RESCUE KIT FOR FLOODS

INDUSTRIAL DESIGN PROJECT III

BY

TUSHAR VIJAY WANKAR

136130008

GUIDE:PROF. NISHANT SHARMA

INDUSTRIAL DESIGN CENTRE

INDIAN INSTITUTE OF TECHNOLOGY BOMBAY

2015

Declaration

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

Name: Tushar Vijay Wankar

Roll no: 136130008

Signature: 

Date: 24/04/2015

Approval sheet

The industrial design project titled as "Rescue Kit for Floods" by Tushar Vijay Wankar is approved in partial fulfilment of the requirement for the degree of 'Master of Design' in Industrial Design, at Industrial Design Centre, IIT Bombay.

Project Guide:

Chair Person:

Internal Examiner:

External Examiner:

Date:

Acknowledgement

I express my deepest gratitude to my guide Prof. Nishant Sharma for making me understand and apply various methodologies in the design process in order to proceed towards a fruitful outcome. This project has been a great learning experience till now. His constant feedback and precious inputs made me explore the domain of product design and understand the fine points related to it, thus enhancing my knowledge base.

I would also like to thank Commandant. Alok Avasthy from NDRF 5th Bt. Pune and whole NDRF 5th Bt. team for their valuable inputs and guidance. I would also like to thank Dr. P. M. Reddy, Sr. Secretary of Student Activity Centre, IIT Bombay for allowing us to use the swimming pool facility for testing and validation.

Last but not the least, I would also like to thank my friend Tonmoy Phukan, Joshua Mathew and all my classmates for their moral support and constant feedback on the project.

Abstract

Floods are annual natural calamities and second most fatal natural disaster in India after earthquakes. Each year, hundreds of people die because of floods. Most of the people are killed because they were not prepared for such type of a disaster and because help was not available on time.

This project deals with the design of a lightweight, portable kit for an individual, which floats on water and can be used for self-rescue from floods. This kit is primarily a personal flotation device which will keep person floating and alive until they get help. This kit will also provide possibilities of self-deployment, giving a signal to the rescuers, rain protection, anchoring possibilities, etc. Kit can be owned by the people or can be distributed by the government as a lifesaving aid. This project focused on strengthening rescue and relief operations in India by providing an opportunity for new product development, catering to human needs at vital conditions.

This project began by understanding the critical human needs by studying the Indian flood scenarios. Using the iterative design process, several options were explored using both buoyant and inflatable materials.

In a scenario like Kashmir flood (July 2014) where the flash flood caused immense loss of life as help could not reach on time. There were difficulties in locating people for rescuers due to landslides, navigation issues and many more problems. Use of this kit will provide timely, secure, safe and self-rescue opportunities.

Table of content

Fig. 1.1: Rural floods

Fig. 1.2: Urban floods

1. Introduction

1.1 Floods

Flood is an overflow of a large amount of water beyond its normal limits, especially over what is normally dry land. Floods occur at irregular intervals and vary in size, duration and the affected areas. Floods are recurrent phenomenon, which cause huge loss of lives and damage to livelihood system, property, infrastructure and public utilities. It is a cause for concern that the flood related damages are showing an increasing trend.

1.2 Damages due to flood [1]

Damages from floods are categorised in two types:

A. Natural Damage:

1. Soil erosion
2. Landslides
3. Damage to flora and fauna
4. Crop damage
5. Water pollution
6. Loss of lives by drowning/ diseases

B. Infrastructure Damage:

1. Communication halt
2. Transportation stagnant
3. Damage to dams
4. Household and important buildings wrecked

Fig 1.1 http://www.rediff.com/news/report/pix-assam-flood-rescue-ops-continue-toll-rises-to-30/20140924.htm
Fig 1.2 http://www.indiawaterportal.org/articles/basic-guidelines-about-floods-causes-consequences-precautionary-steps-and-some-dos-and

Fig. 1.3 Flood prone areas in India

1.3 Floods in India

Floods are annual natural calamities in India. Each year thousands of people become homeless and hundreds of people dies because of it. There are eleven such states in India which faces floods every year. Apart from this, due to constant climatic and geographical changes there are new states like Jammu and Kashmir and Uttarakhand which got badly affected in floods in the last few years. the major flood prone areas of India cover almost 12.5% area of the country. [1]

Flood is reported as the second most fatal natural disaster in India [2]

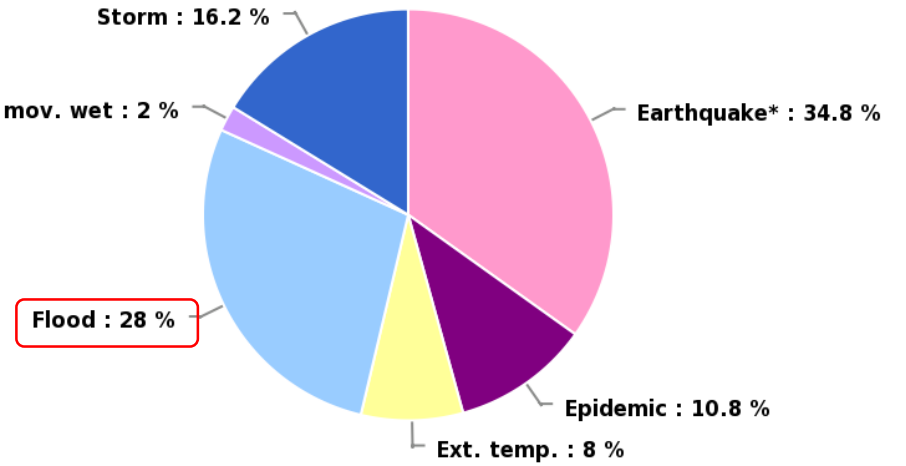


Fig. 1.4 Statistics of percentage people killed By Disasters Type

Fig 1.3 http://www.mapsofindia.com/top-ten/geography/india-flood.html
Fig 1.4 http://appscmaterial.blogspot.in/2012/04/india-disaster-statistics.html

Year	Area	Reason	No of death	Remark
2014	Jammu & Kashmir Flood	torrential rainfall	200	350 villages submerged
2013	Uttarakhand Floods	massive Landslides and heavy rainfall	1000	9 districts submerged
2012	Brahmaputra Floods	monsoon rains	124	worst hit area was Kazirangar National Park,13 great India rhinos and around 500 animals have died.
2010	Ladakh Floods	cloudburst and heavy rainfall all night triggered mudslides	255	71 towns and villages

Chart 1.1 : No. of people killed by floods in India in last 4 years

Fig1.5 Floods in Assam

Statistics show no. of people killed in floods in last five years.

Floods in Assam are annual, and are getting worse every year. Heavy rainfall resulted in the Brahmaputra River in Assam bursting its banks, flooding parts the nearby cities. These cities are vulnerable to flooding since they lie on the banks of rivers.

In such events, there lies a need for safe evacuation of residents.

Chart 1.1 http://www.mapsofindia.com/top-ten/geography/india-flood.html
Fig 1.5 http://floodlist.com/asia/assam-june-2013

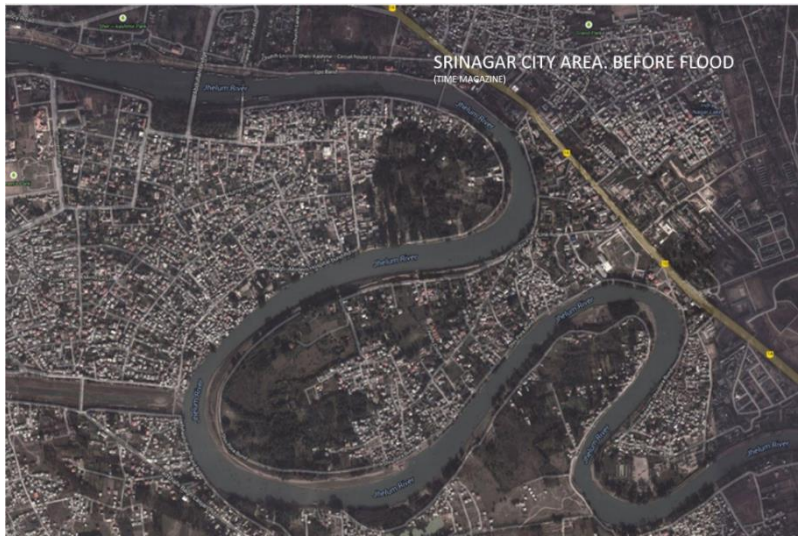


Fig. 1.6: Satellite pictures of Srinagar city before and after flood

These pictures shows how in 2014, how Kashmir the paradise on earth transformed into a valley of sorrow. t is recorded as the worst natural disaster due to floods in Jammu & Kashmir in over 100 years.

Around 5 million people affected. Over 2,500 villages, hamlets and towns submerged in water.

Fig. 1.7: Uttarakhand flood – bridge overflow

In 2013, Indian state of Uttarakhand and near by are received heavy rainfall

A multi-day cloudburst, centered on the state Uttarakhand caused devastating floods and landslides. Due to Continuous Rain the Chorabari Glacier melted and this triggered the flooding of the Mandakini river.

Fig. 1.6 http://time.com/3341129/satellite-images-show-jammu-kashmir-submerged-underwater-after-floods/
Fig. 1.7 http://ibnlive.in.com/photogallery/13749.html

1.4 Motivation

India being the land of rivers, forming an irrigation network, these rivers blessed in many ways. But it also becomes omen of misery by causing devastating seasonal floods. In India these floods cause immense loss of life and property.

Many people are killed in flash floods, many more are injured, while countless others are made homeless. These floods brings with them high risk of diseases and epidemics when dead bodies and animal carcase are begin to emerge.

Providing timely relief for saving precious lives is the need of the hour. This project tries at minimising the time required in saving people's lives in such conditions by looking at the possibility of finding a solution which can let the affected people rescue themselves without needing to wait for rescue operations and thereby saving precious time and lives.

1.5 Design objective

- To make rescue and relief operations more easier, safer and at early stage
- Increase the chances of survival
- Exploring the Possibilities of self rescue

2. Literature Study

2.1 Sources of flood

There are three different types of sources of floods; Natural, Artificial and Coastal.

A. Natural sources of flood

Riverine flooding occurs in relatively low-lying areas adjacent to streams and rivers. In the extensive flat inland regions, floods may spread over thousands of square kilometres and last several weeks, with flood warnings sometimes issued months in advance. In the mountain and coastal regions of flooding can happen rapidly with a warning of only a few hours in some cases.

Flash floods can occur almost anywhere there is a relatively short intense burst of rainfall such as during a thunderstorm. As a result of these events the drainage system has insufficient capacity or time to cope with the downpour. Although flash floods are generally localised, they pose a significant threat because of their unpredictability and normally short duration.

A. Natural sources of flood

Fig. 2.1 Cloud burst

Fig. 2.2 Overflowing rivers

Fig. 2.3 Melting of glaciers

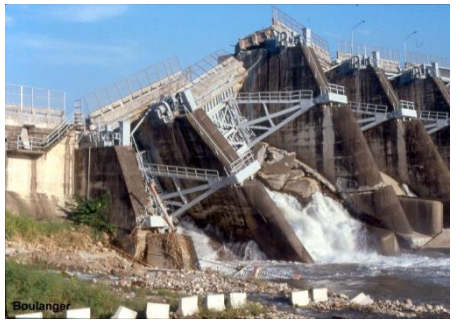


Fig. 2.4 Dam break due to earthquake

Natural sources of flood

Fig. 2.1 http://www.weather-forecast.com/locations/Leh/photos/4008
Fig. 2.2 http://q13fox.com/2014/09/06/more-than-250-people-dead-in-flooding-across-asia/
Fig. 2.3 https://www.pinterest.com/pg1002412/glaciers/
Fig. 2.4 http://www.saarc-sadkn.org/earthquake_seismicity.aspx

Fig. 2.5 Stagnant waterbody: pollution

Fig. 2.6 Catchment areas

Artificial sources of flood

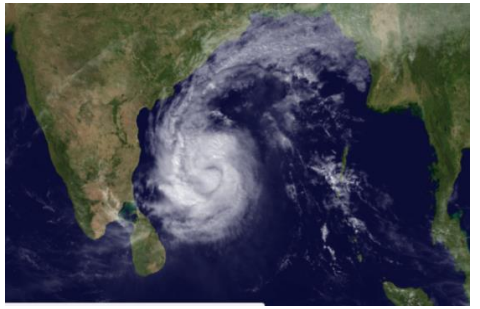


Fig. 2.7 Tropical cyclone

Fig. 2.8 Tsunami

Coastal sources of flood

B. Artificial source of flood

Surface water flooding occurs when heavy rainfall overwhelms the drainage capacity of the local area. It is much more difficult to predict and pinpoint than river or coastal flooding.

Sewer flooding occurs when sewers are overwhelmed by nearby rainfall or when they become blocked. The likelihood of flooding depends on the capacity of the local sewerage system. Land and property can be flooded with water contaminated with raw sewage as a result.

C. Coastal flooding

These results from a combination of high tides and stormy conditions. If low atmospheric pressure coincides with a high tide, a tidal surge may happen which can cause serious flooding.

Fig. 2.5 http://www.riannasfund.org/blog%20india.htm
Fig. 2.6 http://www.thejakartapost.com/files/images2/DRED.jpg
Fig. 2.7 http://www.abc.net.au/news/2013-10-12/india-phailin-mov/5018638
Fig. 2.8 http://indiatoday.intoday.in/story/mock-tsunami-drill-in-indian-ocean/1/154537.html

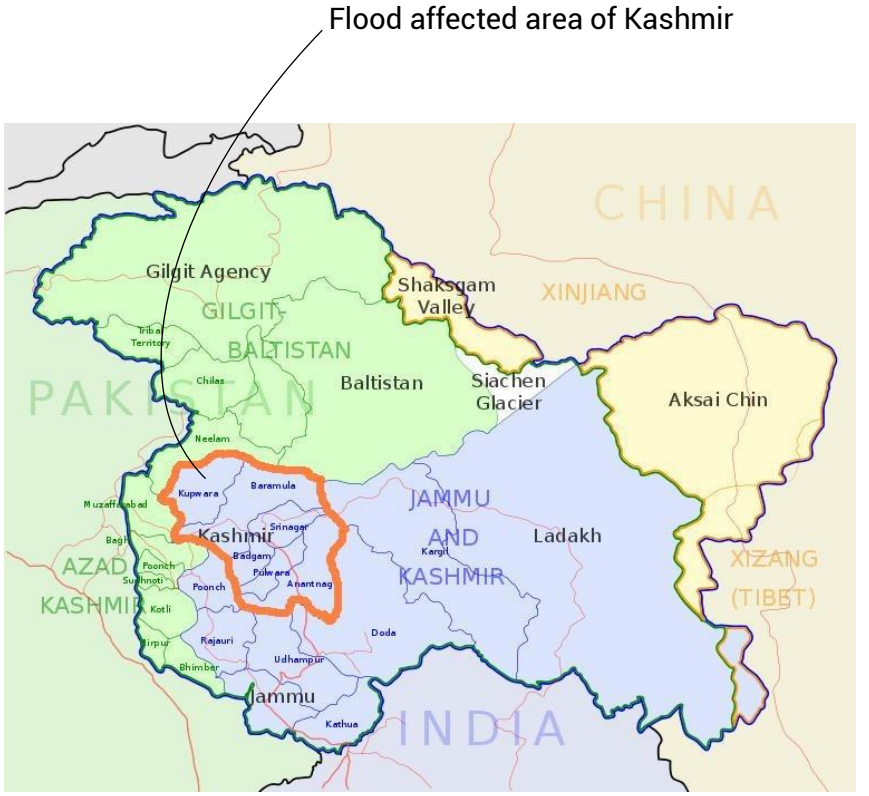


Fig. 2.9 Flood affected area of Kashmir

2.2 Case study –Kashmir flood (2014)

Problems from the Kashmir flood were studied on the basis of images, videos and news articles to identify various issues and problems. Also to understand the depth of problem and users behaviour into the situation, the user research method named Shadowing is tried out. It is the method in which the act of assuming yourself as a user and imagining yourself into the situation, and noting down the insights is conducted.

Kashmir Flood

I. Overview

- The **worst natural disaster** due to floods in Jammu & Kashmir in over **100** years.
- Around **5 million** people affected (**4.5 million in Kashmir** and 500,000 in Jammu areas) Over **2,500 villages**, **hamlets** and **towns** submerged in water [5]
- Latest official **death-count** in Srinagar is **over 284**.
- More than **400 deaths** overall in the Kashmir region [6]
- Over **600,000 people** remained **stranded** in Kashmir Valley. [7]

Fig. 2.9 http://mashable.com/2014/09/08/floods-kashmir/

Fig. 2.10 Evacuation activity of women and the elderly from flood becomes difficult

Fig. 2.11 difficulties in crossing river

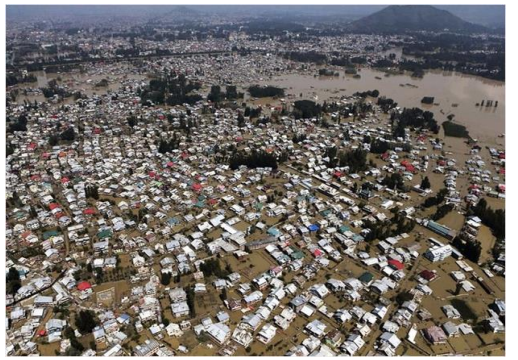


Fig. 2.12 Millions. Displaced, missing, starving

September 2nd

Kashmir was hit by sudden unseasonal and heavy rainfall. It rained more than 200 mm within just 24 hours – four times the average monthly rainfall. Both Jhelum & Chenab River were flowing above their danger levels.

Evacuation activity started at early stage after the water level started raising beyond its danger level.

	Day 2 (Raining starts)
Local people	• Evacuation • Alerted via news, panchayat • Safety preparations
NDRF	• Flood scale estimation • Getting equipment ready • Planning rescue op. • Deploy units in prone area
Weather Reported	• Estimation of bad weather/ harsh monsoon

Table2.1 Activity mapping

http://www.revivekashmir.org/revive-a-home?gclid=CJnzgeLQlcUCFU0mjgodr6YA8g

Fig.2.13 Jhelum river overflow

Fig.2.14 people got stuck because of high rise water

Fig.2.15 water overflows over bridges

September 5th [8] [9] [10]

The Jhelum river in Srinagar reported to be flowing at 22.40 feet (6.83m) which was 4.40 feet (1.34m) above the Danger Mark and at 33 feet (10m) at Sangham in Snantnag district above the danger mark

	Day 3 (Cont. rain, Water – above 3 ft.)	
Local people	• Water level – 3-4 ft. • Evacuation starts by walking/pub. Transport • Managing belongings/live-stocks	• People get stuck • Self rescue starts • Making improvised rafts/ jugaad • Public transportation halts • Problem - food, water, electricity shortage
NDRF Army	• Warning to people for self-rescue/ evacuation to specific locations	• Reaching locations • Rescue planning • Deployment of units with rafts/boats • Evacuation of people • On the spot equipment repairing • Day-night search • Temporary shelter set up • Food supply
Weather Reported	Repeated announcement via Radio/ TV/ Gram-panchayat/ Locals about weather	• Report update

Table2.2 Activity mapping

Fig 2.16 Rescue activity by belongings

Fig. 2.17 Problems of rescuing from 1st floor when water level is till first floor

Fig 2.18 Rescue activity by NDRF personals

September 12th

200 people have died
1,30,000 people rescued by NDRF and Indian Army
Indian Army has deployed around 30,000 troops for rescue and relief operations - 21,000 in Srinagar region and 9,000 in Jammu region. [11] [12] [13]

	Day 10

Local people	• Epidemics
	• Underwater Hazards
	  • Snake bites/ sharp objects/ Manholes, drains/ Deposition of sands, garbage, dead objects
	• Health problems
	  • Age
	  • Diseases/ disabilities
	• Navigation probs. – how to reach safe spot
	• Foul smell
	• Skin rashes

NDRF	Rescue operation
	  • Foot/ Boat/ 4 wheelers
	• Relief
	  • Food and medical facilities
	  • Shelter
	  • Clothing

Weather Reported	

Table2.3 Activity mapping

Fig. 2.19 Airlifting in inaccessible areas

Fig. 2.20 Dead bodies & animal carcasses are beginning to emerge

Fig. 2.21 many people died because of cold water and hyperthermia

September 15th
More than 400 deaths overall in the Kashmir region

	Day 13

Local people	• Shelter
	  • Home (Unaffected) – Repair jobs
	  • Temporary camps – Dependency on Food, Water, Medical facility
	• Epidemic initiates
	• Visible damages
	  • Crop land
	  • Roads
	  • Human & animal settlements
	  • Infrastructures related to transportation/ water/ medical
	• Search operations for lost
	  • Contacting NDRF
	  • Govt. hospitals
	  • At personal level

NDRF	• Search operation for missing
	• Area renovation
	  • Debris removal
	  • Medical camps
	  • Restoration of communication set. Up like making temp. bridges
	• Epidemic control operation

Weather Reported	

Table2.4 Activity mapping

Flood estimation

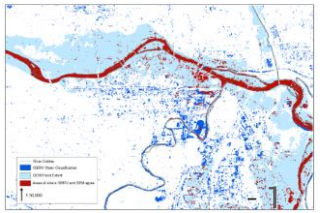


Fig.2.22 Satellite Images

Fig. 2.23 Field observation

Flood Evacuation

- Department centric planning
- Planning: Staff competency, Testing emergency operation
- Making online Inventory
- Coordination between institutes at state, district and national level

Flood Response

Central Level > District Level, State Level

Flood relief

2.3 Study of flood rescue and relief system in India

I. Purpose:

- Understand government body function flow
- To know about the stakeholders of flood rescue and relief operations
- To look into areas where design intervention can happen

II. Overview:

The Flood Rescue system is divided in three major response system. The first one "**Flood Response**" is showing the hierarchy in which

Flood is tackled; i.e. first in the district and state level and then if required the help of central government is taken. When it is a natural disaster, then only the national government intervenes.

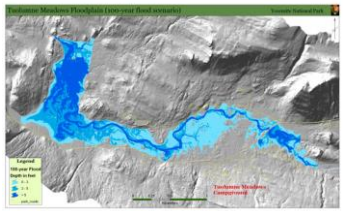
Flood estimation shows the techniques in which a flood is determined and verified.

Flood Evacuation has further subsystems which aids in flood response.

