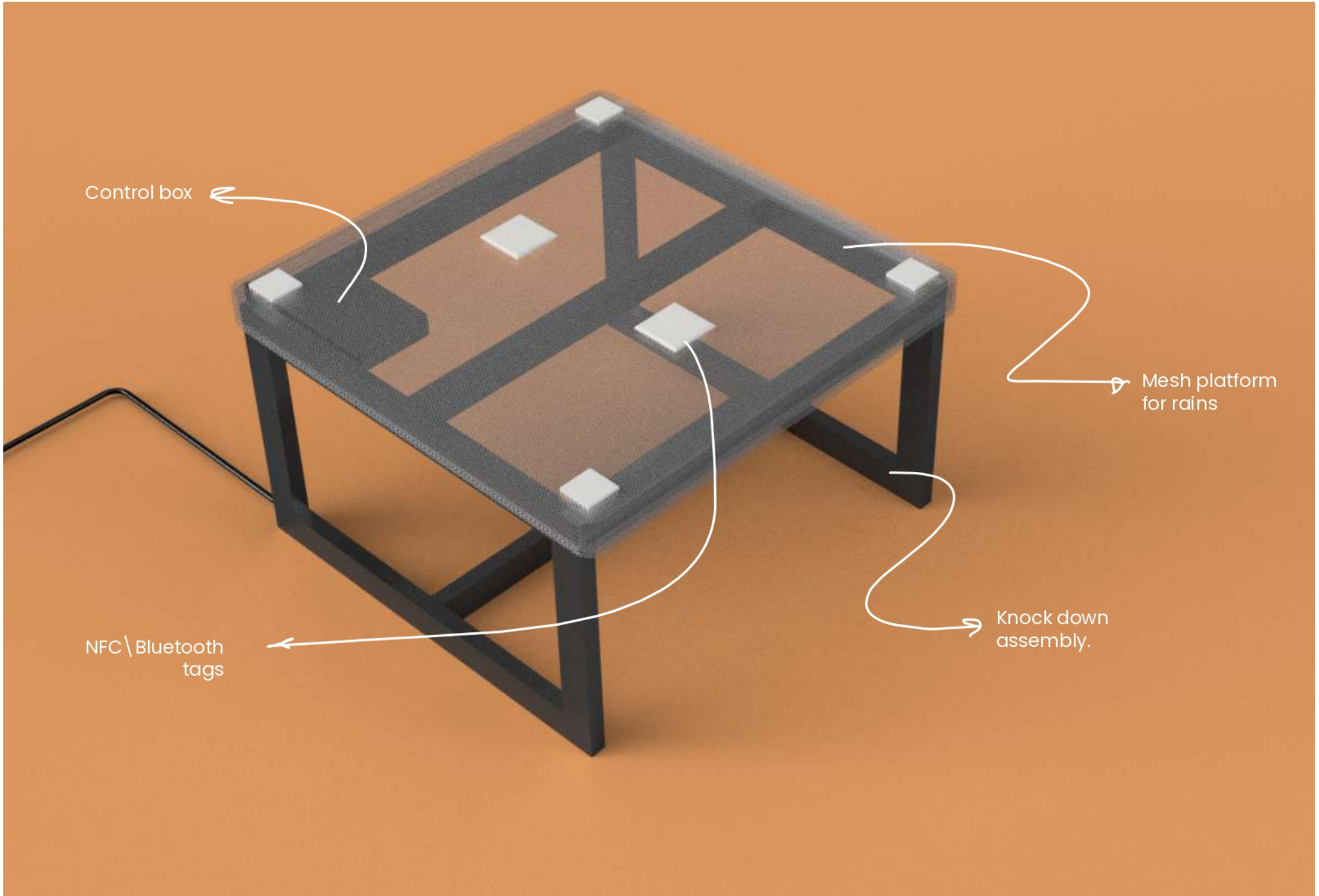


Image 60 : Ideations for departure Stations Image source : Author





Control box

Mesh platform  
for rains

Knock down  
assembly.

NFC \ Bluetooth  
tags

# Pods final design

Next I started working on the pods. I started making activity flow for the pods to understand the probable pain points. The pods will have multiple arrivals and departure. One from the hospital to bloodbank and the other from blood bank to hospital.



Image 61 : Activity Flowchart Image source : Author

## Pain Points :

- Reusability
- Impact resistance
- Texture
- Material
- Space for the tape

Next bodystorming was done to observe and to rectify some points. The activity of removing and placing the label was focused on as this activity was to be done multiple times.

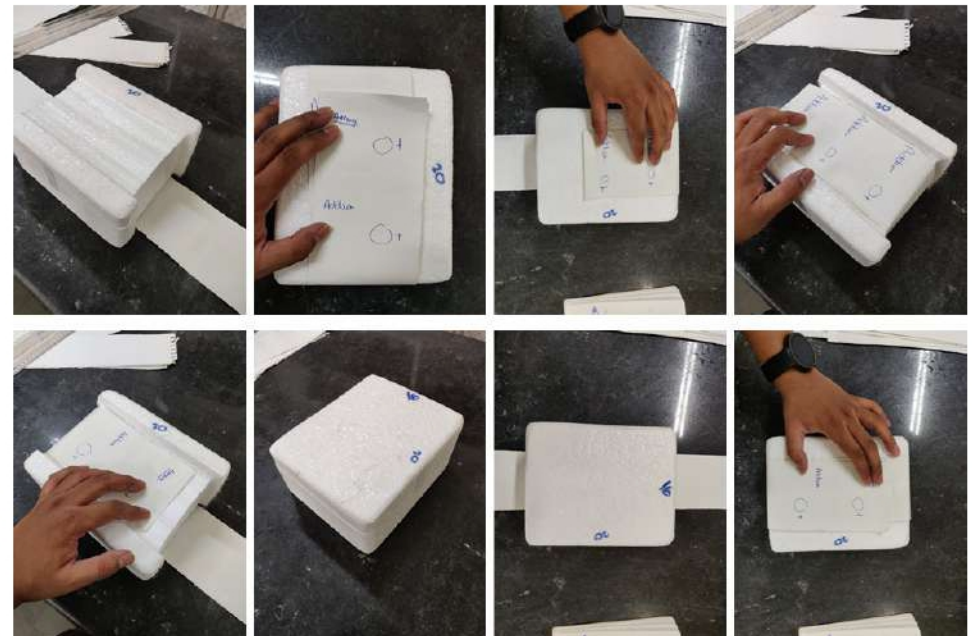
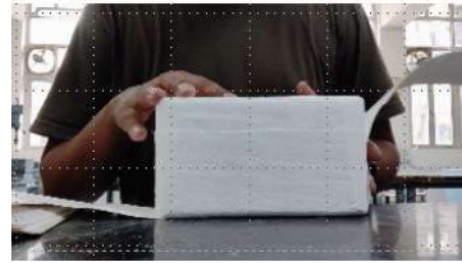
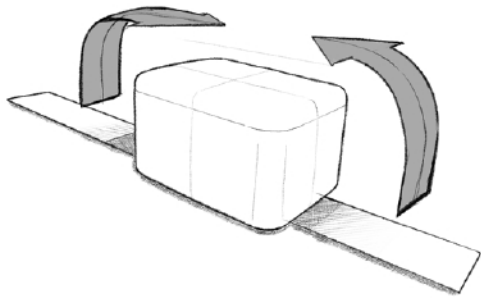


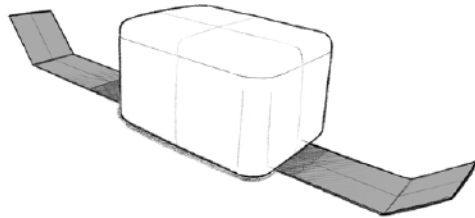
Image 62 : Bodystorming Image source : Author



**Option one.**

If laid vertically the tape is facing downwards and it could cause unwanted confusion while heavy delivery.

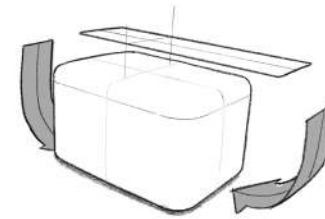
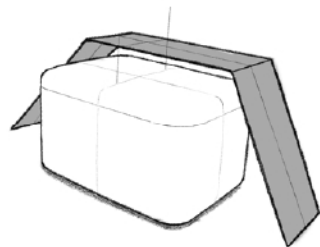
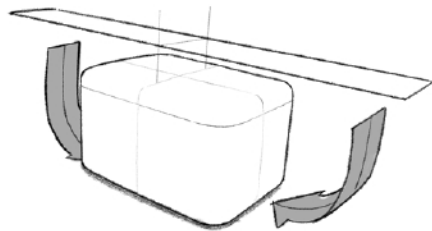
- Address visible while application.
- Tape easy to remove



**Option two.**

If tape is laid on the top its easier to apply but the box has to be lifted.

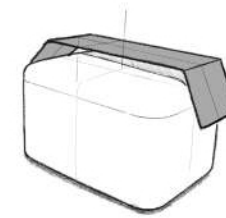
- Address visible while application.
- Tape easy to remove



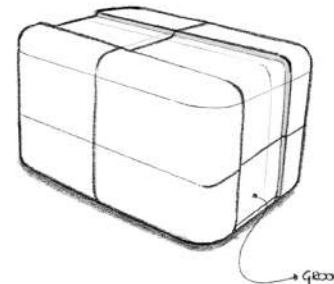
**Option three.**

The tape which can be easily stuck on the top without lifting the box.

The sticker with glue on both ends which can be put on top but this will be harder to remove.



but since there's an activity of removing it also , so option three is not the best option. The final option was chosen to be option number one, where the tape is laid vertically facing downwards and the pod is kept on top of it to tie the pod.



While doing the storming I also observed that even though I was aware of how to put the label I was doing it the wrong way, so a groove was required to intuitively let the user know where to put the label.

A groove will be required to let the user intuitively align the tape in the direction of groove.

- So that its always aligned in the right direction by limiting the affordances.
- The tape won't slip by itAuthor in the process.
- The grove will provide a secure fit.

### Wheat Straw Plastic (Entire material)

- Light weight & hard.
- Moisture free
- Renewable
- Can be molded.

### ABS (Outer Shell)

- Good Impact resistance
- Recyclable
- Tough
- Low manufacturing cost.

### EPS (insulation)

- Light weight
- Insulator
- Non-Recyclable



Image 63 : Wheat Straw Plastic

Then I started looking at materials which can be used like the Wheat straw plastic for the entire pod or ABS for the outer cover, ABS being a good impact resistance material and EPS for the insulation.

This was the final design for the pod which will have a groove for the label slip with EPS for insulation and ABS outer shell for impact resistance.



Image 65 : Final Pod Design Image source : Author



Image 64 : Final Pod Design Image source : Author

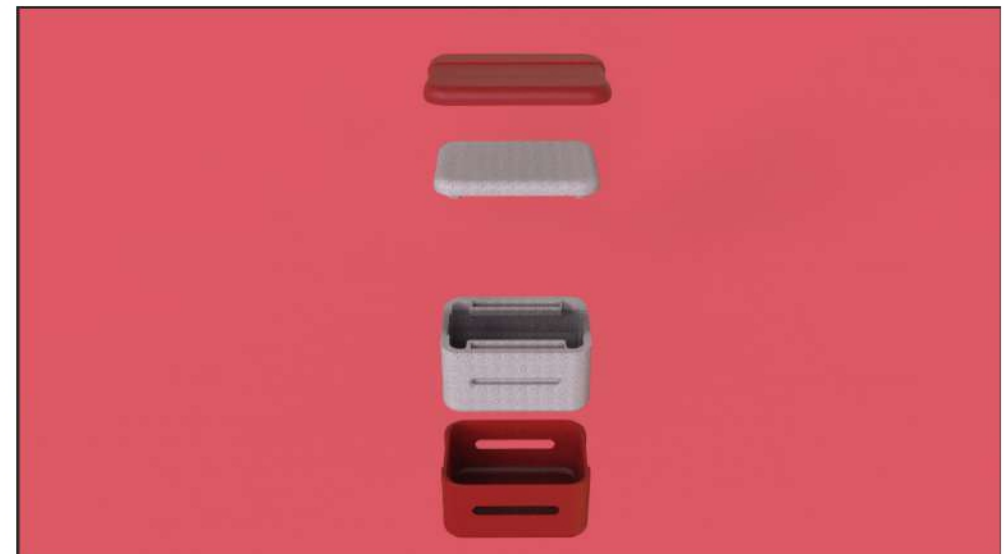


Image 66 : Final Pod Design Image source : Author

Next, I started working on the label design itAuthor. And the necessary details that needs to be on the label.

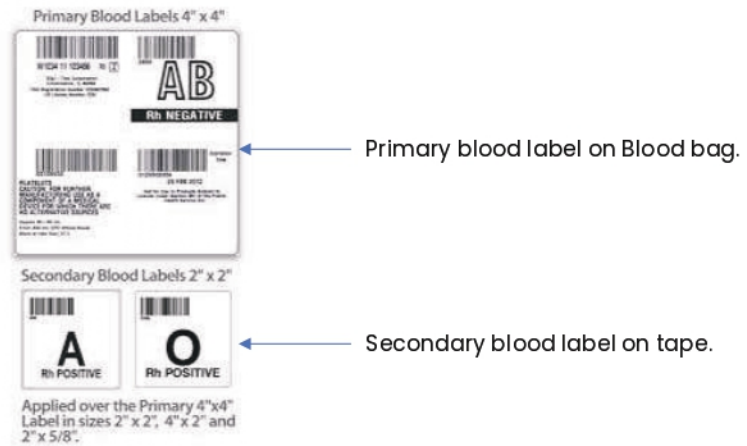


Image 67 : Standard Label for Blood bags Image source : google.com

### Details on the sticker

- Delivery Number
- Delivery address
- Sender's address
- Blood type
- Delivery type (Urgent or not)
- Contact number ( sender )
- Contact number (receiver )

So I created two different labels for two activity cycles for easy identification.

First is the label slip for hospital to blood bank which includes senders address delivery address, Bar code for scanning and also the third party 's contact and details (Image 68)

The addresses needs to be visible because in case of accidents a good Samaritan may call or also deliver the pod to the destination.



Image 68 : Designed Delivery tape for pods. Image source : Author



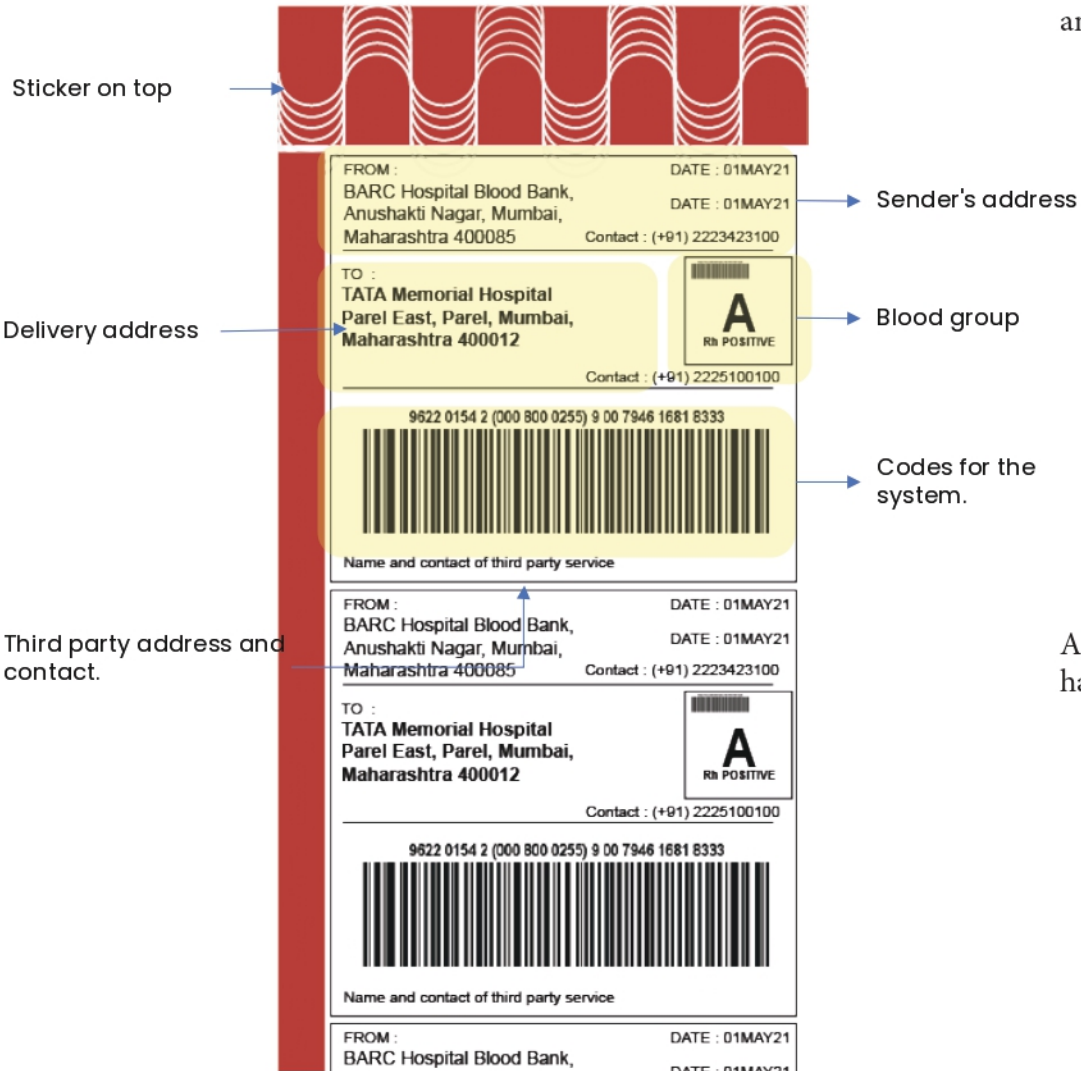
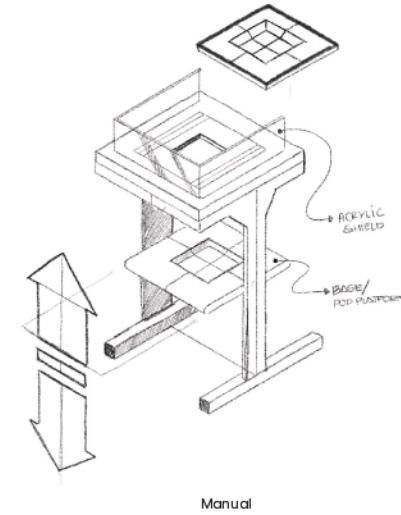


Image 69 : Designed Delivery tape for pods. Image source : Author

Next label was for blood bank to hospital , which Is quite like the previous label with the exception for the color and other that the blood group is mention on the label. (Image 69)

## Station final design

Next, I started working on the stations itAuthor. Previously I explained how there could be two types one manual which would have a low operational cost an would require a person to raise and lower the platform.



