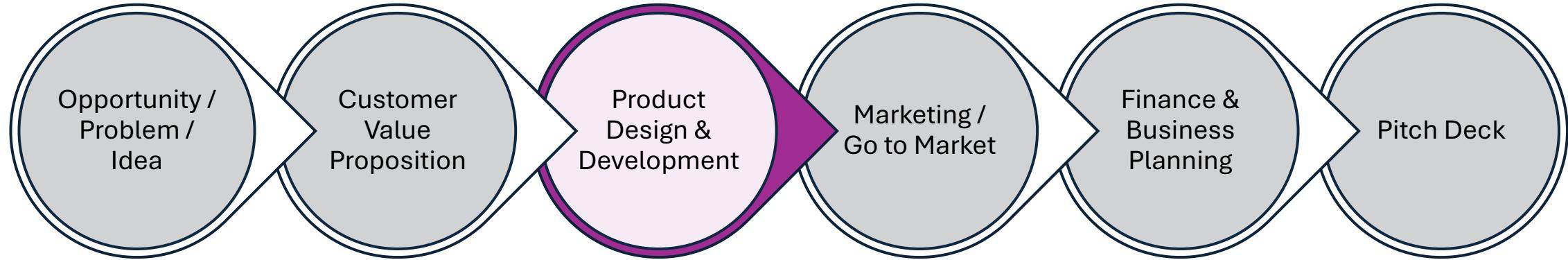


Product Innovation 3rd & 4th Sept 2024

Process for Start up Creation



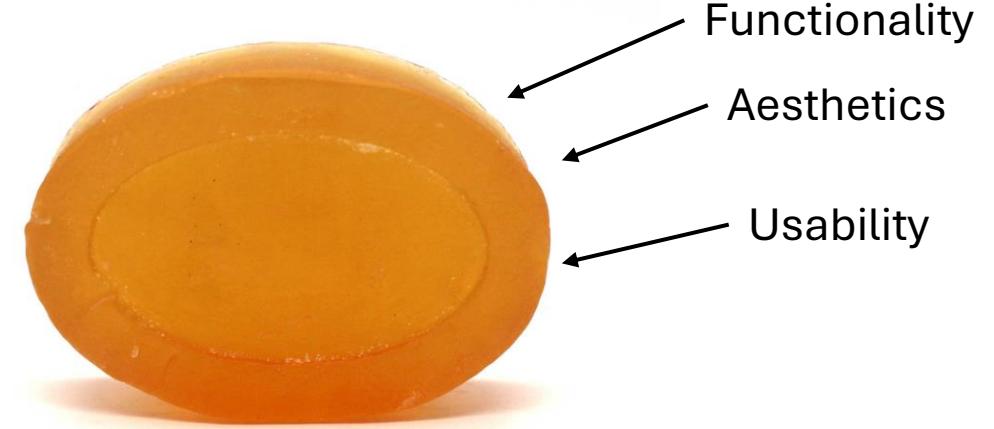
What is Design? (Noun)

Artificial:

“produced by the art rather than by nature, not genuine or natural ; affected; not pertaining to essence of matter.” [1]

Products:

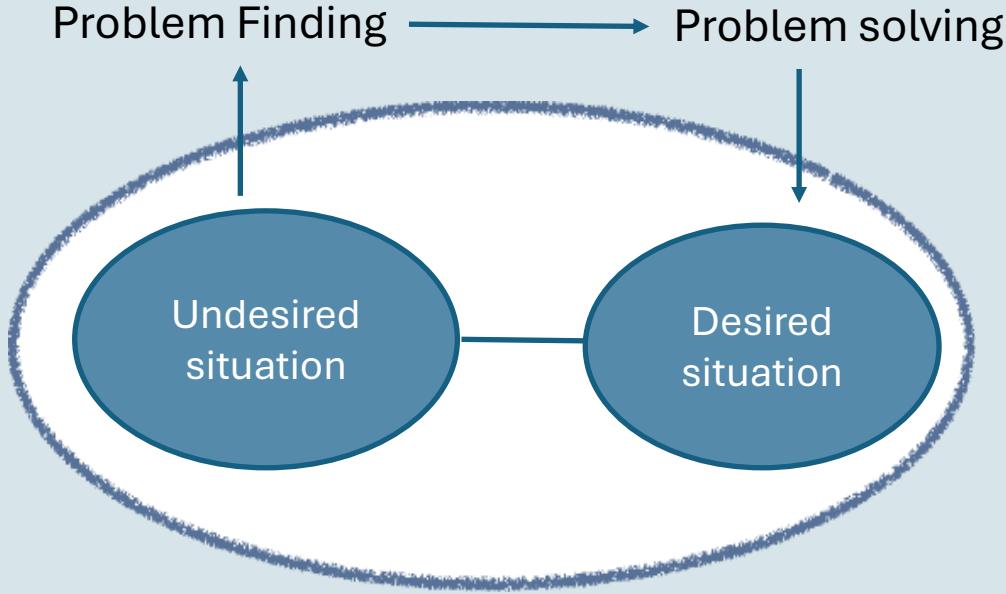
“Products are artifacts conceived, produced, transacted and used by people because of their properties and functions they may perform” [2]



[1] Simon, H.A., 1996. *The sciences of the artificial*. MIT press.

[2] Roozenburg, N.F. and Eekels, J., 1995. *Product design: fundamentals and methods* (Vol. 2). John Wiley & Sons Inc.

What is Design? (Verb)



Design as a 'verb': the process of design [1]

Product Design

“Designing a product is a goal directed thinking process by which problems are analyzed, objectives are defined and adjusted, proposals for solutions are developed and the quality of those solutions is assessed.” [2]

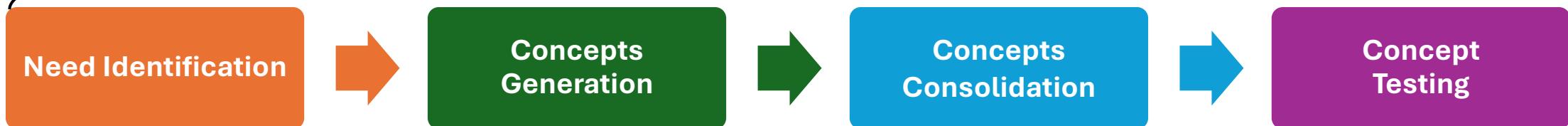
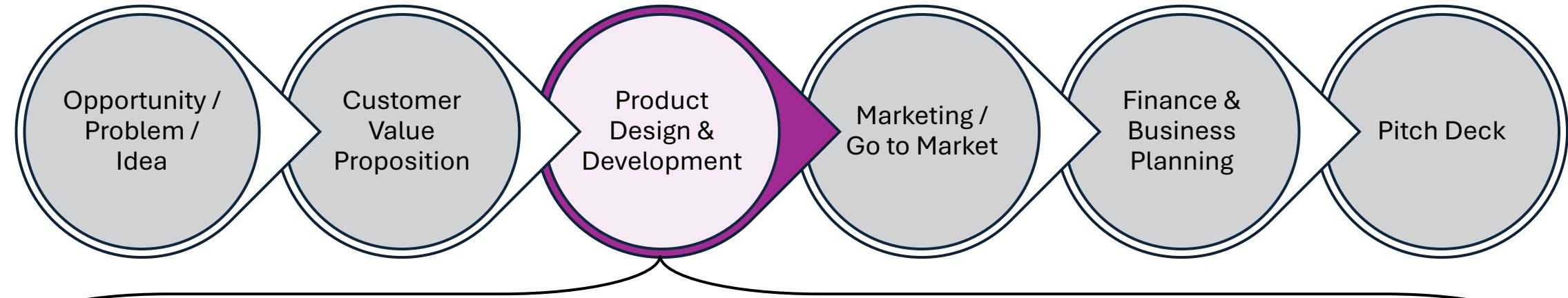
Systematic product design approach:
Prescriptive Models:

- French
- Pahl & beitz
- Roozenburg & Eckels
- Nigel Cross
- Ulrich & Eppinger

[1] Simon, H.A., 1996. *The sciences of the artificial*. MIT press.

[2] Roozenburg, N.F. and Eekels, J., 1995. *Product design: fundamentals and methods* (Vol. 2). John Wiley & Sons Inc.

Product Design Process: Outcome view



- Users
- Problems
- Needs
- Requirements

- Functions
- Ideas
- Concepts

- Sketches
- Mockups
- PoCs
- Prototypes

- MVP

InsuFlo: An Affordable Insulin Pump: A Case Study

Diabetes in India

Type 1 diabetes (T1DM)

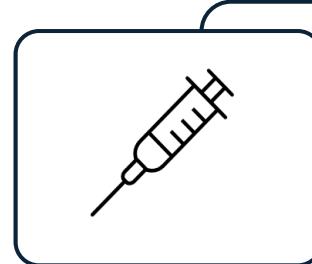
8.1 Lakhs people [1]

By 2040

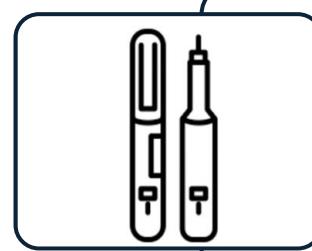
Almost double [1]

Solution

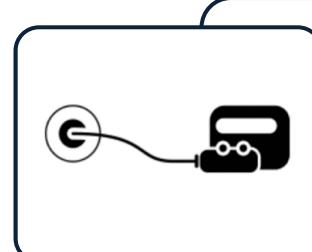
- Multiple Daily Injections (MDI)
- Continuous Subcutaneous Insulin Infusion (CSII)



Syringes



Pens



Pump 5%

[1] *The Lancet Diabetes and Endocrinology*, 2021

Which one is better?

InsuFlo: An Affordable Insulin Pump: A Case Study

Markets in in the United States, Europe and Australia



Tandem



Insulet's Omnipod,



Accu Check

Markets in in India



Medtronic
Cost

Baseline pump: ₹3.6 lakhs, Flagship: ₹5.5 lakhs

- Lead screw/nut
- Precision micro-motor

"An affordable insulin pump for people with diabetes"

InsuFlo: An Affordable Insulin Pump: A Case Study

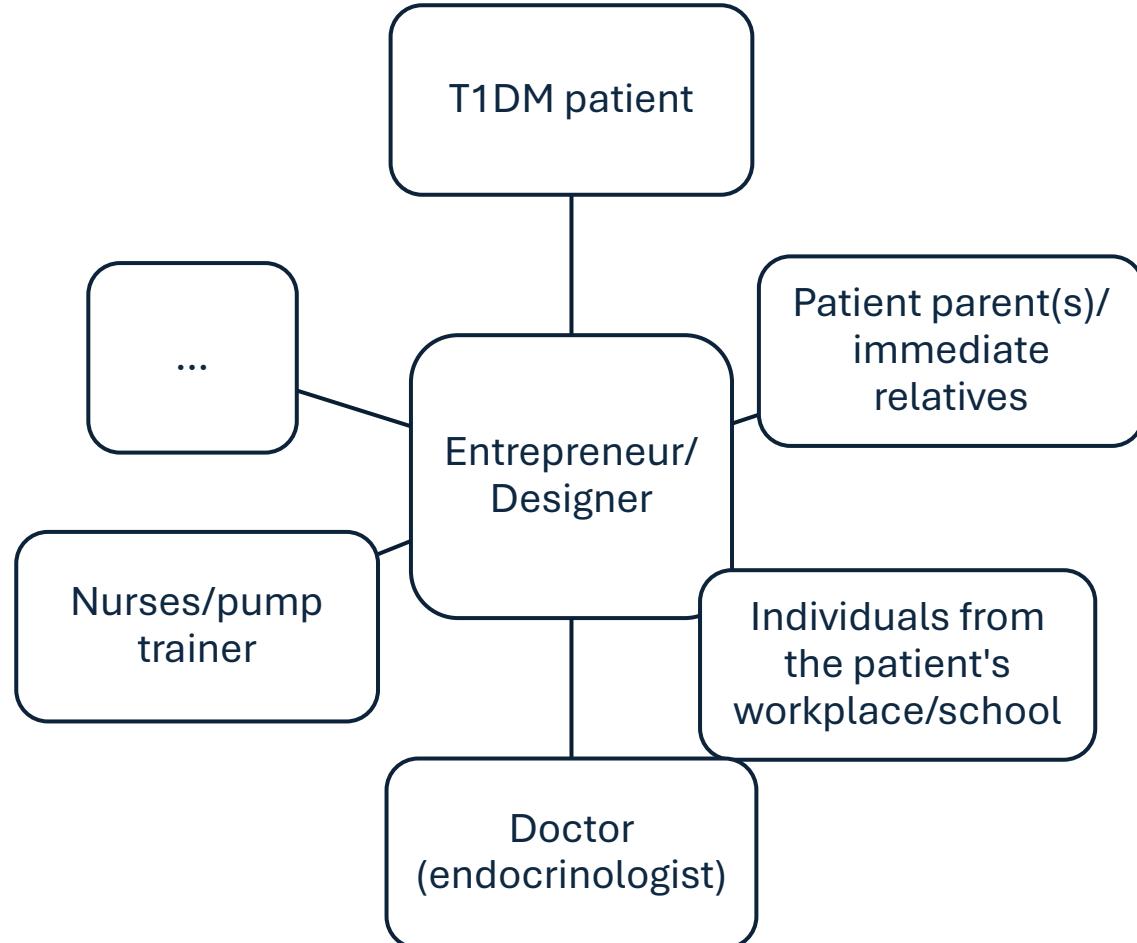


Mr Deval Karia
M.Des, Batch 2018,
CPDM, IISc



Stage 1: Need Identification

List of stakeholders



User segments

- Age
- Lifestyle
- Gender
- **Pain points (Examples)**
 - Women tend to hide the pump under clothing to prevent discovery
 - Make use of a washroom every time they need to administer a bolus dosage or monitor delivery
 - ...