Fig. 2.22 http://earth.esa.int/hydrospace07/participants/77039/pres_77039.pdf
Fig. 2.23 http://www.ndma.gov.in/en/about-ndma/roles-responsibilities.html

Pre flood functions → During flood functions → Post flood functions

- Planning Emergency Relief by State Gov.
- Emergency Response team alerted



GIS maps

Simulation model

Scenario analysis

1. **ICS (Incident Command System):**
   ICS plays a major role by giving live information on floods to authorities at different administrative levels. It uses the following tools for it's operation:

First Responders: Locals (past 80% cases)

Secondary Responders: NDRF, IA, IAF,BSF

NDRF Assistance: ATIS, CD, Home guards, NGOs

Support Team: NCC, NSS (National service scheme)

2. Alerting Response and Support teams:

Image source: http://nidm.gov.in/default.asp
And NDRF Pume

Pre flood functions → During flood functions → Post flood functions

- Planning Emergency Relief by State Gov.
- Emergency Response team alerted

Emergency shelters

Healthcare facilities

Water, food supply

Distributing Relief

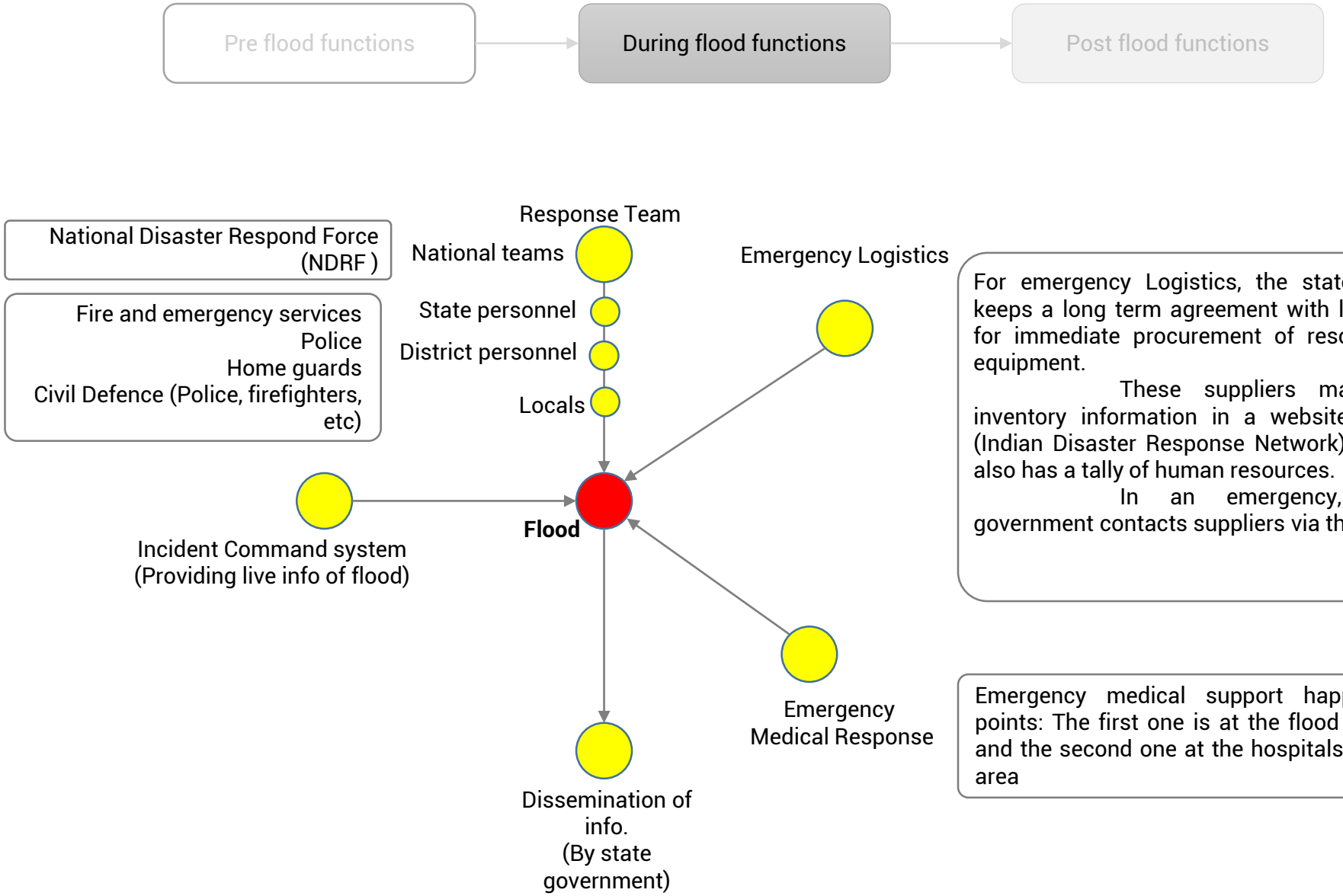
3. Planning and Relief

Planning and Relief is carried out by two teams:

1. Community Level Team
2. District Level Teams

Their functions includes planning and setting equipment and infrastructures for the following:

Image source: http://nidm.gov.in/default.asp
And NDRF Pume


Pre flood functions
During flood functions
Post flood functions
National Disaster Respond Force (NDRF)
Fire and emergency services
Police
Home guards
Civil Defence (Police, firefighters, etc)
Response Team
National teams
State personnel
District personnel
Locals
Emergency Logistics
Incident Command system
(Providing live info of flood)
Flood
Emergency
Medical Response
Dissemination of info.
(By state government)
For emergency Logistics, the state government keeps a long term agreement with local suppliers for immediate procurement of rescue and relief equipment.
These suppliers maintains their inventory information in a website called IDRN (Indian Disaster Response Network). The website also has a tally of human resources.
In an emergency, the state government contacts suppliers via this website.
Emergency medical support happens at two points: The first one is at the flood location itself and the second one at the hospitals in the vicinity area

Pre flood functions → During flood functions → **Post flood functions**

- Relief Camps
- Corporate Funding

Fig. 2.24 Relief Camp setup to provide shelter to those who fled their villages

Operations:

- Mobilisation of relief supplies
- Tents
- Water supply
- Sanitation system
- Communication support
- Medical support

Corporate Funding: Government approved corporate sectors as part of their CSR (Corporate Social Responsibility) scheme provide service and resources immediately in the aftermath of floods. The services includes the following areas:

- Hospital
- Power
- Telecommunication
- Relief supplies
- Search and Rescue equipment
- Water pumps
- Transport and logistics for movement of relief supplies

Fig 2.24 http://www.prokerala.com/news/photos/a-view-of-narayanguri-relief-camp-setup-to-186518.html

3. Field visit at NDRF

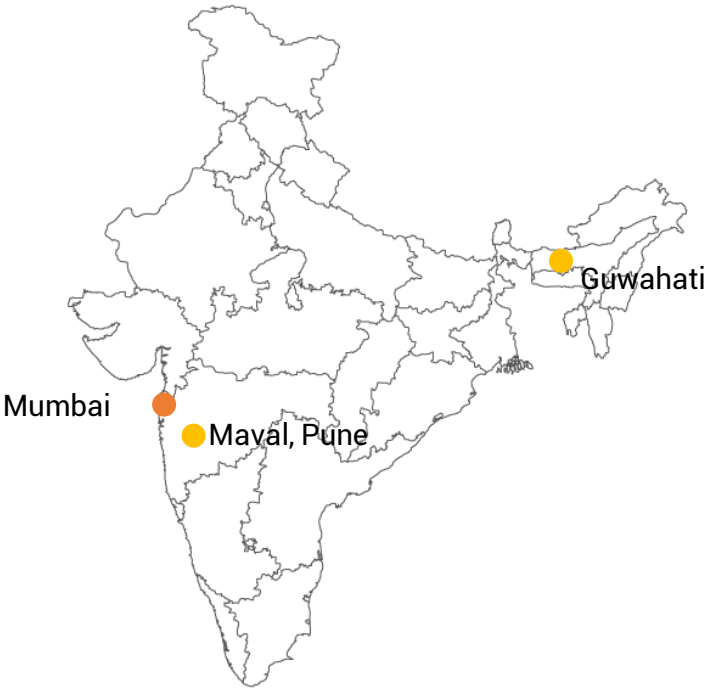


Fig. 3.1 Locations Visited

Locations visited (in order):

- 5th battalion, Talegaon (Maharashtra),
- 1st battalion, Azara, Guwahati (Assam)
- RRC (Regional Resource Centre) in Mumbai

Purpose:

1. Know how of operation procedure
2. Understanding equipment and usage
3. Identifying problem areas
4. Documentation

Methodology:

1. Photo Documentation of equipment
2. Interviews

Fig 3.2: 5th Bn NDRF
Sudumbare Taluka, Distt-Maval,
Pune(Maharashtra)

NDRF logo

3.1 About NDRF:

National Disaster Respond Force - Only dedicated force for disaster management in India and in the world

Established in 2006 by NDMA,10 battalions spread over the India

Disasters including the drowning cases, building collapses, landslides, devastating floods and Cyclones.

People in NDRF:
Force set up from members from various paramilitary forces like BSF, CRPF, ITBP, etc.

Tenure in NDRF:
- 5 Years

Strength per battalions:
- 1149 in one battalions

Total no. of battalions:
- 10 dedicated to each state

Purpose of NDRF:
To provide rescue and relief response to
- Natural calamities like floods, earthquakes, etc.
- Artificial disaster NBC (Nuclear, Biological and Chemical hazards) hazards
- Medical assistance

3.2 Activities of NDRF personals

Basic Training and
Specialised training

Community awareness programme

Study of Typology and Geography

Familiarization exercise, Mock drills

Pre-disaster posting

Operations

1. Rescue 2. Relief 3. Rehabilitation

3.3 Equipment's study

High value equipment's used by NDRF Personals - Boats/ Rafts:

Rubberised boat 25 to 75 HP OBM

Inflatable rescue raft

FRP boats (40 HP motor, carrying capacity: 30 people, Need to be transported in trucks)

Life saving equipment's

Life buoys

Life Jackets

Other equipment:

Diving Suit

ASKA light tower

Portable oxygen unit

I. Inflatable Motor Rescue Boat

Specification:

Engine :

- *Mercury* 25 HP-25
- 5000-6000 RPM
- Electronic fuel injection system
- Water cooled type
- Ultra low emission ratings

Weight:

- Dry weight (raft): 75 Kg
- Motor(OBM): 78 Kg

Material:

- Hypalon/Neoprene

Capacity:

- 7-10 persons

Features:

- 4 internal air compartments
- One way air valves

Air filling:

- Air blower
- Manual air pumps

Price:

- 3.14 lacs

Top speed:

- 40 kmph

II. Air-Deployable Rescue Raft

Specifications:

Pedal operated

Material:

- PU / Rubber Coated Nylon Fabric

Weight:

- Dry weight: 60 Kg (approx.)
-

Capacity:

- 25 persons

Features:

- Double buoyancy chambers
- Air deployable

Air filling:

- CO2 cylinder
- Air blower
- Manual pump

Price:

- 4.56 lacs

The air deployable raft can released from an airplane or a helicopter in the areas where people are trapped. It can also be dropped in areas where people are stuck in water. It comes with a CO2 cylinder which gets activated when released by a pin while dropping. This cylinder inflates the tube in 2 mins. diminishing any manual effort.

This raft provides a dry, floating shelter which can be moved using pedals. The raft has a 25 people on-board capacity and has ropes in the outside perimeter to give support to additional no. of people. The cone area has two LED lights; one towards outwards to flicker and signal and the other inwards to illuminate the interiors. The light can work for 48 hours.

Apart from these, it has also got small lifebuoys inside.

a. Set up:

The following is the process of manual set up:

Unfolding raft

Inflating by air blower

After 30 mins. The entire tube frame will get inflated

Folding and packing up of the raft

b. Features:

CO2 cylinder: activates when dropped from airplane

Interior light: battery powered

Air pressure control valve

Top LED flicker light

Ingress Step

III. Improvised Floating Devices

During non operation period, NDRF is extensively busy in community awareness programs in rural areas.

In such programs people are taught about the mandatory precautions to be taken for floods and also about how they can use day to day life products for saving themselves.

The following are some of the equipment which can be made out of daily usage products and materials


Water bottle vest


Coconut shell vest


Matka and tin-can floating units

Basketball

Plastic pots

Plastic pots

Thermocol units

3.4 Chart representation comparison of various flotation devices and boats

Factors	Rubber Raft (Circular)	Inflatable Boat (OBM)	FRP Boat	Banana boat	Improvised (Single person unit)	Bamboo Raft
image						
Structure	Tubular	Tubular + Al chanels + Plywood	bowl type	Banana tree + wooden bed	Flexible + tied	Modular + tied
Types	Close	Open	Open	Open	Vest	Flat bed
Material(s)	Hypalon/neoprene, PVC or Poly urethane	Rubber coated Fabric, Nylon Reinforced Hypalon	FRP Boat	Banana tree	Coconut shell/ Pl. Bottle / tin - can	Bamboo
Auto deployment	Yes	Yes	No	No	No	No
Maintenance	Semi skilled	Skilled people	Skilled people	Semi skilled	Semi skilled	Semi skilled
Indication	Light on top + reflectors + orange color	Bright Colours	Bright Colours	None	None	None
Depth of water req. to float	1-2 feet	2-3 Ft	2-3 ft	0 - 1 feet	0 - 1 feet	0-1 feet
Capacity (People)	25 people	07-10 people 800kg	12 (1200KG)	Non standard	1	Non standard
Safety features	One way valve + multi compartments	1 way valve, provided with bow storage bag and safety kit	remote control steering	always floating	always floating	always floating
No. of people to drive	2 (pedaling)	1	1	1 (pedaling)	1 (pedaling)	1 (pedaling)
Weight	less tha 100 kg	Drt wt. 75 kg (w/o OBM)	350 kg (w/o OBM)	Non standard	less than 2 kg	Non standard
Size (lbh)	64"H x 25"L x 23"W	4200X1800X1000 19' tube dia	15ft X 6ft X 2.5ft	Non standard		Non standard
Cost	4.5 lacs	3.14 lacs	4.11 lacs			
Packaging	Foldable	Foldable	non foldable	Non folddable	Foldable	Non folddable
Transportation	By air/ trucks	Truck	Truck	Manual lifting/ trucks/ air	Manual lifting	Manual lifting
Power source	Human powered	Motor - 25HP	motor - 40HP	Human powered	Human powered	Human powered

3.5 Inference

NDRF is a specialised Co-responders if the disaster is predictable they preposition themselves to tackle the disaster as in case of floods.

Sometimes it takes too long to reach the location and to the person due to problems such as navigation, inaccessibility of boats rafts, locating the personals, water problems and many more.

when floods comes thousands of people gets affected at the same time and hence it is required for the locals to be prepared at initial stage.

The making of improvised flotation devices depends upon the availability of the materials.

Boats and rafts are very costly and are in limited numbers with limited capacity.

3.6 Design Directions

Problems and Issues which are critical

1. Being Prepared for the situation
2. Quantity of the safety equipment's
3. Safety in water (flow, depth, snakebites)
4. Direction (navigation) and search for the safe place
5. Provision of water, food and medicine
6. Safety of belongings

The direction chosen on the basis of research is based on user centric

These are:

1. Design of a self rescue kit

To increase the chances of survival at any level of flood by individuals themselves

To Design a victim centric, portable, self rescue kit for an individual in urban flood scenario which will keep person floating, allow him to move in still water and also help him to anchor at one place in high current flow situation.

or

2. Design of a portable boat for families

Which will be own by the people

Collapsible, modular, inflatable quick assembly boat system

4. Design brief

To Design a victim centric, portable, self rescue kit for an individual, in urban flood scenario which will allow person to float, move in still water and also will protect from flash floods.

Basic specification
Capacity - 1 person (120 kg max)
Users male/female (10-70 years)
weight – should be less than 5 kg
min life span- approx. 5 years

Critical
Floating
Prevention from toppling
Protection from debris
Easy to use even by the illiterate
Prevention from drifting away

Important
Portable
protection from rain
Quickly deployable within 1 min
Keeping person dry
Indication to the rescuers

Desirable
Reusable
Navigation aid
Night rescue assistance
Owned by the people

4.1 Problems need to be addressed

Rescue from home

Broken glass on wall

Barbed wire

Wall railings

Navigation

Fast flowing water

Whirlpool

Open Manholes

Dangers

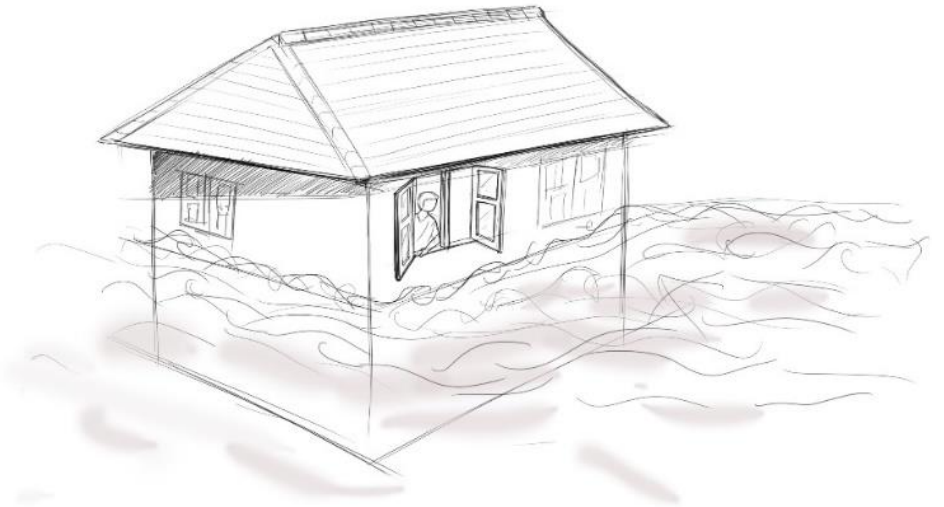
Parked cars

Electricity wire

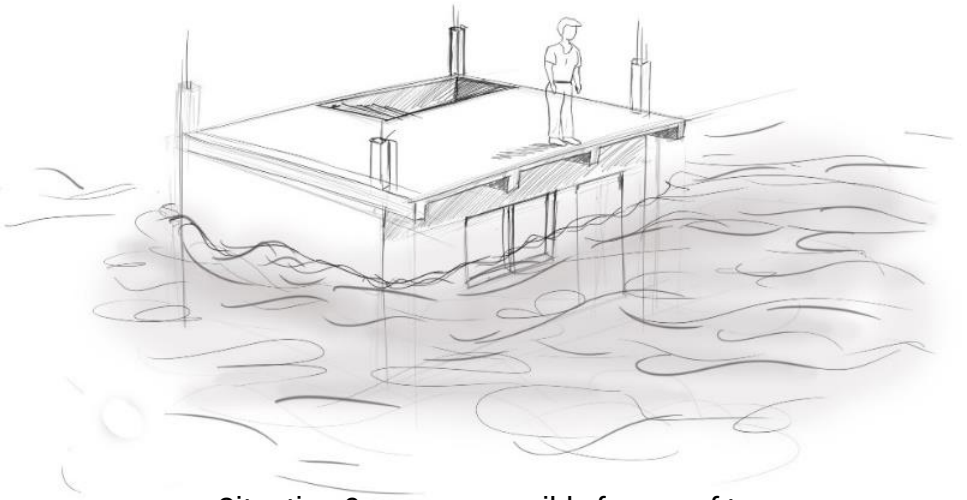
Snake

Debris

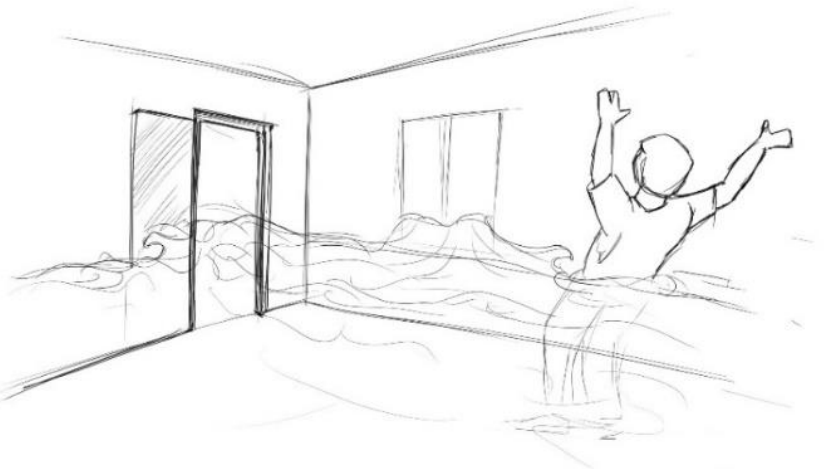
4.2 Rescue situations



Situation 1 : rescue possible only through window



Situation 2 : rescue possible from roof top



Situation 3 : when water starts rushing into the house

5. Product Study

Fig.5.1 Kerala's traditional circular boat - Coracle

5.1 Parallel product study

I. Traditional boats

Bowl shape of the coracle maintains the balance even if the load not concentric. It is made of a local material with bamboo weaving which is the main structural member. It gives strength and maintain the shape of the coracle. It is lightweight easy to carry, can be made locally, repair possibilities are there.

Fig. 5.2 Indian Small Boat

Traditional wooden boats is used for work, fishing and pleasure also. Its pointed end helps it to move easily in water.

Fig. 5.1 http://dualartspress.com/wp-content/uploads/2012/02/20120204-065945.jpg
http://www.boatsdepot.org/types-of-boats/coracle/
Fig. 5.2 http://cdn.c.photoshelter.com/img-get/I0000HbZ6Y5L5lUo/s/600/600/flood-117-ap.jpg

EVA foam floats

Fig 5.3 A standard EVA foam kickboard

Fig 5.4 Waist belt

Fig. 5.5 Foam Grip Pull Buoy

Air filled floats

Fig 5.6 arm bands

Fig 5.7 Ring buoy

Fig. 5.8 air filled life jacket

II. Swimming pool flotation devices

These are mainly used for training and practice purpose into the swimming pools. These comes in different sizes and shapes depends upon the buoyancy required and activity being done with it.

Kick boards (fig 6.3) can help the arms to rest keeping the head above water and allowing a swimmer to concentrate on the leg kick.

Swim belts (fig 6.4) keep the free movement of arms and legs which is valuable to the swim. It can help to maintain a good vertical body position

Pull buoys (fig 6.5) are floats which are held between the thigh. They are a float for legs you can just concentrate on getting your arms right.

Arm bands (fig 6.6) can keep a swimmer off the pool bottom with the head above water. When learning to swim armbands can make it more difficult to achieve a streamlined position because the support is on the upper body.

Fig 5.3 Image Source: http://amazingpics4you.blogspot.in/2011/10/swim-safe-funny-picture-joke.html
Fig.5.4 http://stuartmconde.hubpages.com/hub/How-to-choose-the-right-Swim-Training-Aids
Fig 5.5 http://stuartmconde.hubpages.com/hub/How-to-choose-the-right-Swim-Training-Aids
Fig 5.6 http://www.swimming-techniques-learn.com/swimming-equipment.html
Fig.5.7 http://www.slideshare.net/suryasarma2/indianjugaad

Fig.5.9 Swimming Pool Chairs

Fig. 5.10 inflatable pool float

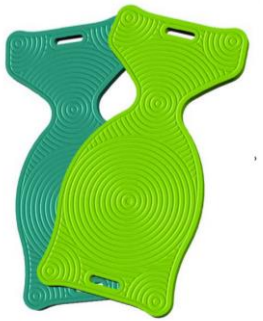


Fig. 5.11 buoyant pad

Fig.5.12 Swimming Pool Chairs

III. Amusement Park floating devices

These equipment's are designed for leisure and are used in still water where there is no danger of puncture due to debris. Hence material used mainly thin PVC plastic sheet or waterproof foams. Pool toys allow to do more with water than just swim, float, and soak up the sun.

amusement equipment's come in various shapes and sizes to suit various activities. **Inflatable pool float** (fig 9) has double-hand grips that are made slip-resistant. Constructed of heavy gauge vinyl the shock rocker measures 75 inches in diameter. Four people can fit on this large pool float that features headrest for added comfort and a hole in the middle for feet.

Swimming Pool Lounges and Chairs (fig.11) are designed to provide countless hours of relaxation and enjoyment. long lasting pool floats that come in all shapes, sizes and colours.

Fig-5.9 http://wizzley.com/pool-floats-for-adults/
Fig-5.10 http://www.trendhunter.com/trends/kai-pet-pool-floats
Fig-5.11 http://www.toysplash.com/inflatablefloats.html
Fig-5.12 http://www.oneinhundred.com/Wholesale-customized-printed/various-other-2_17.htm :

IV. Stretchers

These are mainly used for patient transfer from water. The tubular structure is used to increase the strength and foam floats or inflatables are used to keep stretcher floating.