And the other that the station could be entirely automated. But this would have a high operational cost.



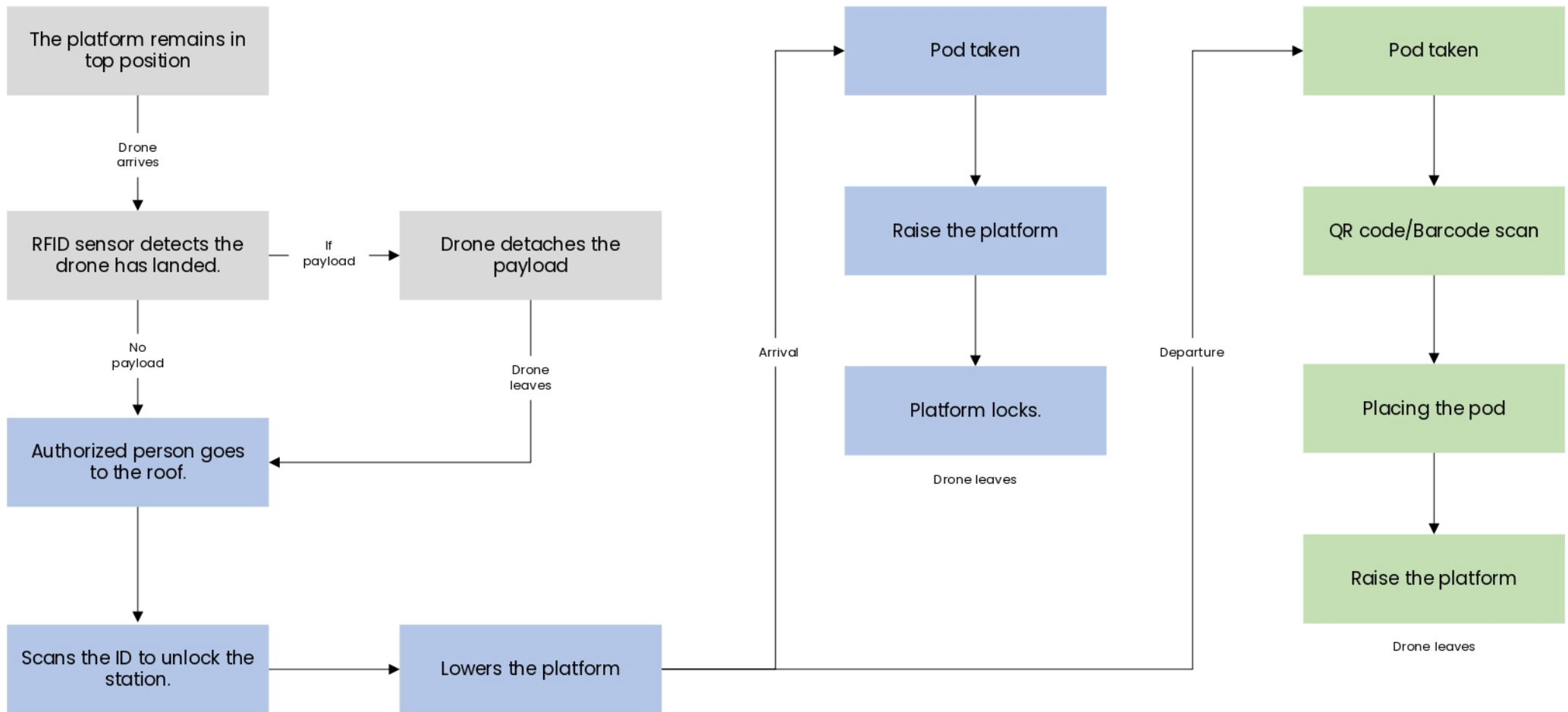


Image 70 : Activity Flow Chart Image source : Author

I created an activity flow chart, (Image 70)

Initially the platform will always remain in the up position and would require a scan for unlocking.

whenever the drone arrives the sensors will notify the system, if drone carries the payload, drone will detach the payload and leaves . The authorize person can collect the pod later by lowering the platform.

If the drone doesn't have any payload the authorized person goes to the roof scan the station for unlocking the platform lowers the platform. Places the

pod and raise the platform again , drone grabs the pod and leaves.

Few pain points for this activity were identified through the flow chart like -

- Material
- Weatherproof
- Shade for the user
- Scanning of the box
- Components
- Shield for the user
- Security
- Anti- vandalism
- Signifiers for the user around it.

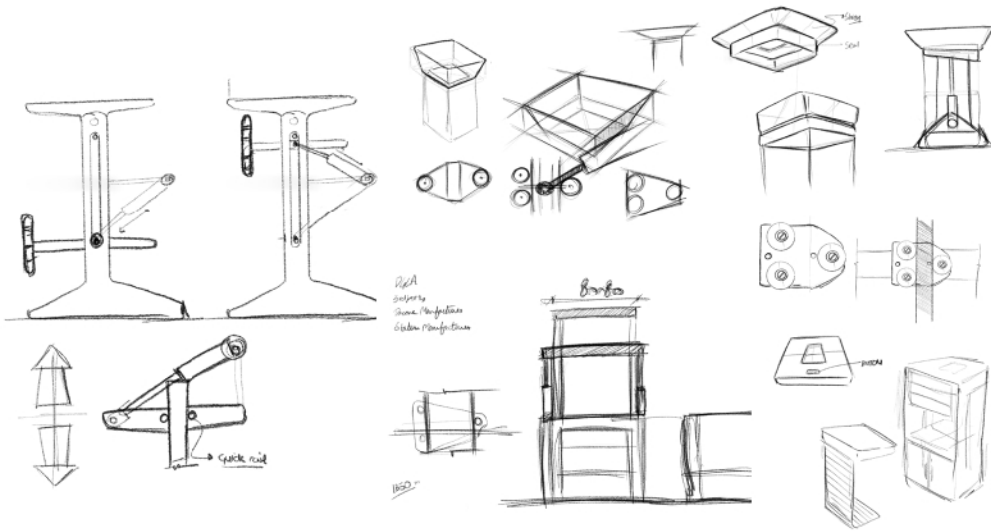


Image 71 : Delivery Stations Ideations Image source : Author

So first I started with the mechanism for the same, I was looking at a lot of components and ways for the same. But to get a better understanding about the components. I created thermocol and alluminium models. (Image 72)



Image 72 : Delivery Stations Models Image source : Author

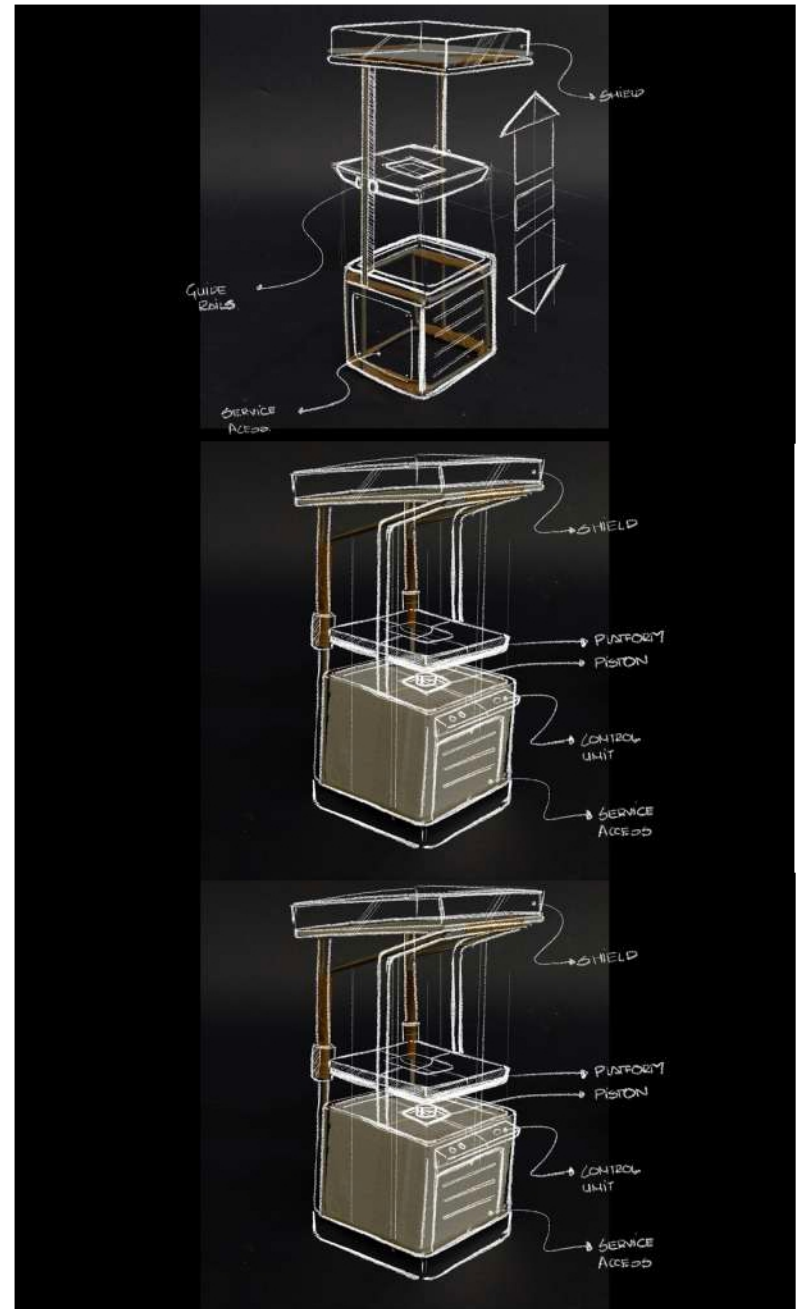


Image 73 : Delivery Stations Models Image source : Author

With this I was able to sketch out and visualize various probable mechanism and I though using a piston or actuator will work well. (Image 74)

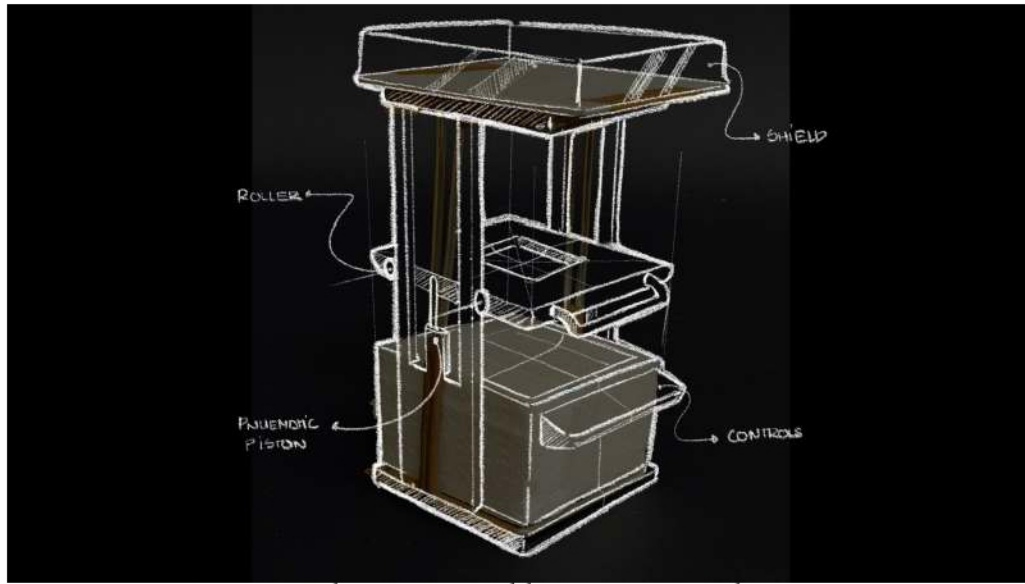


Image 74 : Delivery Stations Models Image source : Author

### Usability



Image 75 : Body Storming Image source : Author

To understand the usability issues, I crated some role plays.



Image 76 : Body Storming Image source : Author

Usability aspects like lowering and raising the platform. (Image 76)

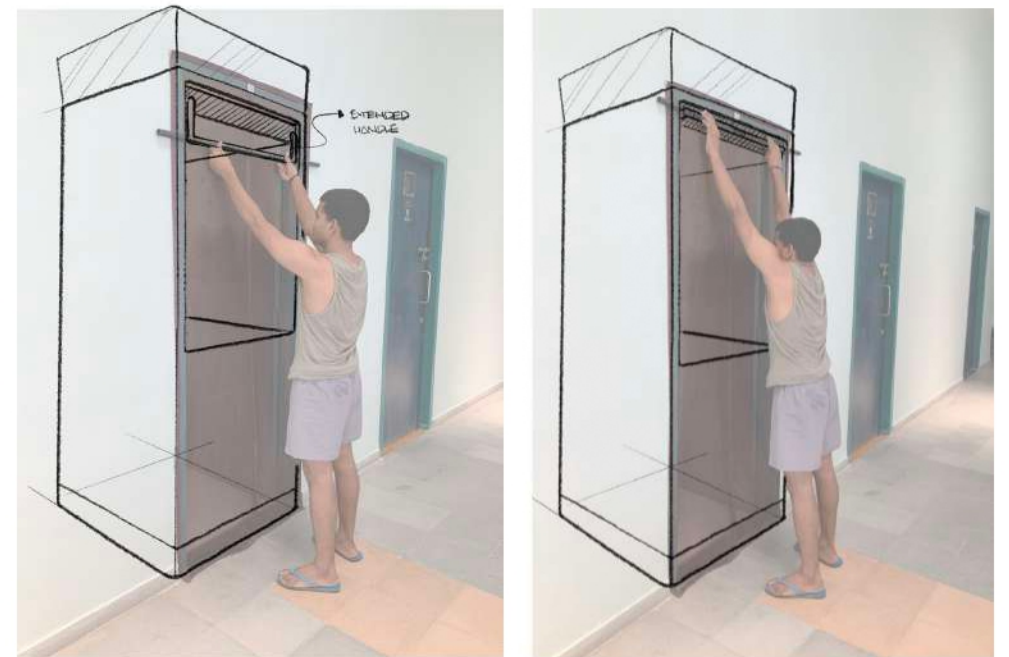


Image 77 : Body Storming Image source : Author

And the user being shorter than average hence, there was a need of placing an extended handle. (Image 77)

But if a female user must use it, based on the ergonomic knowledge that women are generally shorter than men. The handle might need to be extended further. (Image 78)



Image 78 : Body Storming Image source : Author



Since the extended handle needs to come down, the space becomes a very accidental prone. (Image 79)

← Accident area.

Image 79 : Body Storming Image source : Author



Image 80 : Body Storming Image source : Author

The extended handles needs to be flushed yet have enough room to not let the user's finger or hands or legs get hurt. (Image 80)



← Accident area.

Also since the platform is raised. The area become a pain point like the user might get his/her hand stuck in the process or something might get wedged in between.

Image 81 : Body Storming Image source : Author

## Why the tower shaped stations?

I assume that there must be a question that why in this case the tower is needed and not in the case for departure /charging stations.

All the hospitals and blood banks that I visited were small scale meaning that these institutions were part of a multi story building. The first or the ground floor is basically a blood banks or a hospital and the rest of the floors are residential. That means that the roof is accessible to not only the employees but the residents of the building as well.



Image 82 : Site Visit Image source : Author

- Are small scale hospitals and blood banks.
- Are part of multi story building with residential floor above.
- Don't have much surface area on the roofs.



Can't be just a pad on the ground level.



A platform of adequate height must be placed.



A shield will be needed to avoid accidental damages.

( Will be hard for the drone to land into. )

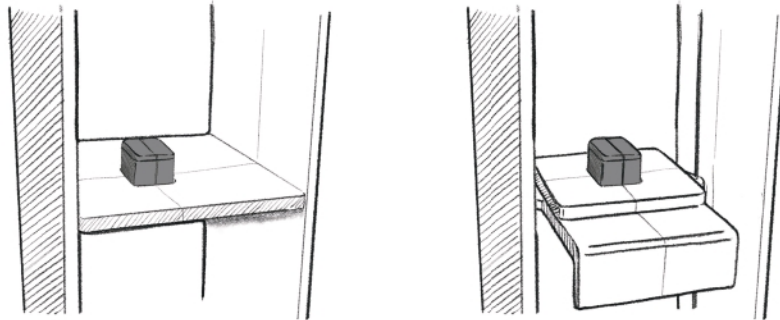


Fencing would be required to minimize vandalism.

Image 83 : Roof Analysis Image source : Author

If the pad is placed on the ground , to avoid any adulteration the entire station must be kept behind fences which would take space. which these roofs don't have, So that's why the tower.

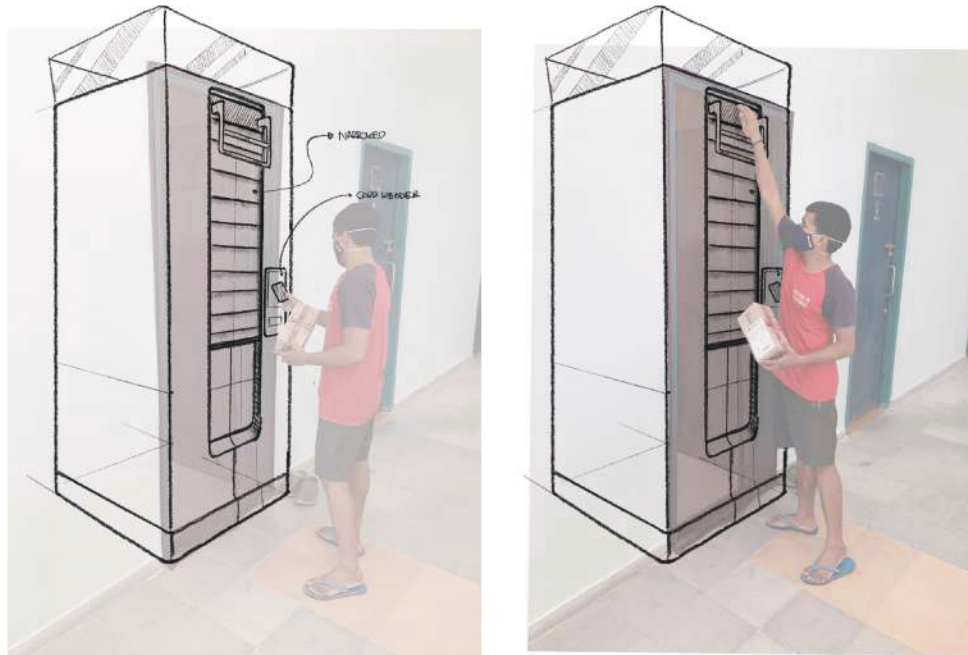
And since there was a space required for scanning the ID cards, I reduced the size of the platform which has to be raised. And by reducing the size of the platform.