Stage 1: Need Identification

List of stakeholder requirements

Rank	List of Stakeholder Requirements
1	Extremely precise insulin delivery as dictated by medical requirements
2	Malfunctioning of the device in extreme environments must be informed to the user
3	Adequate alarms/response to Hypo-glycaemic and Hyper-glycaemic episodes
4	Device performance should be reasonably independent of external environmental conditions
5	Provision to vary the Basal delivery rate across the day
6	The initial investment on the pump and recurring costs must be affordable to a majority of the Total Addressable Market (TAM)
...	...

Stage 2: Concept Generation

Functions

Ideas

Mounting the cannula into the subcutaneous tissue

Mechanical actuation to **precisely** drive insulin into the tissue

Detecting obstruction in delivery (occlusion detection)

...

Stepper motor with lead screw

Piezoelectric actuation

Thermo-pneumatic/ Thermo-peristaltic micro-pumps

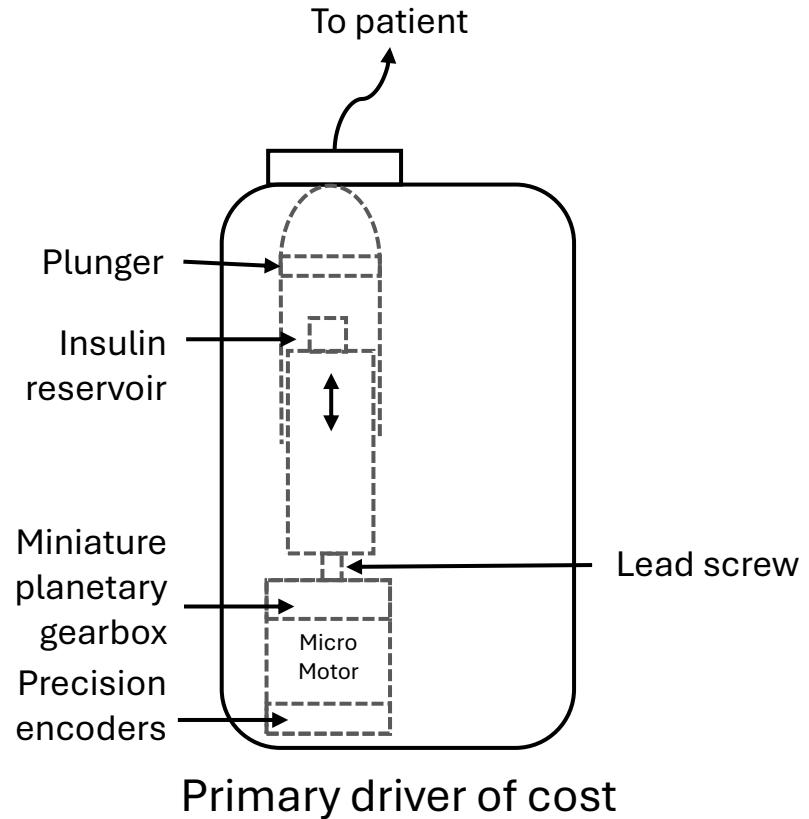
Shape memory alloy

Diaphragm pump

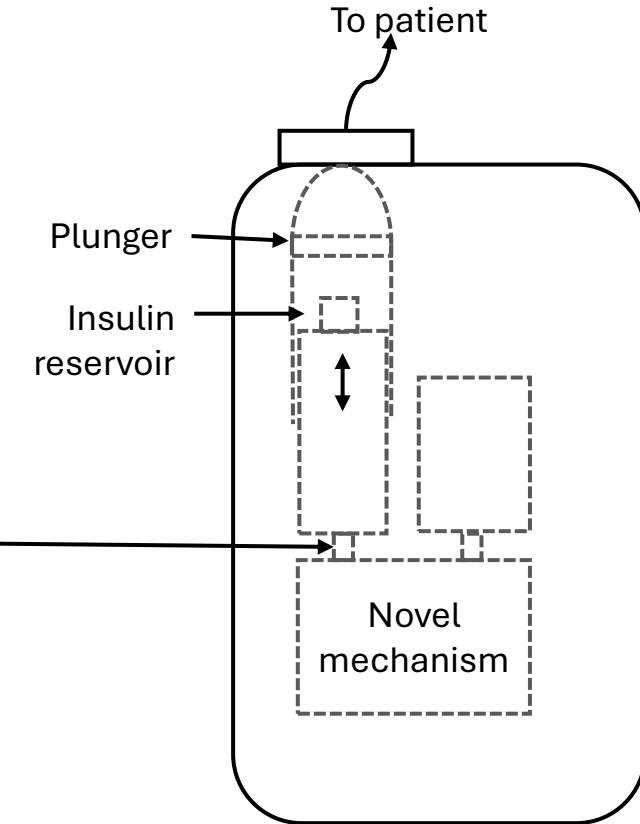
...