Fig. 5.13 Stretcher with foam material for buoyancy

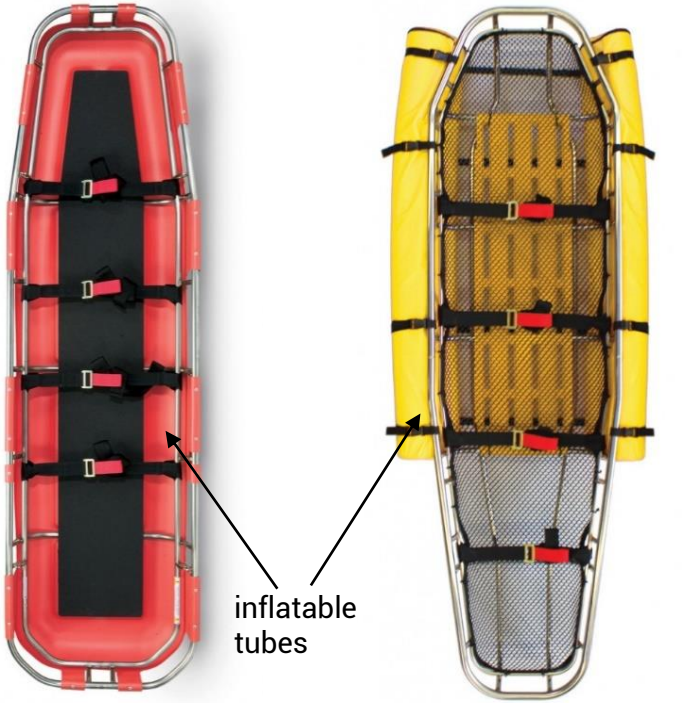


Fig. 5.14 Stretcher with inflatable tubes

Fig. 13 http://www.cmcrescue.com/equipment/litter-flotation-collar/
Fig. 14 http://amazingpics4you.blogspot.in/2011/10/swim-safe-funny-picture-joke.html

Fig. 5.15 rubberised inflatable boat

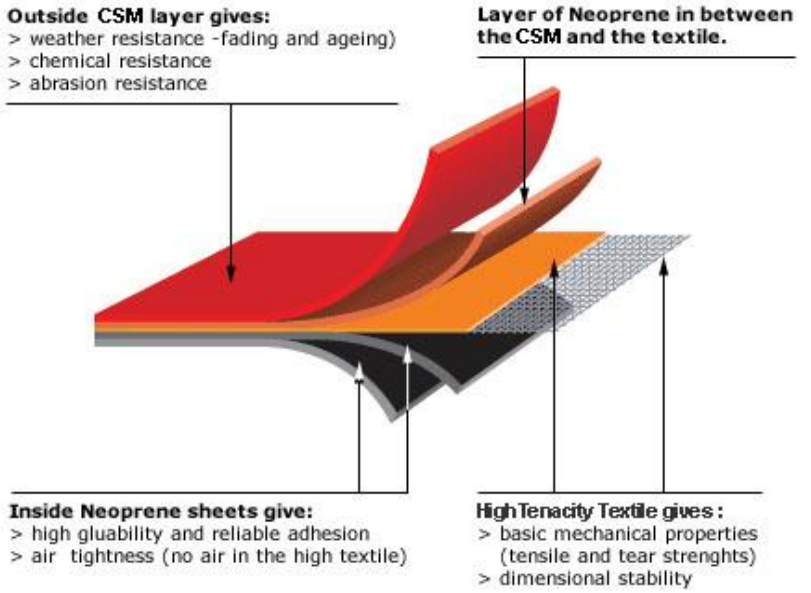


Fig 5.15 Source: http://www.polymarine.com/advice/boat-fabric-guide/

5.2 Material study

In this section the various materials used for flotation devices are studied. Following are the list of some of them

I. Inflatable Boat Tube Fabrics
In inflatable boats mainly two types of materials are used.
1.Hypalon and Neoprene Coatings
2. PVC coated fabric

1. **Hypalon** is the synthetic rubber material with excellent air holding capabilities and oil resistance. Hypalon coated onto polyester or nylon fabric with an interior coating of neoprene a very reliable and durable inflatable boat fabric and can last for more than a decade even in the harshest environments. Hypalon and neoprene glued seams are so strong and reliable that the fabric will fail before the seams.

Source: http://www.polymarine.com/advice/boat-fabric-guide/

2. PVC coated fabric is used as a coating on polyester or nylon to increase the strength and tear resistance. Because it is a type of plastic, it can be thermobonded or glued.
PVC coated fabrics come in a larger array of colors than Hypalon.

Fig.5.16 kickboards

Fig. 5.16 http://en.wikipedia.org/wiki/Ethylene-vinyl_acetate

Swimming pool floats- kickboard

Ethylene-vinyl acetate (EVA) is one of the materials popularly known as *expanded rubber* or *foam rubber*. Is most widely used in swimming pool floats A **swimming float** is normally used to learn how to swim, or during exercise or training purposes. These devices, which come in many shapes and types, are used to aid them with buoyancy.

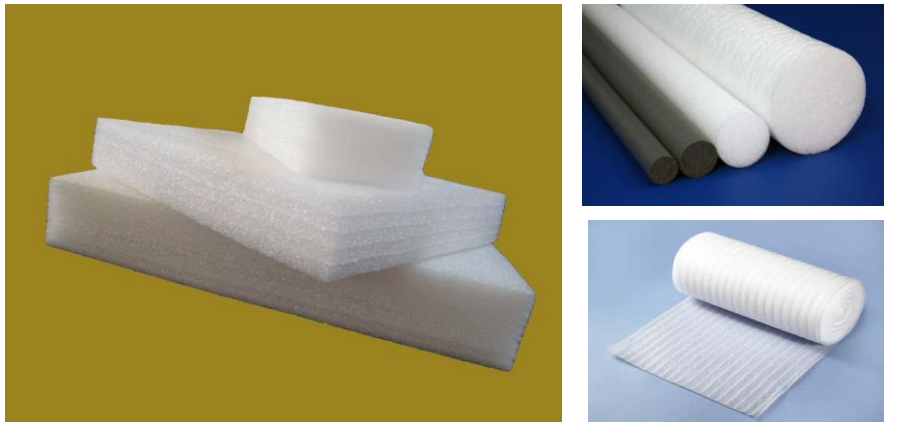


Fig. 5.17 EPE foam in different shapes

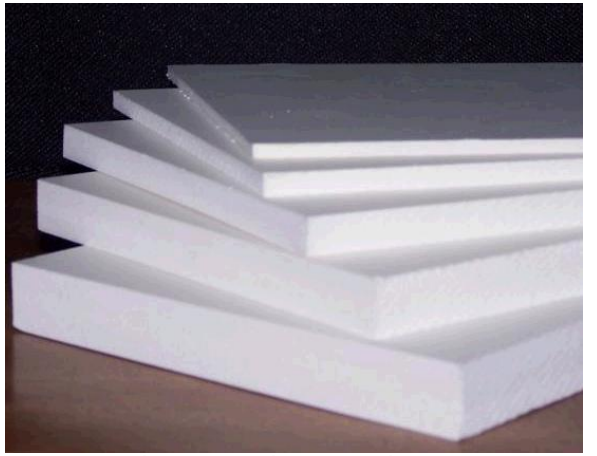


Fig. 5.18 Thermocol

Following materials can be used for the construction of the flotation devices because they offers excellent properties required for the construction.

EPE Foam (expanded polyethylene)

- Waterproof
- buoyancy: up to 50 times lighter than water
- lightweight material, density range from 20 to 50 gr/litre
- flexibility even under cold temperature
- resilient (total shape memory)
- inert: resists to organic solvents and numerous chemicals
- non toxic
- easy to cut by hot wiring or sawing
- complex shaping using aluminium melds

EPS (Expanded Polystyrene) thermocol

- lightweight material which floats (density 150-400 kg/m3)
- excellent mass to volume ratio
- excellent thermal and acoustic insulation
- excellent mechanical properties (strength, damping)
- waterproof and mold resistant
- non-toxic (no CFCs)
- easy to produce and ship
- versatile and easy to shape
- best price/performance ratio than most construction materials

Fig. 5.17 http://www.ecothermindia.com/product.php?prod_id=6
Fig. 5.18 http://www.ecothermindia.com/product.php?prod_id=6

5.3 Study of life jackets

IR-5.19

Off-shore Life Jacket
- 22 pounds of buoyancy.
- Inflatable and Inherently buoyant types.
- Used for Open, rough, or remote water, where rescue may be slow in coming.

IR-5.20

Near-shore Buoyant Vest
- 15.5 pounds of buoyancy.
- Inflatable and Inherently buoyant types.
- Good for calm, inland water, or where you have a good chance of a fast rescue.

IR-5.21

Near-shore inflatable Vest
- 15.5 pounds of buoyancy.
- Inflatable and Inherently buoyant types.
- Good for calm, inland water, or where you have a good chance of a fast rescue.

life jackets

A life jacket also called as **personal flotation device** is piece of equipment designed to assist a wearer to keep afloat

There are many different types of life jackets based on the buoyancy they offer and based on materials. who may be either conscious or unconscious

Human body is almost a neutral having same density as of water due to 70% human body contains water. Most adults need an extra 7 to 12 pounds (3-5kg) of buoyancy to keep their head above water. minimum buoyancy for lifejacket is 16- 22 pounds(7- 10 kg)

IR-5.19 http://boatersafety.org/life-jacket-types-what-the-coast-guard-life-vest-ratings-mean-for-you
IR-5.20 http://www.safeboatingcampaign.com/choose.htm
IR-5.21 http://www.mailspeedmarine.com/guides/removing-mould-life-jackets/

Fig. 5.22: Inflatable Life jacket before and after inflation

Fig. 5.23: CO_2 Cylinders used in life jacket for Inflation

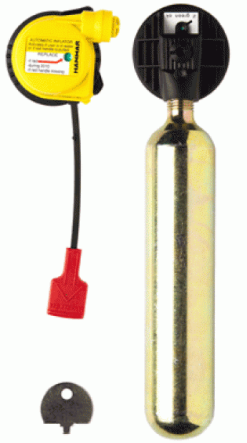


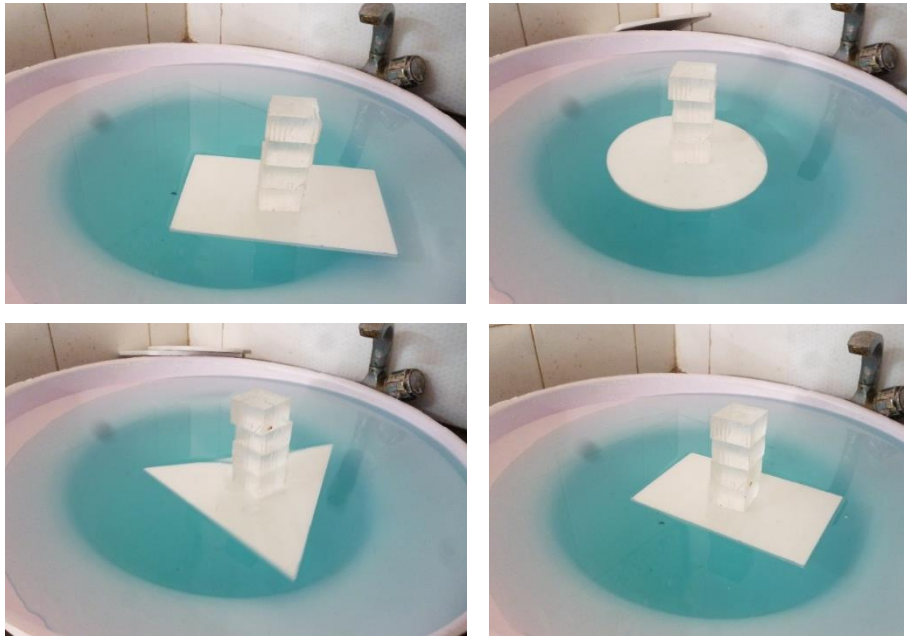
Fig.5.24: valve arrangement for CO_2 cylinder

Inflatable life jacket (cont.)

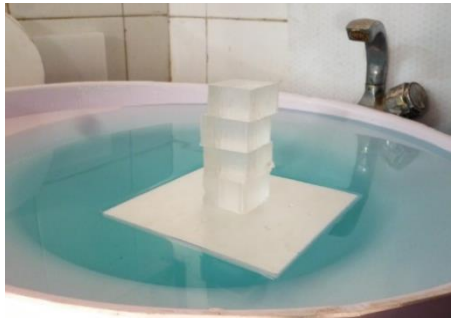
Inflatable life jacket use technology of compressed gas cylinder to inflate the jacket. The assembly consist of a quick release valve with a cylinder consist of a compressed Carbon Di-oxide (CO_2)gas. Reason for using CO_2 is that it does not contains moisture and does not corrode the wall and hence increasing the lifespan of the jacket even it is not in use.

The amount of CO_2 gas required for inflation is calculated in grams Generally 18-33 Grams of CO2 is required for creating buoyancy of 7- 10 kg. [4]

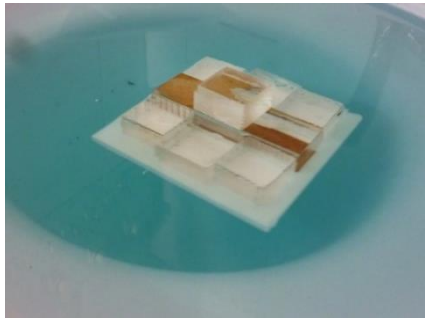
Fig. 5.22 http://www.lifejackets.co.uk/products/111/hammar-m1a1-standard-rearming-kit-33g
Fig. 5.23 http://i01.i.aliimg.com/wsphoto/v0/1044370381/Tacx-Automatic-inflatable-life-vest-Metal-16g-CO2-Gas-Cylinder-Standby-Miniature-Portable-Inflatable-bottle-Tube.jpg
Fig. 5.24 http://www.sinosecu.com/Products.asp?ClassID=82



Load carrying capacity by different shape



Concentric load
(Standing position)



Distributed load
(Seating position)

5.4 Study of buoyancy and flotation

In order to understand the performance characteristics of the kit, different tests of buoyancy and flotation are carried out with the small test samples.

1. Load carrying capacity by shape

Different shapes with same surface area (100 square cm) were made and tested in water with test loads to calculate load carrying capacity. Following result were obtained.

Same surface **AREA** = Same load carrying **CAPACITY**

2. Load carrying capacity by weight distribution

Distributed load close to the water carries more weight than concentric load at the centre

3. Stability test

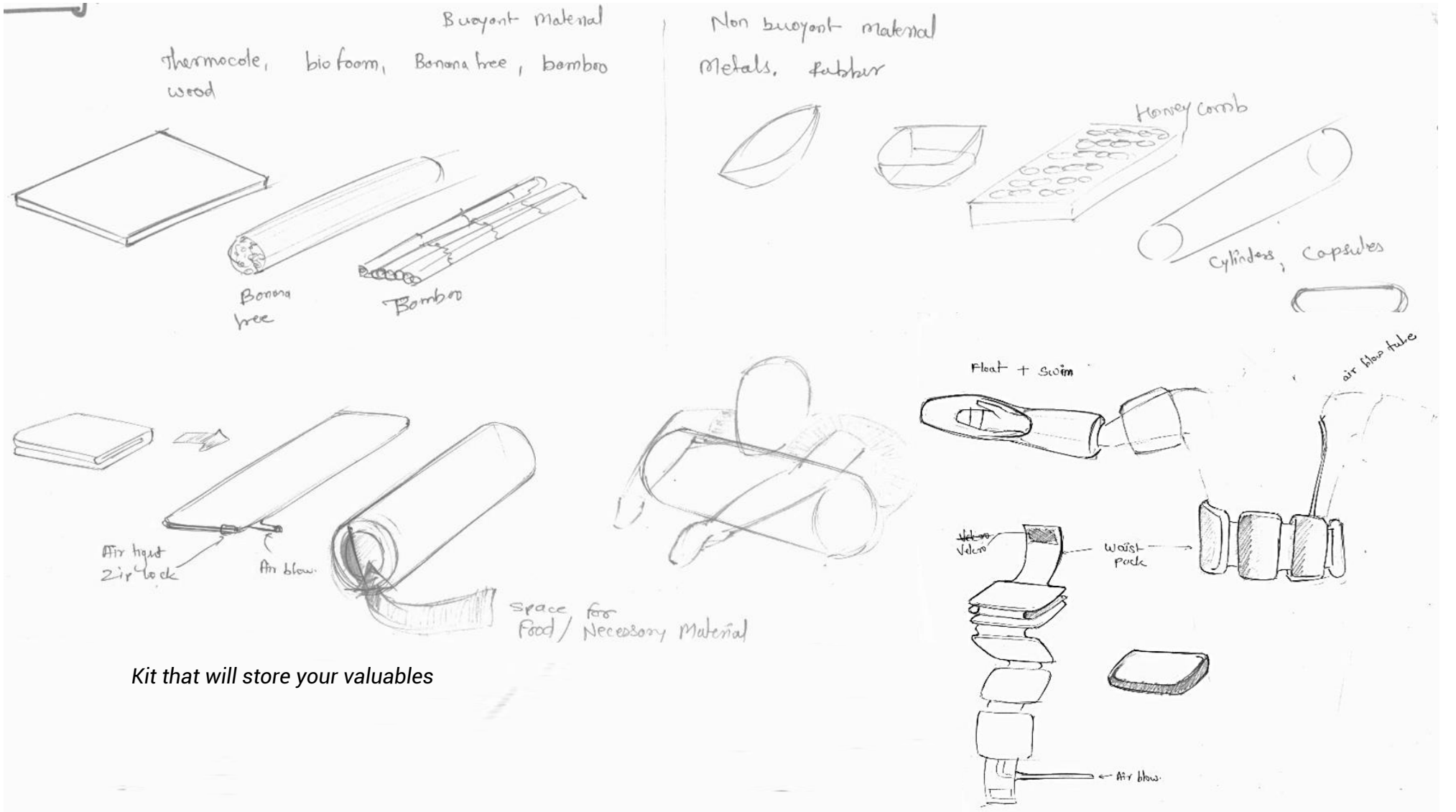
more the C.G. of the body closer to the water, more stable will be the float.

Wide span of the float also gives more stability

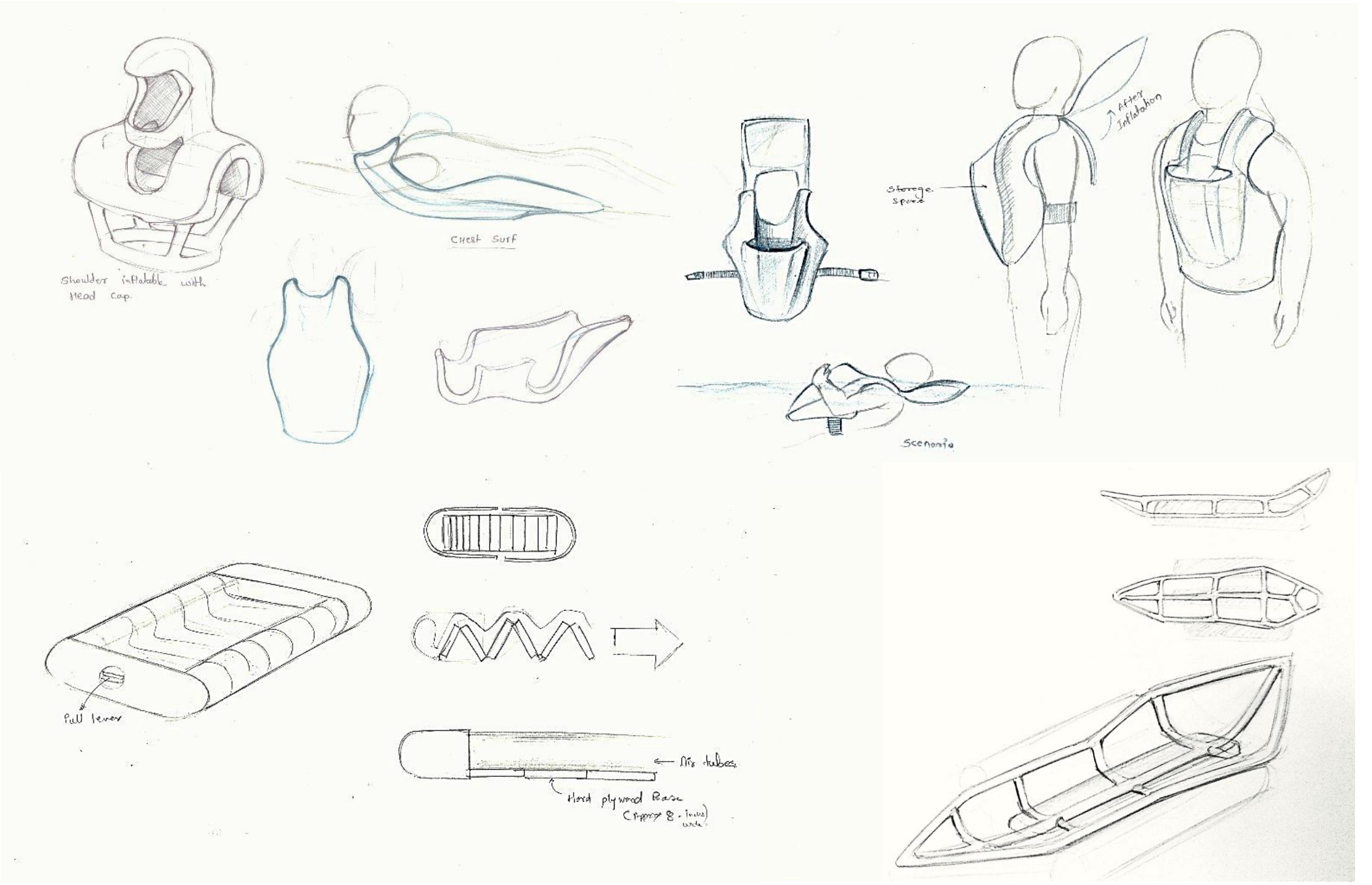
6. Design

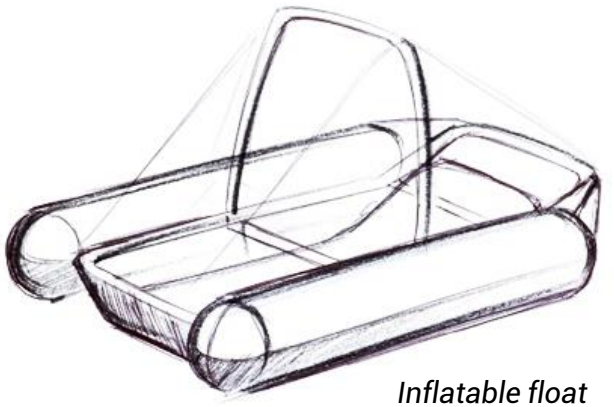
6.1 Doodles

Exploration of various floating possibilities



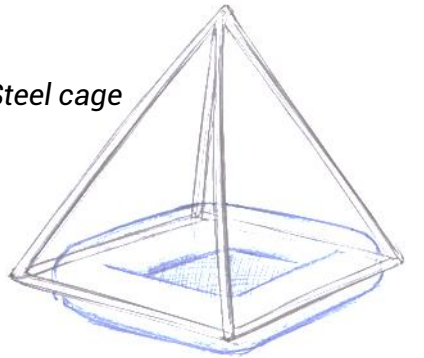
Kit that will store your valuables


Shoulder inflatable with Head Cap.
Chest Surf
Storage space
After Inflation
Scenario
Pull lever
Air tubes
Hard plywood Base