Full size platform will take larger surface area

Narrowed platform for the pod

**Image 84 : Platform reduced** Image source : Author



**Image 85 : Interaction elements added** Image source : Author

There could be enough real estate to put different user interaction elements.

Like for the user to scan the card for unlocking the platform a space for card reader is required. (Image 85)



**Image 86 : Interaction elements added** Image source : Author

And since the pod may become heavy. During the role play the user kept the pod on the ground before lowering the platform. (Image 86)

So, it was observed that there was a space needed for putting the pod somewhere.

After that I started making an underlying structure for the same.



Image 87 : Mechanism ideation added Image source : Author

While ideating I realized a few things which I may have overlooked. (Image 88)

Like whenever the drone drops the pod. The platform has to be lowered by a person in order to procure it. And until the person arrives the pod is kept on the top.

Which is not ideal because it can be susceptible to theft or damage or can just fell.

So, this part might require some kind of automation.

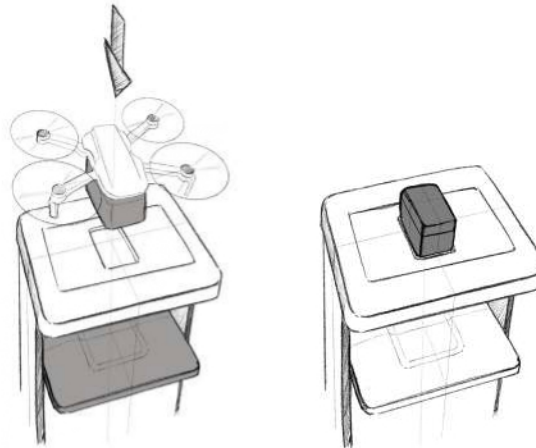


Image 88 : Problem with the activity added Image source : Author

And that's when I moved to automation. Now as I mention earlier that automation may increase the operational cost, increase the manufacturing cost, and increase the number of components.

**But it can make the structure slimmer and will be better in terms of usability.**

So then I started looking at different components in the market that can be used for this assembly.



Image 89 : Mechanism added Image source : Google.com

And the entire assembly can be done with a stepper motor and guide rail, which is similar to how a 3D printer works on X, Y, and Z planes.



Stepper motors.

Guide rails

Image 90 : Mechanism added Image source : Google.com



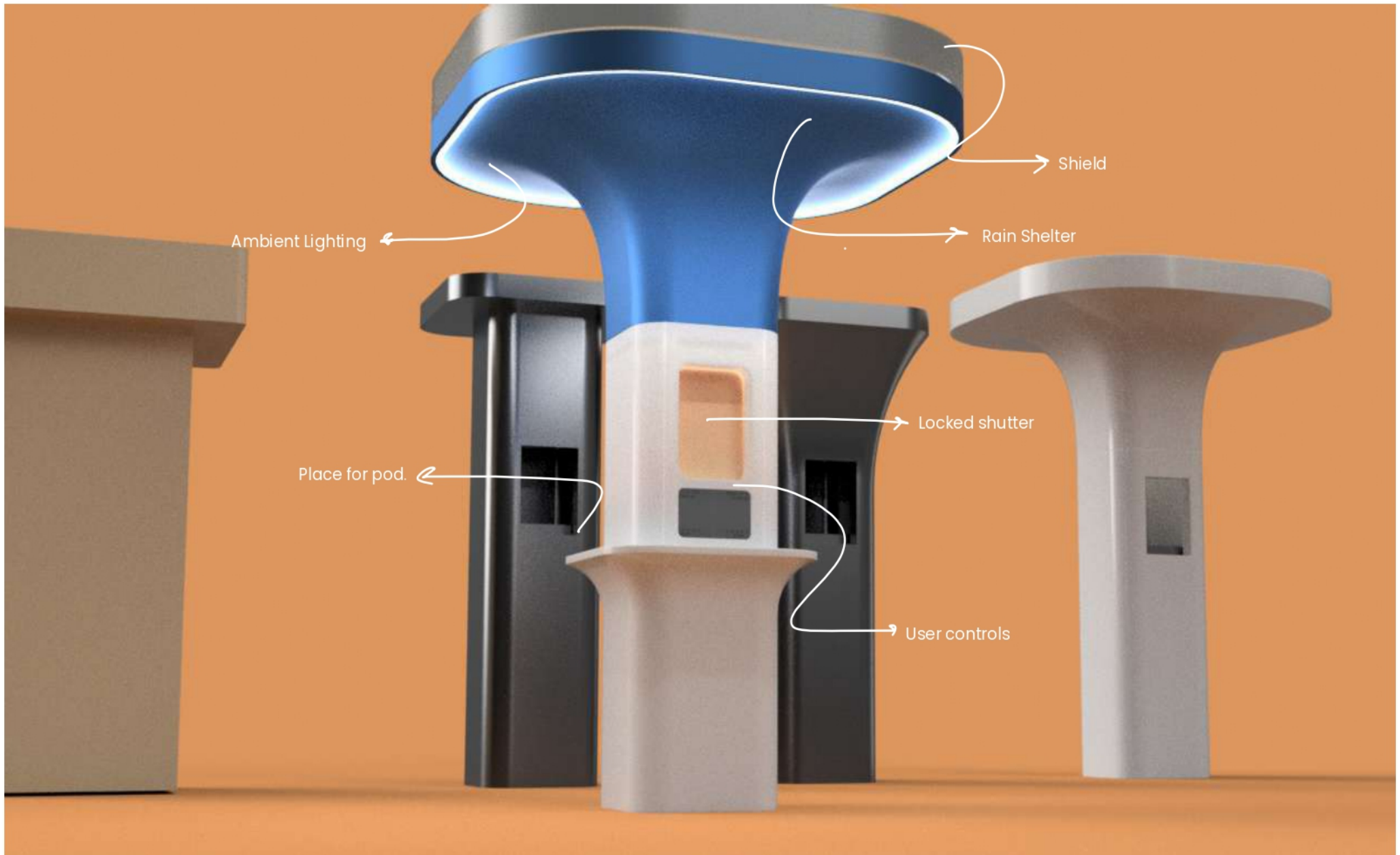


Image 91 : Preliminary concept for Station Image source : Author

Based on the previous pain points a rudimentary setup is created which is a wide base for the drone to land on to and a slimmer profile base with the interaction elements like ID card scanner, a place to put the pod inside, and a place for the pod to be kept when not handled by the user.

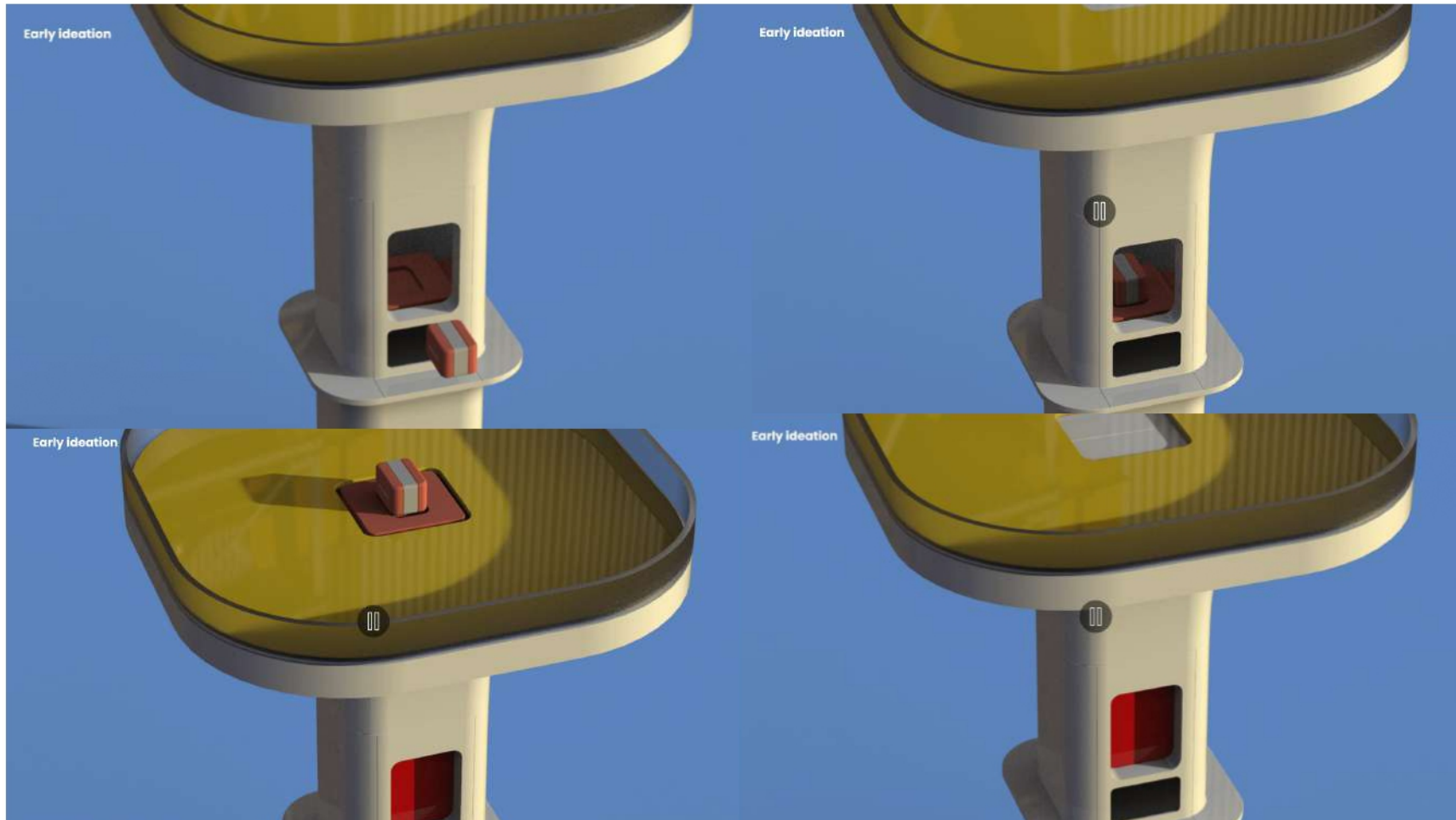


Image 92 : Preliminary concept for Station Image source : Author

The machine would work like this. The id card will be scanned which will raise the locked door , pod will be placed inside and the door will close and the pod will escalate and approach the drone.

This kind of construction also comes with challenges like how can we ensure birds don't become an issue or how the cleaning of the base will be done, what will happen when it rains, where the card should be scanned, how we can decrease the number of steps and how can the pod placement be made more user friendly.

- Anit- Bird
- Cleaning
- Rainwater
- Place for scanning the card
- Decrease the number of steps
- Placing the pod
- Connections



Bird nets



Bird Repellent Outdoor Laser



RFLT-1 Reflect-a-Bird Deterrent



Ultrasonic Solar Powered Animal Repeller



Spikes



Reflective tape

Image 93 : Bird Deterrents Image source : google.com

I started looking at bird deterrents like net, repellent lasers, reflectors, ultrasonic repellents, spikes and reflective tapes.

I did some research and found that birds don't really like flashy lights and mirrors. So, implementing a reflective surface can be used to act as a bird deterrent.

source: Int.J.Curr.Microbiol.App.Sci (2019) 8(2): 1035-1039

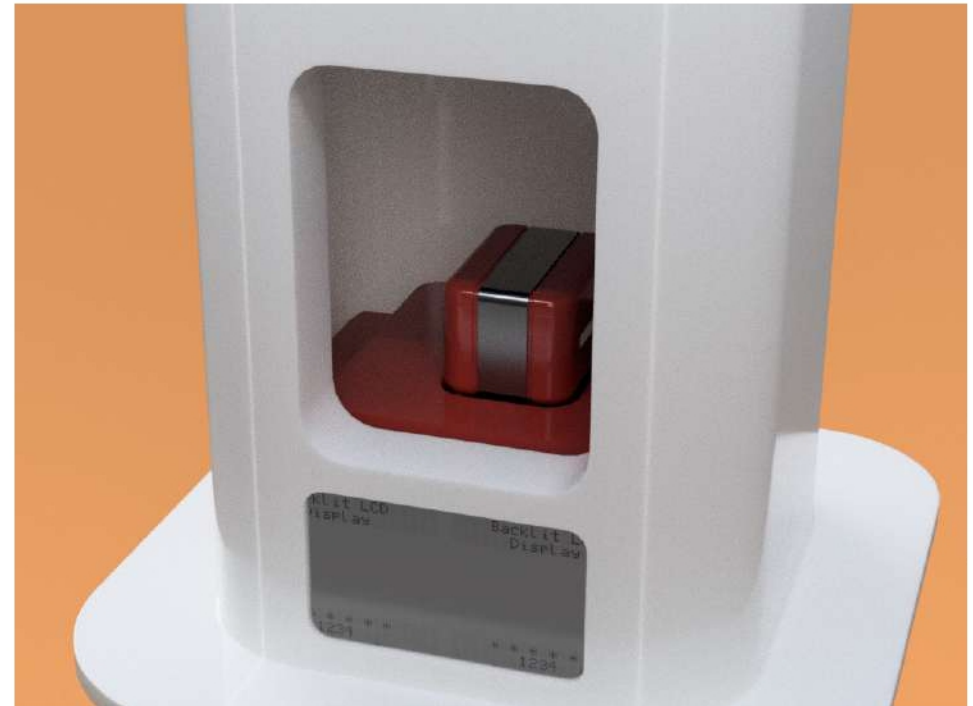


Image 94 : Pod access Image source : Author

Next was to improve the pod placement, as you can see the placement for this pod is quite awkward. the effort to put inside the pod through the

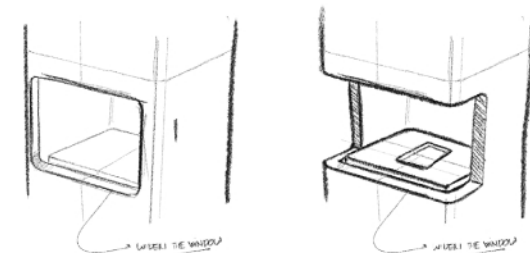


Image 95 : Widening the pod window. Image source : Author

I started ideating on how to improve the placement, like increasing the size of the door

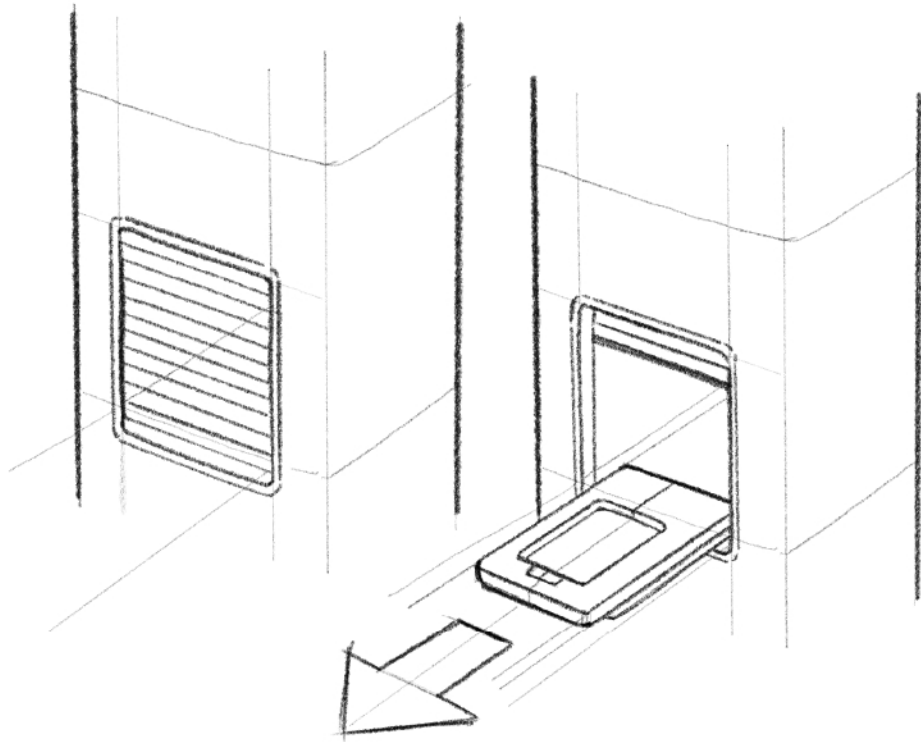


Image 96 : Pod platform protruding out. Image source : Author

I settled on creating a mechanism in which the pod protrudes towards the user for placing the pod.

Next issue was the usability and controls , by control I am referring to the placement for card scanners and user interaction elements like screens and buttons.

Since now the pod protrudes forward the controls needed to be in a specific position. And the placement should be ergonomic.

### Controls and equipment's needed

- Scanner for Employee card
- Interaction button for screen
- User instruction board

And a place to keep the pod while doing the activity of scanning the card.