Stage 2: Concept Generation

Commercially available pumps

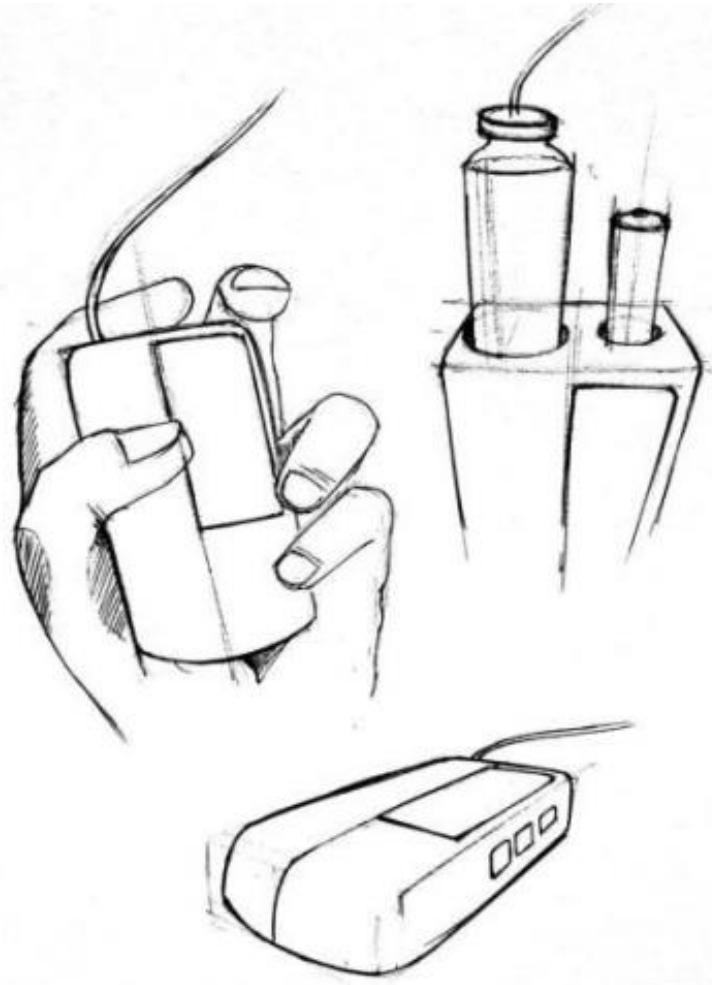


New design

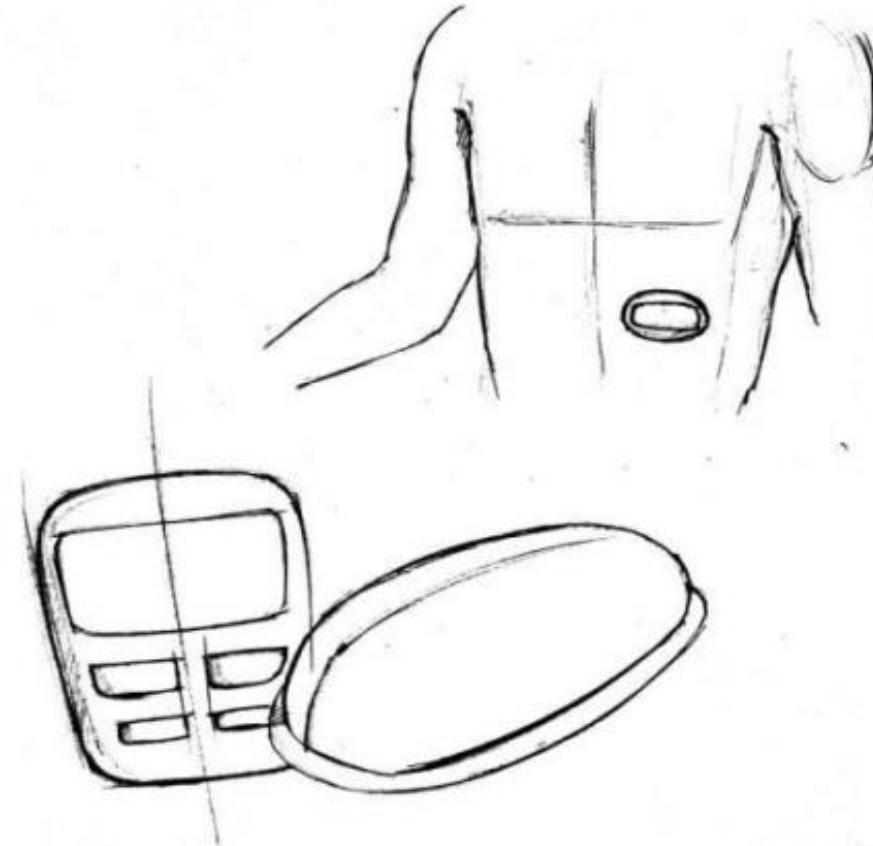


Stage 3: Concept Consolidation

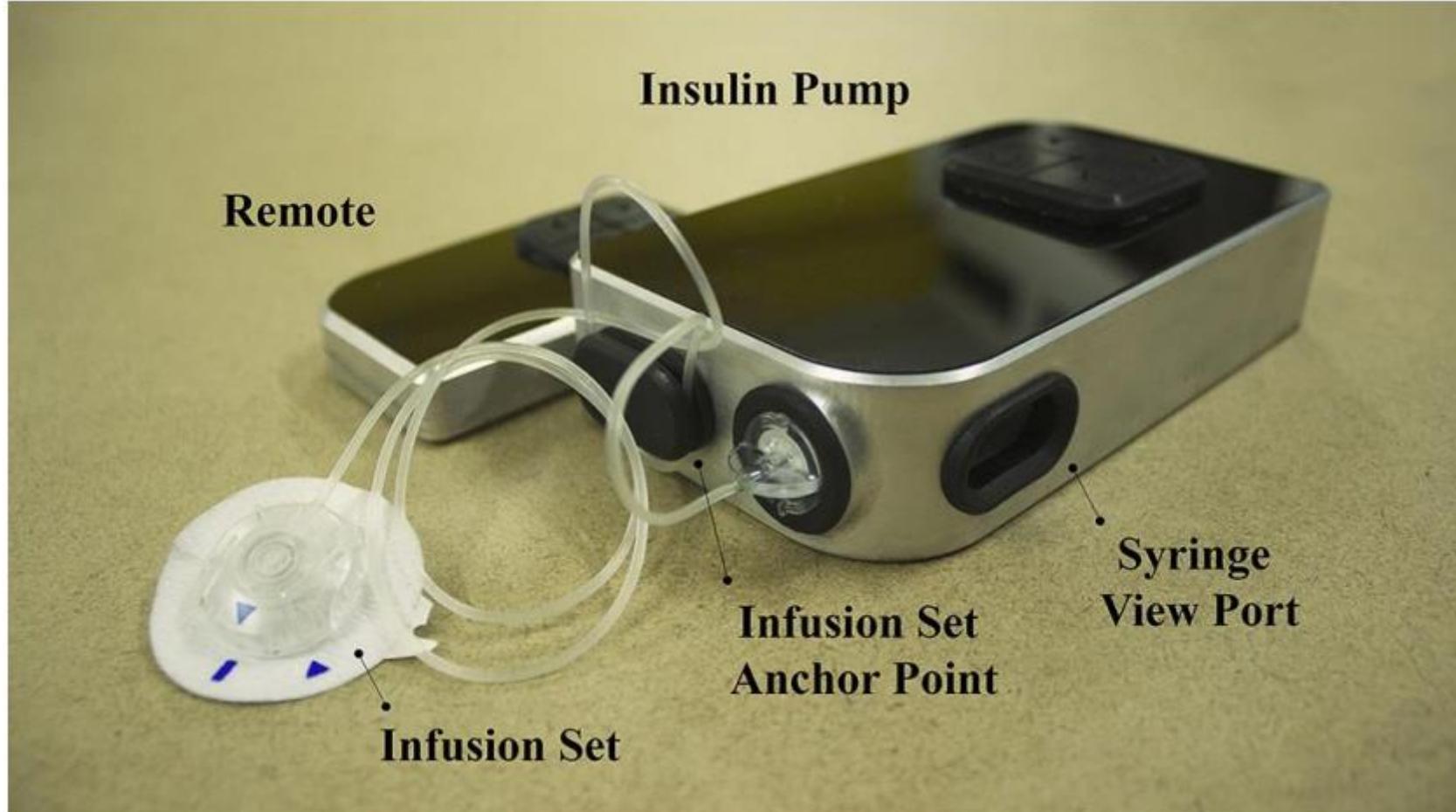
Embodiment 1: Infusion set



Embodiment 2: Patch based



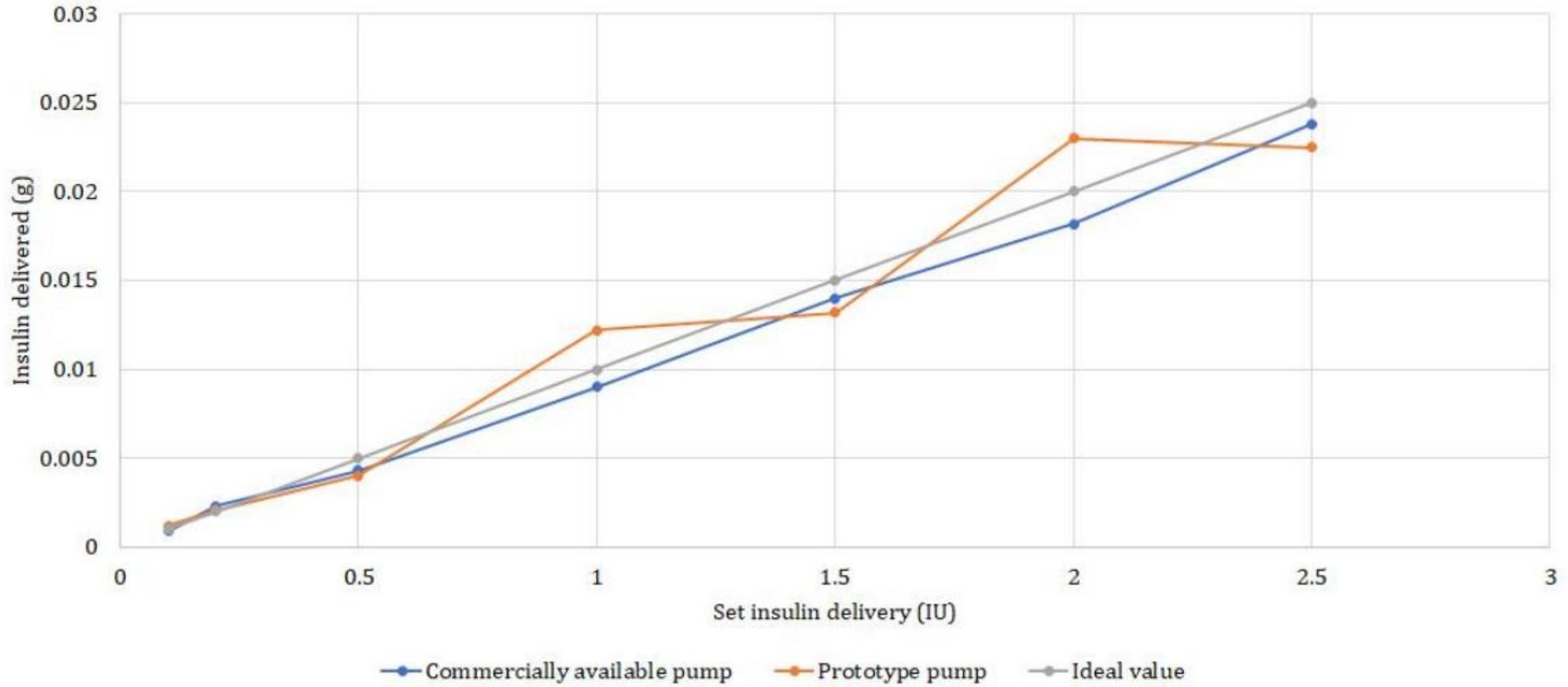
Stage 3: Concept Consolidation



Prototype insulin pump and remote

Stage 4: Concept Testing

Comparison of insulin delivered for a set value (commercially available vs. prototype pump)



Stage 4: Concept Testing



Pump

Insuflo

M722G

Programmed Bolus
Value (U)

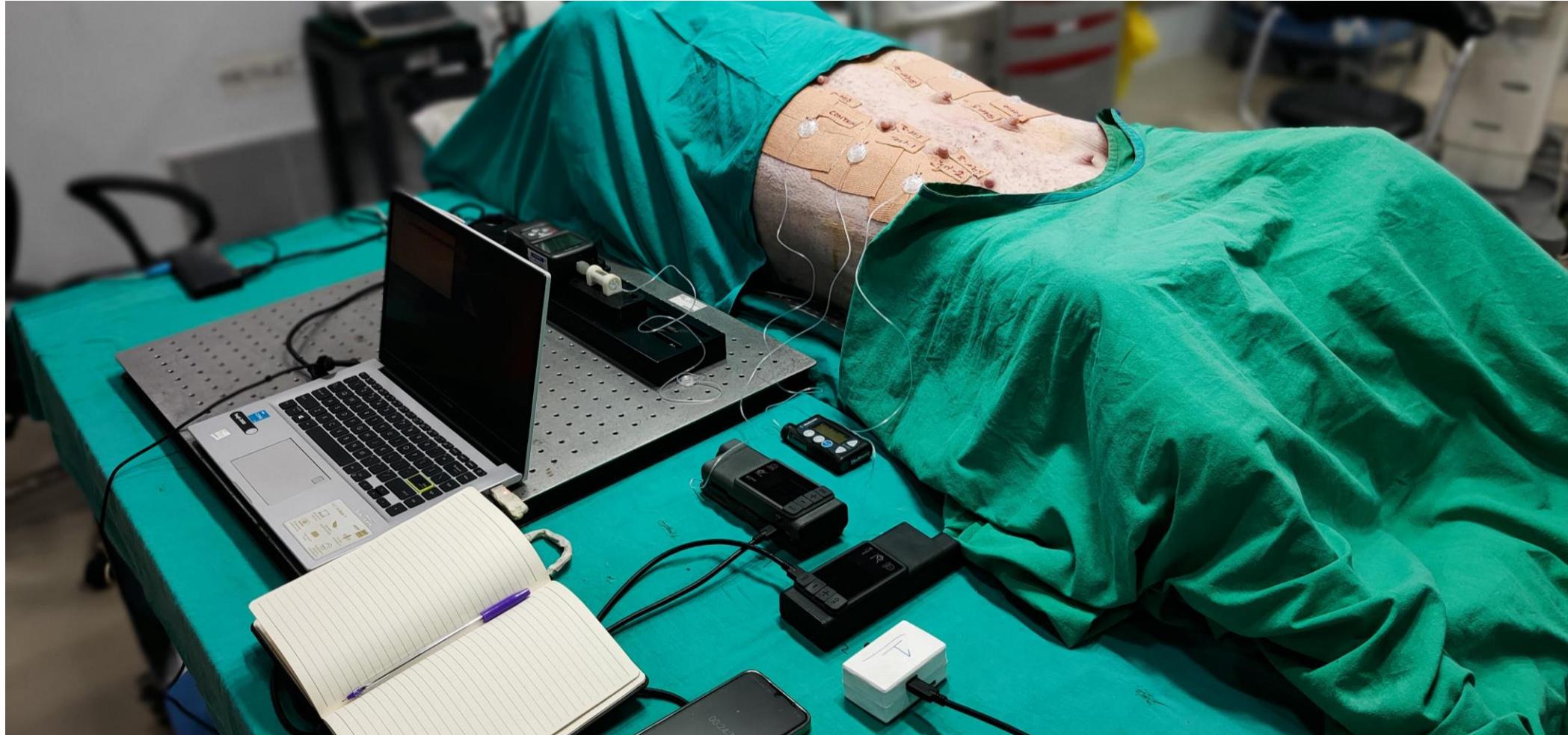
1 (0.01 ml)

Delivery Error
Mean (%)

2.62 ± 0.066

-0.26 ± 0.019

Stage 4: Concept Testing



Pre-clinical animal investigation at a GLP certified facility
Delivery accuracy comparable to competitor device

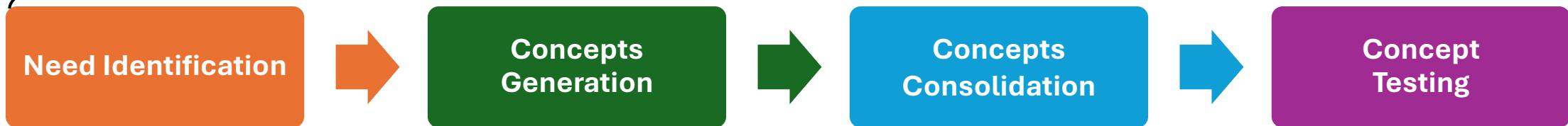
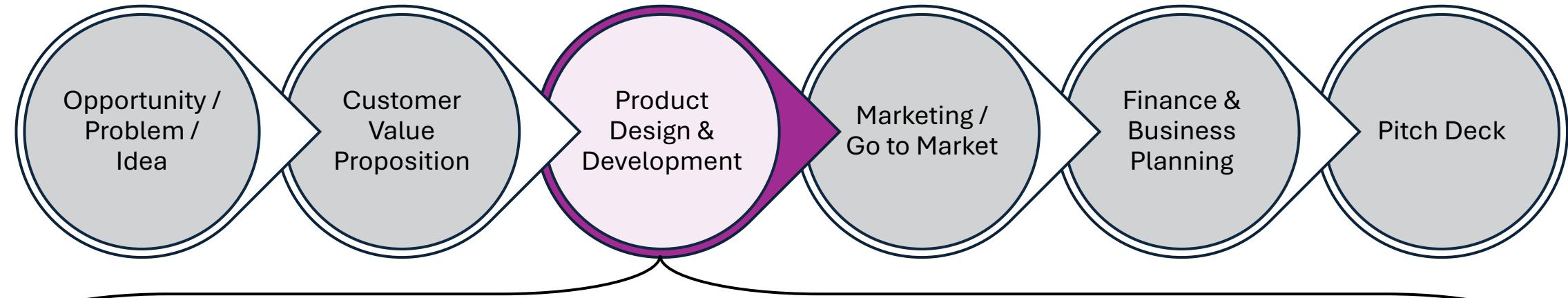
Go to Market



The image shows the Insuflo insulin pump. It has a black cylindrical reservoir at the bottom and a white control panel at the top. The control panel features a small LCD screen displaying 'Bolus' and 'Bolus history' with a single entry: 'Last 10:44 am 0.4 m'. Below the screen are four buttons labeled 'OK', 'esc', '^', and 'B' (bottom), and another four buttons labeled 'OK', 'esc', '^', and 'V' (bottom). The word 'Insuflo' is printed vertically on the right side of the device. A green callout bubble at the bottom contains the text: 'An **affordable** insulin pump for people with diabetes'.