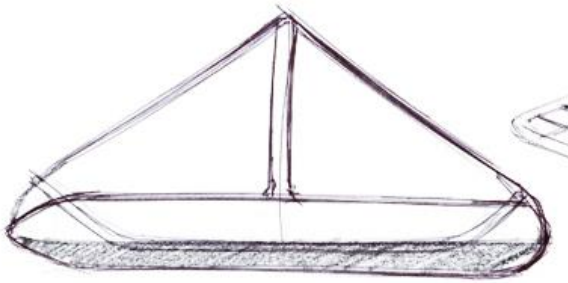
Inflatable float

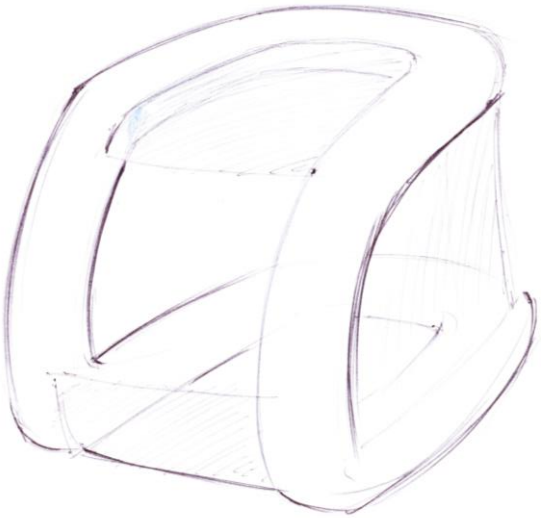
Steel cage



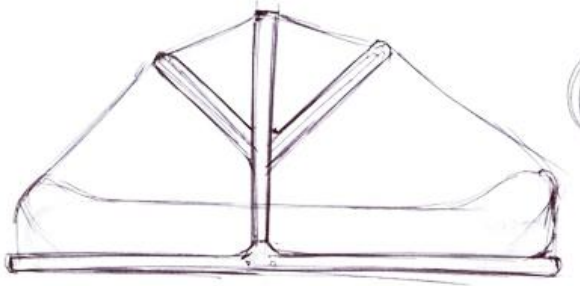
Inflatable float

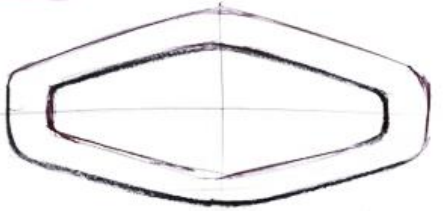
Steel frame

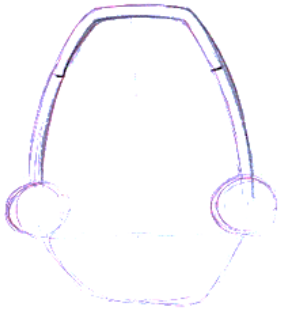


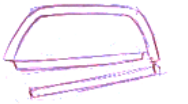


Rubberised inflatable





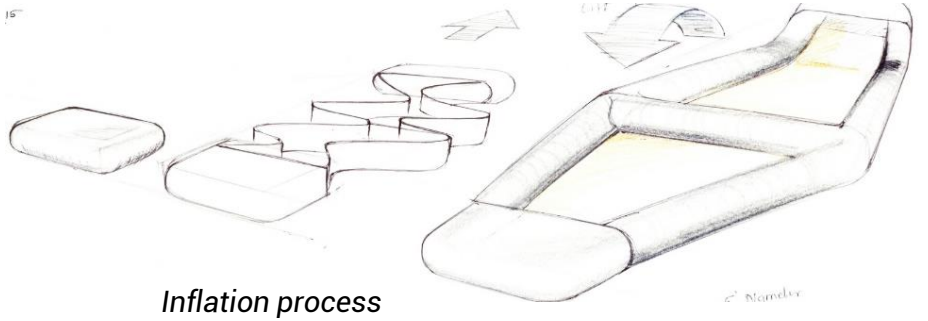




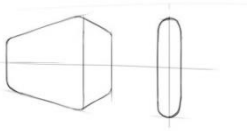
Concepts

6.2 Ideation

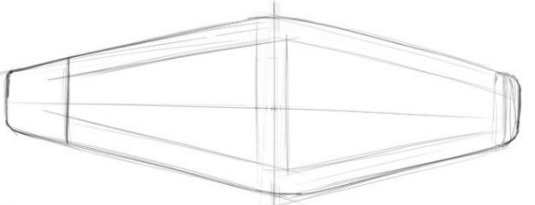
#1 Foldable roof



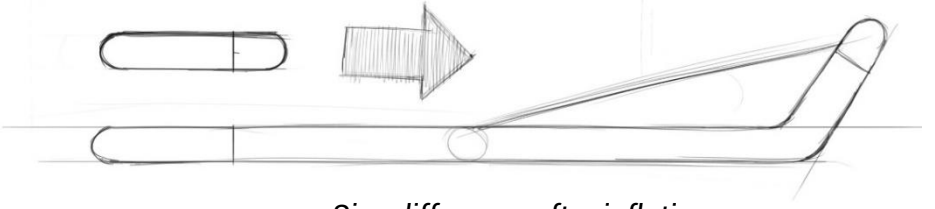
Inflation process



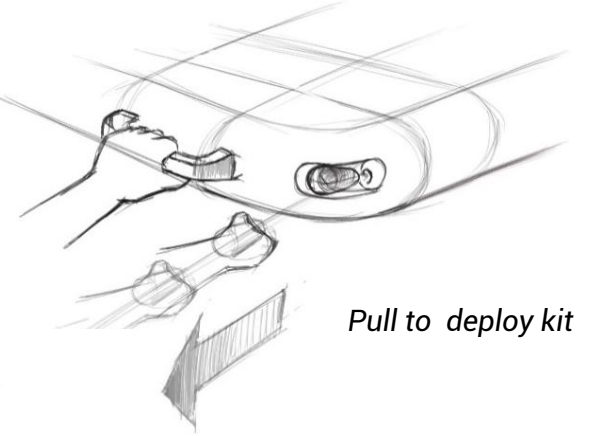
Form of the kit



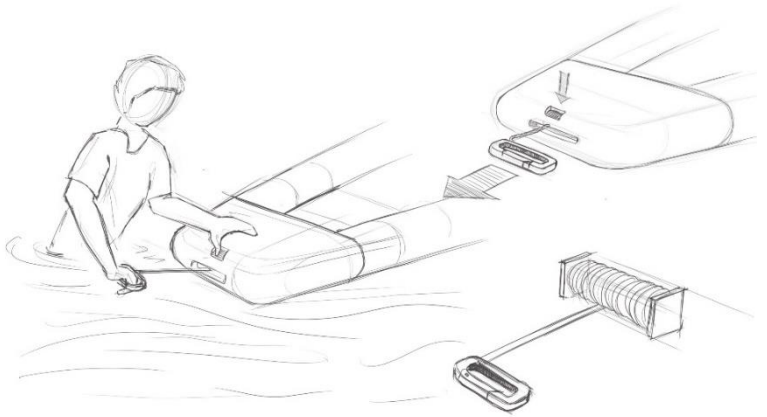
Top view of deployed kit



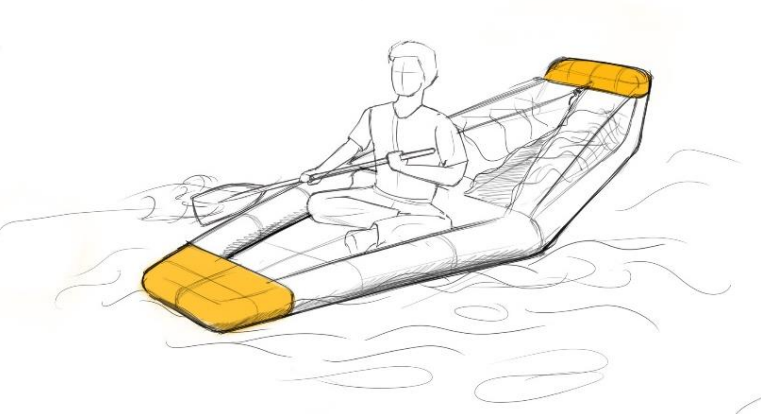
Size difference after inflation



Pull to deploy kit



Hook arrangement for anchoring

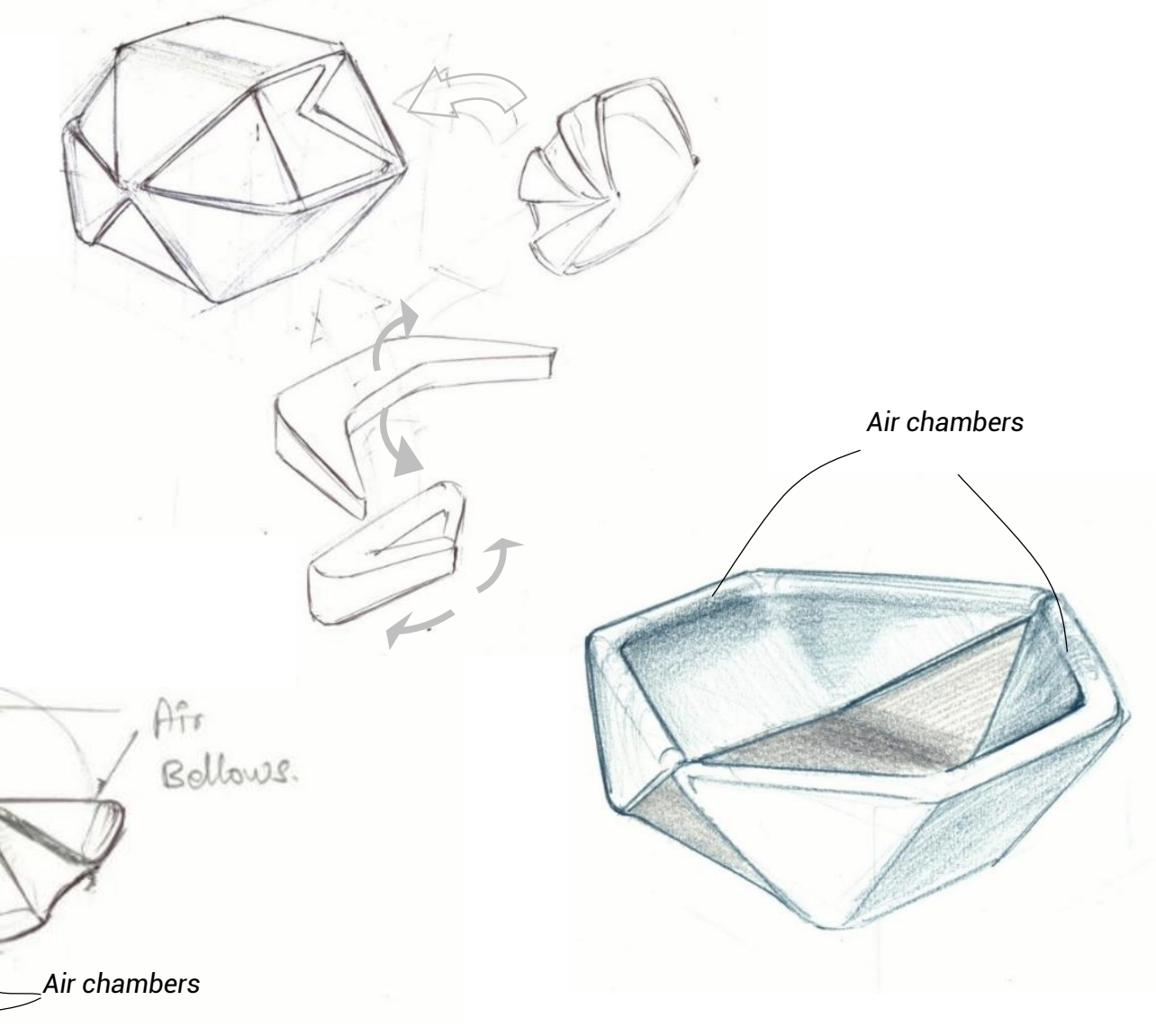


Both directional mobility

Foldable rain cover

Inspiration: Coracle

#2 Hexagonal inflatable floating device

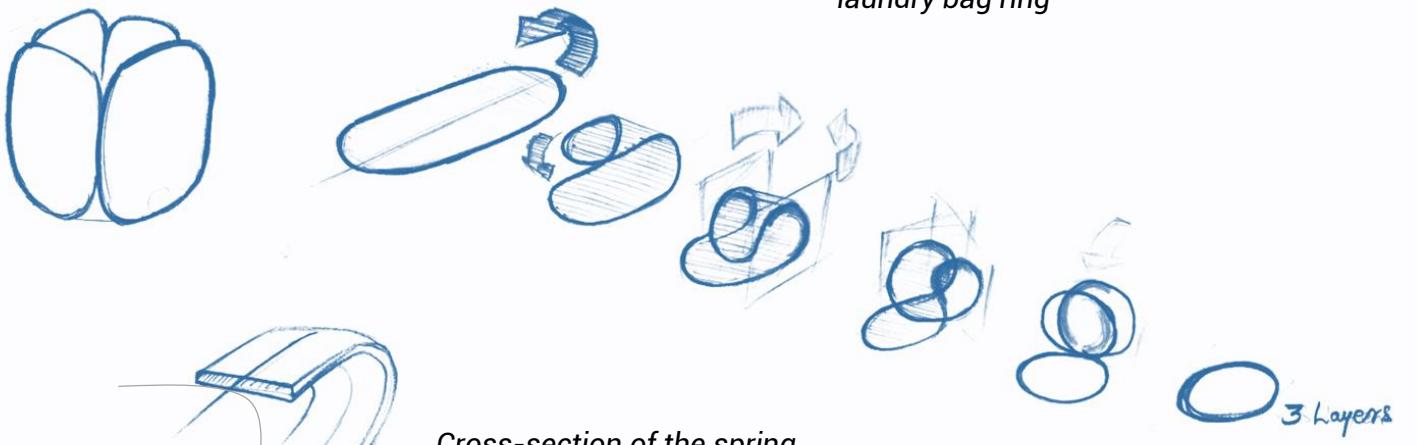


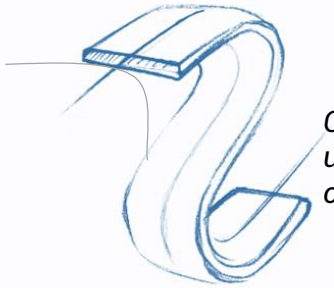
Inspiration : Laundry bag

Laundry bag

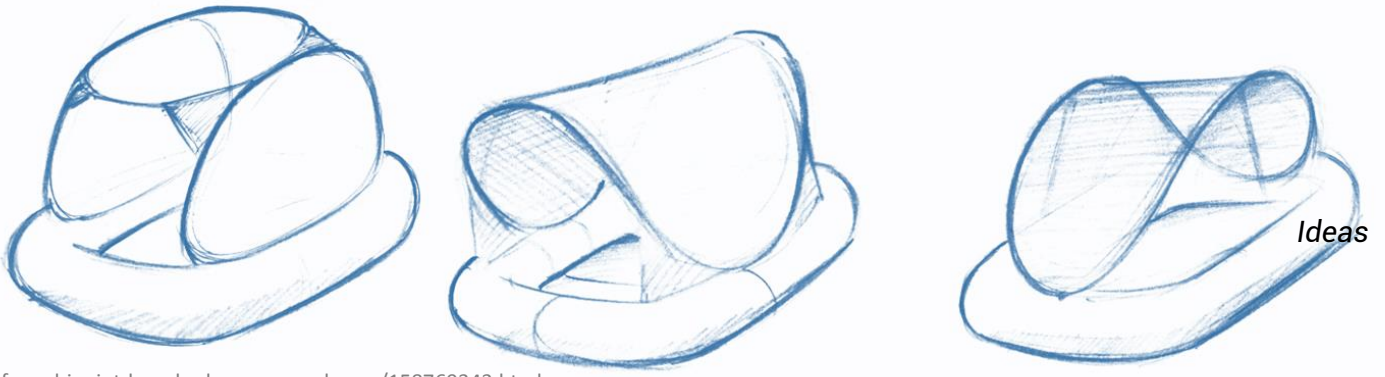
#3 Inflatable

Stepwise folding process of laundry bag ring





Cross-section of the spring use din laundry bag for collapsibility

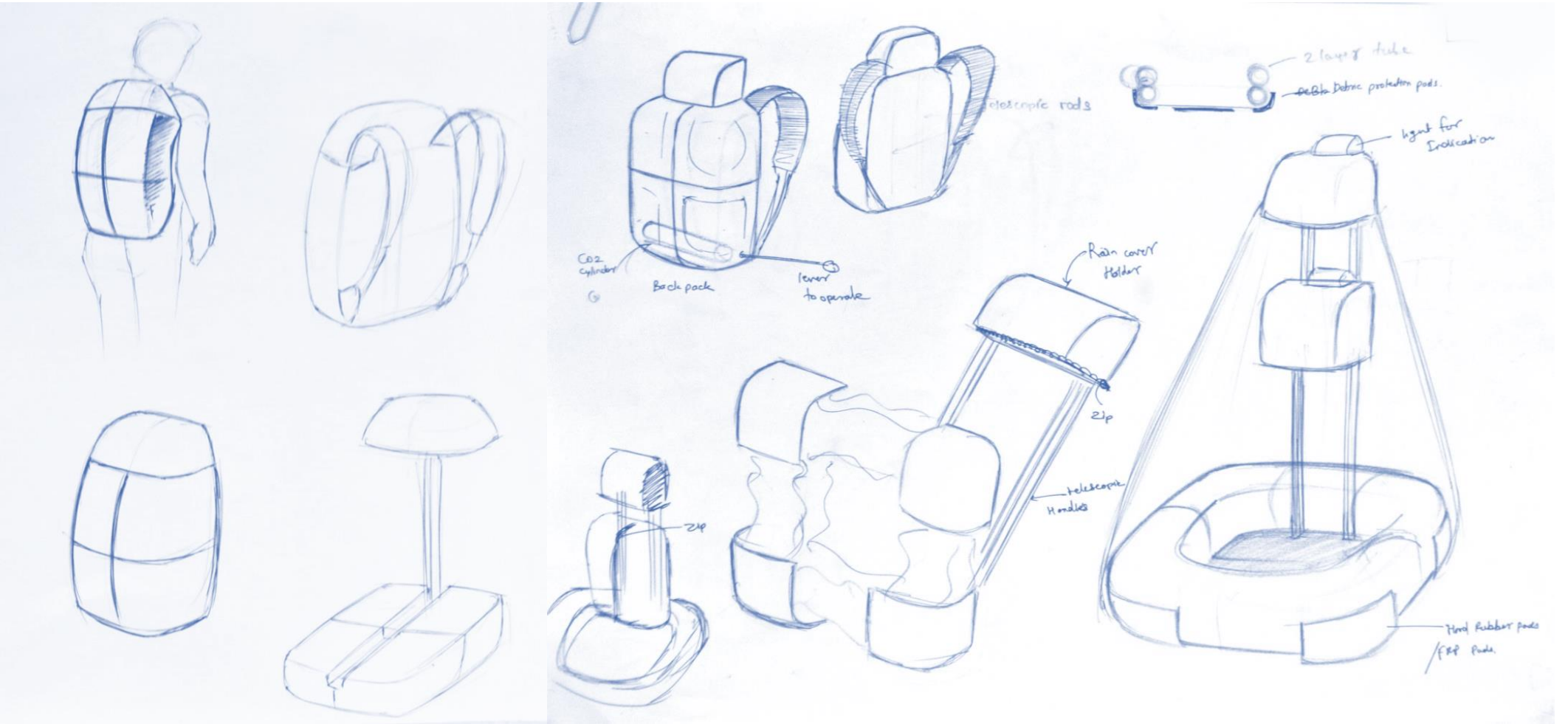


Ideas

http://www.dhgate.com/store/product/20pcs-free-shippint-laundry-hamper-mesh-pop/158769343.html

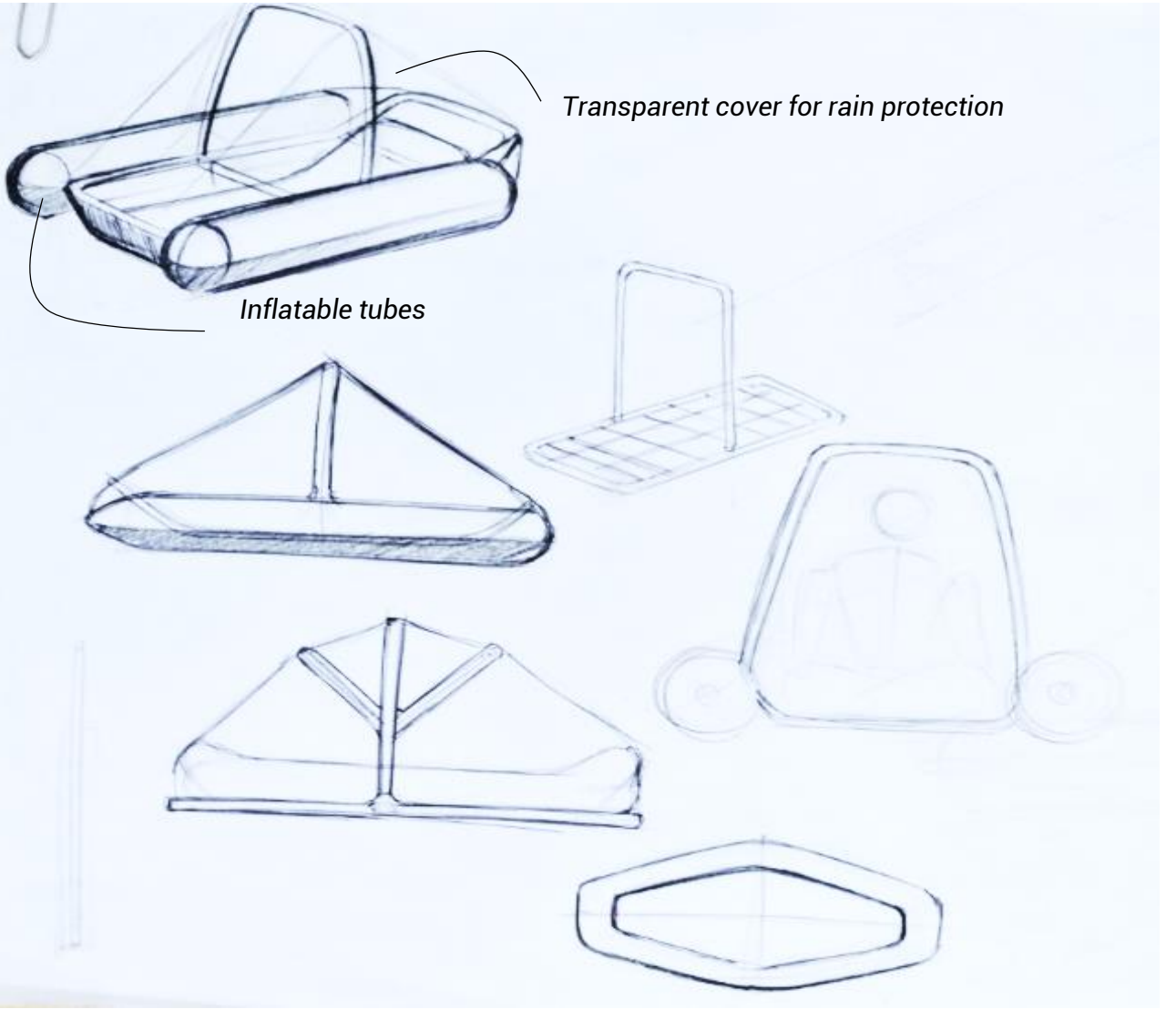
#4 Telescopic Backpack

The idea is to design a backpack which will inflate with CO2 cylinder and will form the float. It will be wearable and the telescopic head will consist transparent rain cover for rain protection