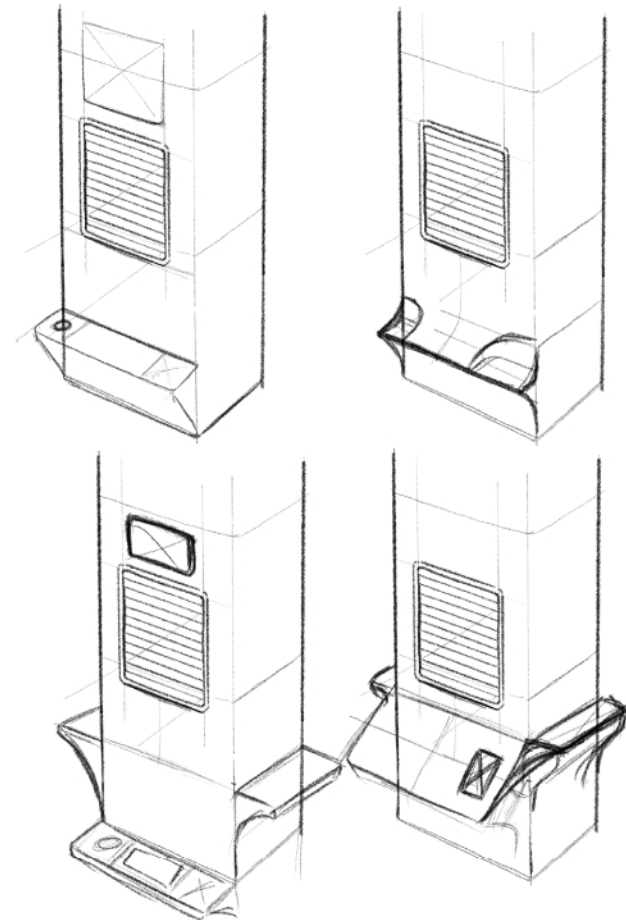


Image 97 : Interaction ideations. Image source : Author

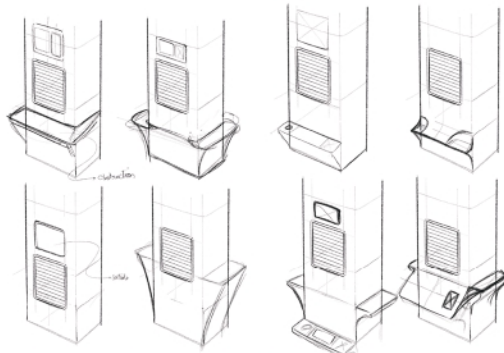


Image 98 : Interaction ideations. Image source : Author

For that I created a series of different paper mockups for role playing which were drafted basis on the ergonomics and I tested out different position and placements like

1. where controls are at the top and pod window below it.
2. where the controls are on the side and pod window between it.

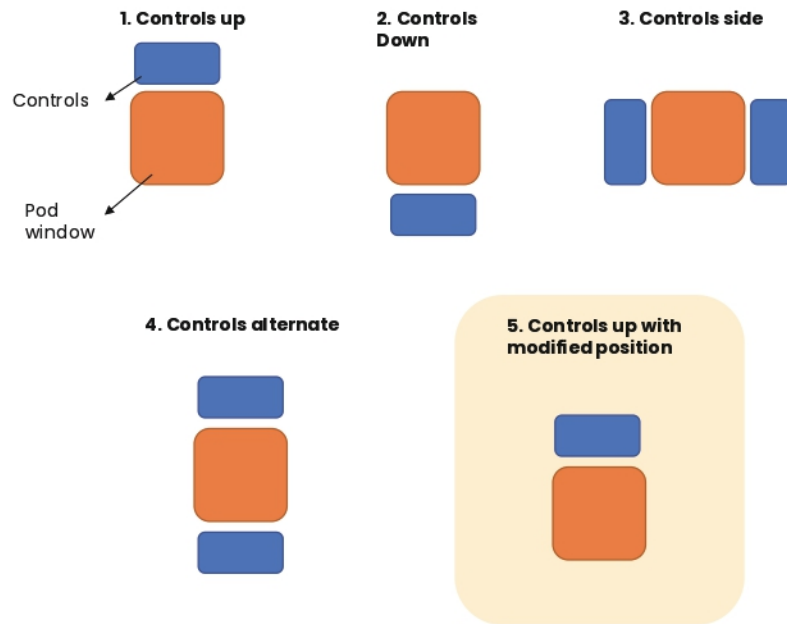


Image 99 : Interaction ideations. Image source : Author

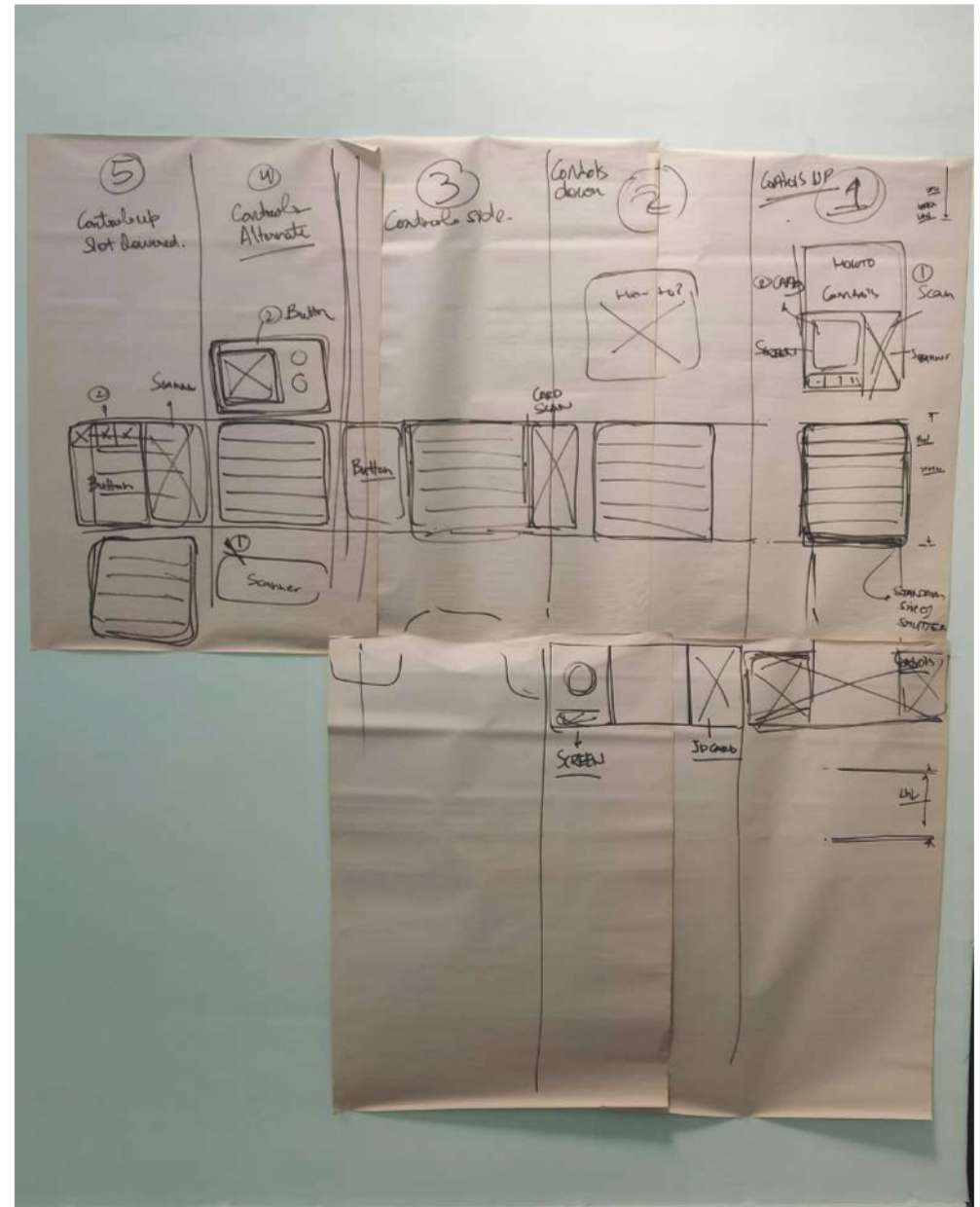


Image 100 : Interaction user testing Image source : Author

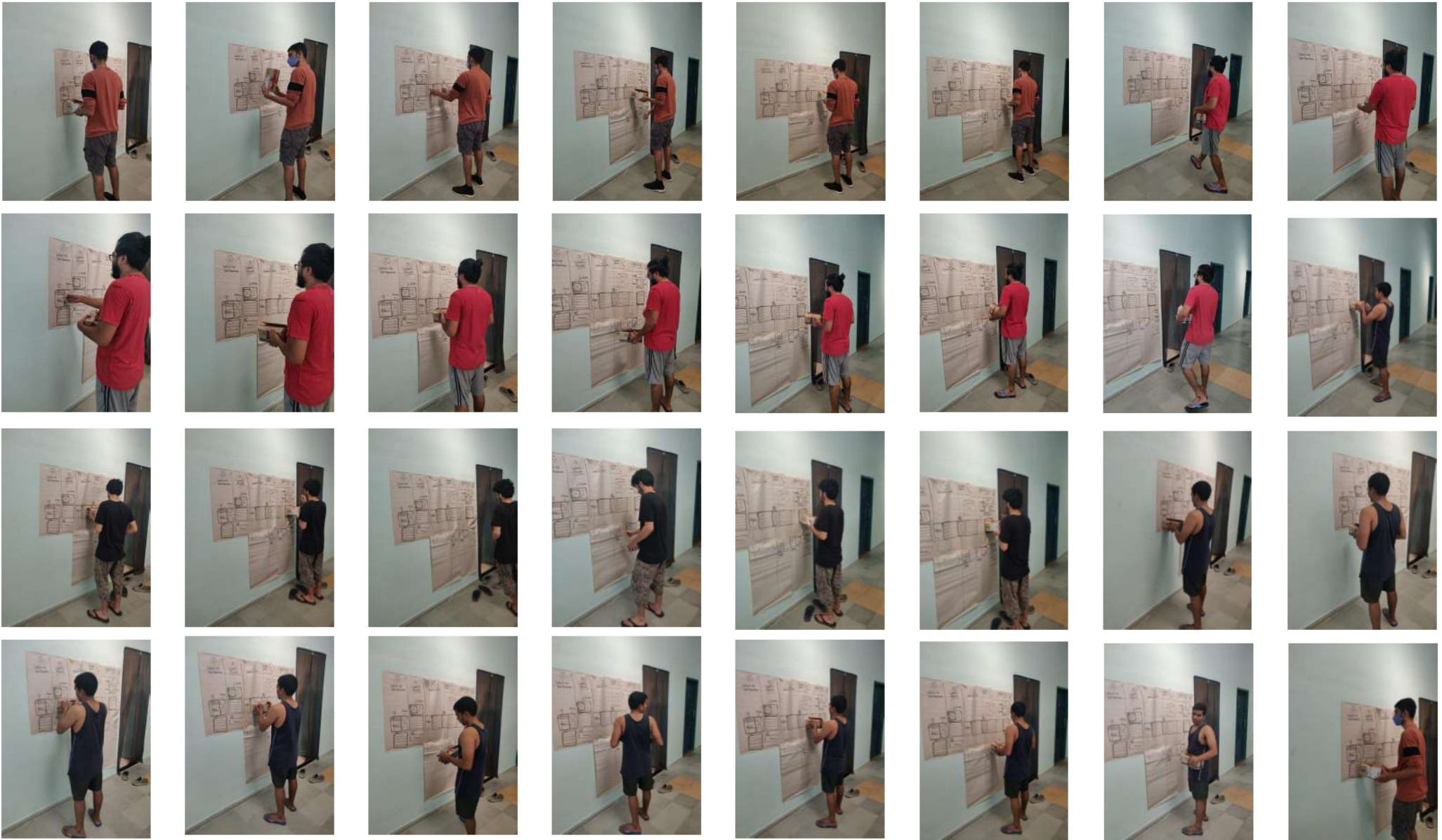
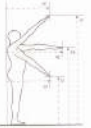


Image 101 : Interaction user testing Image source : Author

With the help of my fellow classmates, I was able to test them out



7.10. Parameters Definition (brief)


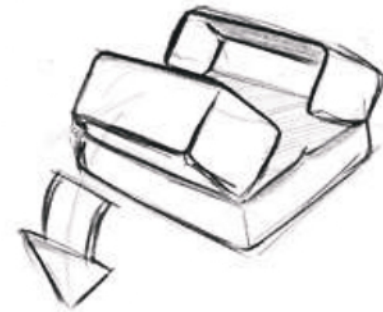
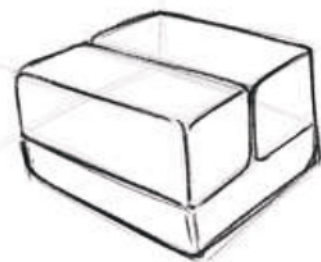
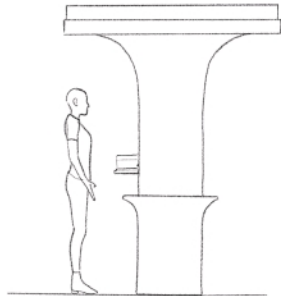
26. 50. Hand height (reaching): Forward controls are reached from back and heights from floor

27. Standing eye level (back): Forward controls and position given reach height from back

8.10. Parameters

	Min	5th Percentile	50th Percentile	95th Percentile	Max	Min	5th Percentile	50th Percentile	95th Percentile	Max
44. Upper arm length	Male	465	515	555	605	595	635	675	715	755
	Female	425	475	515	555	595	635	675	715	755
	Combined	425	475	515	555	595	635	675	715	755
47. Upper arm height	Male	1375	1485	1595	1705	1815	1925	2035	2145	2255
	Female	1255	1365	1475	1585	1695	1805	1915	2025	2135
	Combined	1255	1365	1475	1585	1695	1805	1915	2025	2135
48. Mid position length (forward arm reach)	Male	585	635	685	735	785	835	885	935	985
	Female	545	595	645	695	745	795	845	895	945
	Combined	545	595	645	695	745	795	845	895	945
49. Mid position height	Male	1335	1445	1555	1665	1775	1885	1995	2105	2215
	Female	1215	1325	1435	1545	1655	1765	1875	1985	2095
	Combined	1215	1325	1435	1545	1655	1765	1875	1985	2095
54. Lower position length	Male	385	435	485	535	585	635	685	735	785
	Female	345	395	445	495	545	595	645	695	745
	Combined	345	395	445	495	545	595	645	695	745
55. Lower position height	Male	1115	1225	1335	1445	1555	1665	1775	1885	1995
	Female	995	1105	1215	1325	1435	1545	1655	1765	1875
	Combined	995	1105	1215	1325	1435	1545	1655	1765	1875
57. Forward and position given reach length	Male	515	565	615	665	715	765	815	865	915
	Female	475	525	575	625	675	725	775	825	875
	Combined	475	525	575	625	675	725	775	825	875

**5. Controls up with modified position**

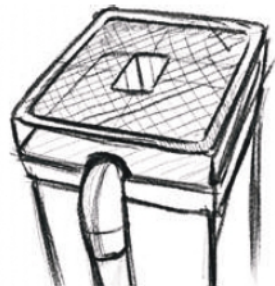
Mechanical cover

Image 102 : Rain Shelter Image source : Author

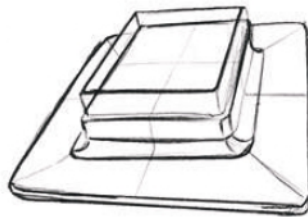
The preferred controls were chosen to where the controls are on the top and pod window below it. The length/ height of the window is to be kept according to the Dev Kumar's ergonomic book.

I started ideating for the same issue that is like creating a gutter around the pad or creating a canopy around the pod or creating a mechanical cover . Or creating a mesh pad and giving an angle to the bottom panel for water drainage.

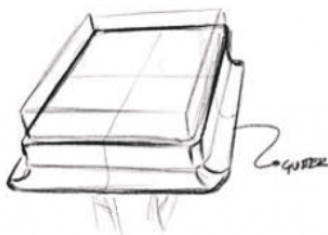
**Water drainage**



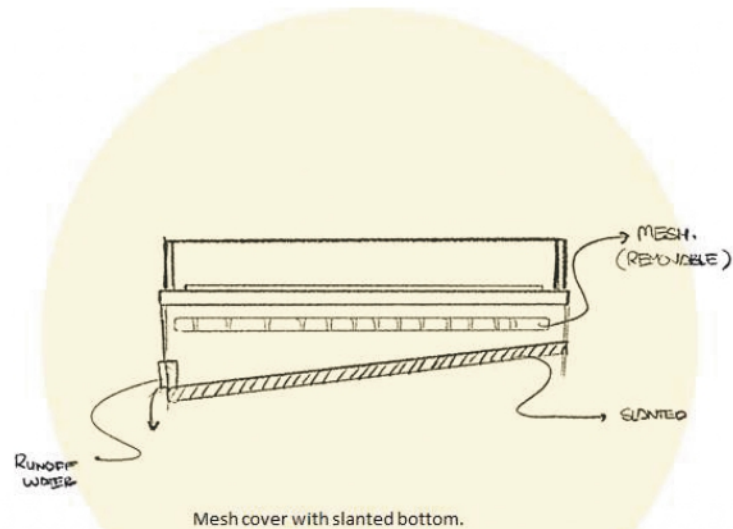
Water pipes



Canopy



Gutter



Mesh cover with slanted bottom.