An **affordable** insulin pump for
people with diabetes

Product Design Process: Activity view



- Observation
- Interaction
- Experience

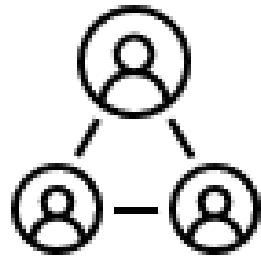
- Ideation
- Inspiration
- Syntheses

- Sketching
- Prototyping

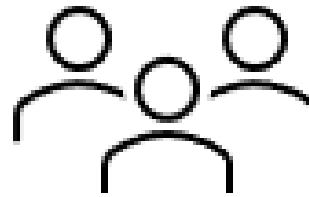
- Analysis
- Evaluation
- Selection

Stage 1: Need Identification

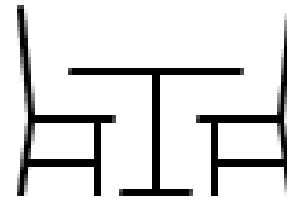
Observing habitats: A Good Starting Point to Identify Problems



Activities



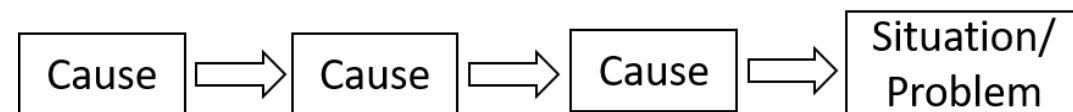
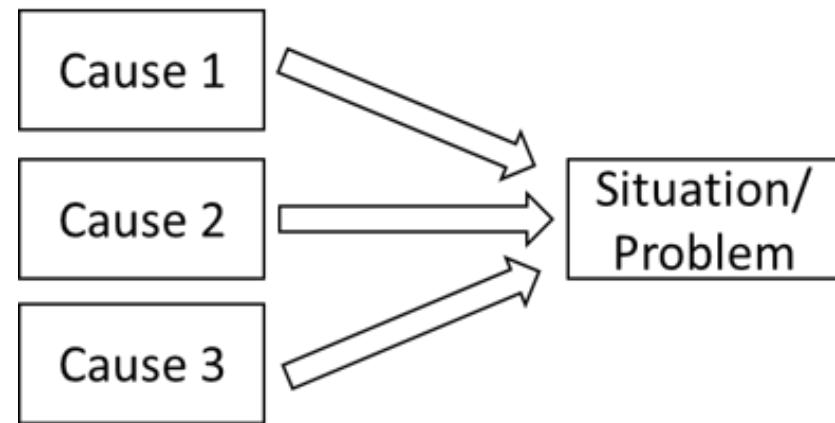
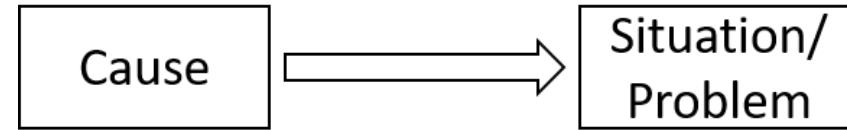
People



Objects

Stage 1: Need Identification

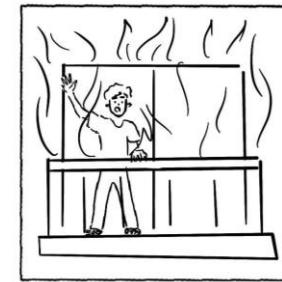
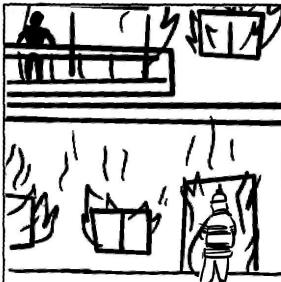
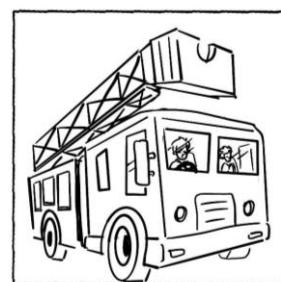
Analyzing the cause, root cause, and effect of problems



Stage 1: Need Identification

What activities the fire worker do during fire emergency?

User Journey Map



Firefighters receive a briefing about a rescue mission at a burning building.

Upon arrival, firefighters assess the situation.

Firefighters enter the burning building, where the smoke is dense.

Firefighters locate victims, by navigating through the building.

Firefighters communicate with each other and with command.

While searching for victims, firefighters encounter intense heat and falling debris.

After locating and rescuing victims, firefighters retrace their steps to exit the building.

Stage 1: Need Identification

Mindset: Empathy/ Human centredness

- Ability to see and experience through another person's eye
- Recognize why people do and what they do
- Understanding what people are thinking and feeling



Stage 1: Need Identification

Interaction with Users

- Interaction with multiple users
- Interaction with multiple segments of the users

The user statements gathered by interacting with the garbage collector:

"Many residents do not segregate garbage."

"I wish people would make the garbage ready upon my arrival."

"During summer, people provide me with cold water to drink."

"I'm not particularly eager to stand in the garbage pile to organise the waste."

"I suggest making the truck-bin height lower so that I can easily dump garbage into the truck."

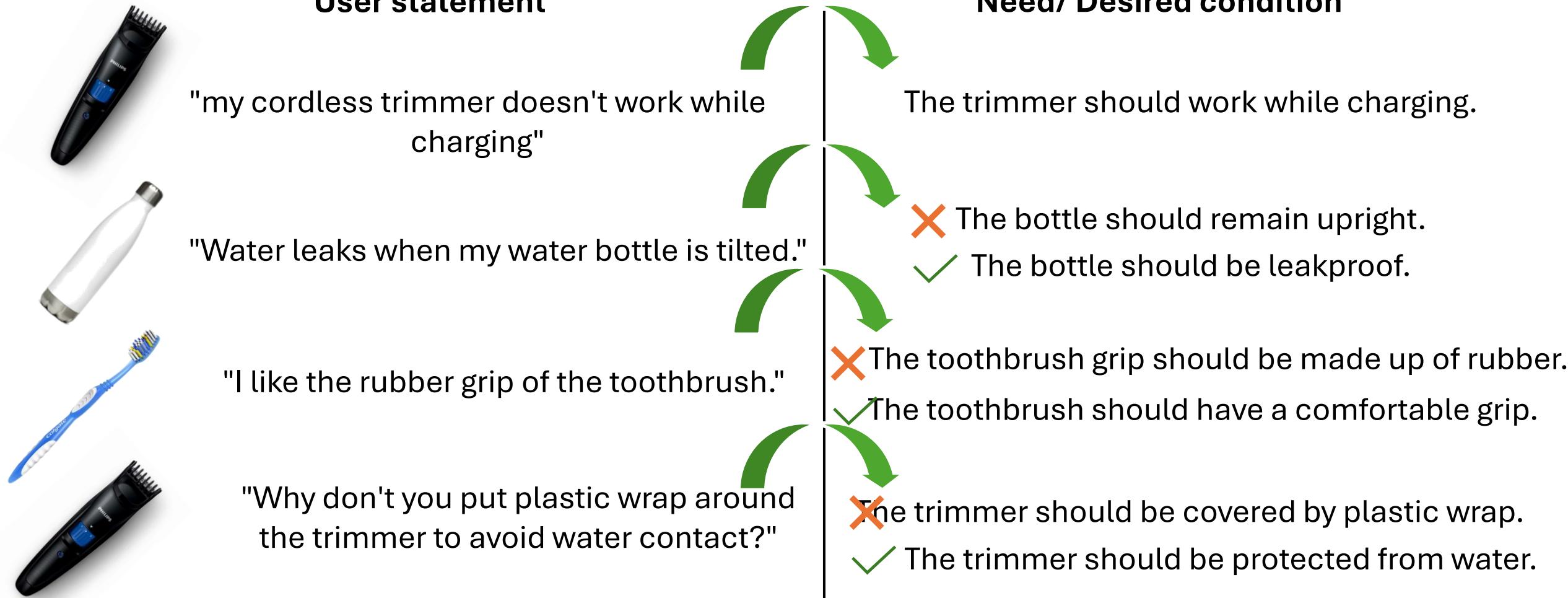


Types of user statement

- Problem statement
- Desire
- Likings
- Disliking
- Improvement

Stage 1: Need Identification

Converting Problem Statement into Need Statement/ requirement



Stage 2: Concept Generation

Establishing Functions

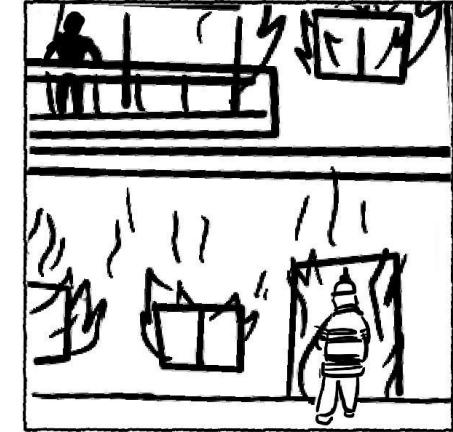


Helmet of firefighters



Functions

- Visibility
- Breathability
- Communication
- Head protection



Stage 2: Concept Generation

Establishing Functions

Robots to collect garbage from water bodies.