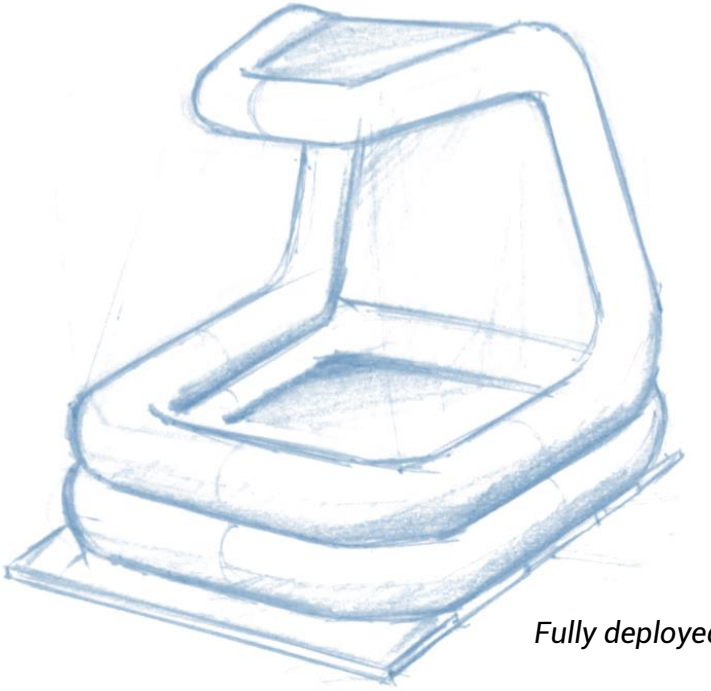


Inflatable tabular tent

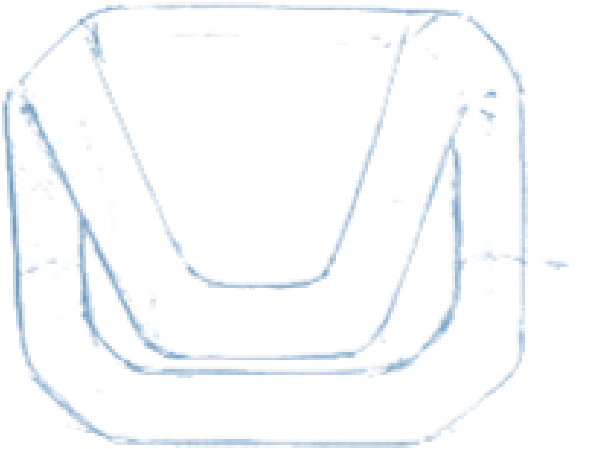
#5 Inflatable roof



#6 Inflatable roof

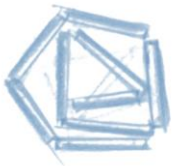


Fully deployed kit

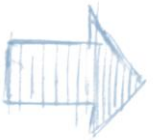


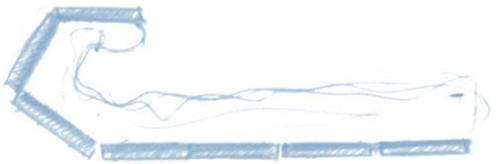
Top view

Infatuation process of float

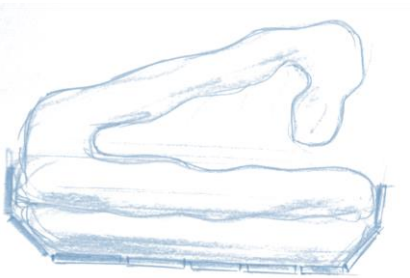


Wooden planks in rolled form

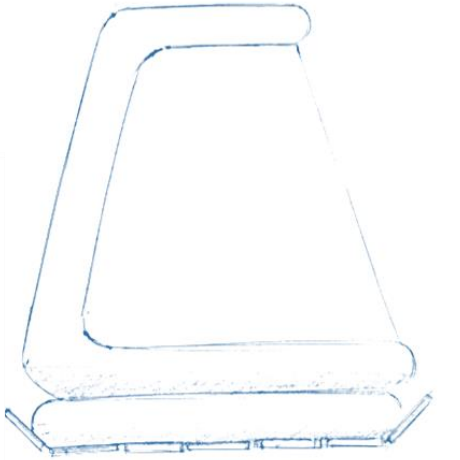




Unrolling of wooden planks



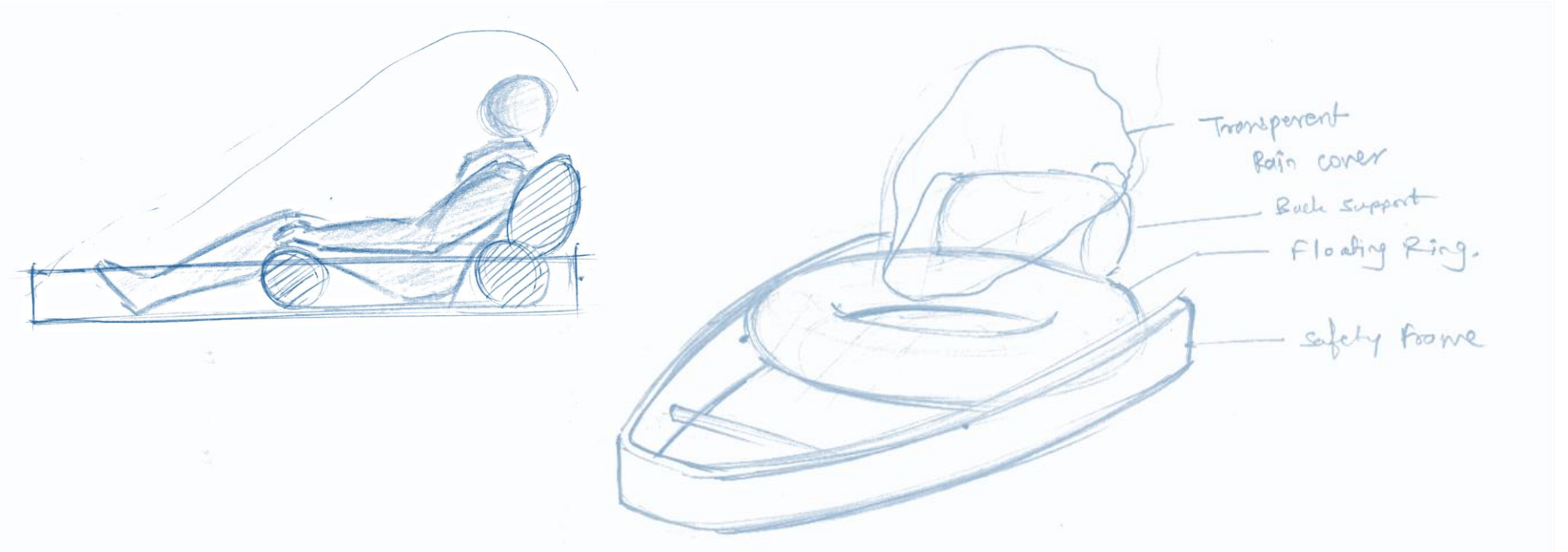
Inflation of rubber tubes



Inflatable tubes

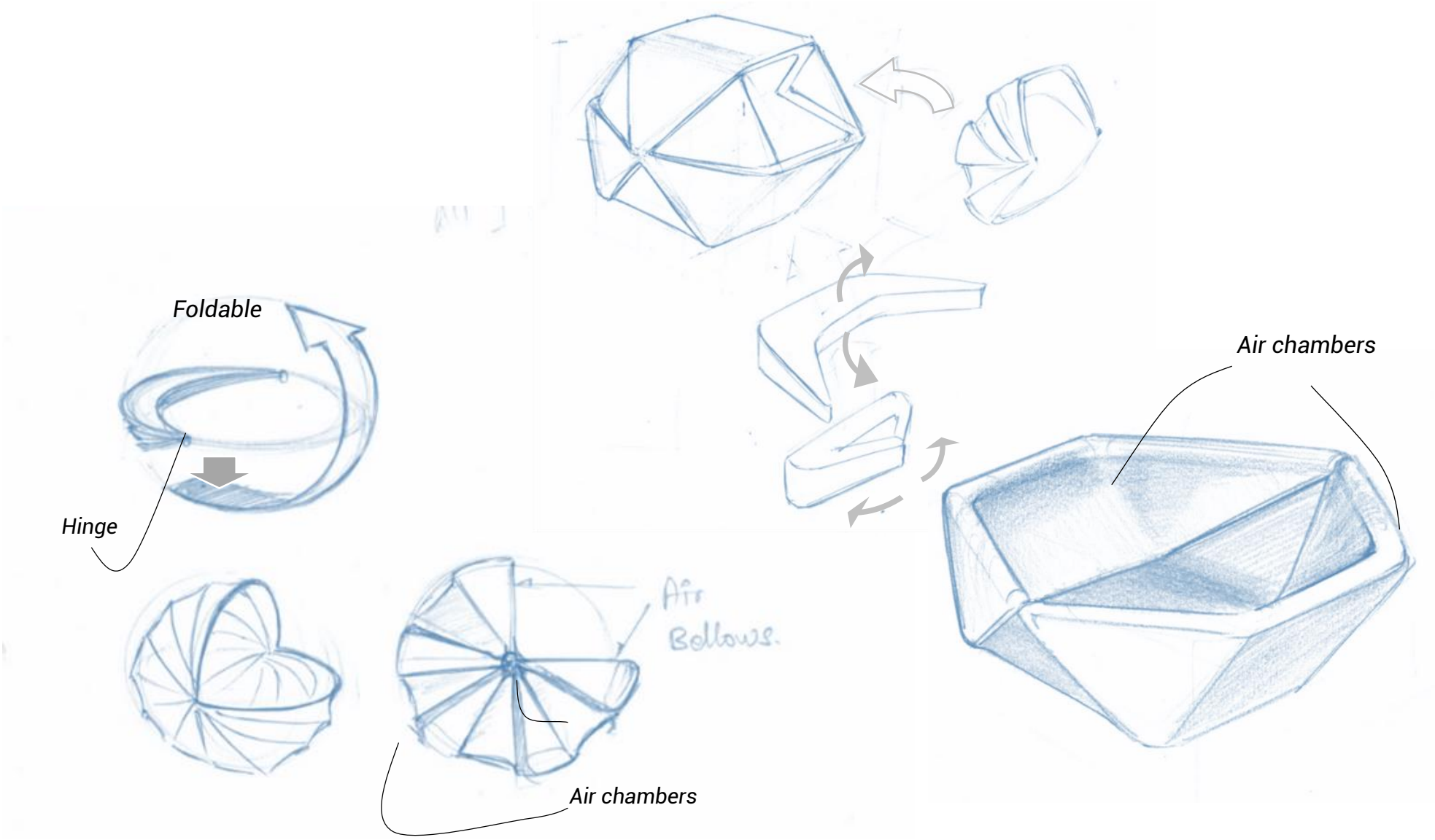
Inspiration : swimming pool hair headphones

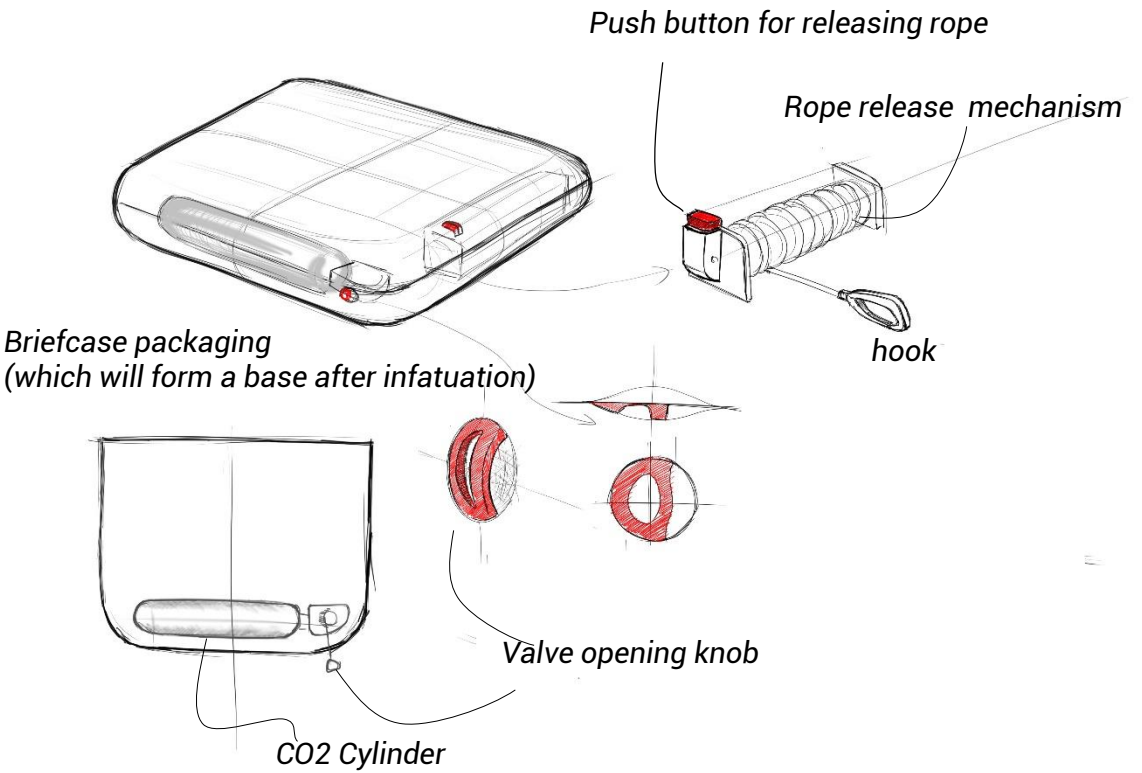
#7 Railing support

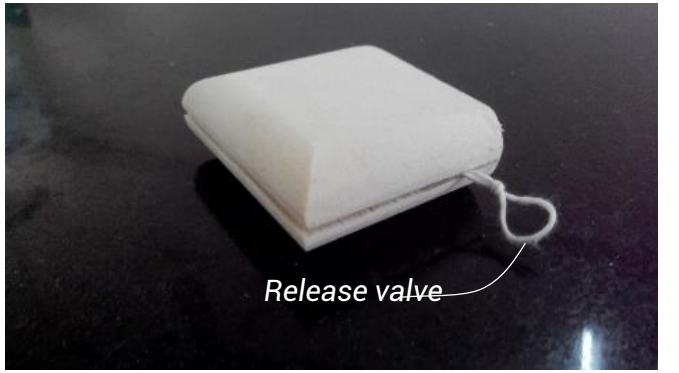


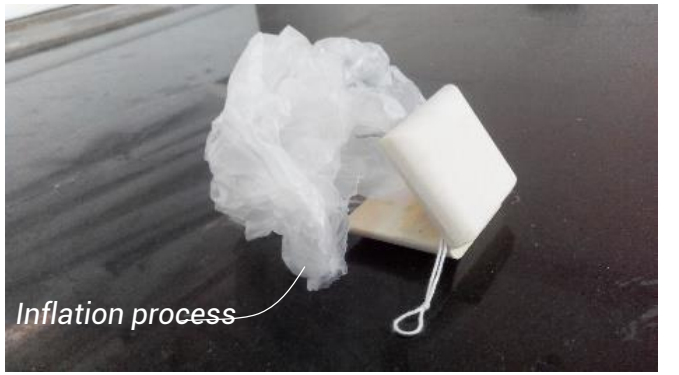
6.3 Concepts

Concept 1 : Hexagonal floating device




Push button for releasing rope
Rope release mechanism
hook
Briefcase packaging
(which will form a base after infatuation)
Valve opening knob
CO2 Cylinder

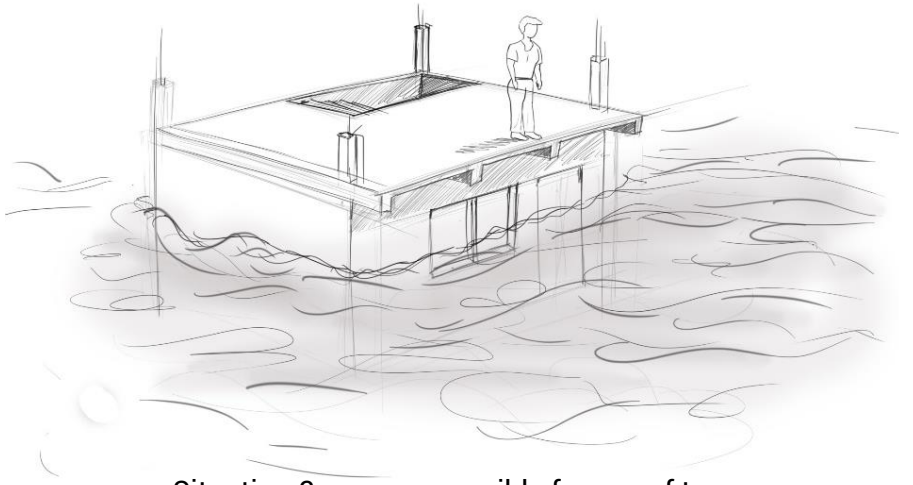

Release valve


Inflation process

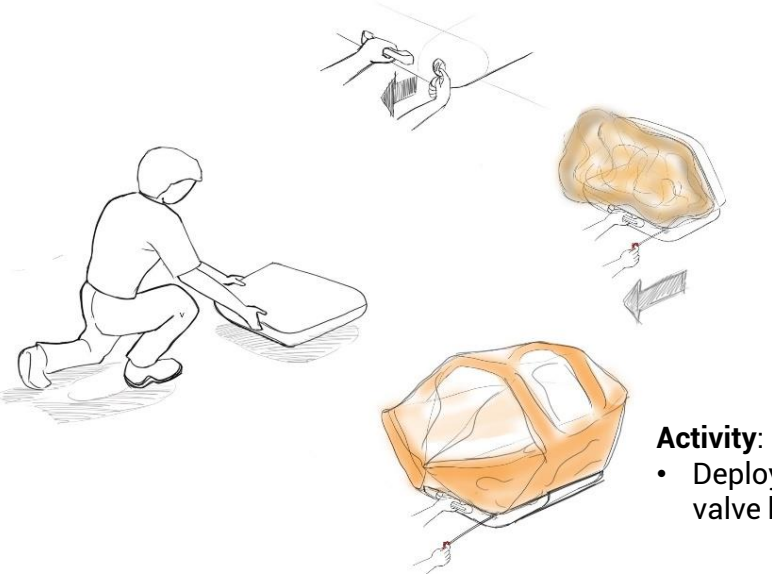

Completely deployed kit

Situation 1 : rescue possible only through window

Activity:
- Tie kit rope to the strong structural member
- Deploy kit outside the house when water level is near to the window sill

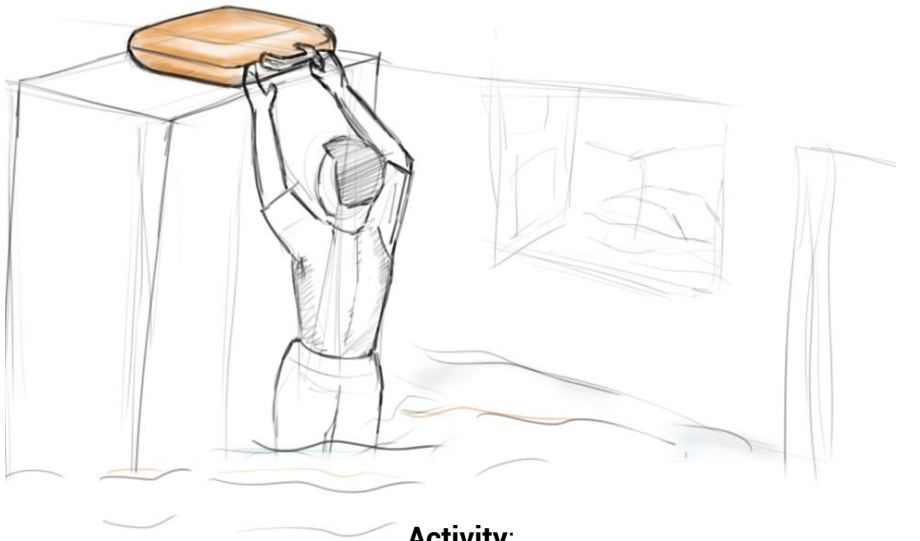


Situation 2 : rescue possible from roof top



Activity:
- Deploy kit by pulling valve knob

Situation 3 : when water starts rushing into the house

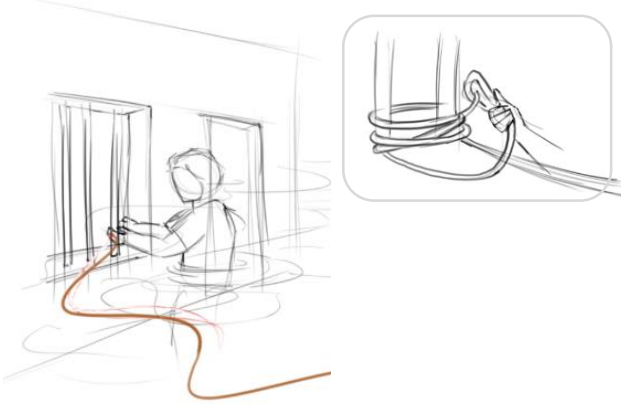


Activity:

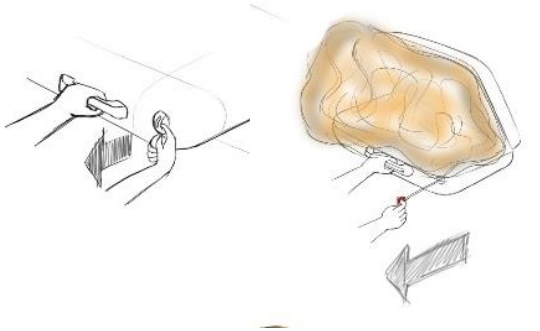
- Deploy the kit outside the house as soon as possible

Illustration of activity of deployment of kit

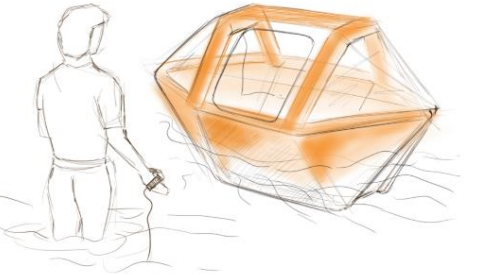
1 Tie rope of the kit to the safe place with the help of hook