Image 103 : Rain Shelter Image source : Author

## Cultural aspect

But since the roofs where these stations will be placed are not only the hospitals or blood banks roof but are also shared with the residents of that building. Goal here was trying to not make the stations a hindrance for those residents. (Image 104)



Image 104 : Roof Interaction Image source : Author

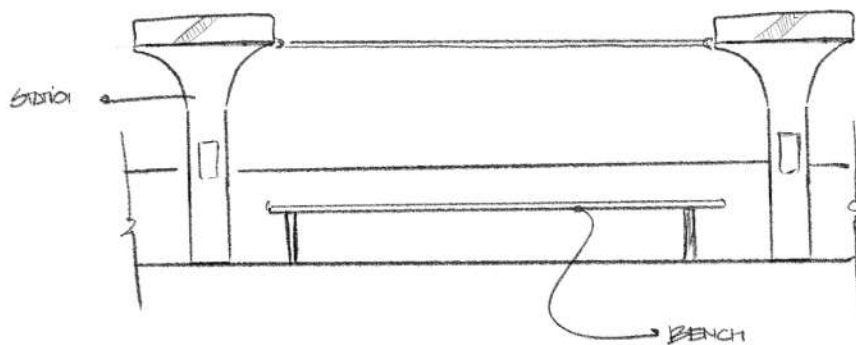


Image 105 : Roof Interaction Image source : Author

I started ideating on how these stations can create a space for gathering

## Mechanism

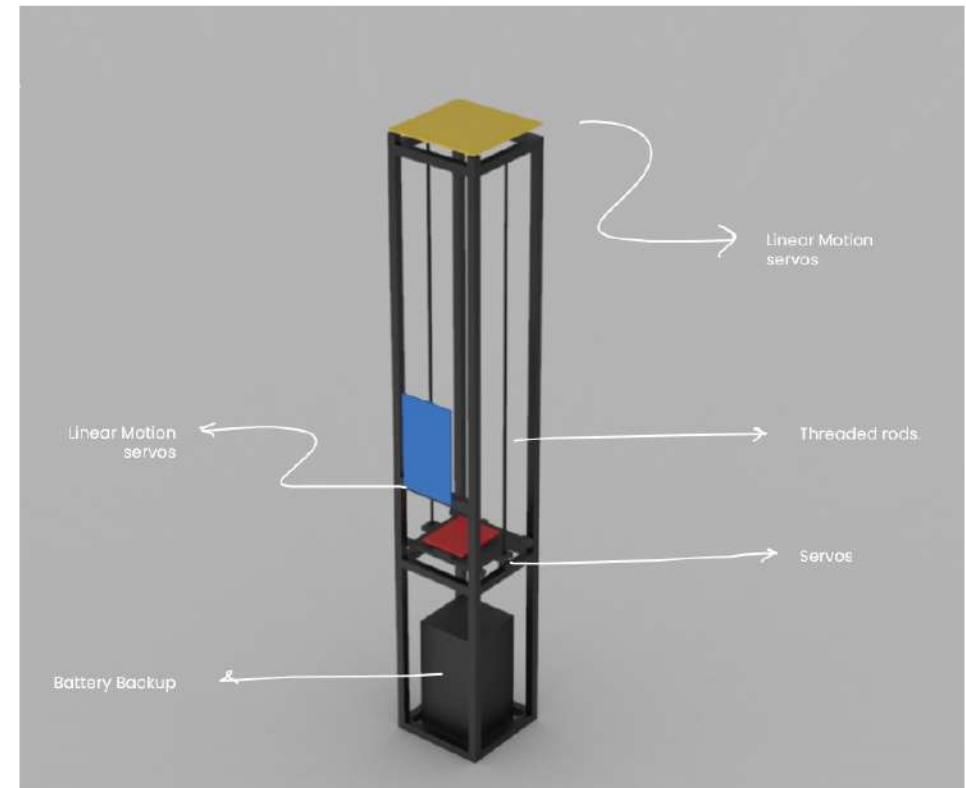


Image 106 : Mechanism Image source : Author

So I started to create an underlying structure first the entire assembly will be powered with the batteries and power from the grid, the motion of the component will be done with the help of servos and threaded rods and stepper motors.



## Form

For studying form I am started looking at a lot of futurists like Syd Meads



And I started ideating to find a form I did a lot of sketching



Image 107 : Form generation Image source : Author

With the help of Thermocol models I sketched some forms incorporating the number of components and elements needed. (Image 108)



Image 108 : Form generation Image source : Author

Since the device in question is not just a form or just a medical equipment but it is kind of both.

And the understanding that the tech is new and still not accepted. The form must be friendly, inviting and non-aggressive in nature,

The form must be :

- Friendly
- Inviting
- Non aggressive



Image 109 : Form generation Image source : Author

And at this point I have been working on the form using CAD software.

The reason behind this bright color is first that it makes it stand out from the rest of the space. Second that, with the help of bright colors the drone pilot will be easily able to identify the station while in the air.



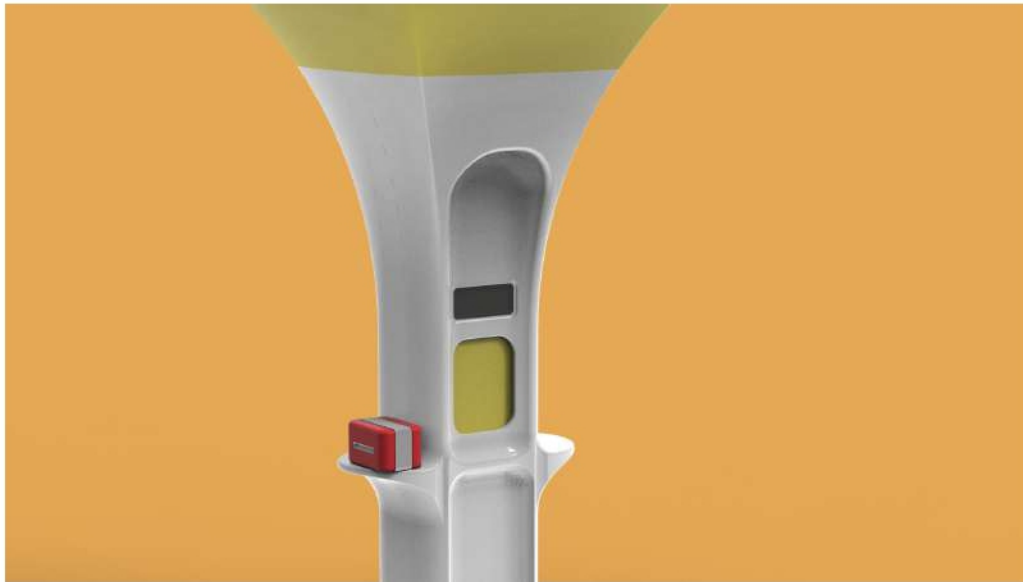
Image 110 : Preliminary Form Image source : Author



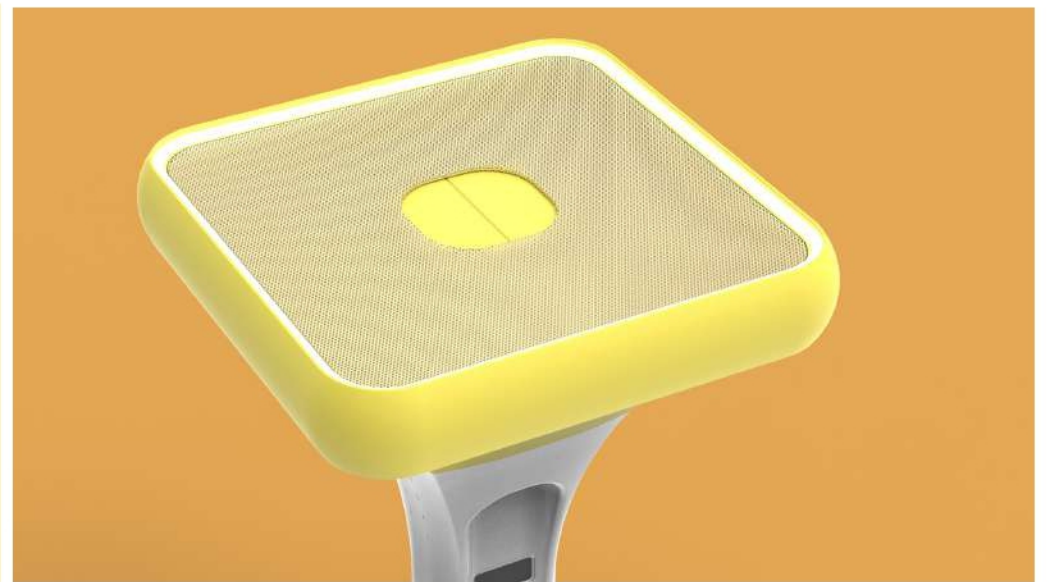
Ambient lighting for the user and the residents around it.



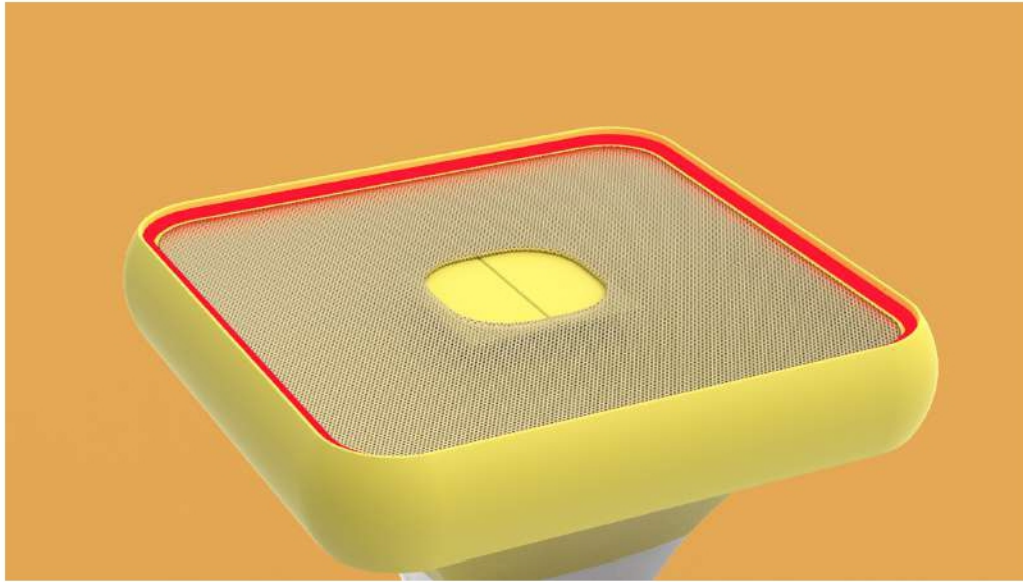
Platform protruding outwards when the pod needs to be placed on the platform.



A place for the pod on the left and the right side of the station



On the pad itAuthor, The base of the pad will be mesh pad which will allow the water to not sit on the pad itAuthor. And the led's around the rim of the pad.



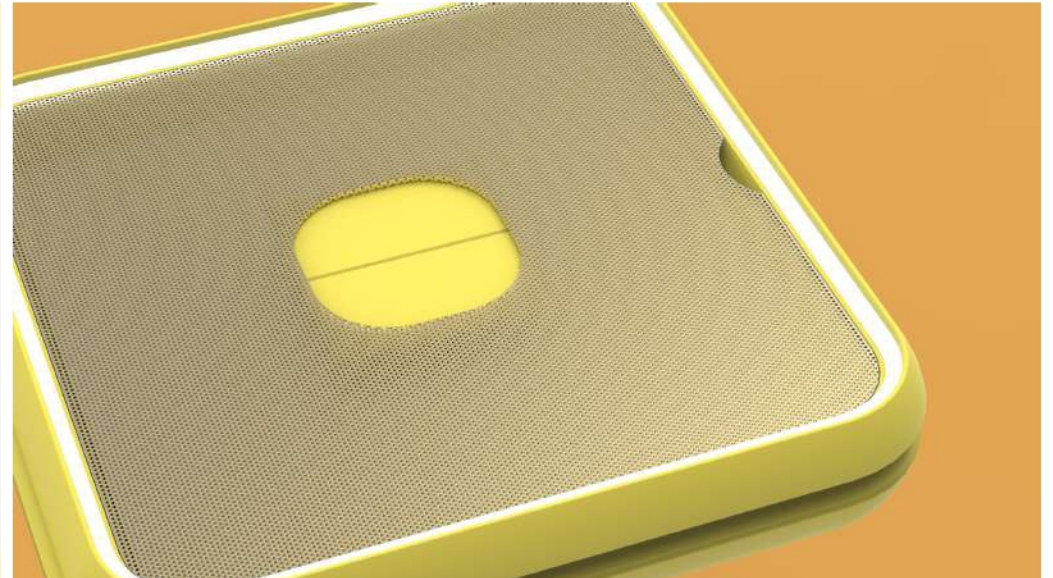
Will change color whenever the drone had to land on the pad. Allowing the users and other people to be cautious.



And ended up with creating a detail, where the pole can be slid into the groove .



The station can be used to create spaces for the people to sit under or as a gathering space.



I also realized that the maintenance aspect of the pad. A groove was required for the maintenance staff to lift up the mesh pad.

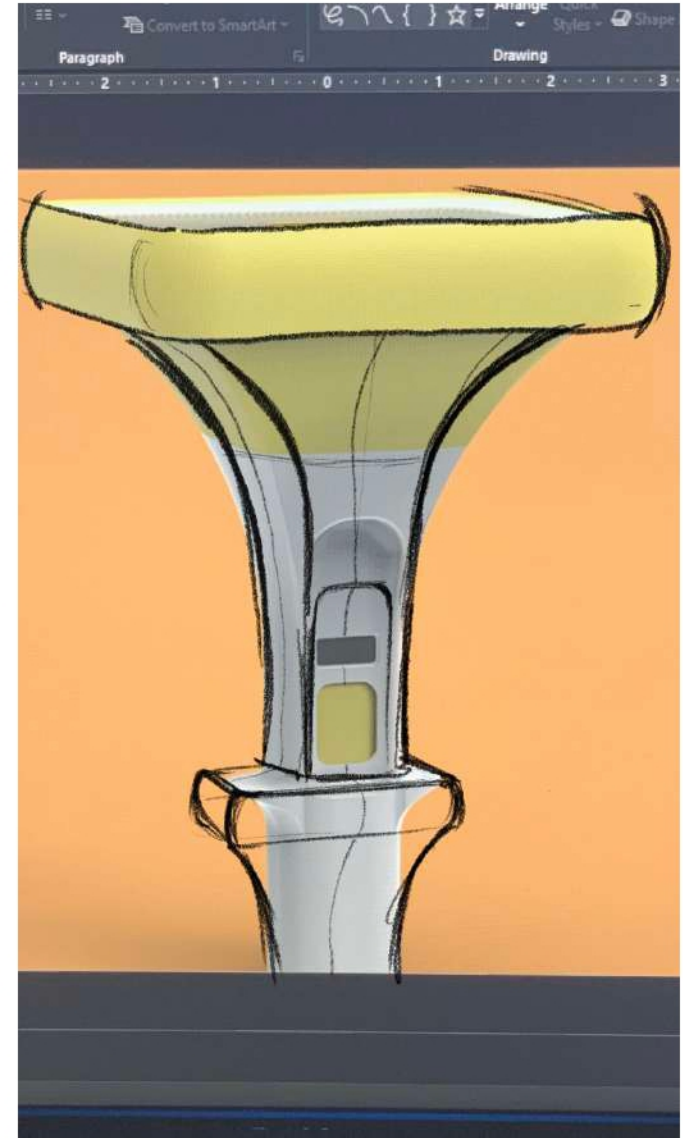
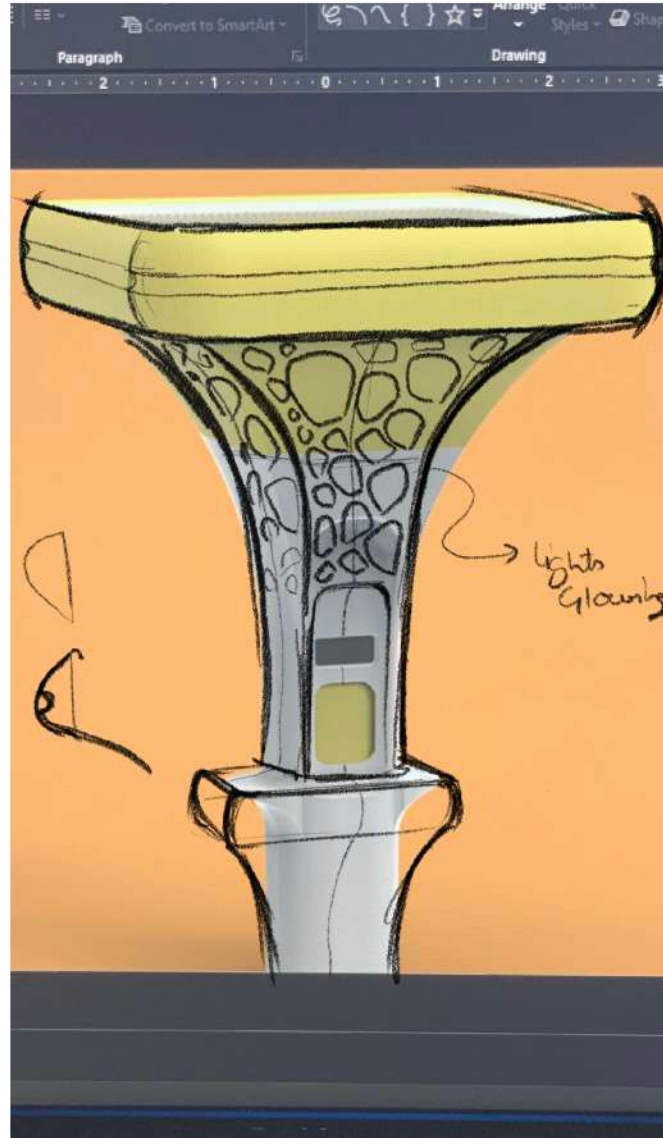
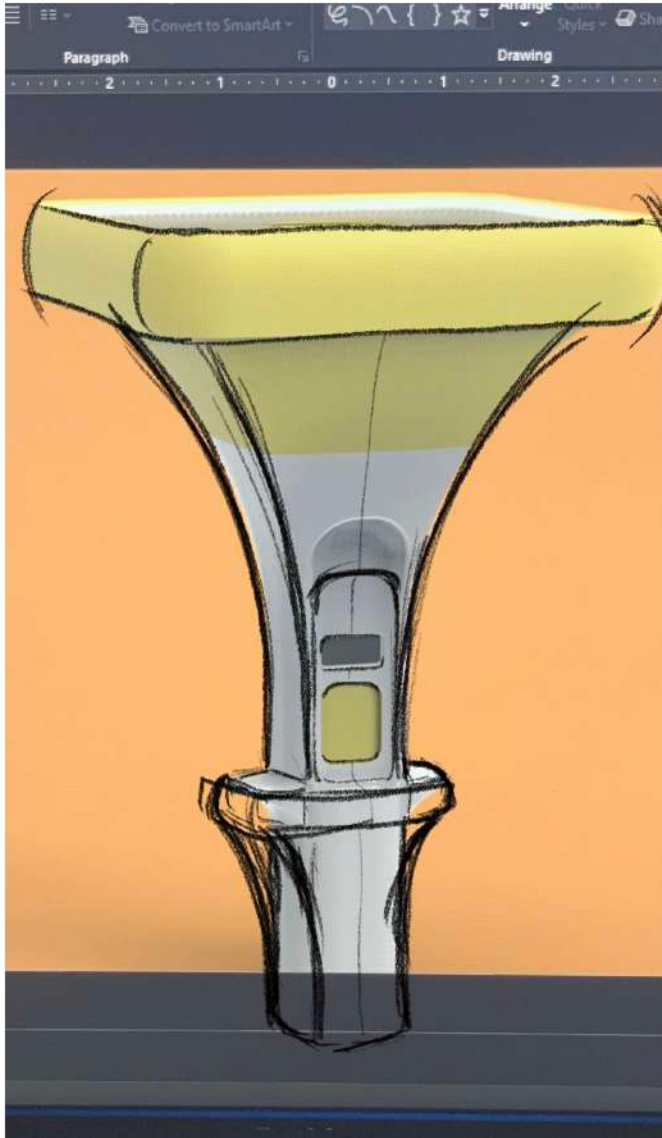


Image 111 : Improvements in the form Image source : Author

Next I was in the process of improving the form, I was very much interested in creating a vornoi texture surface of the front panels to give it a lighter form both visually and in the sense of structure.