It should not disturb marine life

Locating garbage

Navigation

Waterproof

Stability

Cost

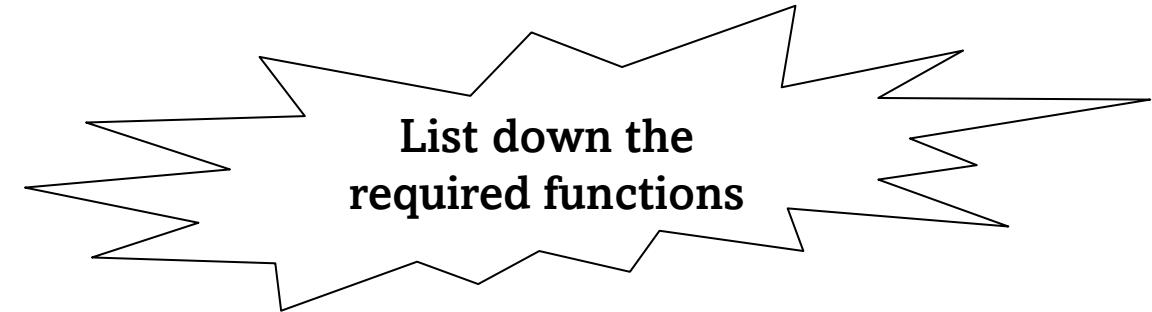
Collecting garbage

Avoiding obstacles

Easily operatable

Storage of Garbage

Power supply



Stage 2: Concept Generation

Establishing Functions

Making wheelchairs navigate patients across stairs

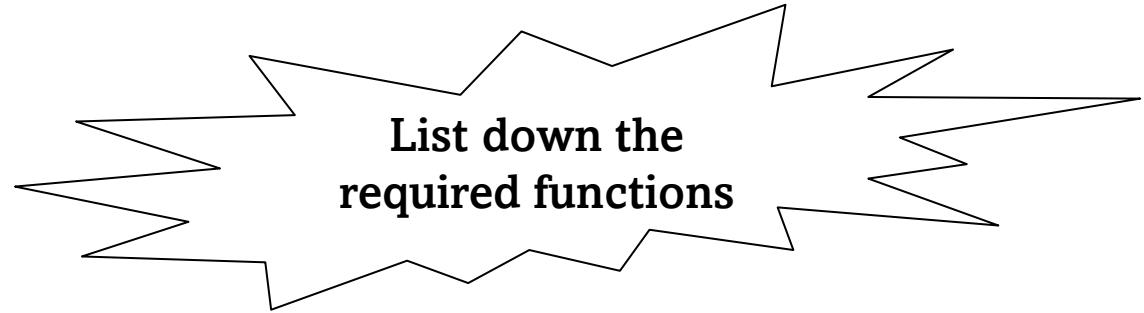
Adjust according to stairs

Should not be affected by weight of patient

Not topple on ramps

Stable and should not vibrate

Comfort



List down the
required functions

Stage 2: Concept Generation

Establishing Functions

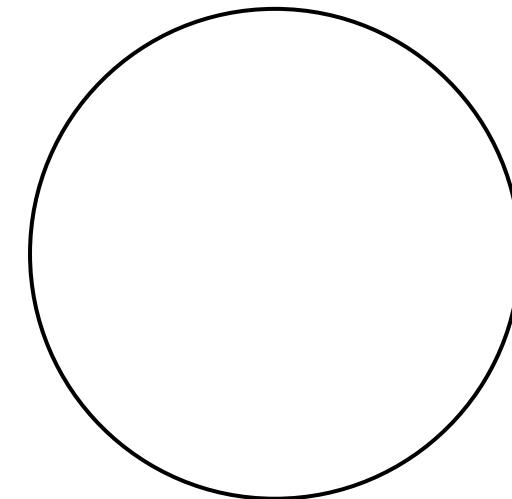
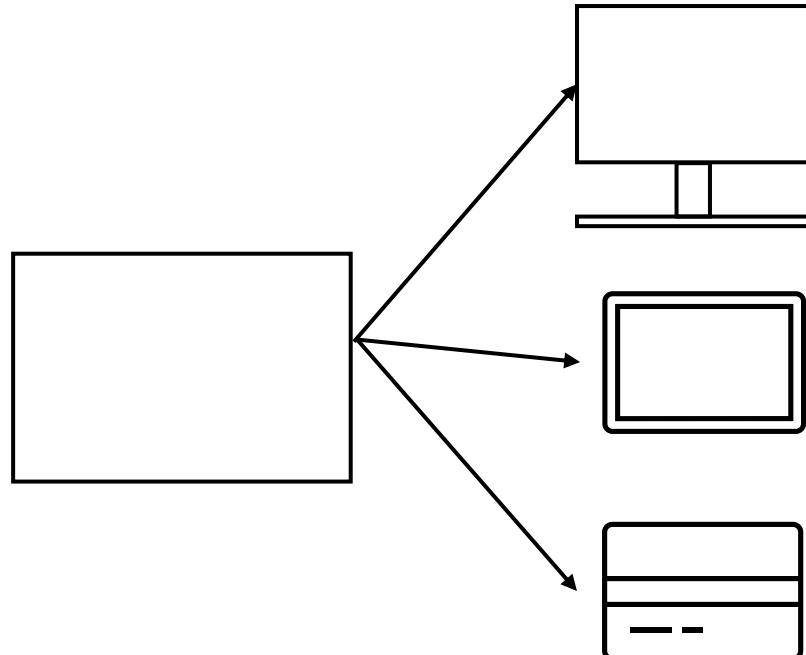
Modular Upgradable Mobile Phone

List down the
required functions

Stage 2: Concept Generation

Creativity

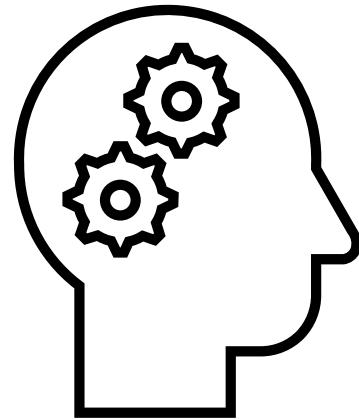
- Adapt the given shape into objects of various forms and generate as many objects as you can.
- Use A4 Paper for the exercise.
- Time limit is 2 min



Stage 2: Concept Generation

Creativity

- Capable to produce something novel, valuable, surprising..
- Rhodes' 4P of Creativity (1961):
 - Person: Intelligence, knowledge, motivation, open-mindedness..
 - Product: Novelty, value...
 - Press: Context, team, organization...
 - Process: methods, activities, tools...



Stage 2: Concept Generation

Creativity

- Rhodes' 4P of Creativity (1961):
 - Person: Intelligence
 - Below 120 point, IQ and creativity rise together
 - Above 120 point, IQ and creativity are unrelated

Person: Motivation and personality [1]

Creative people are
Motivated
Open to new experiences
Confidant

Creative people are
Original
Fluent
Elaborative
Abstract
Open-minded

[1] Feist (1999) *The influence of personality on artistic and scientific creativity*

Stage 2: Concept Generation

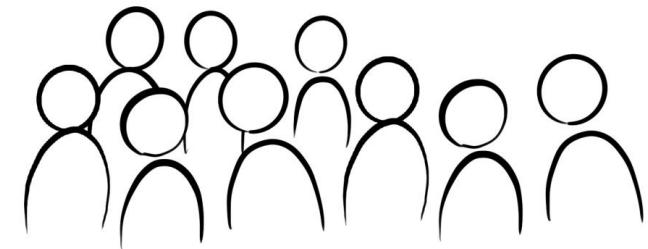
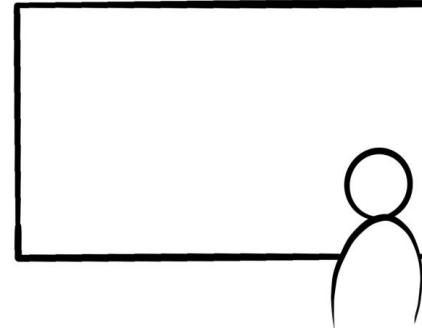
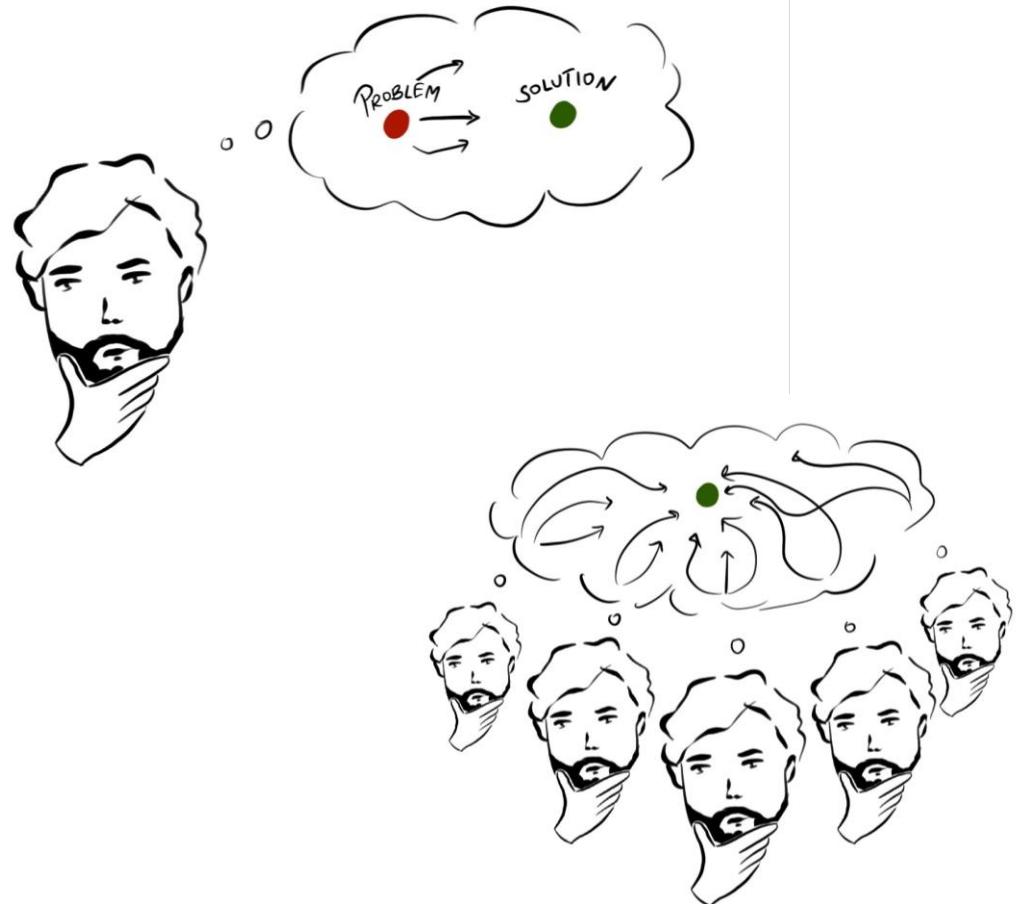


Creativity

- Rhodes' 4P of Creativity (1961):
 - Product: Novelty
 - Originality
 - Uniqueness
 - Surprise
 - ...
 - Product: Value
 - Functionality
 - Usefulness
 - Quality
 - Elegance
 - ...