2 Release the knob by pulling it

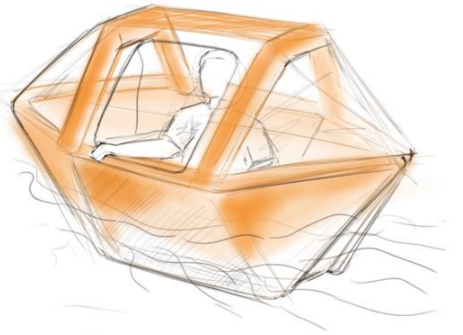


3 Pull out the kit with rope



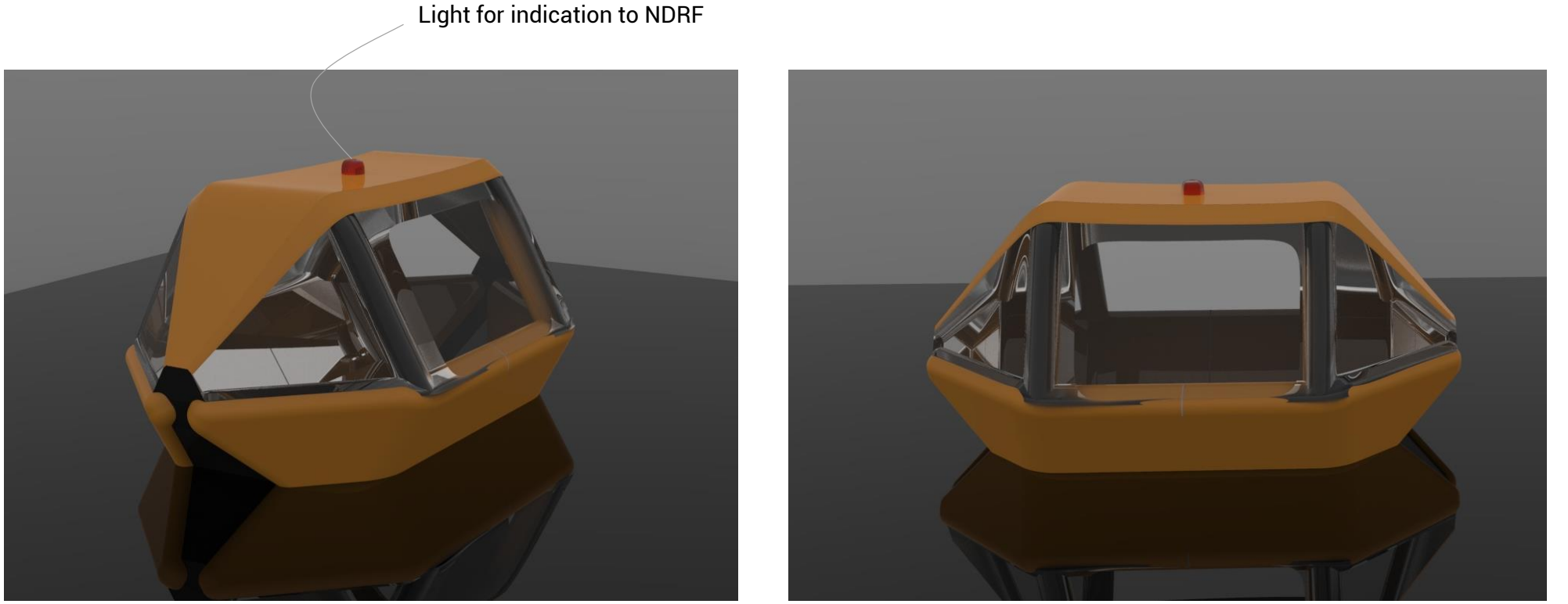
4 Slide in to the kit

5 Turn around to get in



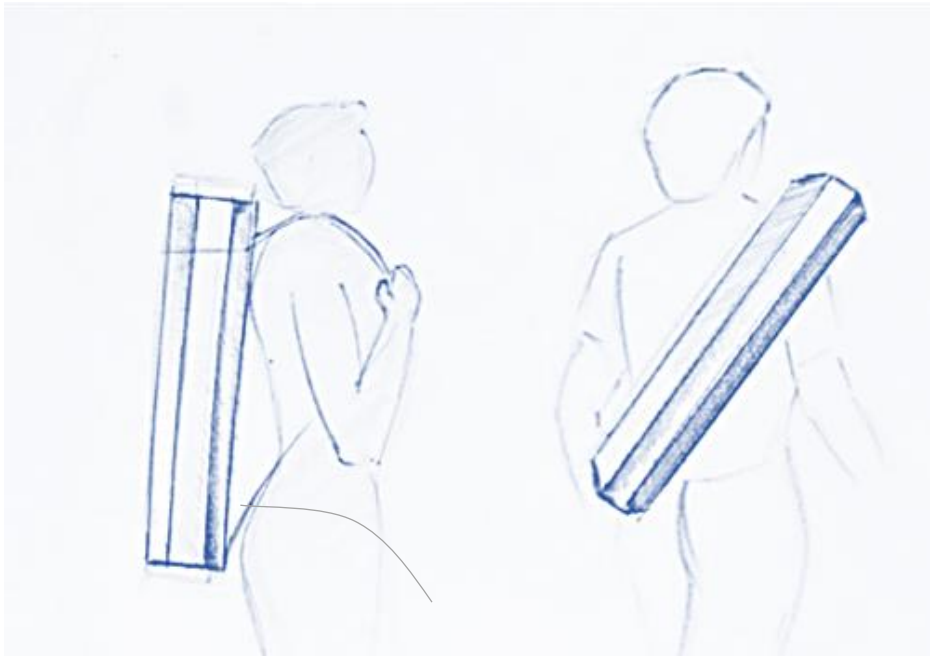
6 Zip on to close rain protection cover

7 Mobility with the help of pedals

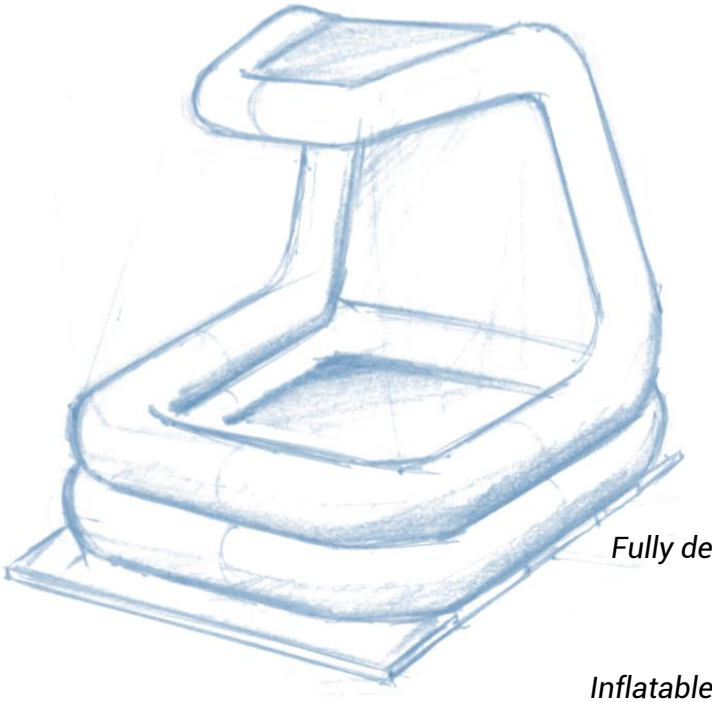


Digital model

Concept 2

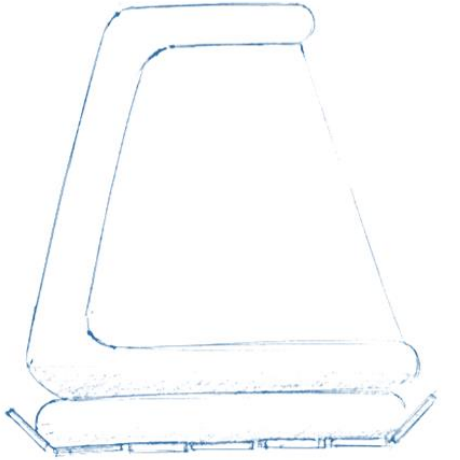


Kit in folded form

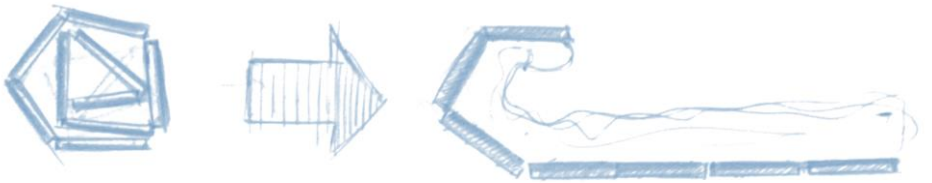


Fully deployed kit

Inflatable tubes

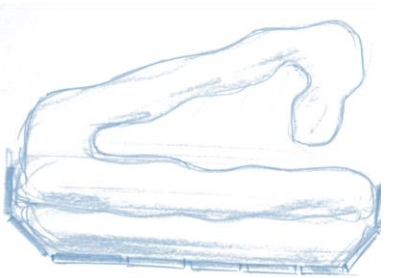


Infatuation process of float

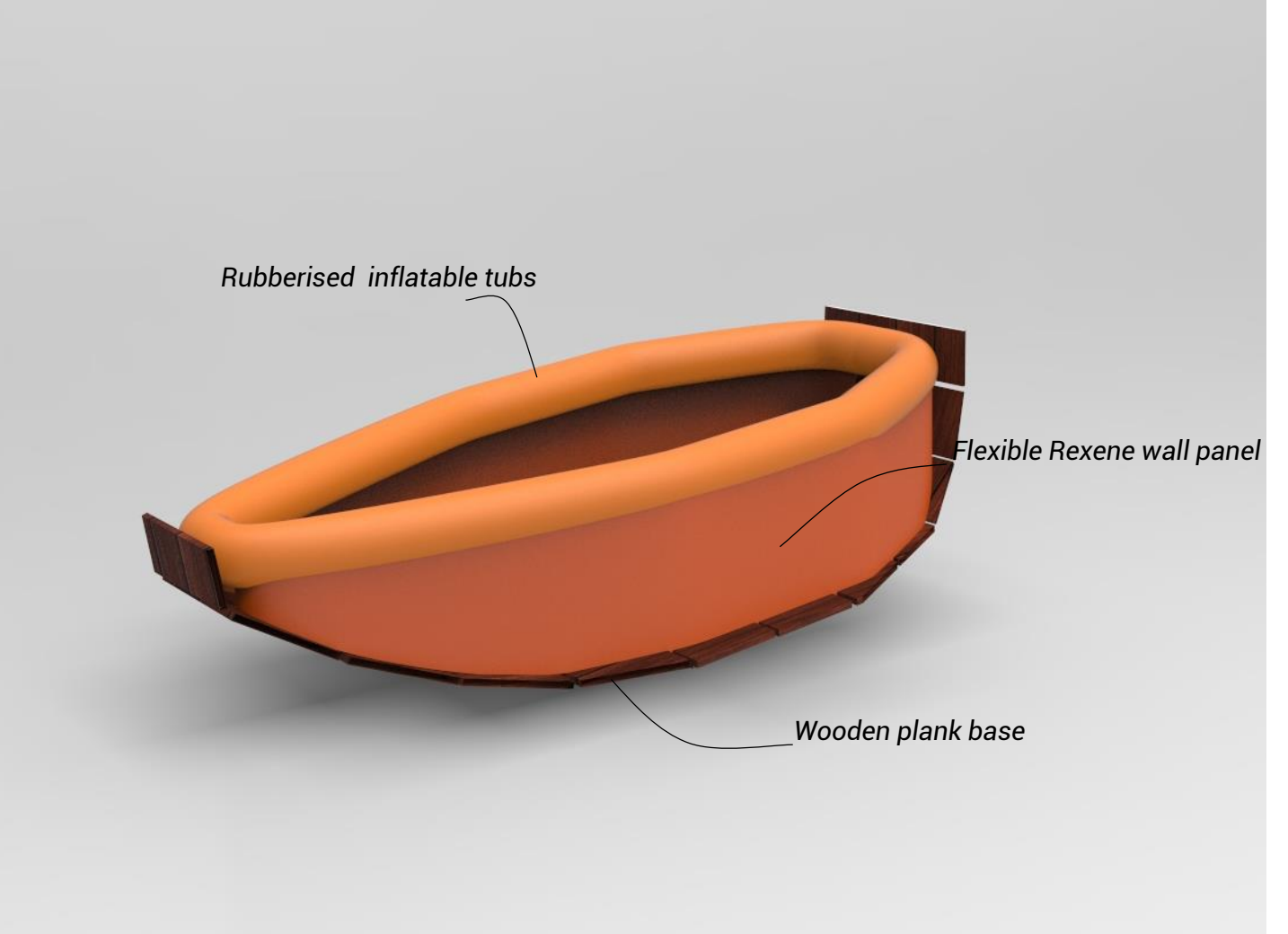


Wooden planks in rolled form

Unrolling of wooden planks



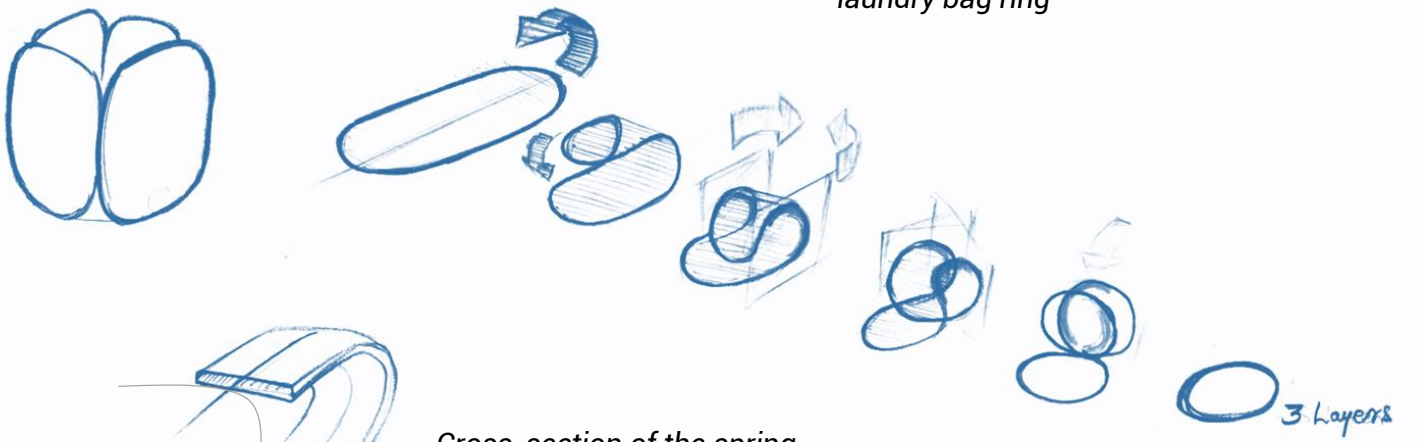
Inflation of rubber tubes

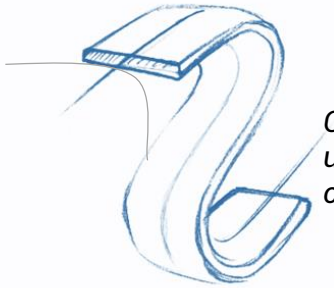

Rubberised inflatable tubs
Flexible Rexene wall panel
Wooden plank base

Concept 3

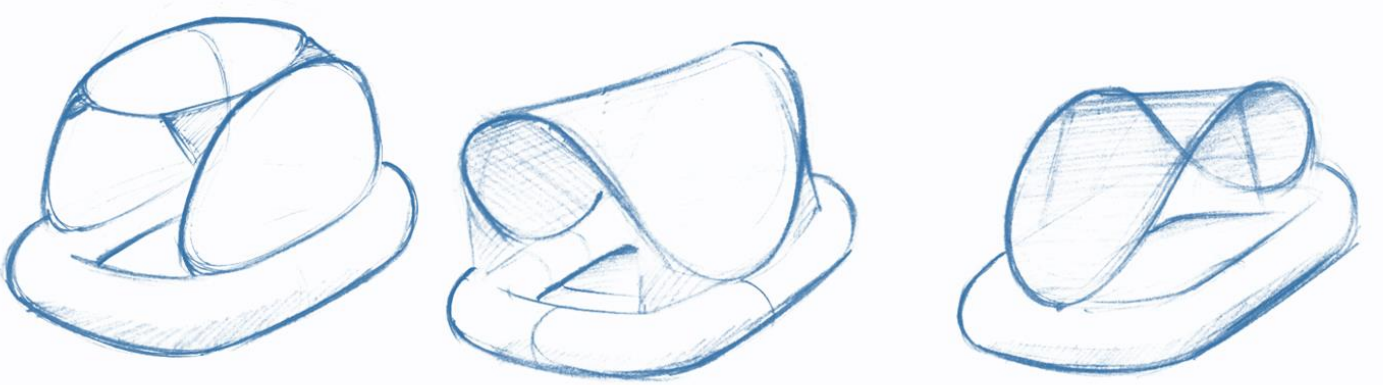
Laundry bag

Stepwise folding process of laundry bag ring

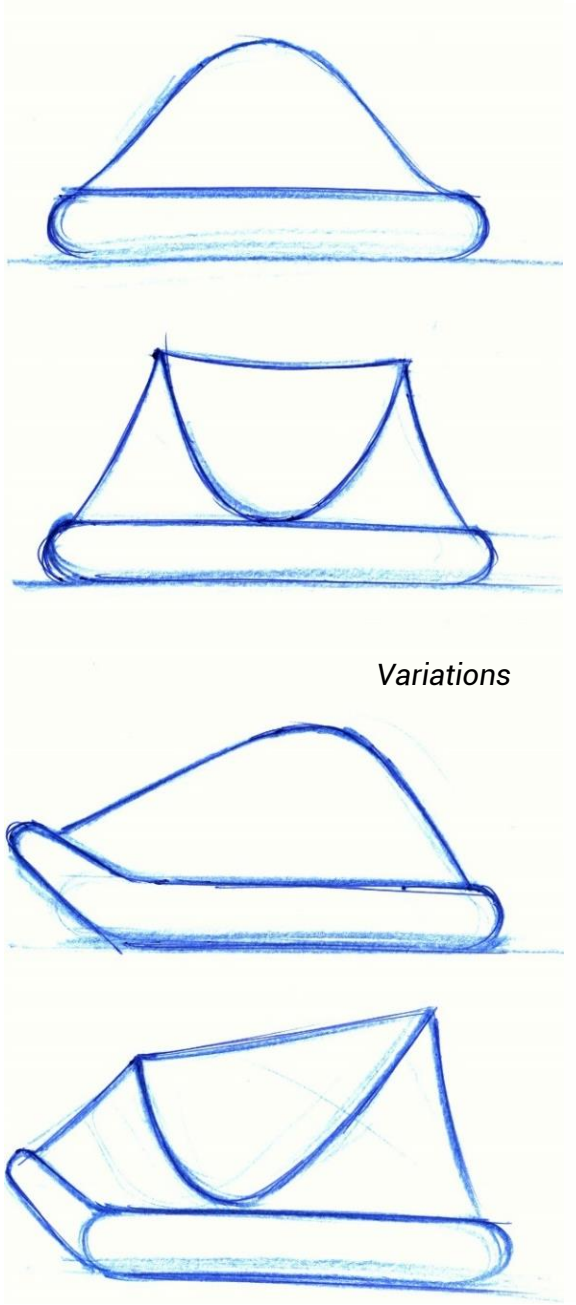




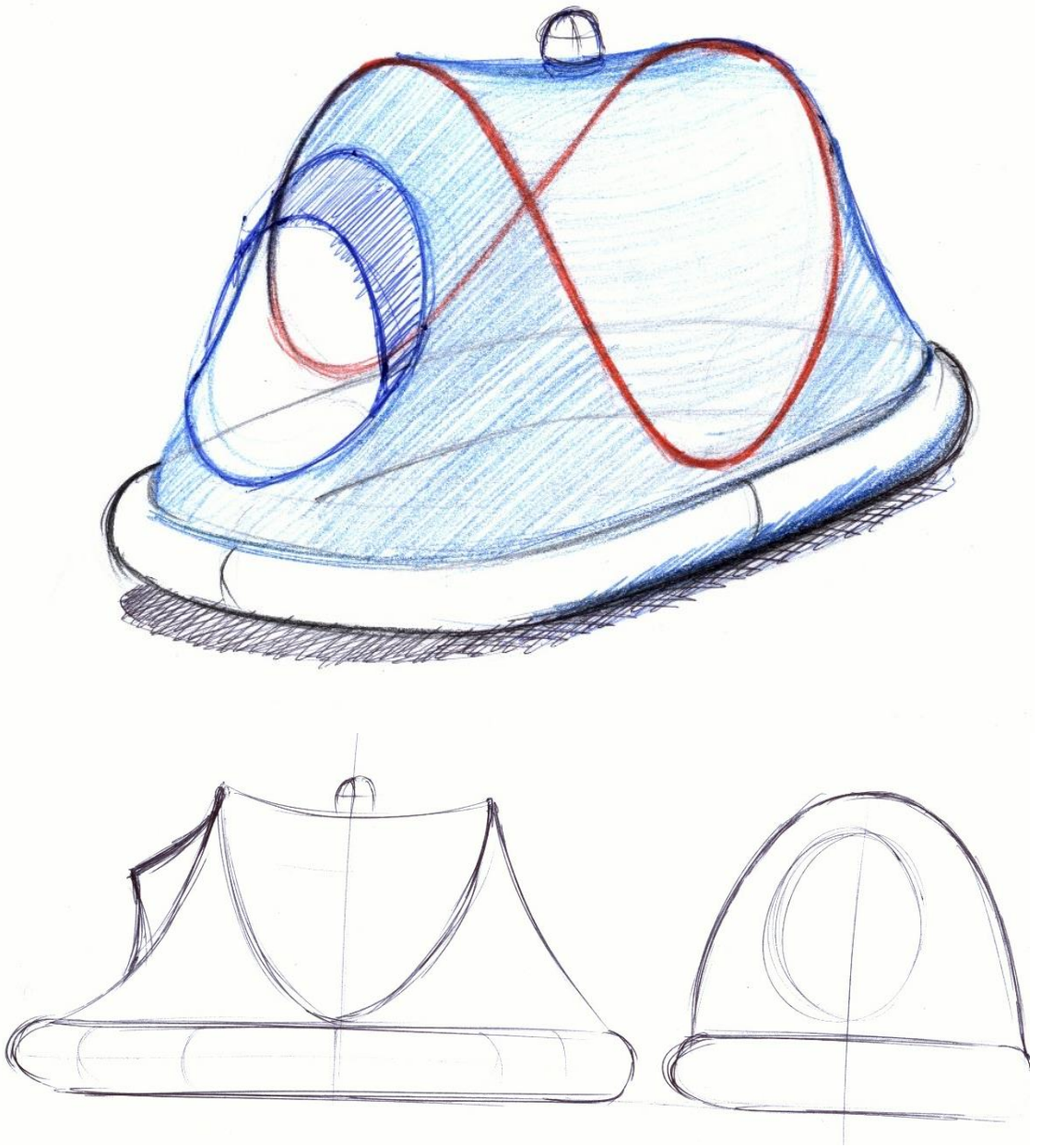
Cross-section of the spring use din laundry bag for collapsibility

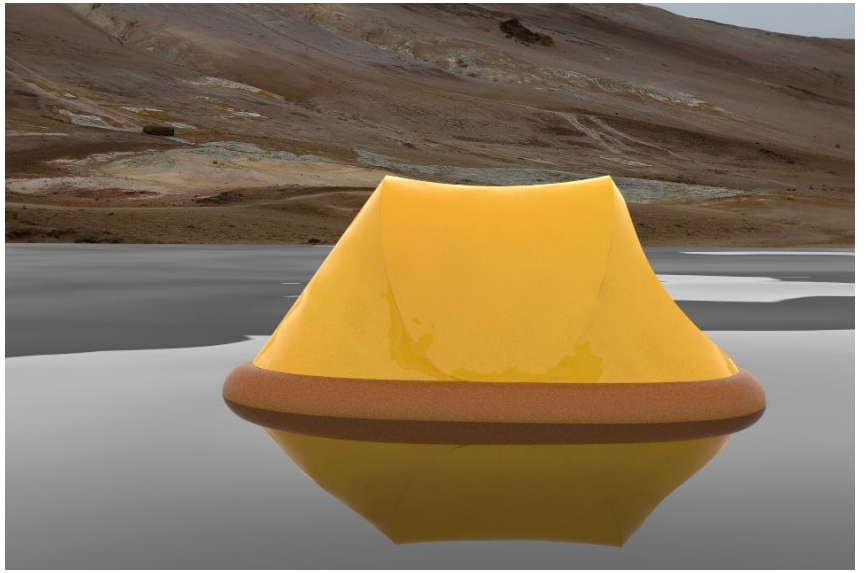


http://www.dhgate.com/store/product/20pcs-free-shippint-laundry-hamper-mesh-pop/158769343.html



Variations





Digital models

Physical mock-up model

Co. Alok Avasthy
(Commandant 5th Bt. NDRF)

NDRF Personals attending presentation

6.4 Feedback from NDRF

The 3 concepts were taken to the NDRF personals for review. Based on their understanding about the product and experience in flood situations they suggested the following

Issues to be addressed critically

1. Toppling of kit during ingress and egress
2. Strength of the anchoring rope
3. Cost of the product should be minimum
4. Protection from debris and harmful objects in water is essential.
5. Demonstration and activity or stepwise procedure need to be explained.
6. Building confidence and trust is important.

Suggestions

1. Try to accommodate 2 people minimum because people will have their children's also
2. To install a sensor or something which will give signal to us when the kit is deployed (as this kit is to be meant for flood, it will help to track people. And also in rescuing in night
3. Provide manually operated pumps so that it is possible for them to do it themselves
4. Suitcase or a hard base will be a better idea as sometimes floating derbies like tree can damage the inflatables, also mud and insects, water animals can cause injuries.

Insights

1. People in Assam prepare themselves for flood (by learning swimming, making Improvised Flotation Device's).
2. They also experiments with different floatation devices at their own. There is a definite need.
3. Life jacket is not very helpful in flood situations.
4. Elderly must have dry kit.
5. Majorly it will help elderly a lot who don't know how to swim.

Good points

1. Its an very innovative concepts
2. It will give relief to use also
3. People in Assam makes improvised floatation devise at their home. They will definitely use such kind if kits
4. Will be very helpful in scenarios like Kashmir
5. Idea of whistle and Overhead light is very good to identify

6.5 Feedback from Stage 3

- Ingress and egress into the kit when it is deployed is very difficult.
- Stability wont be there in flood water.
- There are no constraints in the design brief in terms, its open ended.
- Jumping into the kit will not be possible

Suggestions:

- Make it wearable and attached to the body while getting into the water.
- Focus primarily on keeping persona alieve.

6.6 Redefined Design Brief

Objective :

Design of a victim centric **self rescue kit** for an individual in urban flood scenario

Key points :

Rescue a person and keep him alieve

Individual floatation device (Non motorised or propelled)

Wearable and portable (foldable)

Mass producible rescue kit

Price within (approx. 1000-1200 Rs)

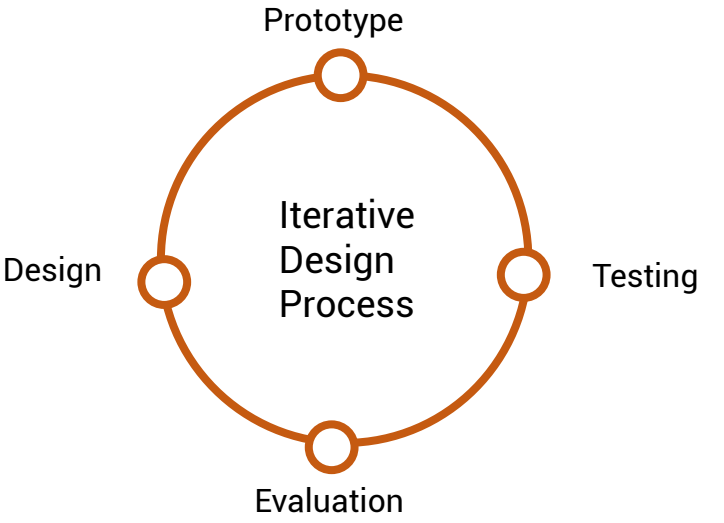
Features:

- *Rain Cover*
- *Deployment within 30 sec*
- *Lightweight (less than 5 kg)*
- *Indication to the rescuers*
- *Size – approx. length of 1 person*
- *Prevention from drifting away– provision of rope with hook*
- *Protection from debris*

7. Concept refinement, Prototyping and testing

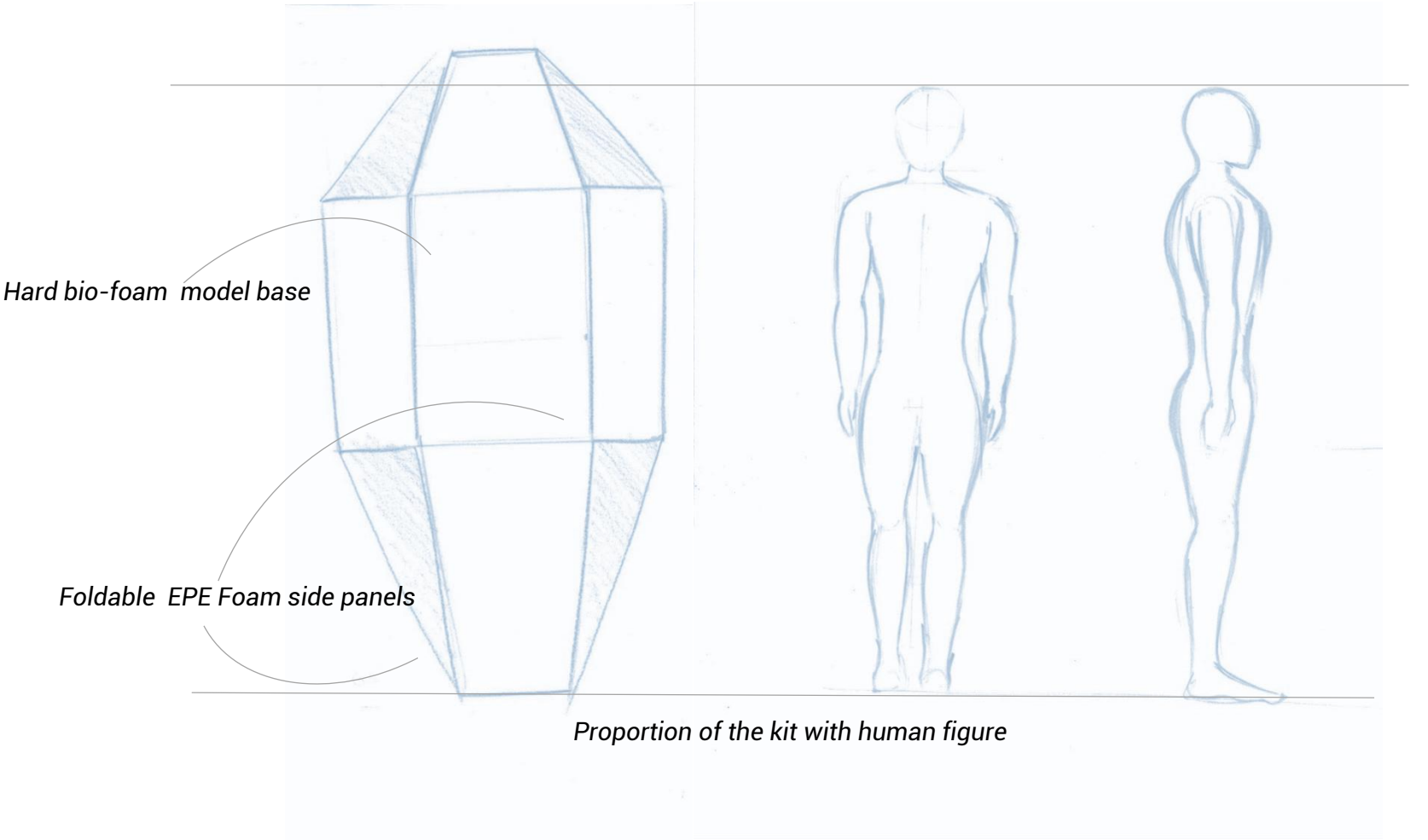
7.1 Iterative design process

Iterative design is an approach of incrementally developing and refining a design based on feedback and evaluation. Based on the results of testing the most recent iteration of a design, changes and refinements are made. This process is intended to ultimately improve the quality and functionality of a design.