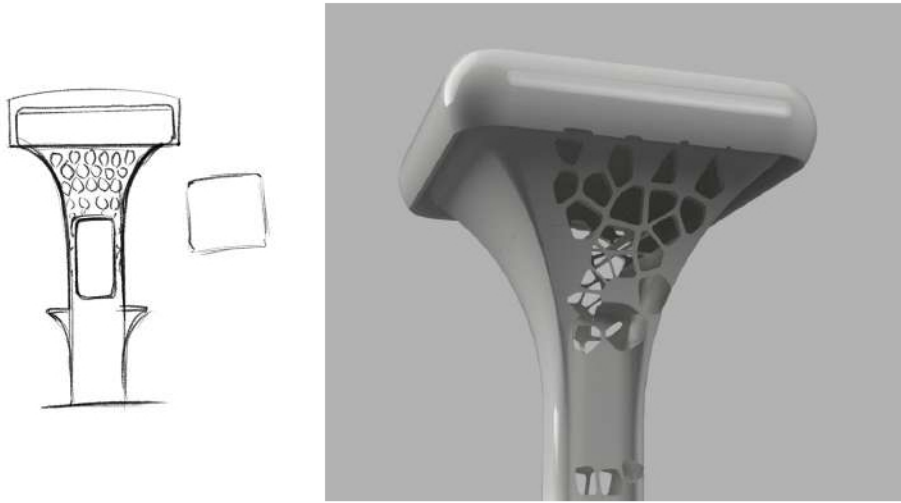


Image 112: Voronoi texture in place. Image source : Author

As I started experimenting with the form, after applying the voronoi texture (Image 112) the resultant form was neither friendly nor futuristic. So I started exploring again.

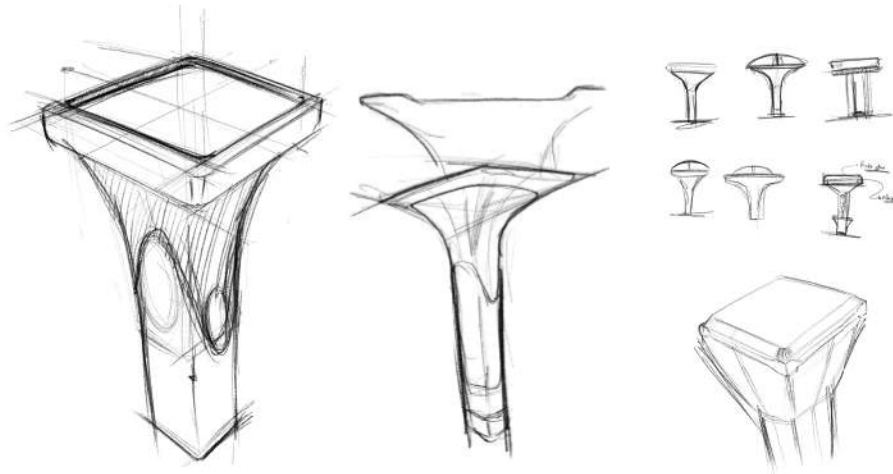


Image 113: Improving the form Image source : Author

Initially I started ideating to improve the existing rectangular form with addition of curved elements to make it appear more friendly. (Image 113)

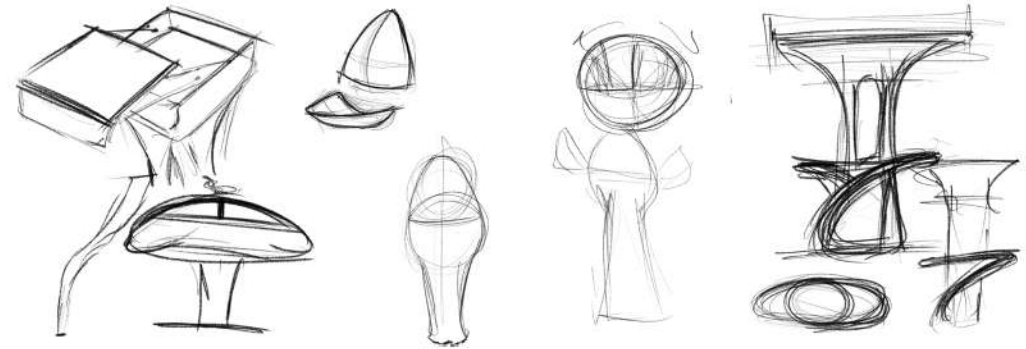


Image 114: Nature inspired forms. Image source : Author

I tried to move away from the existing forms to explore more natural forms inspired by the flowers (Image 114), Also in the process I initially thought of adding an openable cover for the pad but later discarded it as it would increase the parts.

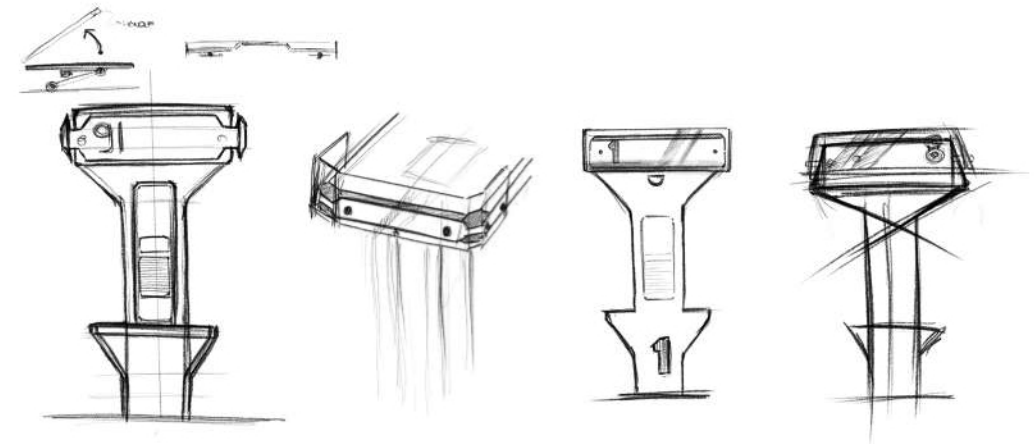


Image 115: Exploring aggressive forms Image source : Author

Next I started exploring more futuristic aggressive forms inspired by outdoor equipments that are robust and utilitarian. (Image 115) but later discarded the aggressive form all together.



Image 116: Neo-Futurism mood board Image source : Google images

I tried to create a mood board with neo-futuristic elements in mind, based on the mood board I began to create the final form.

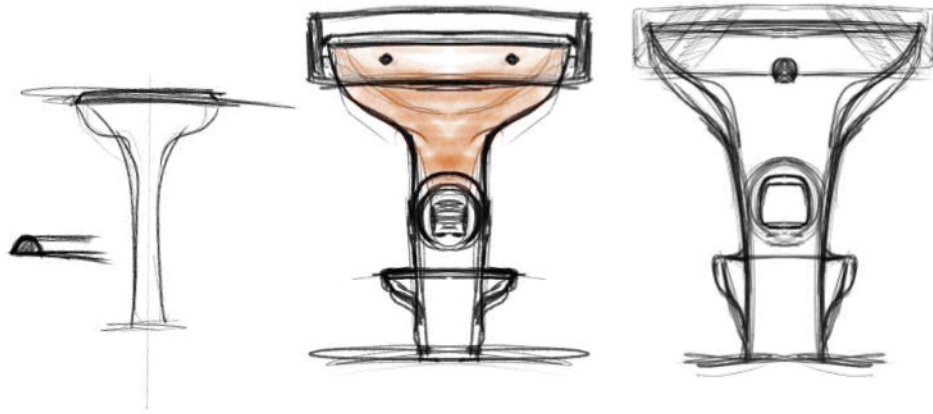


Image 117: Circular form Image source : Author

Then I started creating the overall form inspired by pillars and circular forms. (Image 117).

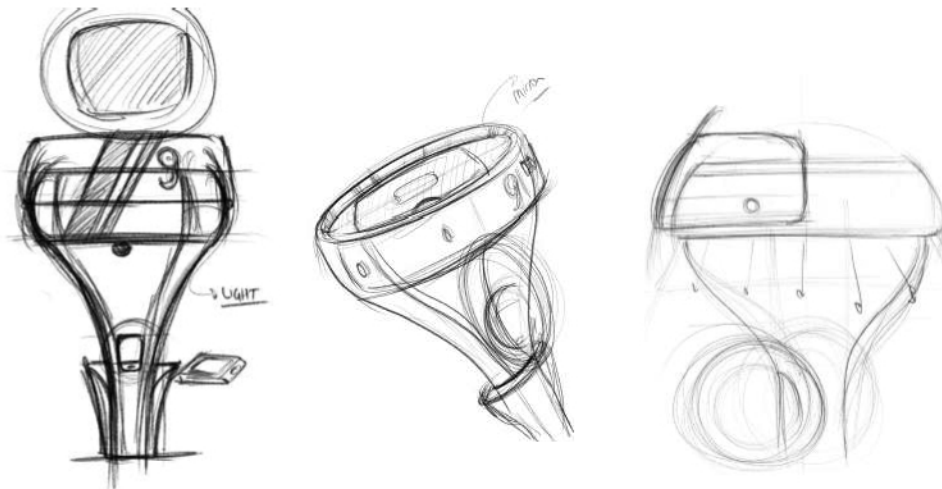


Image 118: Improved explorations Image source : Author

I wanted to create a Futuristic yet freindly form, that would look utilitarian also. Upon further explorations, I was able to achieve the desired effect. (Image 118)

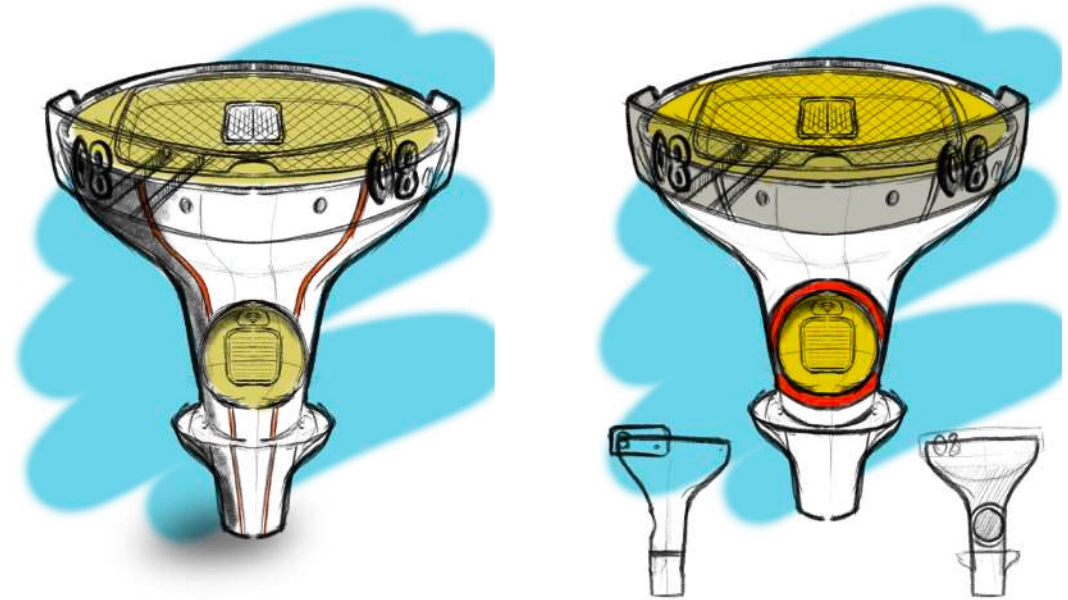


Image 119 : Final ideation Image source : Author

The final form was inspired by the neo-futuristic elements and utilitarian aspect of the existing medical equipments.

The final two iterations (Image 119) had a focused user interaction elements shown with the help of the yellow concave surface, with lighting elements highlighting the same elements.


The user interation screen was removed to streamline the user interaction to only scanning the Identification card and pressing the button to complete the task in hand.

Upon further improving the final iterations, the following form was chosen to be the final outcome.



Final form



A futuristic white robot with a rounded head and black joints stands next to a white cylindrical pod. The pod has a yellow window with horizontal lines and a small blue light above it. The background is a solid light blue color.

The user must scan the card using the RFID sensor placed above the Yellow pod window to unlock the door,

For security reasons, a video surveillance camera above the eye line of the user like in ATM banks.

After the scanning is completed the light placed above the pod window starts to illuminate, notifying the user that the station is unlocked.



The glass at the top of the station describes the station number and also describes the orientation of the pod for the drone pilot while landing.

The frosted glass also adds a sense of futurism to the entire form creating a coherent example of utilitarian and futurism.

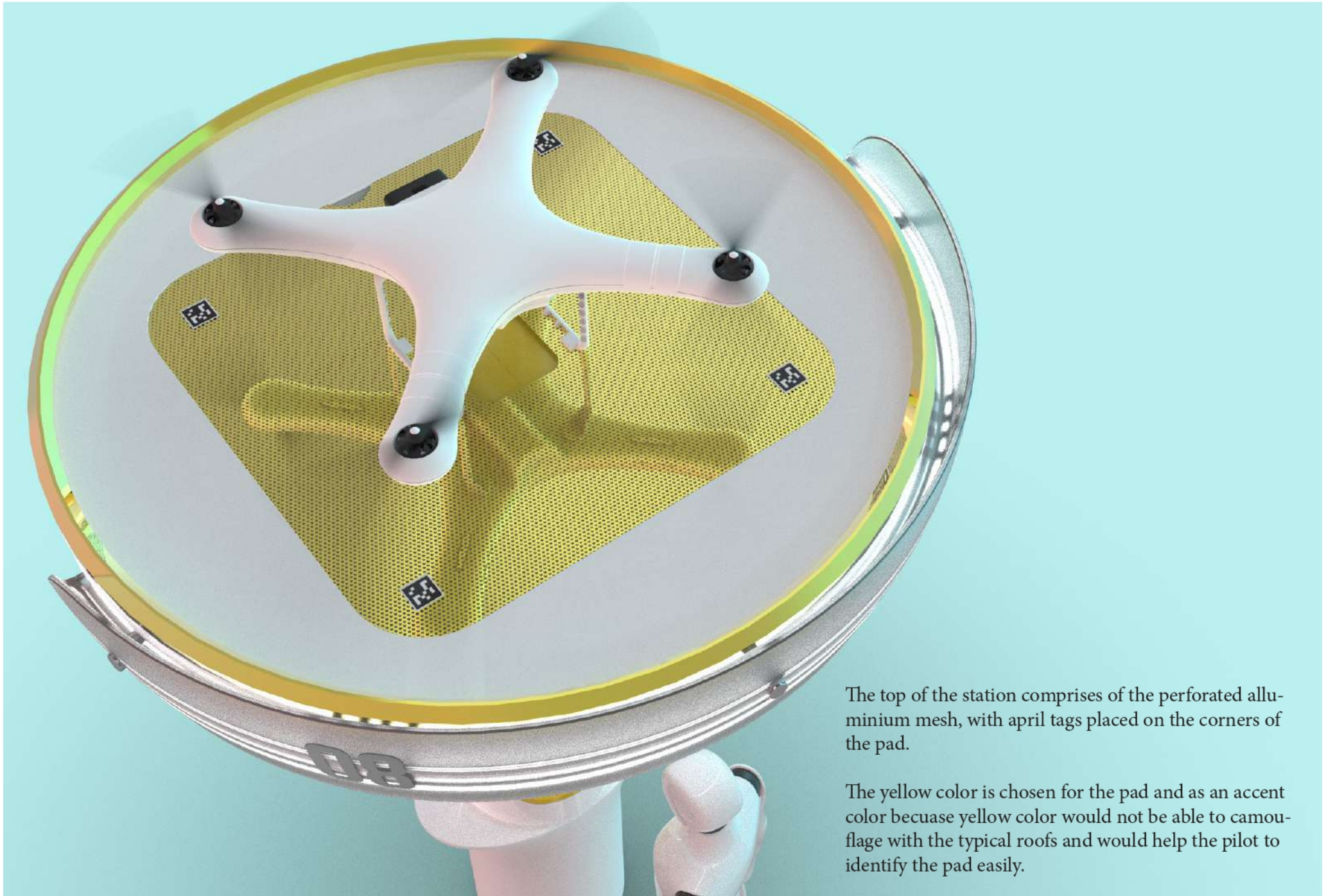


Unlike previous Iterations, the user interaction screen has been entirely removed, instead a Card reader and a touch button has been placed.

card reader at the front panel and the touch button at the pod platform where the pod will be placed.