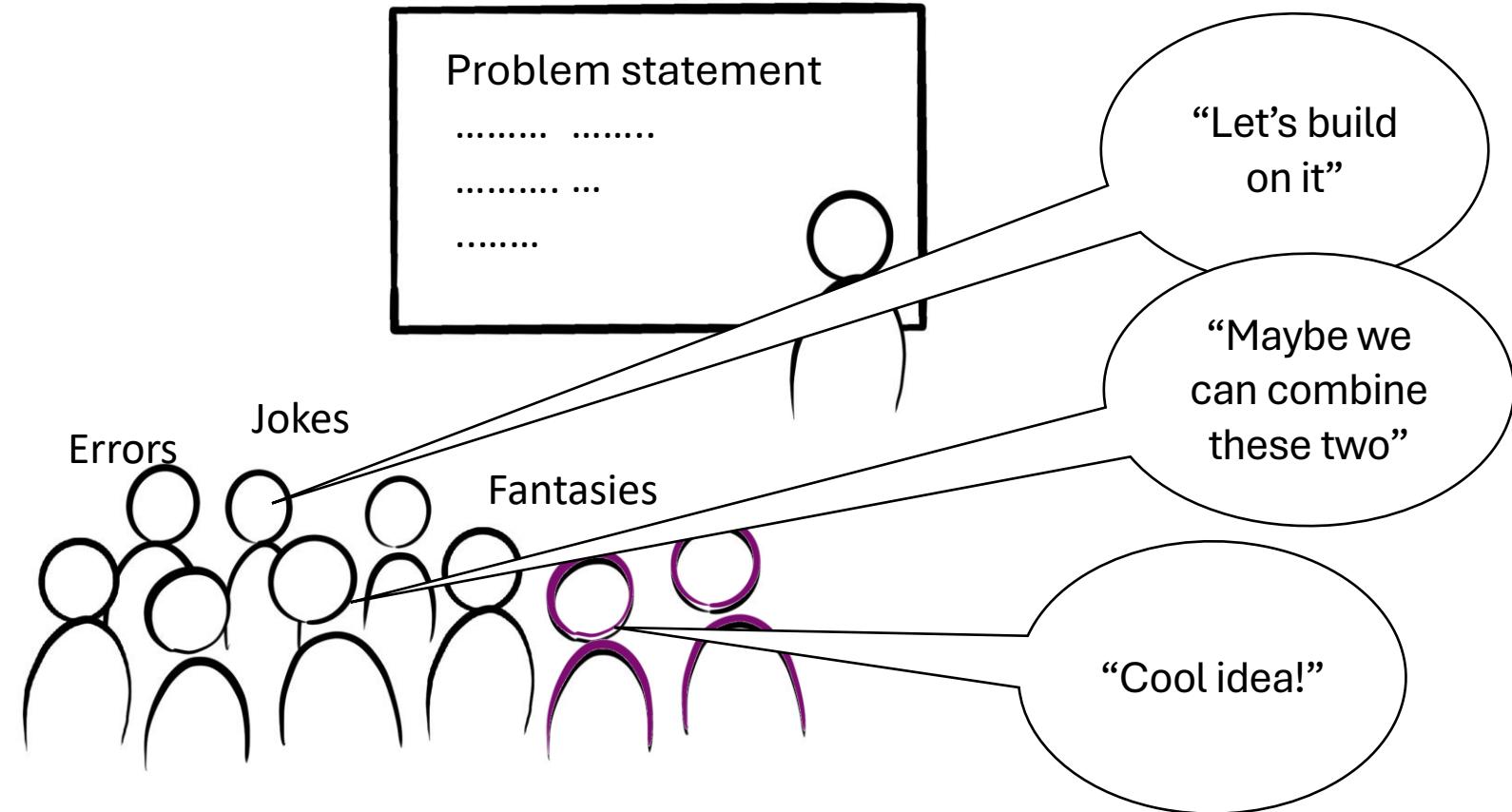
Stage 2: Concept Generation

Idea Generation: Brainstorming



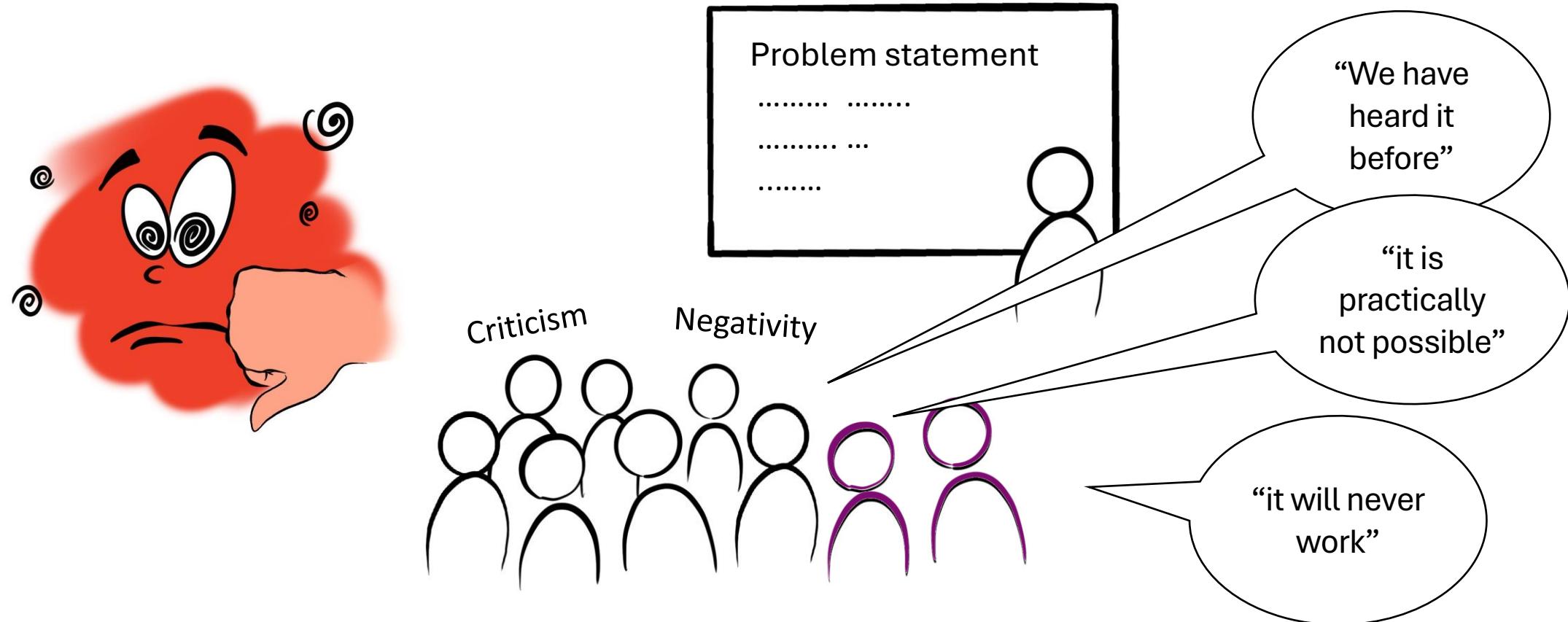
Stage 2: Concept Generation

Idea Generation: Brainstorming



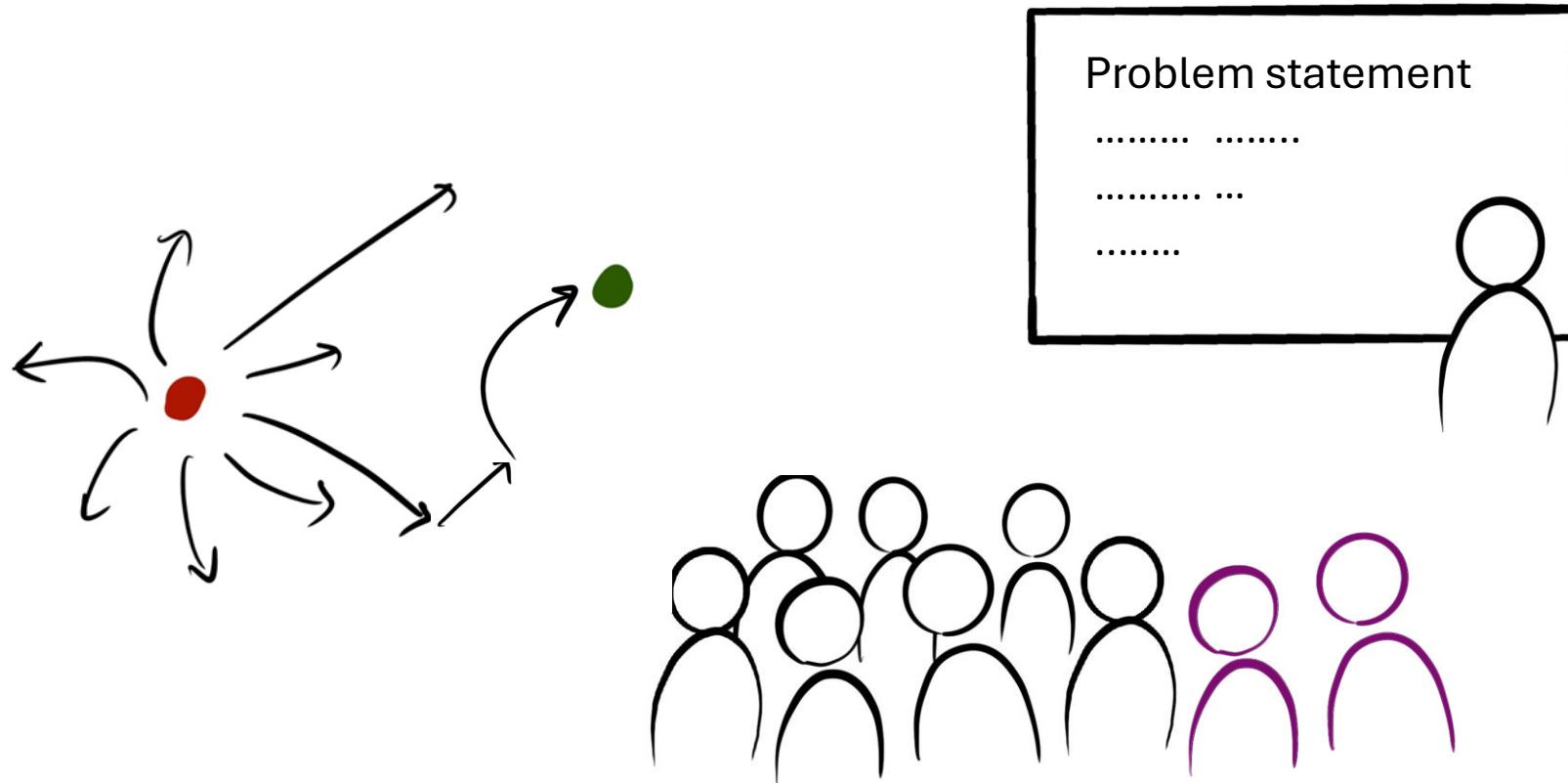
Stage 2: Concept Generation

Idea Generation: Brainstorming



Stage 2: Concept Generation

Idea Generation: Brainstorming

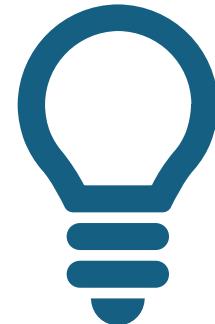


Stage 2: Concept Generation

Idea Generation: Brainstorming

"Fire fighters cannot see through smoke."

- Build a target identification system
- Use a powerful spotlight to illuminate
- Use a prob camera to assess the fire ground and create a travel path
- Use thermal imaging to distinguish human targets
- Develop a smoke separating agent
- Use ultra-sonic to sense the environment
- Use a huge catalytic converter to capture all smoke
- Use IR imaging to enhance vision



Stage 2: Concept Generation

Idea Generation: From function to form

Making wheelchairs navigate patients across stairs

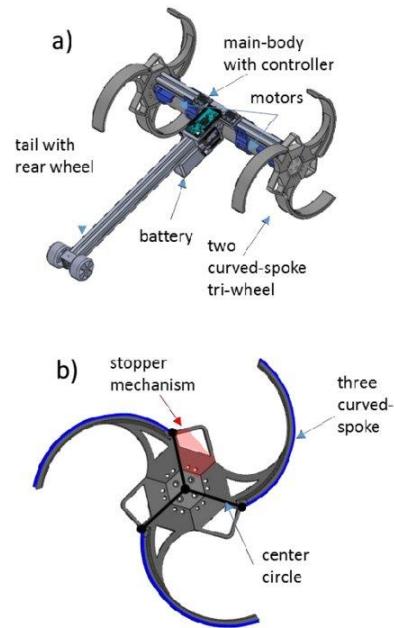
“Navigating stairs (ascend and descend) for patients, regardless of the staircase's configuration”



Track based
Mechanism



Tri-Wheel
Mechanism



Curved-Spoke
Tri-Wheel Mechanism



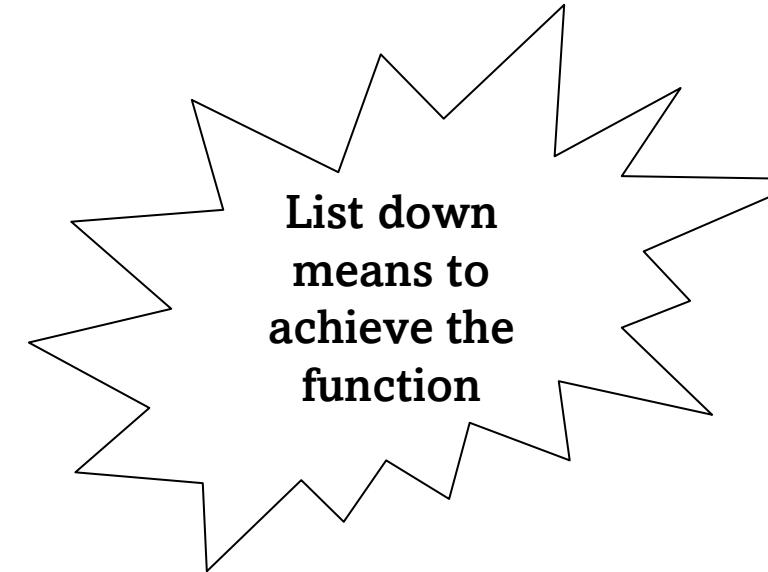
Stair lift

Stage 2: Concept Generation

Idea Generation: From function to form

Heating food

Soldiers in extreme environments can rapidly heat meals, regardless of their location or the conditions