7.2 Iteration 1

Testing for floating and seating posture



Proportion of the kit with human figure

Unfolding of kit

Activity of deployment of kit

Leaning Backward Position

Leaning Backward Position

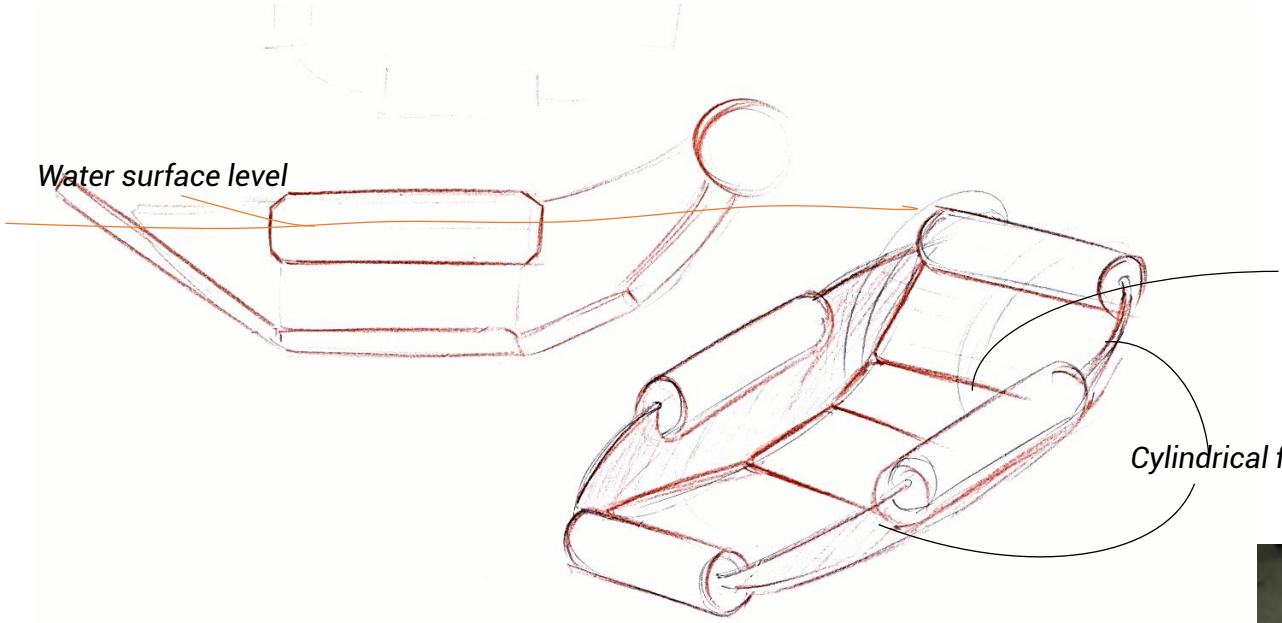
Seating Position

Insights from water testing

- Kit is more stable in leaning position whereas when person tries to be straight kit becomes unstable. Use of rigid foam material may solve the problem.
- It can take shape of a boat. Water mobility is easy with pedal.
- More thick material can make kit more buoyant.
- Thickness of the EPE foam required to increase to make material more buoyant
- Getting into the water is needs to be simplified.

7.3 Iteration 2

Test prototype model of kit



Testing Prototype

Stepwise deployment activity of the kit

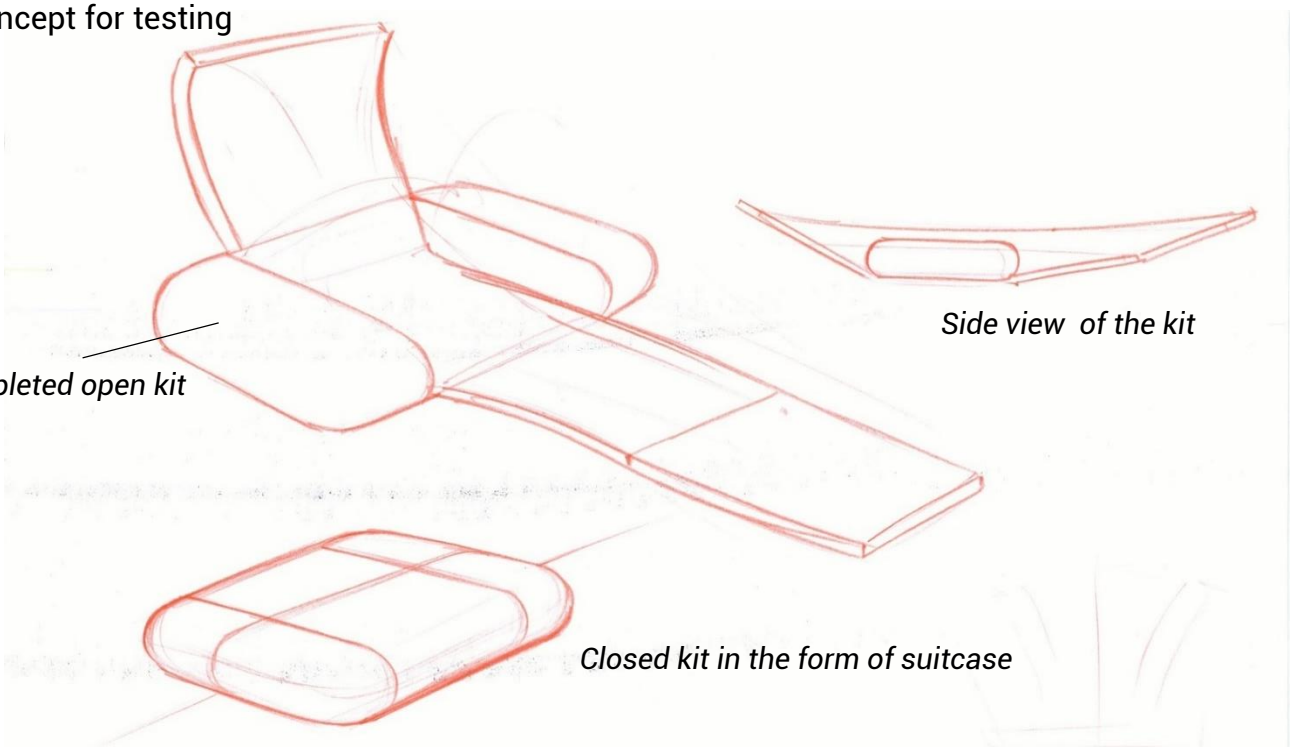
Testing for flotation of a prototype in water

Insights from water testing

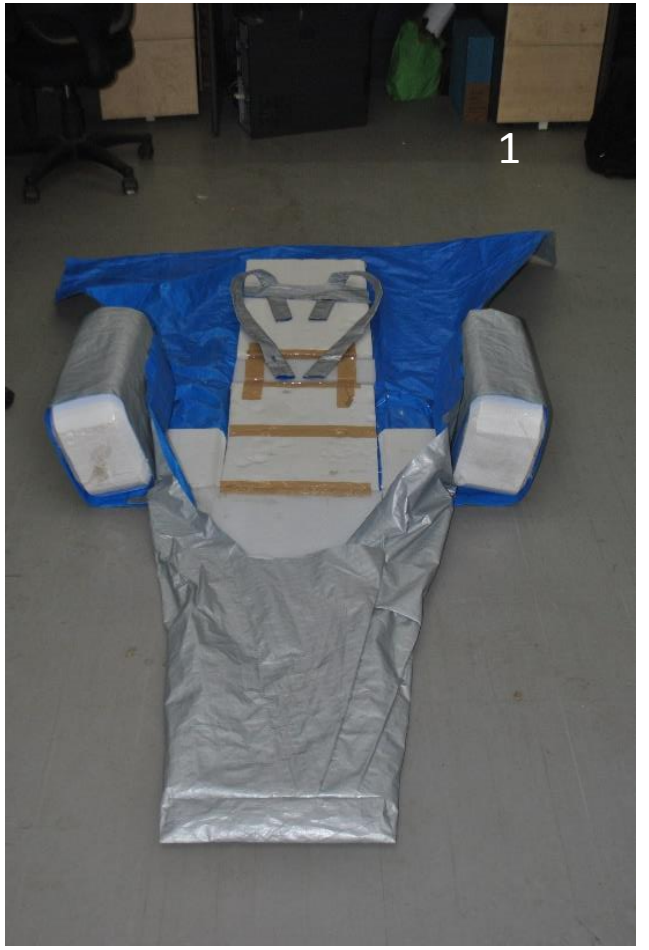
- Support for the neck is required.
- As the side float is near to the waist, harness can be used to tie kit to the person
- Multiple positions straight seating and recumbent are possible as the structure is made of a flexible material.
- More volume for the buoyancy is required.
- More stable due as the centre of gravity of the body is close to the water level.
- Water tight sealing is a critical issue needs to be addressed.

7.4 Iteration 3

Prototyping of the concept for testing



Prototype



Deployment activity

Folding activity

Testing of prototype in water

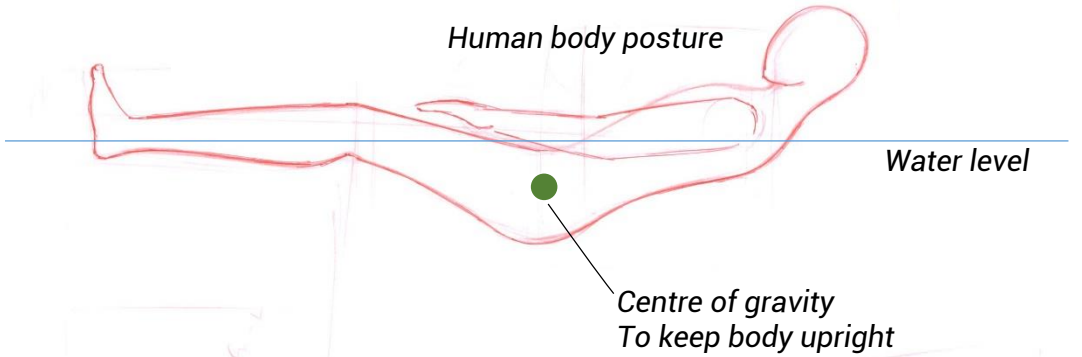
Exploration of possibilities of floating with buoyant material

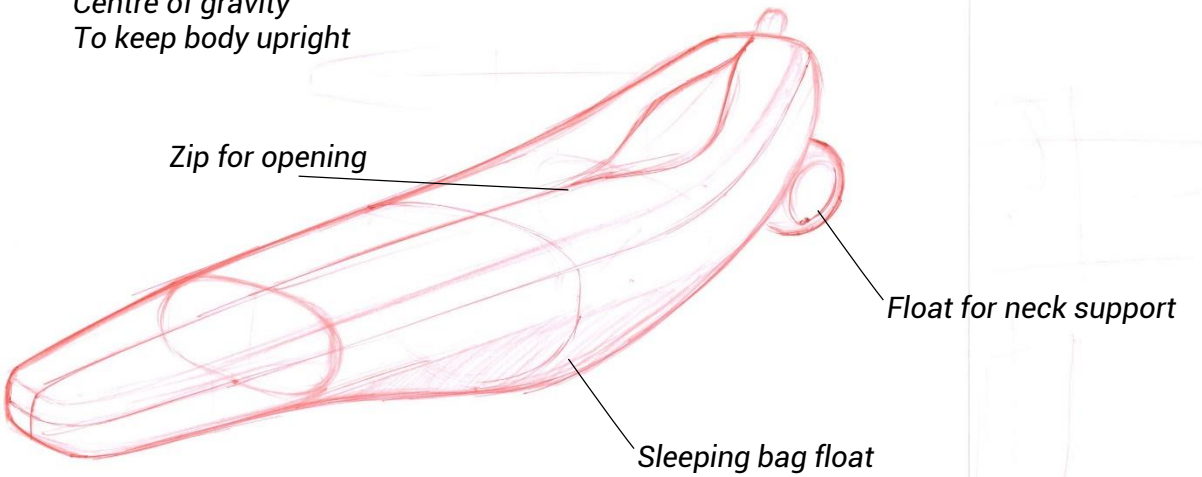
Insights from testing

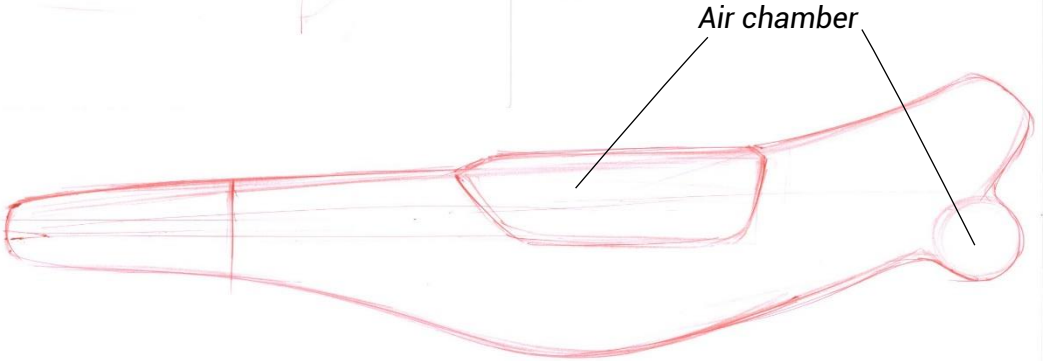
- Float was capable of taking bodyweight
- Leaning backward and sitting both position were possible
- Float need to be stretched long and pointed at the ends for better stability.
- Possibility of legs in-out need to be explored
- Head protection gear required.

7.5 Iteration 4

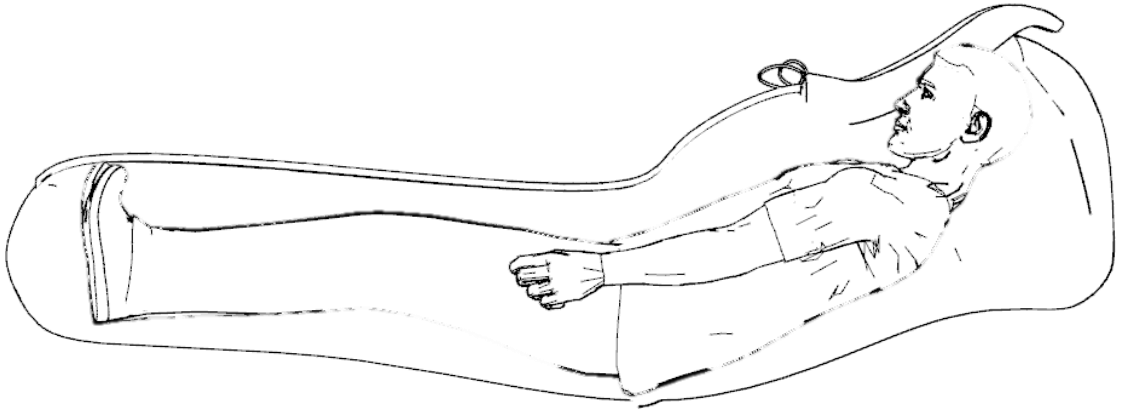
From the iteration process it is found that the best posture for balancing and prevention from toppling is the recumbent posture. Also the requirement of float is majorly below the neck support and near the cheats. These insights were taken into consideration to develop the concept with a fully packed body to prevent from rain. Also, it has possibility of sitting posture when the zip is opened.



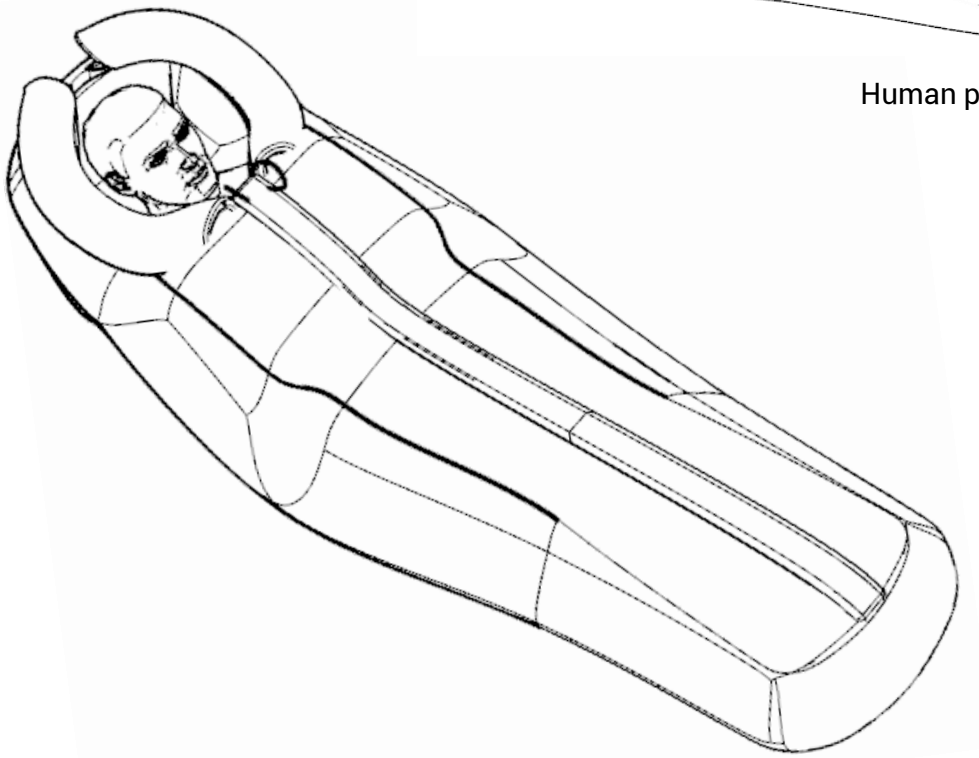


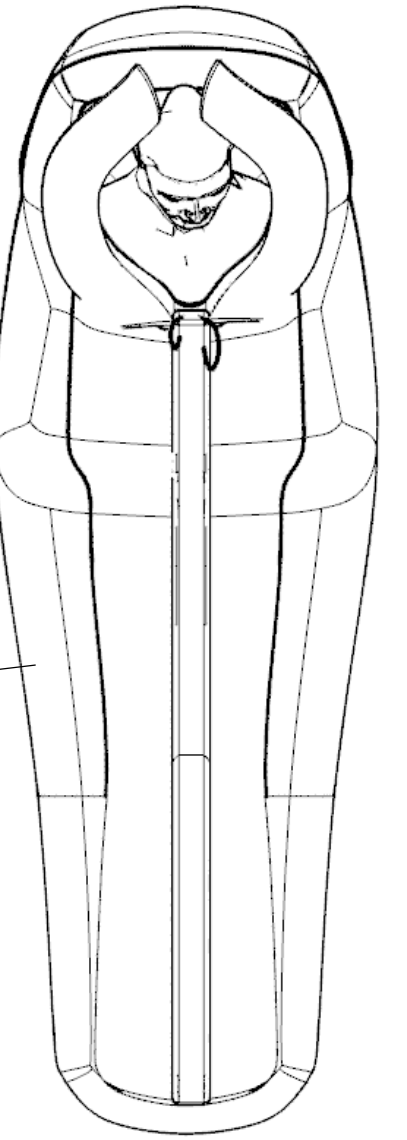


Side view

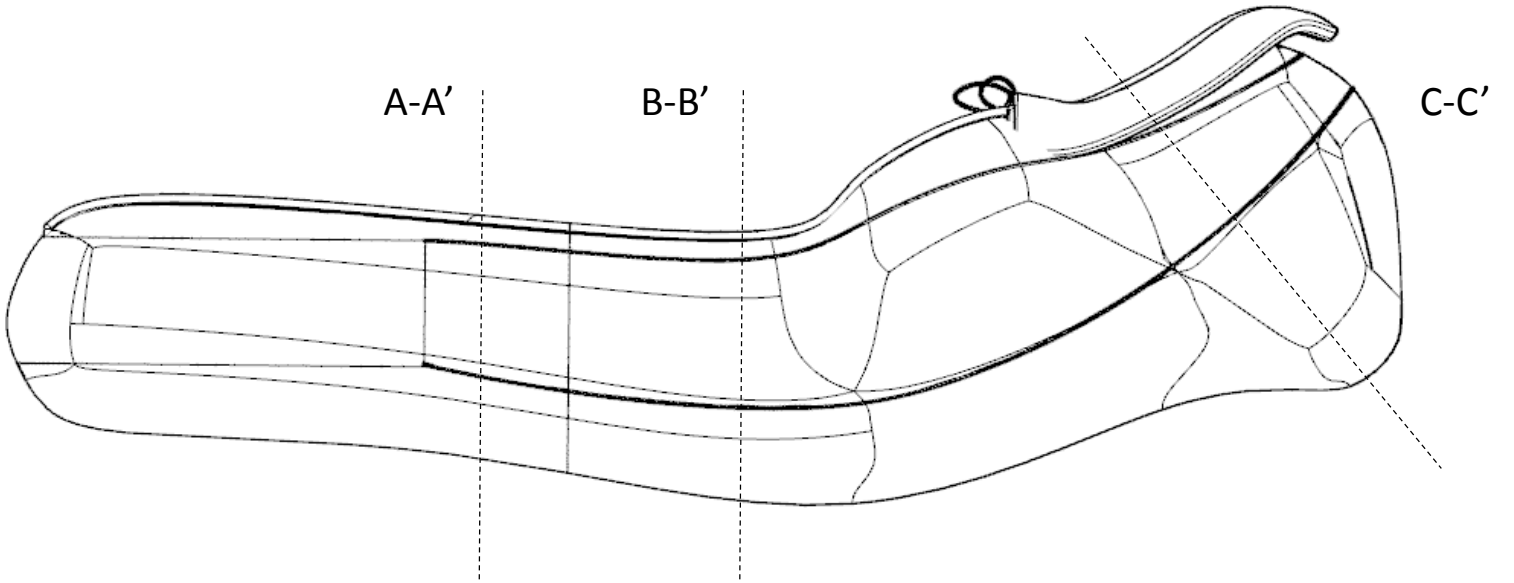


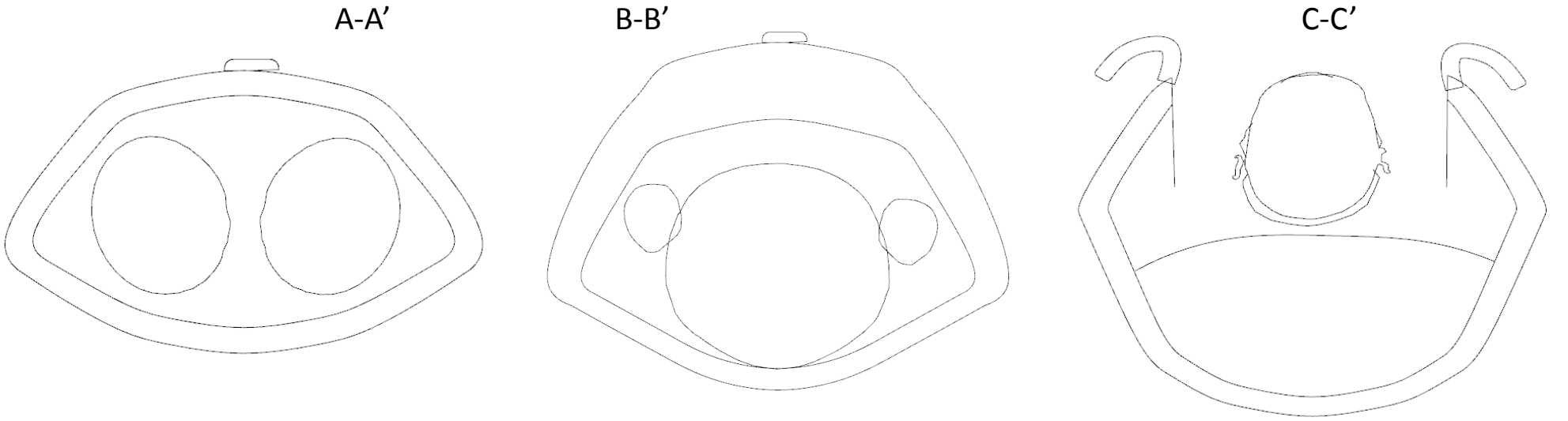
Human position inside the Kit





Side floats





Sectional views


CAD Model

Physical model

Testing

Insights

- Enclosing legs inside the bag constraints the movement and also there is no space to move body.
- Toppling resistant is not work in closed shell.
- Ergonomically uncomfortable creates back pain and stomach pain.
- Difficult to ingress and egress.