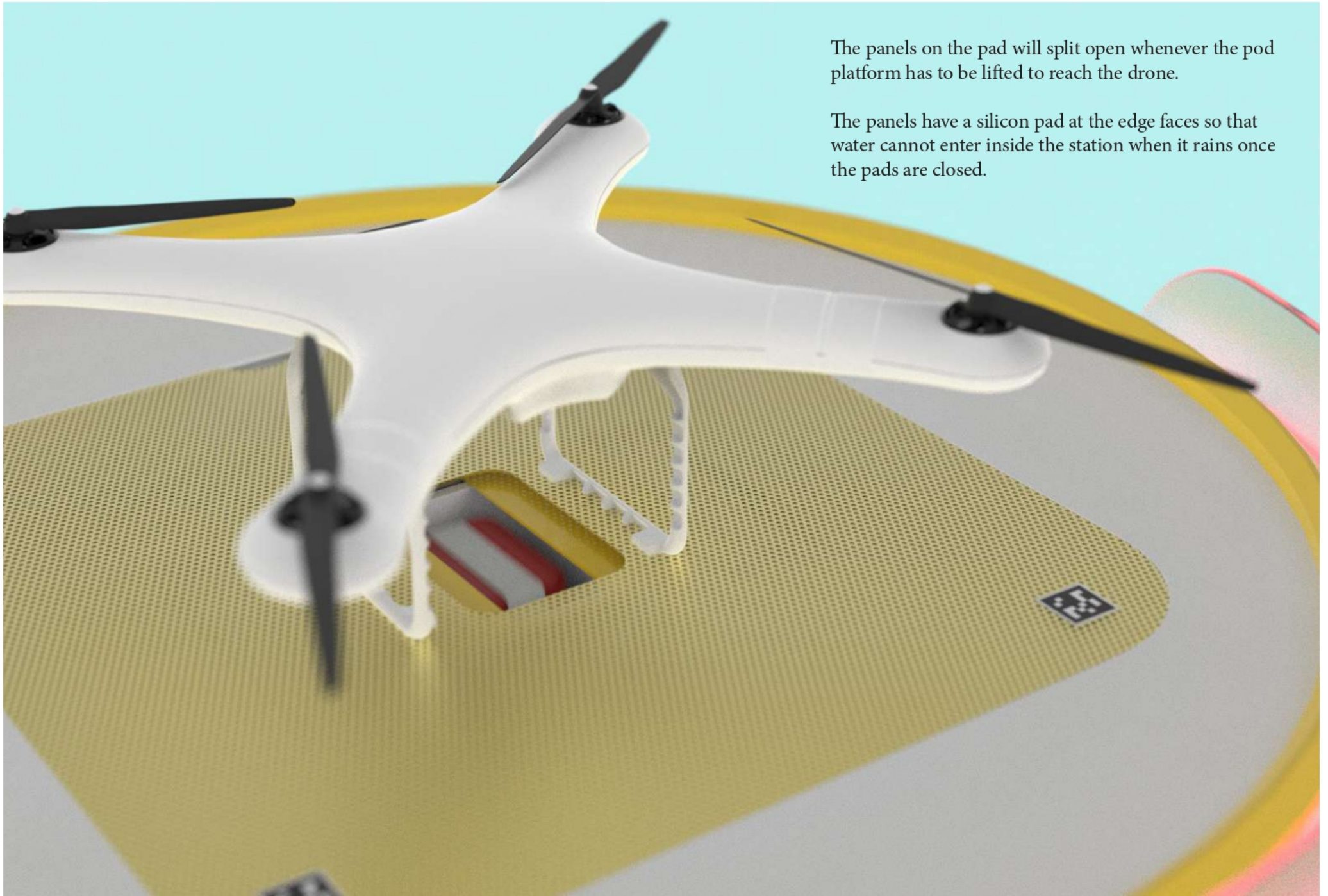
Once the stations has been unlocked using the card, the light illuminates and the shutter door of the station starts to open above and a platform to place the pod or to collect the pod protrudes towards the user.

After placing or removing the pod, station can again be locked by simply pressing the capacitive touch button placed in the front side of the platform.



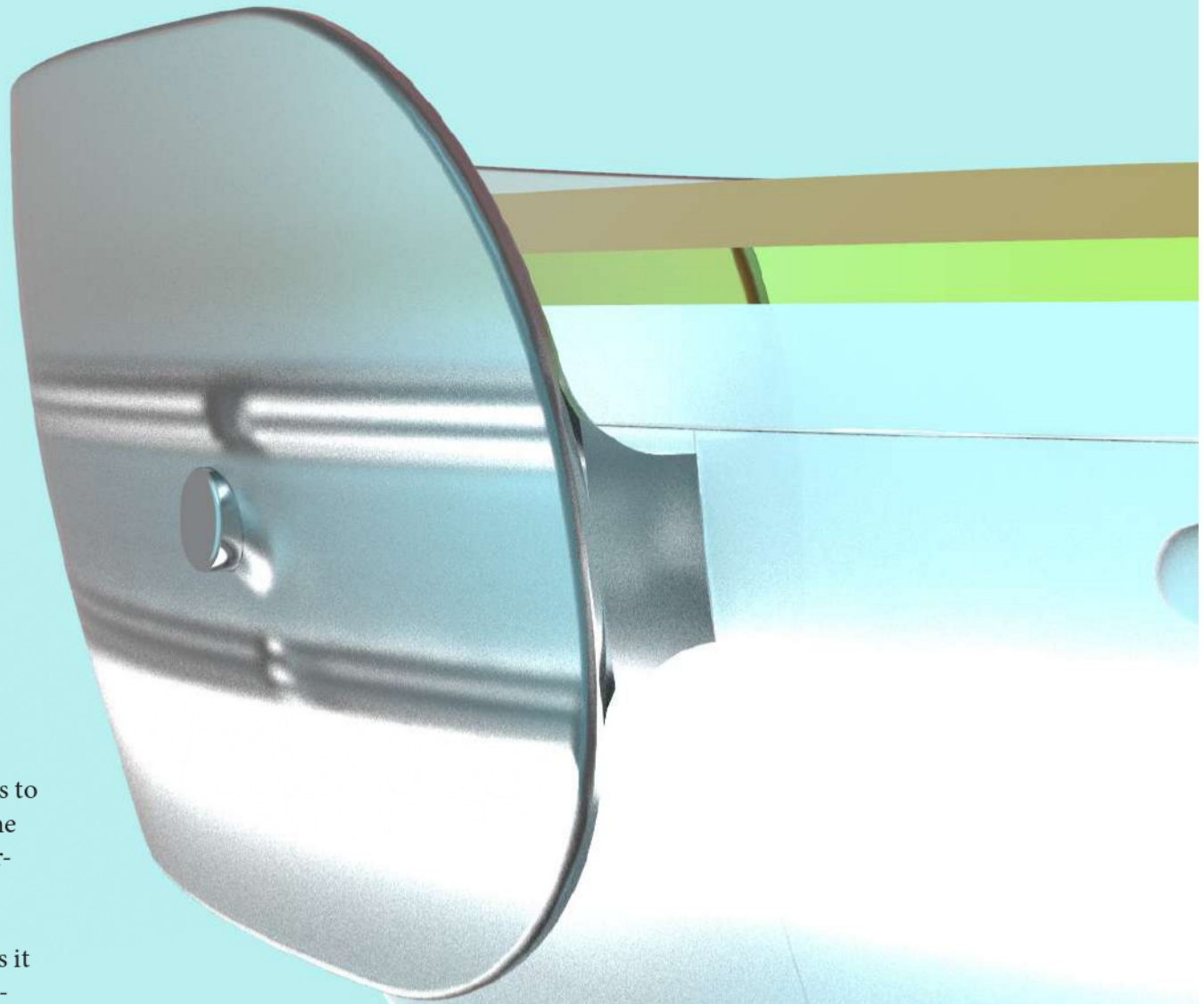
The top of the station comprises of the perforated aluminium mesh, with april tags placed on the corners of the pad.

The yellow color is chosen for the pad and as an accent color because yellow color would not be able to camouflage with the typical roofs and would help the pilot to identify the pad easily.



The panels on the pad will split open whenever the pod platform has to be lifted to reach the drone.

The panels have a silicon pad at the edge faces so that water cannot enter inside the station when it rains once the pads are closed.



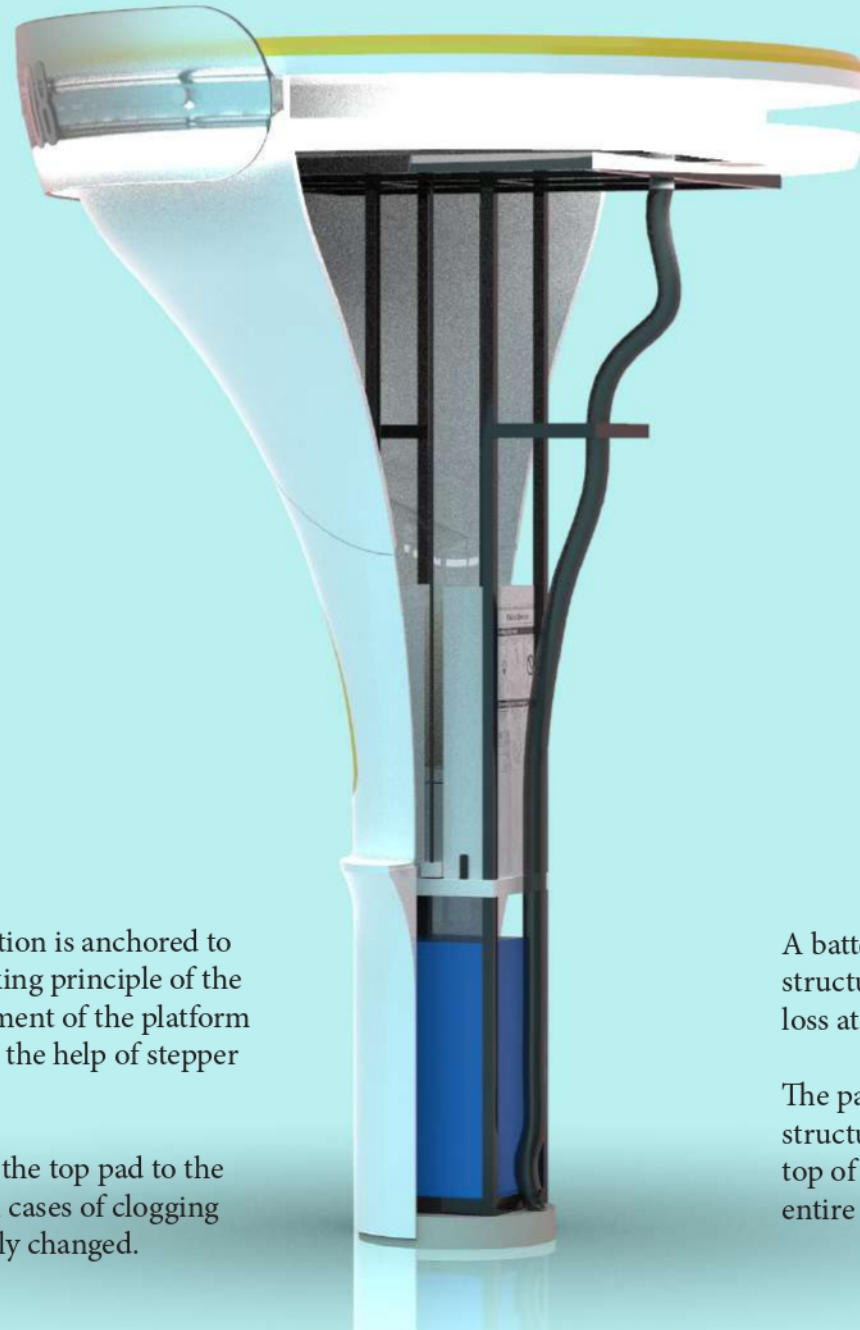
The metallic ring visible is placed for accent as well as to be used as a bird deterrent, as mentioned earlier that the reflective surfaces are found to be the best bird deterrents.

The frosted glass component is placed in the front as it also avoids the rain water to flow towards the components that the user interacts with.

The lighting system would change colors whenever there's an ongoing delivery in process and would also allow the users and the people in the surrounding to get notified about the delivery and be aware of the surrounding in case the drone fails to land correctly.







The under structure of the entire station is anchored to the cement and is based on the working principle of the XYZ 3D-Printer in which the movement of the platform in X axis and Z axis is executed with the help of stepper motors and threaded rods.

The Plastic tube for water flow from the top pad to the bottom has been made removable in cases of clogging and repair work the tube can be easily changed.

A battery pack will also be placed at the bottom of the structure (Blue color) to be used in emergency power-loss at the time of delivery in place.

The panels of the body will be attached to the anchored structure with the help of screws. The light ring on the top of the station will be placed after assembling the entire structure.

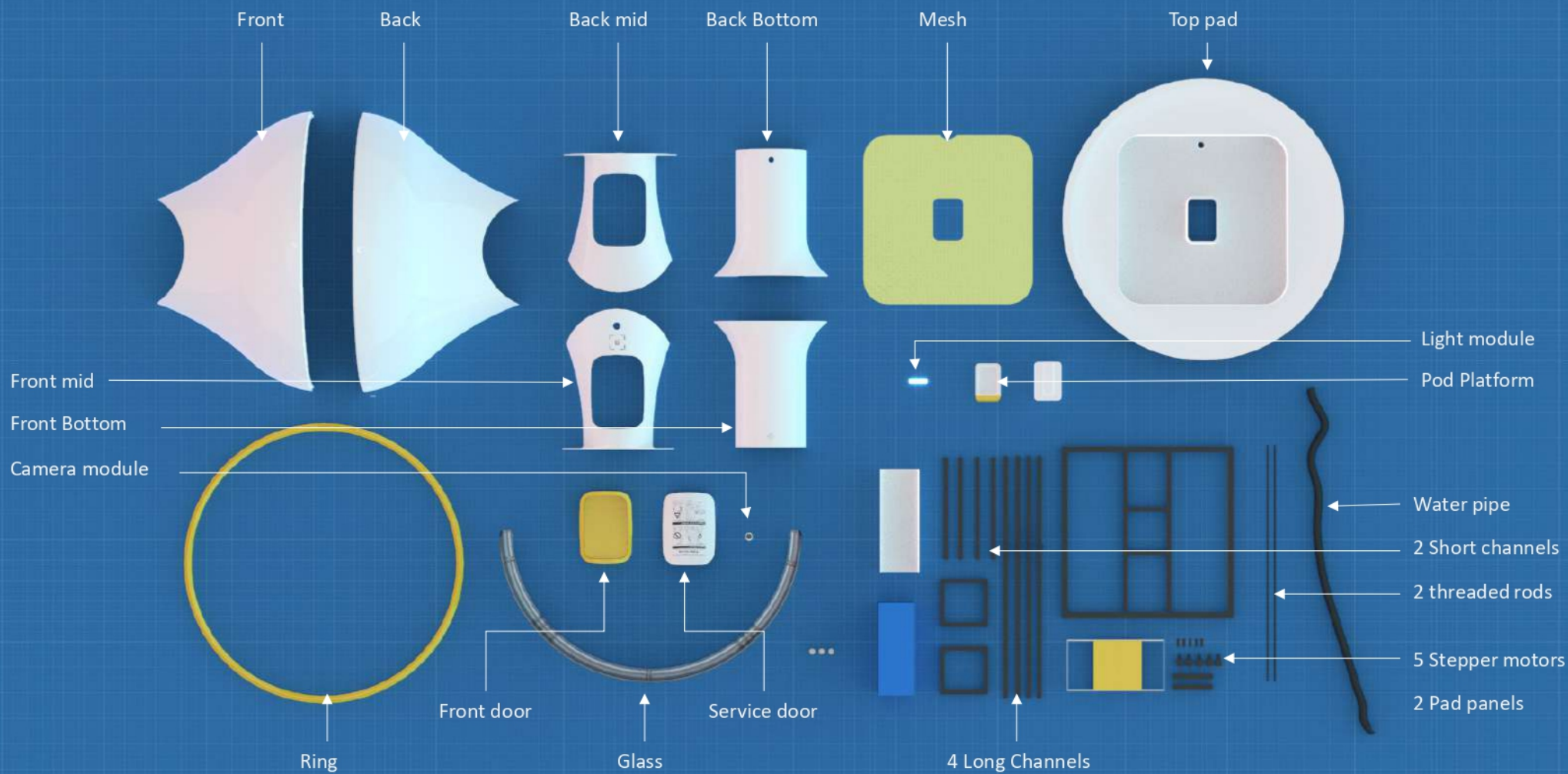


Image 120: Components Image source : Author

The panel have been designed in such a way that the mould required to build both front and back panel can be the same.

The entire body will be made of 7 panels,

- Three on the front,
- Three on the back,
- One on the top.

The components that will be used in the stations will be :

1. 7 Body Panels.
2. 1 reflective ring
3. 1 Glass panel
4. 1 Door frame
5. 1 Door
6. 1 Service Panel on the back
7. 1 Aluminium mesh on the pad.
8. 1 RFID sensor
9. 2 lights
10. 1 plastic pipe
11. 16 aluminium channels for mechanism
12. 1 battery
13. 1 steel frame
14. 6 stepper motors
15. 1 Pod platform
16. 2 Threaded rods

Which gives the total number of components to be 44 components.

The dimensions of the structure are 2.6 meters X 1.8 meters at the top and the base of the structure is 0.5 meters in diameter.

The base of the structure was made slimmer as it reduces the scrutinisation of the roof to the minimum.

Materials :

As the number of panels were reduced to bring down the overall cost, The size of the panels are still large. Initially, The use of ABS was considered and using injection moulding the panels can be constructed.

But, the size of the panels still being large the final decision was considered to be FRP ( Fibre-reinforced Plastic ) as FRP is ideally used for outdoor applications.



Image 121 : FRP application process Image source : google images

The channels for the mechanism will be aluminium channels.