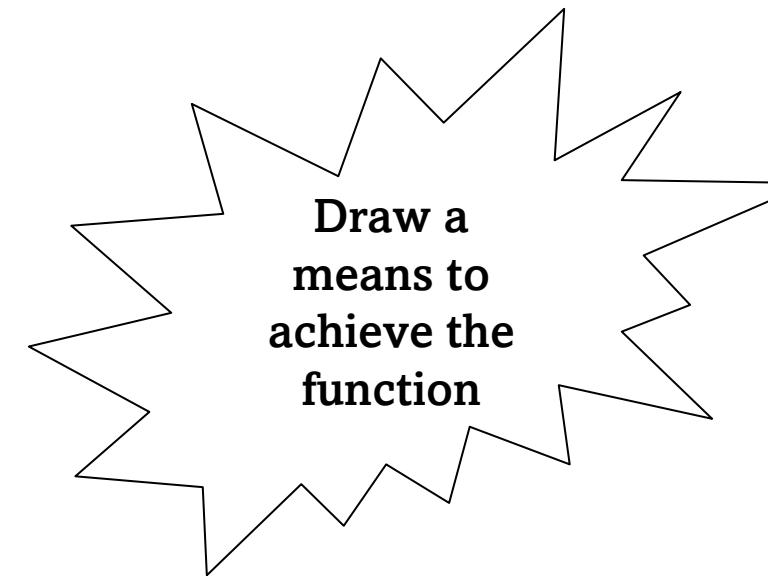
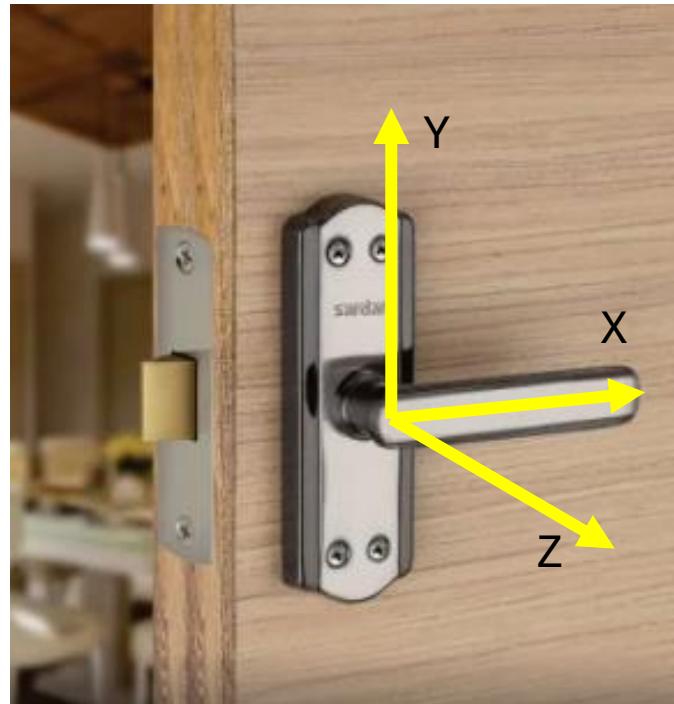


Stage 2: Concept Generation

Idea Generation: From function to form

Door latch

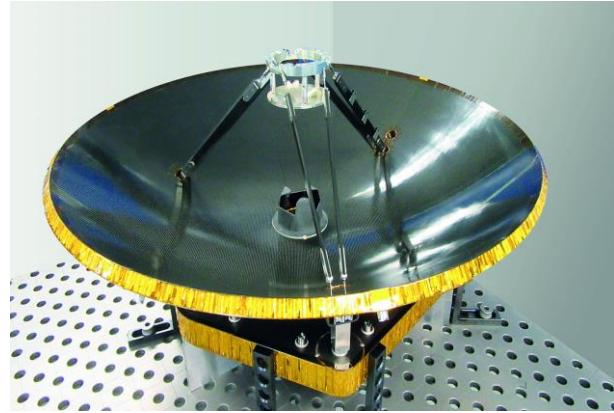
When an effort is applied on handle around its z-axis in the clockwise direction, it should rotate, and simultaneously the block should translate in the positive direction along its x-axis



Stage 2: Concept Generation

Idea inspiration: Design by Analogy

George de Mestral



Stage 2: Concept Generation

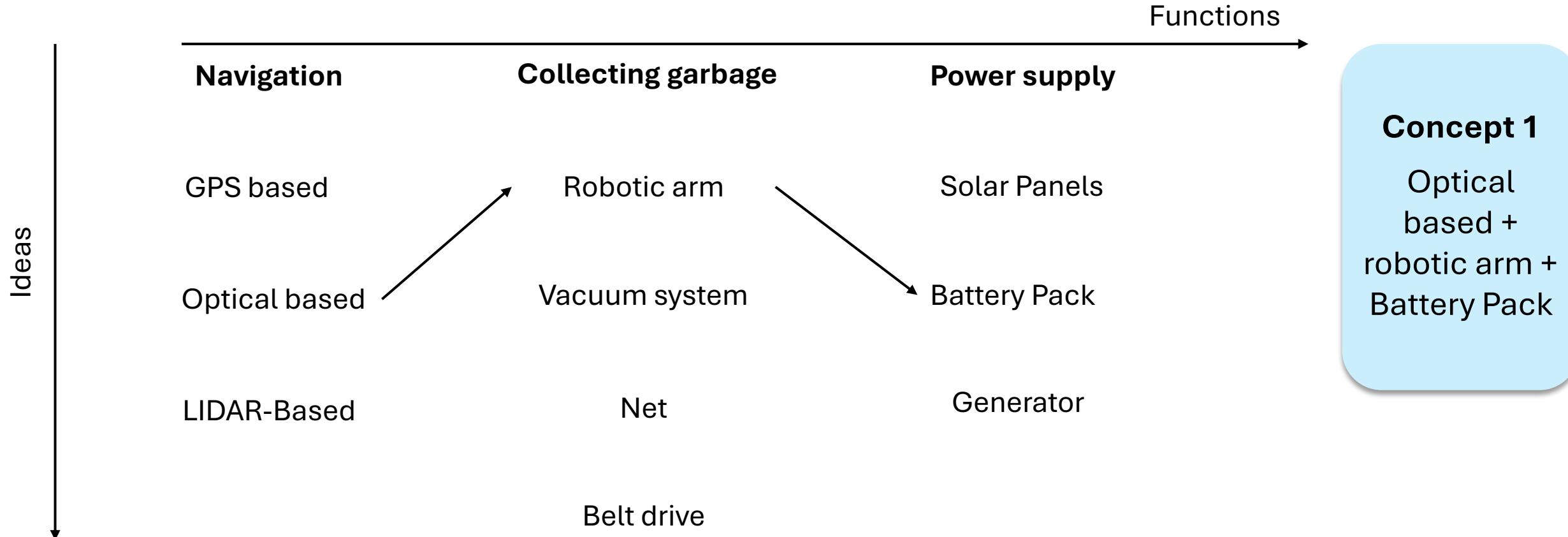
Idea modification

- Feasibility
- Utility
- User-friendliness
- Safety
- Environmental aspects
- Economic aspects
- Simplicity

Stage 2: Concept Generation

Combining ideas into concepts

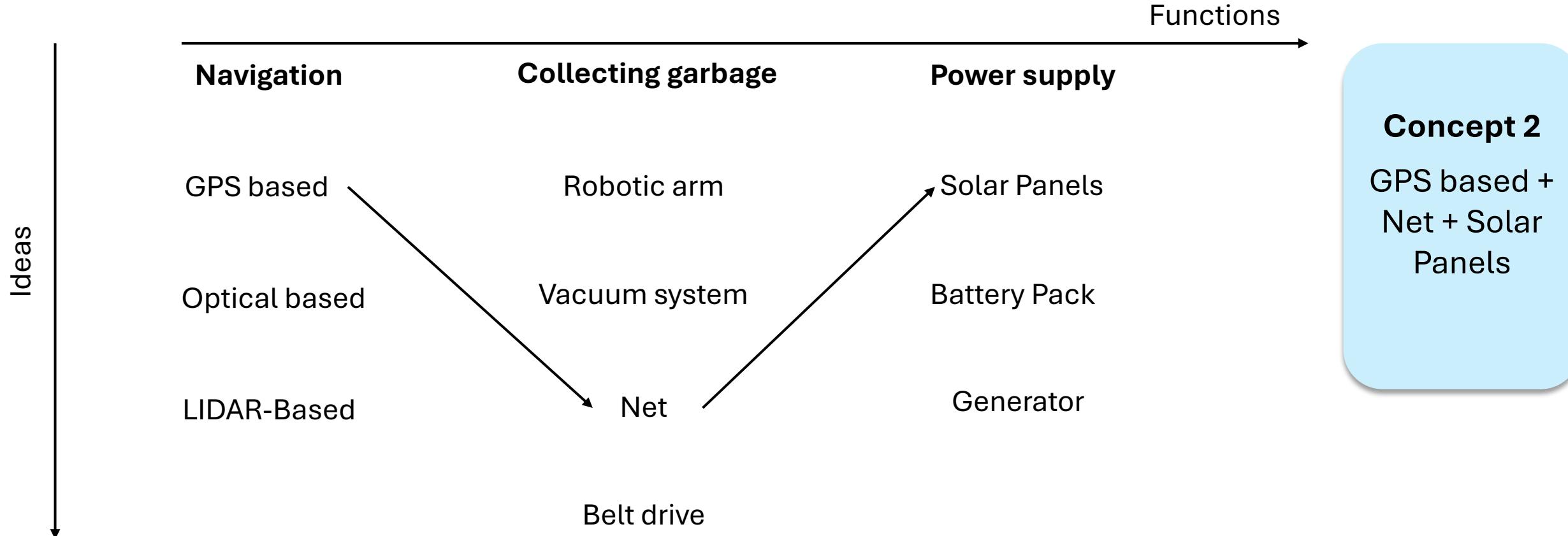
Robots to collect garbage from water bodies.



Stage 2: Concept Generation

Combining ideas into concepts

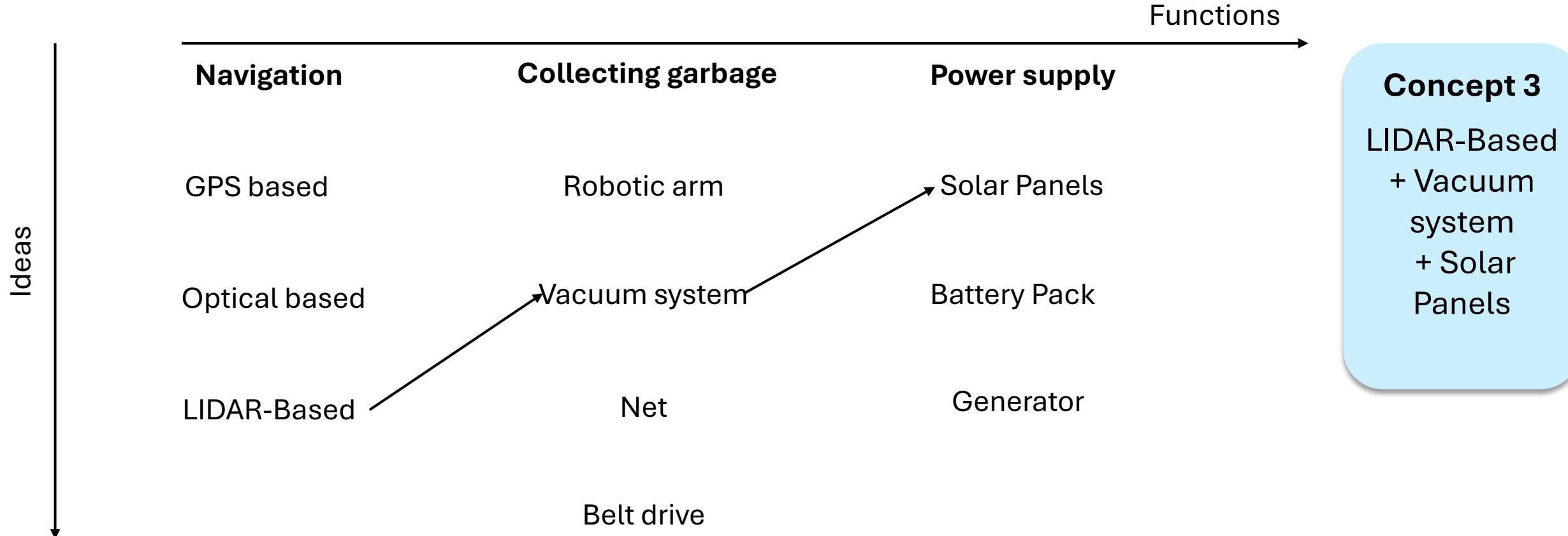
Robots to collect garbage from water bodies.



Stage 2: Concept Generation

Combining ideas into concepts

Robots to collect garbage from water bodies.