7.6 Iteration 5

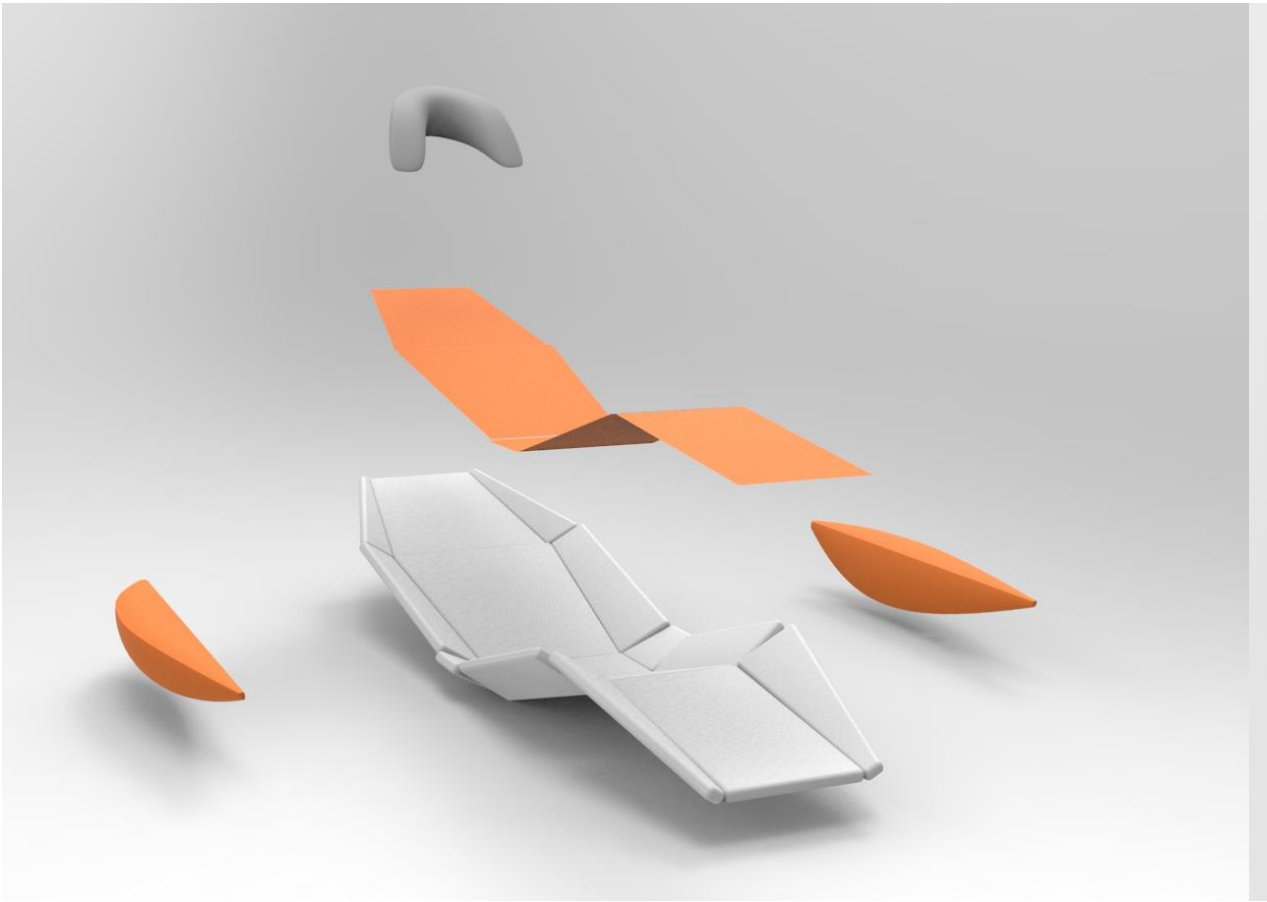
Exploration with various shapes and sizes of floats.

Exploration of possibilities of floating with buoyant material

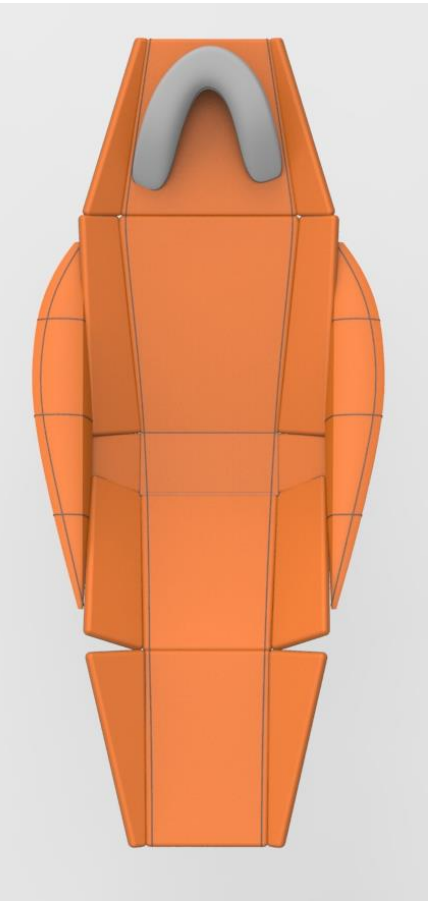
Exploration of possibilities of floating with buoyant material

8. Final Product

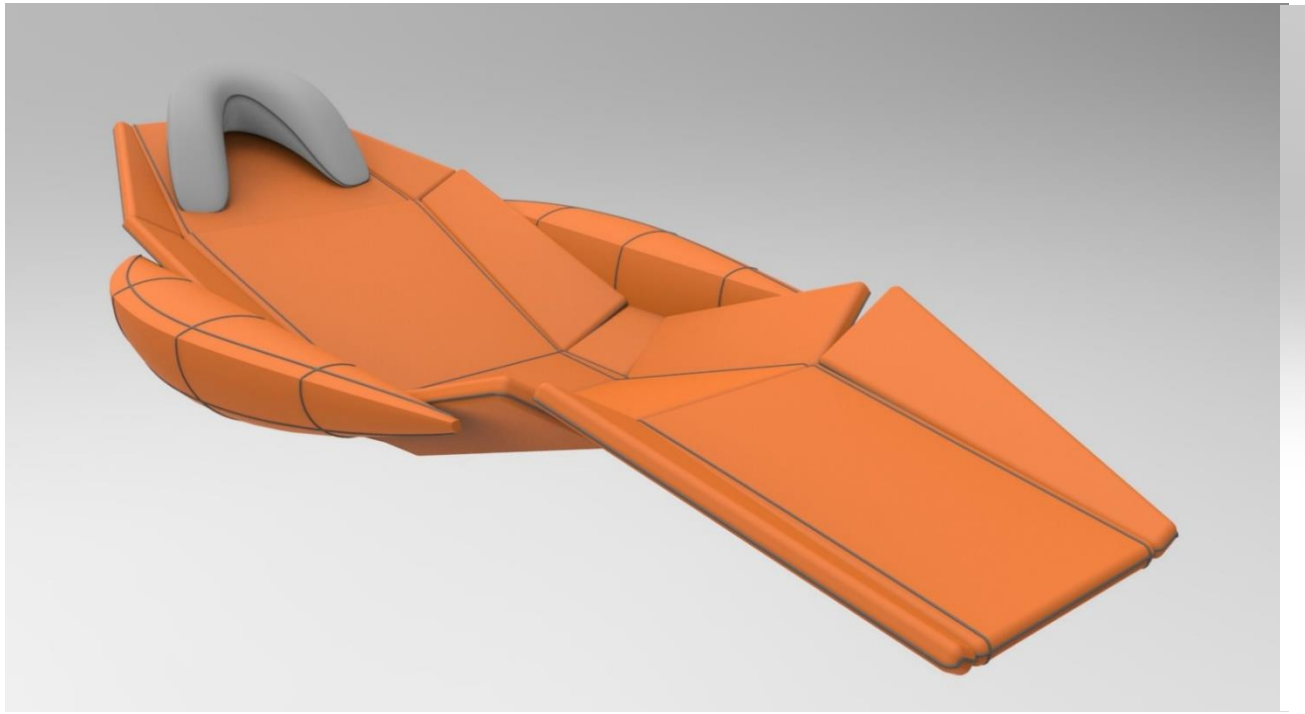
8.1 CAD model



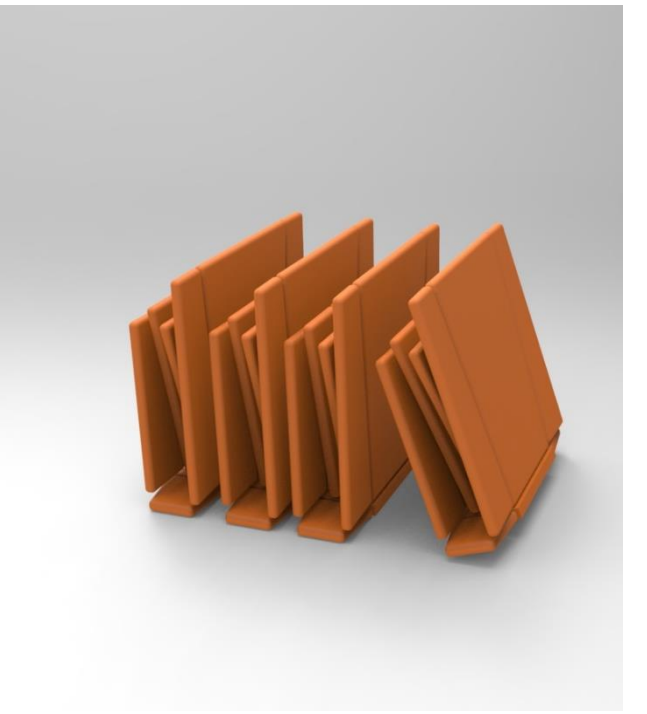
Exploded View



Float Layouts



Opened Rescue Kit



Packed Rescue Kit

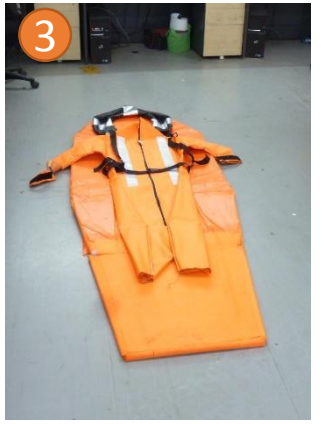
8.2 Physical Model

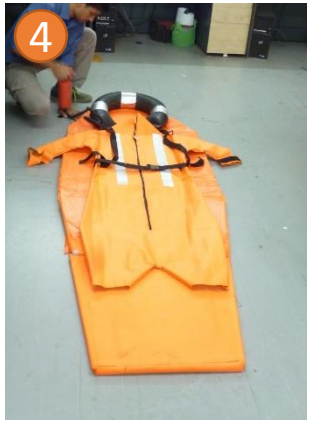
Folded

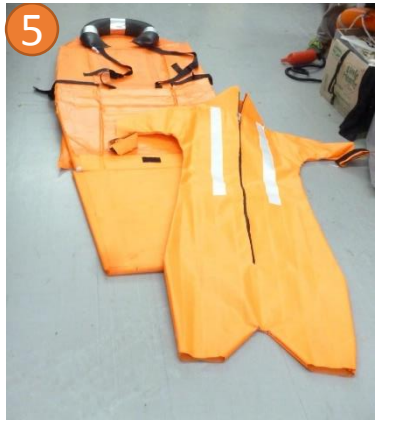
Unfolded

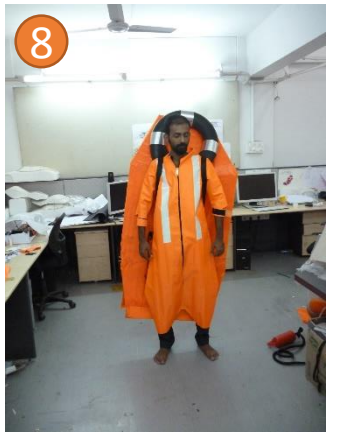
Usage

8.3 Activity of deployment

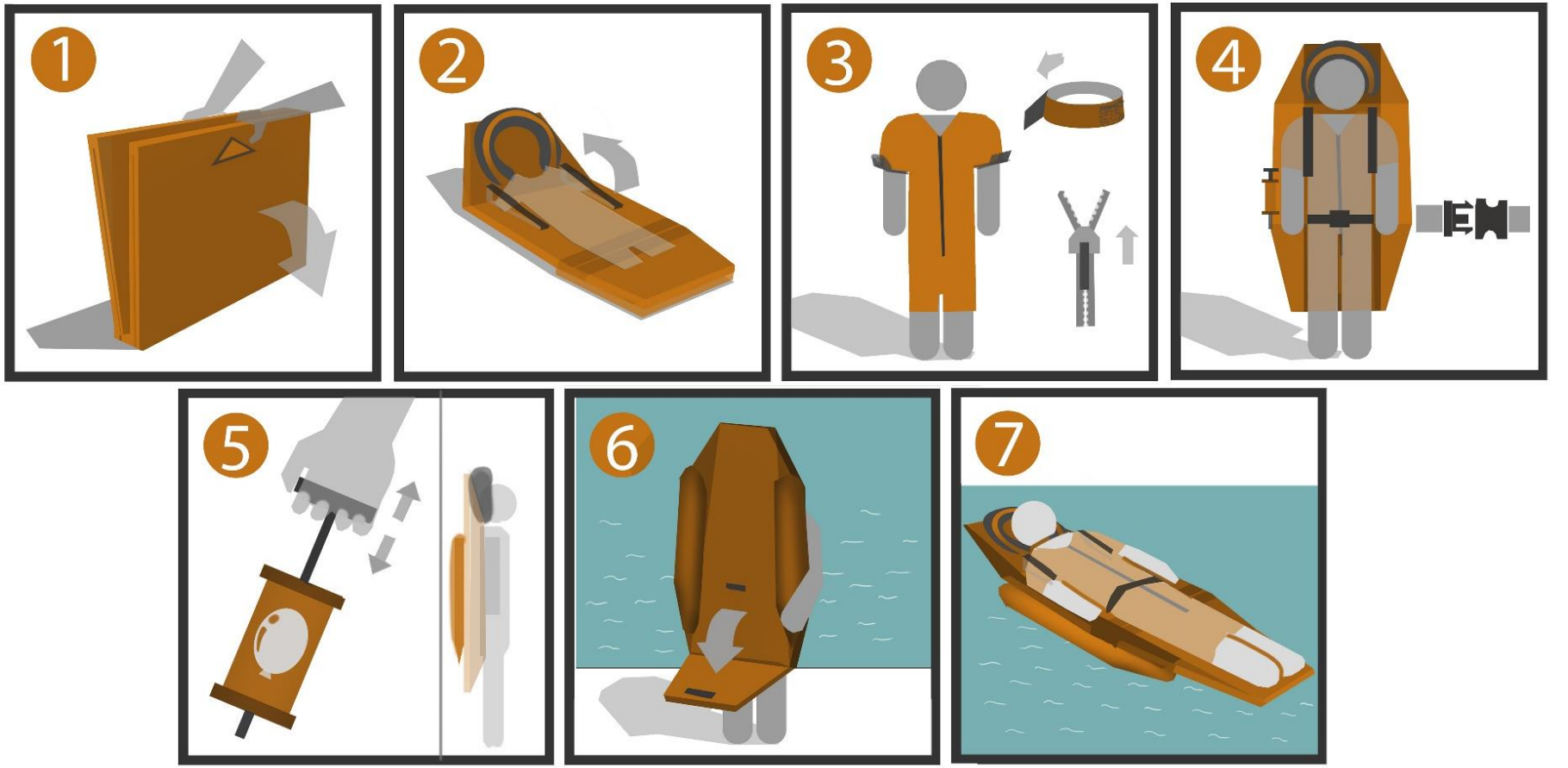




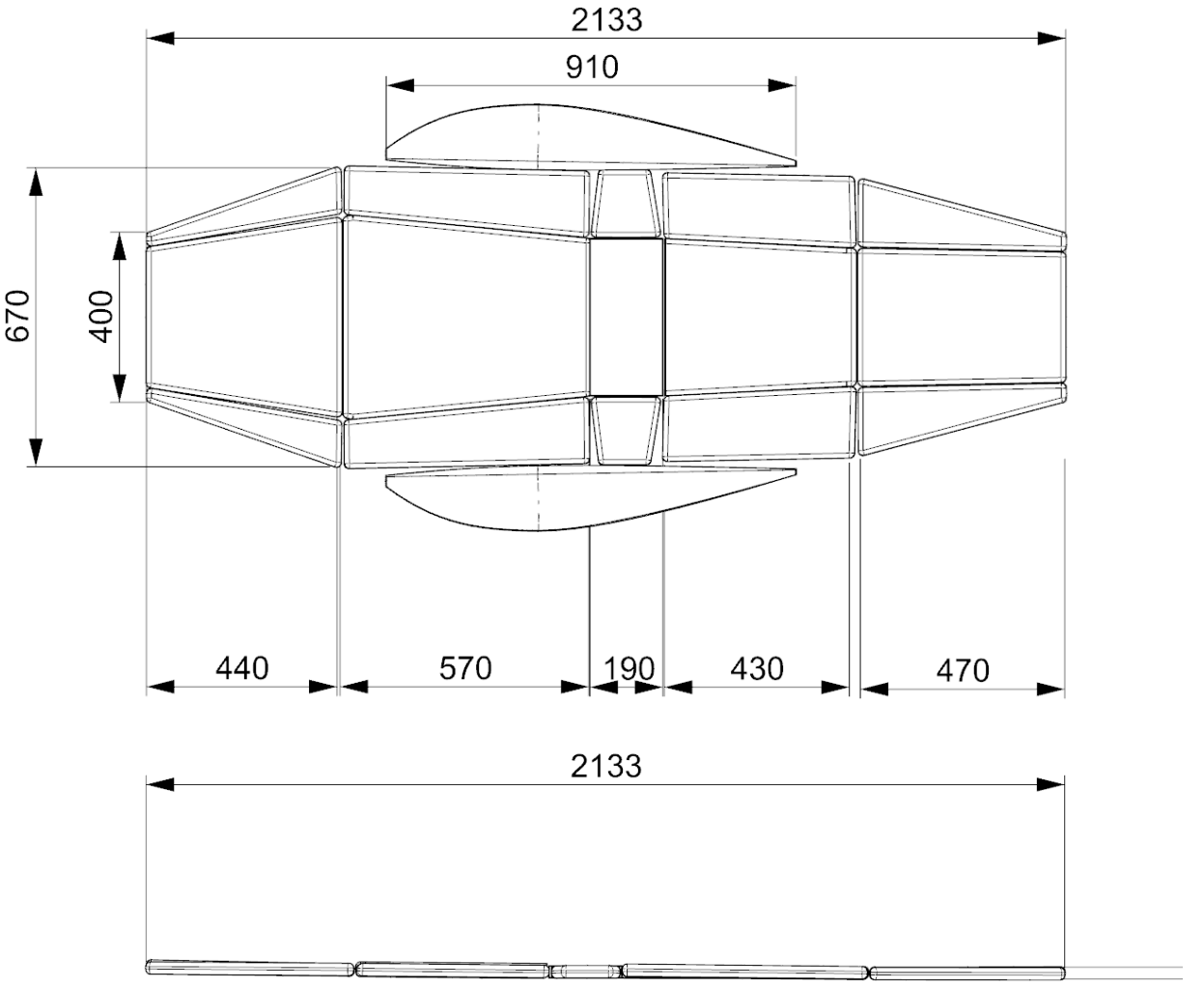




8.4 Illustration



8.5 2D Drawing



8.6 Scenario Render

Scenario – User Deployed kit and starts floating

Scenario – Rescue personnel rescuing the user from the kit

Scenario – User Deployed kit and starts floating

9. Reference

[1] http://www.ehow.com/info_8066168_kinds-damage-can-floods- do.html

[2] http://www.mapsofindia.com/top-ten/geography/india-flood.html

[3] http://www.polymarine.com/advice/boat-fabric-guide/

[4] http://www.pfdma.org/choosing/types.aspx

[5] http://qz.com/263010/these-10-numbers-tell-the-story-of-the-catastrophic-floods-in-jammu-and-kashmir/

[6] http://timesofindia.indiatimes.com/india/JK-floods-Death-toll-mounts-to-284/articleshow/43259123.cms

[7] http://indiatoday.intoday.in/story/jammu-and-kashmir-floods-srinagar-indian-army-ndrf/1/382425.html)

[8] http://indianexpress.com/article/india/india-others/pm-modi-reviews-flood-situation-in-jammu-region-with-omar-abdullah/

[9] http://in.reuters.com/article/2015/04/01/kashmir-floods-idINKBN0MS4TR20150401

[10] http://humanityroad.org/Donations/?gclid=CIS6tuLQlcUCFUonjgodjDgAAA

[11] http://www.dailymail.co.uk/indiahome/indianews/article-2747103/Kashmir-faces-deadl iest-floods-living-memory-So-160-dead-450-villages-water-did-Government-forecasts-ignore-disaster.html

[12] http://www.ndtv.com/india-news/kashmir-floods-ignored-warnings-magnified-a-disaster-waiting-to-happen-661277

[13] http://www.thethirdpole.net/floods-create-havoc-in-jammu-and-kashmir/

[14] http://www.amphibiousvehicle.net/amphi/E/edag/edag-01.jpeg

[15] http://www.amphibiousvehicle.net/amphi/E/edag/edag-02.jpeg

[16] http://i2.cdn.turner.com/cnnnext/dam/assets/120704013517-india-flood-2-horizontal-large-gallery.jpg

[17] http://www.nauticexpo.com/prod/sealegs-international-limited/outboard-rescue-boats-inflatable-boat-semi-rigid-center-console-26316-196928.html

[18] http://cdn8.wn.com/ph/img/b9/93/72cf5c096386519e99a624212c9e-grande.jpg

[19] http://www.centurydrivesystemsinc.com/images/gto_airboats.jpg

[20] http://www.tuvie.com/air-rope-inflatable-rescue-tunnel-for-safely-cross-flooded-river/

[21] http://www.fastamphibians.com/wp-content/uploads/2014/02/Gibbs-Humdinga-side-muddy-water.jpg