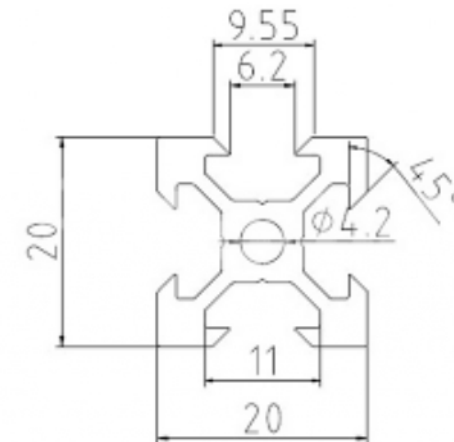
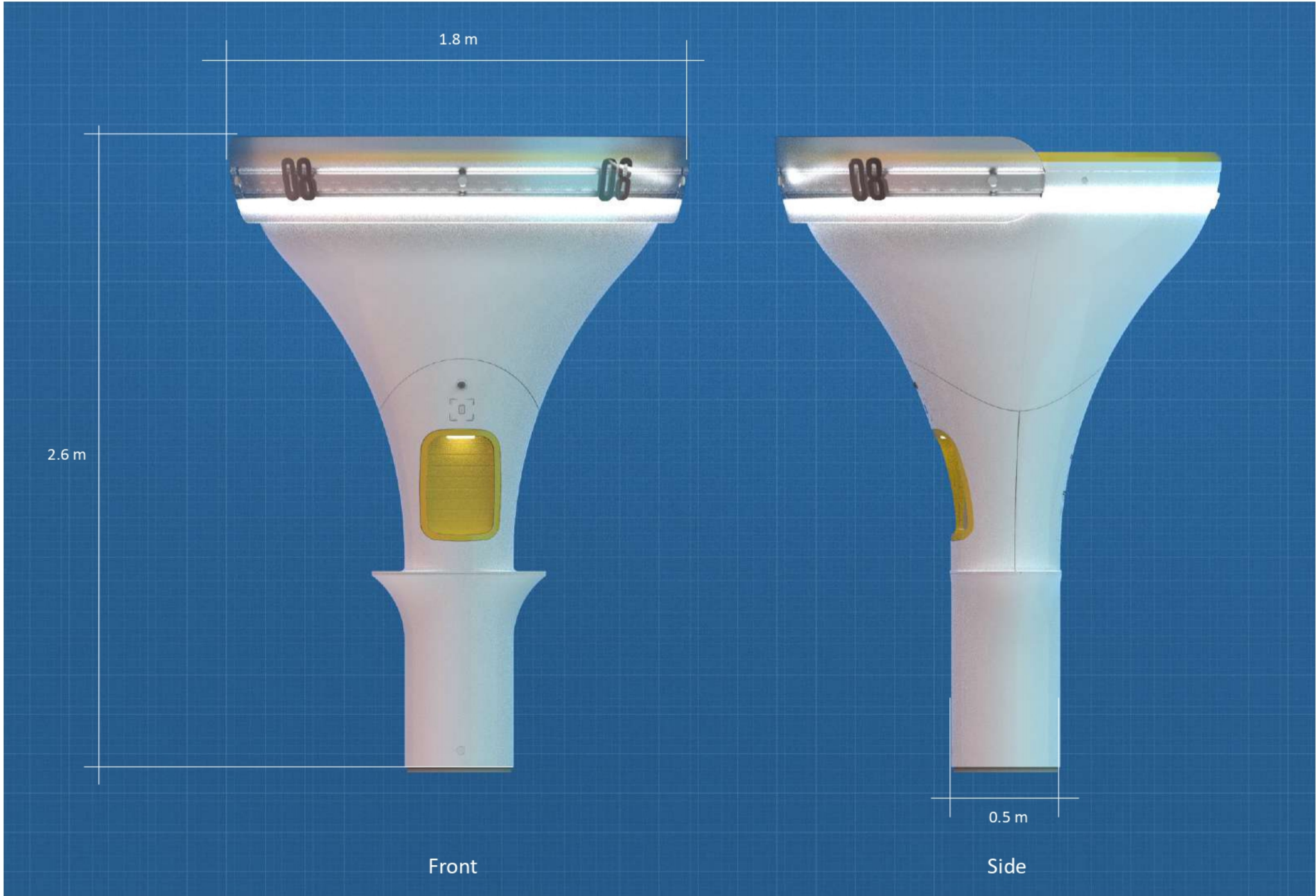
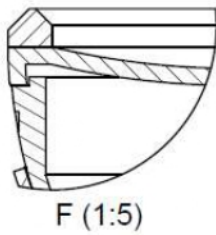


Image 122 : Aluminium channel Image source : indiamart.com

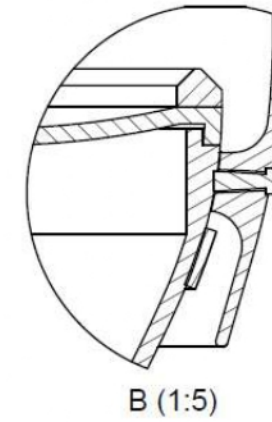
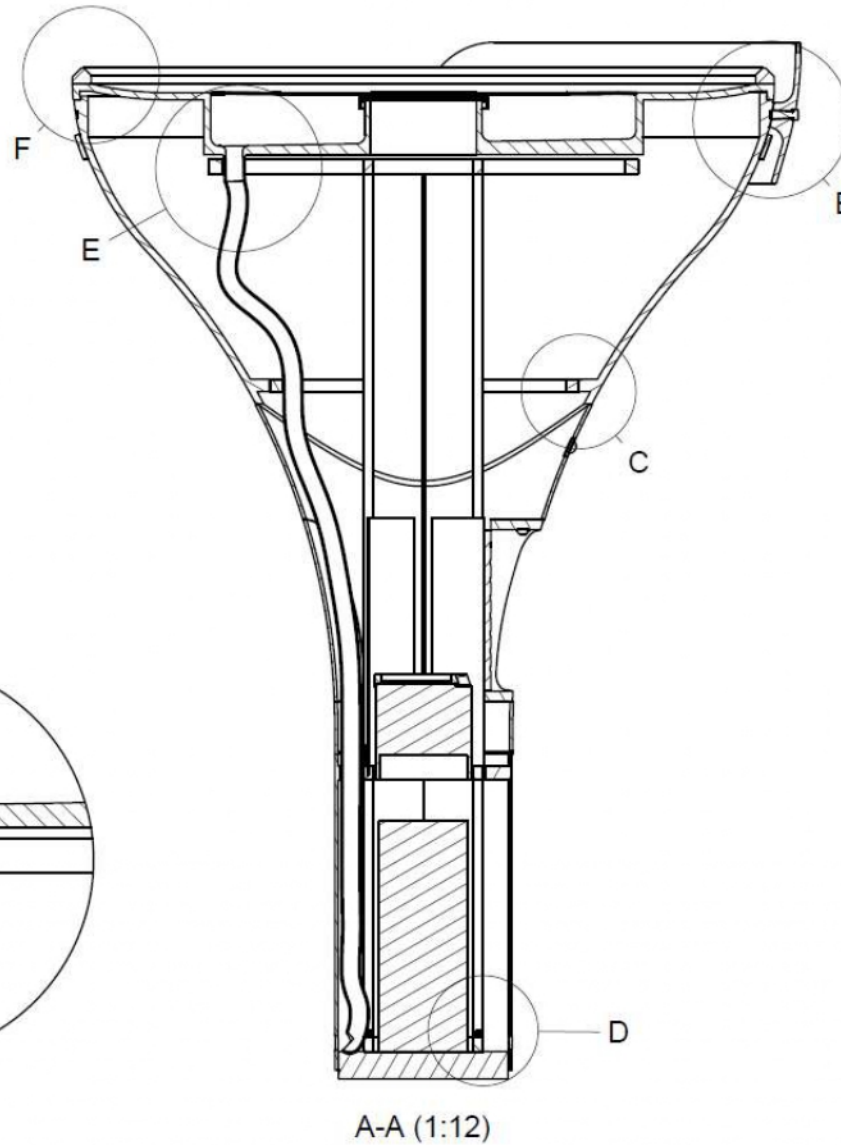
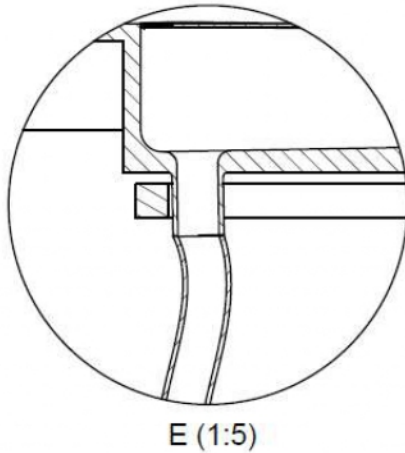


## Details

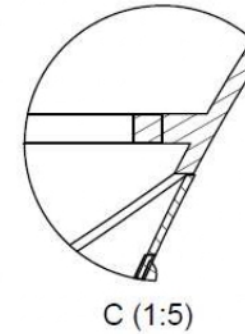
The top pad creates a lip  
For the bottom panel to  
get attached.



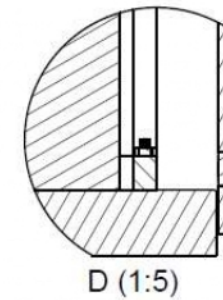
The water outlet is  
Attached with the top  
Pad and is changeable.



The glass on the front is  
Connected using metal  
Bolts.

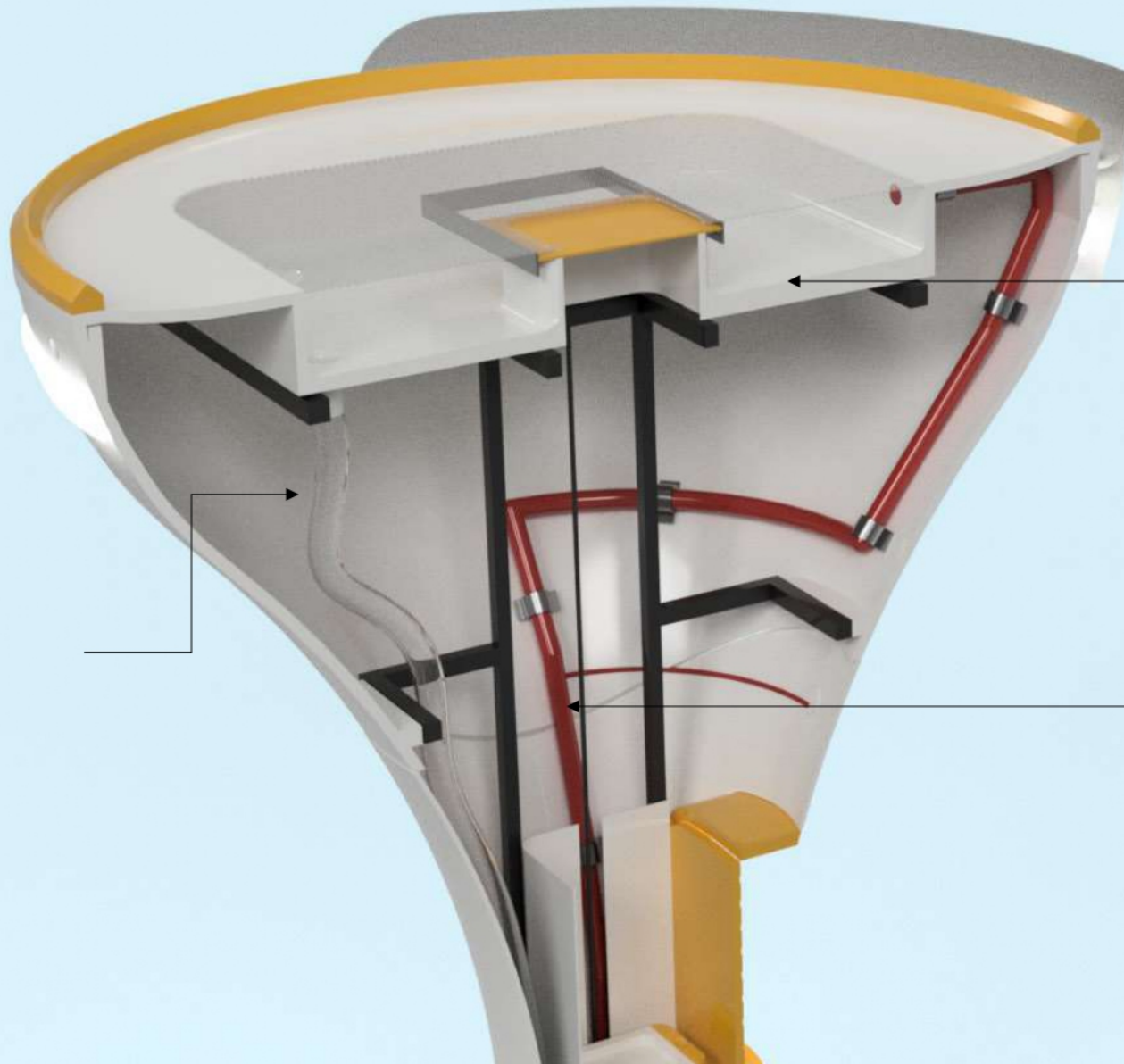


The rest of the front panel  
Is fixed using screws from  
the inside.



The entire frame is fixed  
Using anchor bolts that  
are fixed into the cement.

Image 123 : Sectional Details Image source : Author



The water outlet is Attached with the top Pad and is changeable.

The cavity below the pad is angled at a 3 degrees to channel all the water that may enter after rain.

The red cables are wire paths Required for all the electrical connections and will be attached with the help of brackets.

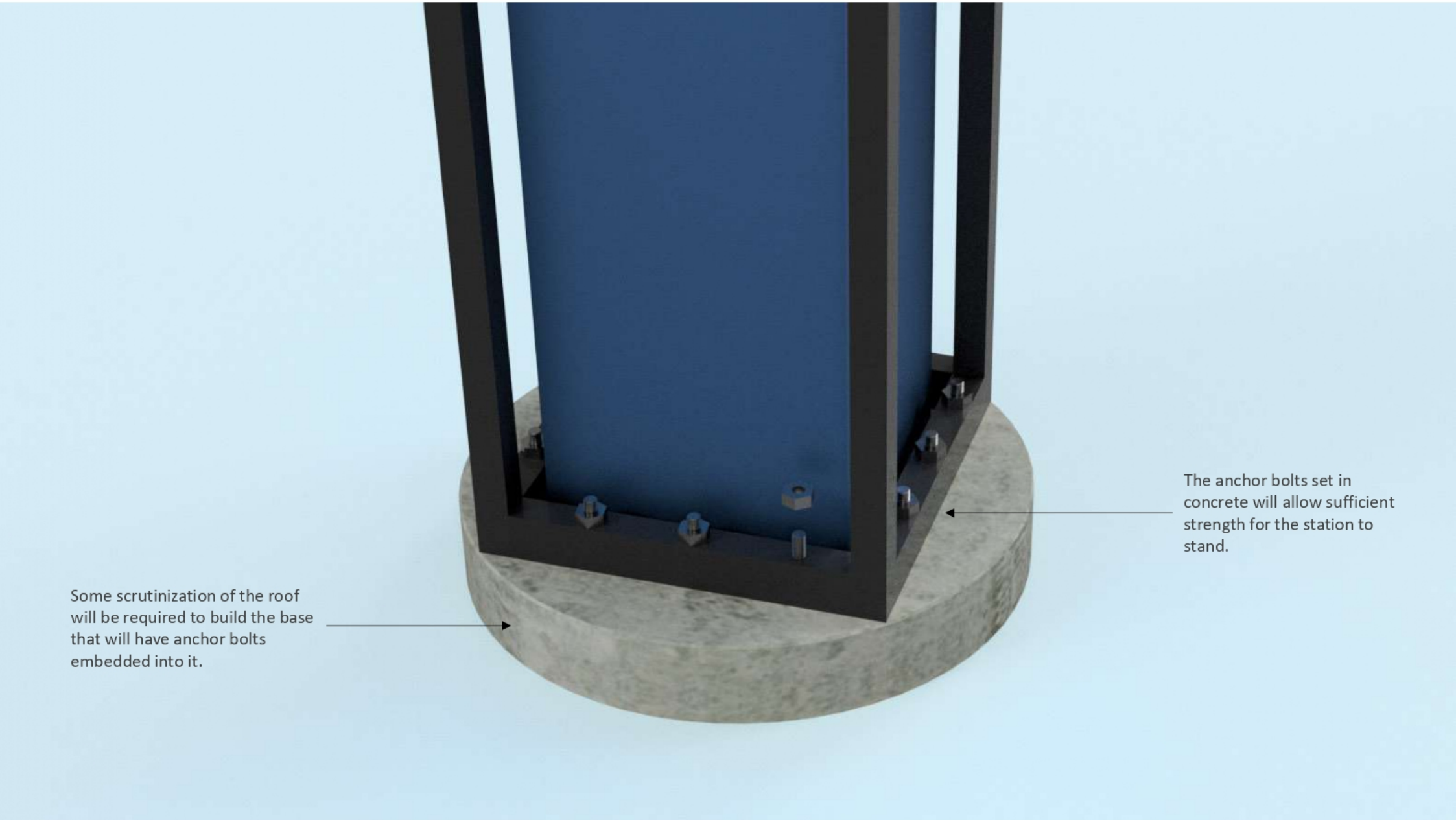
Image 124: Sectional Details Image source : Author



The wire will have a L-bracket that will allow the wire to bend and be away from any damages.

The cables coming from the stations will be anchored to the floor using brackets, and will be shielded to avoid any damage to the wires.

Image 125 : Connection details Image source : Author



Some scrutinization of the roof will be required to build the base that will have anchor bolts embedded into it.

The anchor bolts set in concrete will allow sufficient strength for the station to stand.

Image 126: Anchor details Image source : Author



## Way Forward.

Learnings from the project.

- The project was done during the pandemic with limited resources on hand, I realised that I had to do the work with whatever I can find and creatively solve the problems which wouldn't be in a normal flow of events, for example conducting body storming excercises.

Improvements

- New technologies like better batteries or better drone models can be implemented to enhance the efficiency of the entire system.
- Same system can be expanded to create a system where the drones can deliver things apart from blood like vaccines or parcels.
- User testing is required to test the usability and improve on the shortcomings within the system.
- A pilot study is needed to be done within a focus group or a smaller area to test the efficiency and potential problems in the system.

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India's first commercial drone policy overview : <https://www.youtube.com/watch?v=y8YsFYQ4Tko&t=790s>

Criticism about drone delivery : <https://www.youtube.com/watch?v=aW2Yg9N4vF4>

Zing drone services : <https://www.youtube.com/watch?v=aElZ4ljCa14>

Dues Drones : <https://www.youtube.com/watch?v=1GOO8yz8mT0&t=874s>

Shanghai pad based delivery : <https://www.youtube.com/watch?v=SRg-qb0Var4>

Parachute based delivery DHL : <https://www.youtube.com/watch?v=1FC12zhiTdY>

Amazon pulley (string) based / bee hive system : [https://www.youtube.com/watch?v=zv12CC\\_Dhk0&t=205s](https://www.youtube.com/watch?v=zv12CC_Dhk0&t=205s)

Slingshot ( Parachute based ) : <https://www.youtube.com/watch?v=jEbRVNxL44c>

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Drone Logistics Insights : <https://www.itln.in/indias-evolving-landscape-of-drone-delivery-aviation>

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