Stage 2: Concept Generation

Combining ideas into concepts

Firefighter's helmet

	Functions			
	Visibility	Breathability	Communication	Protection
ALTERNATIVES IDEAS	Smoke vents	Smoke filters	Radio communication device	Double walled helmet
	Thermal Imaging	Oxygen capsules to carry around	Shout loudly	Fire protection gel
	High contrast vision	Precipitate smoke and eliminate smoke	Elongated wire communication device	Protective shell
	Confine smoke to a small area	Smoke extractor	Light signals	Ceramic matrix fire suit
	IR imaging	Catalytic converter	Hand signals	Carbon Fibre suit
	Quick settle smoke	-	Ultrasonic device	Sleek, under fire suit

Concept 1

Use of thermal imaging, smoke filters, radio communication device and protection shell

Stage 2: Concept Generation

Combining ideas into concepts

Firefighter's helmet

	Functions			
	Visibility	Breathability	Communication	Protection
ALTERNATIVES IDEAS	Smoke vents	Smoke filters	Radio communication device	Double walled helmet
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	Confine smoke to a small area	Smoke extractor	Light signals	Ceramic matrix fire suit
	IR imaging	Catalytic converter	Hand signals	Carbon Fibre suit
	Quick settle smoke	-	Ultrasonic device	Sleek, under fire suit

Concept 2
Use of quick settling smoke device, the use of oxygen capsules to carry around with hand signals with ceramic matrix fire suit

Stage 2: Concept Generation

Combining ideas into concepts

Firefighter's helmet

Concept 1

Thermal imaging with smoke filters with radio communication device and protection shell

Concept 2

Quick settling smoke device combined with the use of oxygen capsules to carry around with hand signals with ceramic matrix fire suit

Concept 3

Double walled helmet with elongated wire communication device enabling visibility through use of IR imaging coupled with smoke filters.

Concept 4

Carbon-fibre suit with ultrasonic device for communication using a probe camera for better visibility coupled with catalytic converter.

Concept 5

Double walled helmet communication through light signals visibility through smoke vents using a catalytic converter for better visibility.

Concept 6

Thermal imaging device coupled with oxygen capsule to carry in the fire round with fire protection gel the phone using auditory signals for communication.

Concept 7

Protection shall combined with ultrasonic navigation for visibility a smoke expected for better breath ability and communicating through hand signals.

Concept 8

Ceramic matrix fire suit attached with elongated wire communication device using a probe camera for better visibility and improving the breath ability by precipitating smoke and eliminating it.

Concept 9

Sleek under fire suit with high contrast vision for better visibility using a catalytic converter for better readability and light signals for communication.

Concept 10

Use ultrasonic device to communicate, a double walled helmet for protection, IR imaging for better vision and precipitate smoke to eliminate smoke.

Stage 2: Concept Generation

Combining ideas into concepts

Firefighter's helmet

Concept 1

- **Helmet material-** GFRP
- **Solution for vision-** Powerful lighting with large anti glare visor
- **Communication solution-** Wireless transmitter
- **Breathing solution-** Air filter with vents

Concept 2

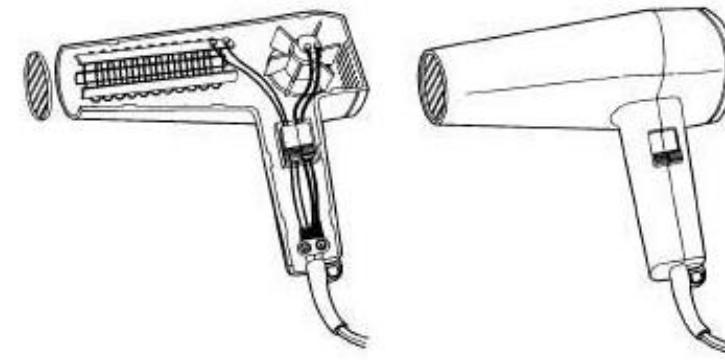
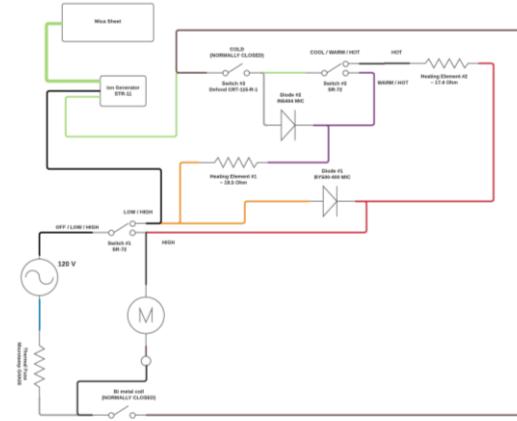
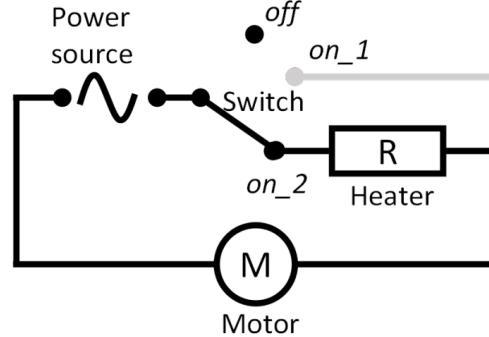
- **Helmet material-** ABS PC
- **Solution for vision-** IR Imaging camera
- **Communication solution-** Wireless transmitter and speaker
- **Breathing solution-** Replaceable mask

Concept 3

- **Helmet material-** ABS
- **Solution for vision-** Powerful lighting
- **Communication solution-** Wireless transmitter
- **Breathing solution-** Replaceable air filter patches with vents

Stage 3: Concept Consolidation

Languages of design



Sketch



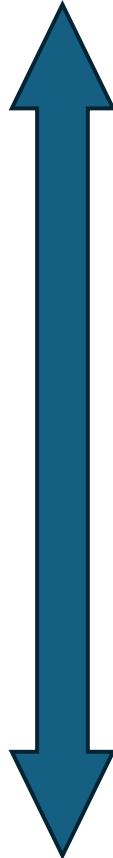
3D model



Stage 3: Concept Consolidation

Languages of design

Abstract



Text	→ Description and explanation
Chart/ Diagram	→ Structure, flow, or networks
Sketches	→ Shape, form, layout
Drawings	→ Dimensions, annotations, technical specifications
CAD Models	→ Geometry, proportions, and form
Mockups	→ Colours, materials, and finishes,
Prototypes and PoC	→ Functionality, user interaction, and performance

Real

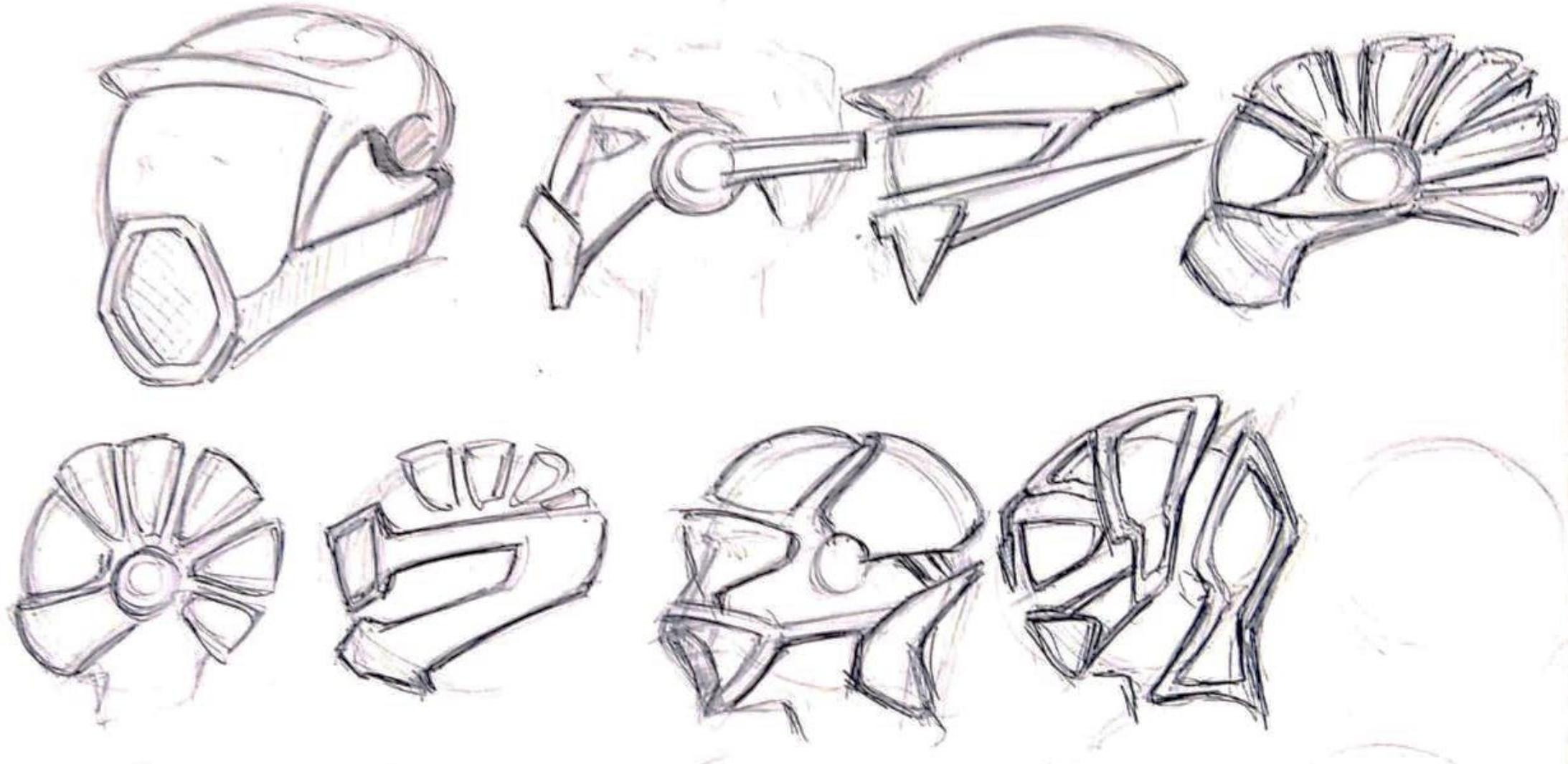
Stage 3: Concept Consolidation

Languages of design



Stage 3: Concept Consolidation

Concept sketches



Firefighter's helmet

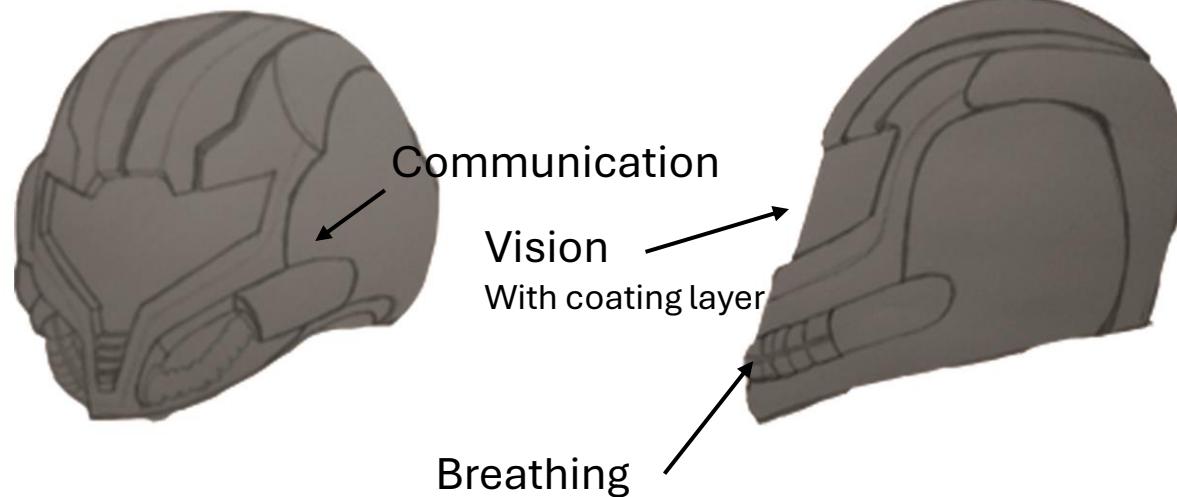
Stage 3: Concept Consolidation

Concept sketches

Communication – Batman



Breathing – Star wars

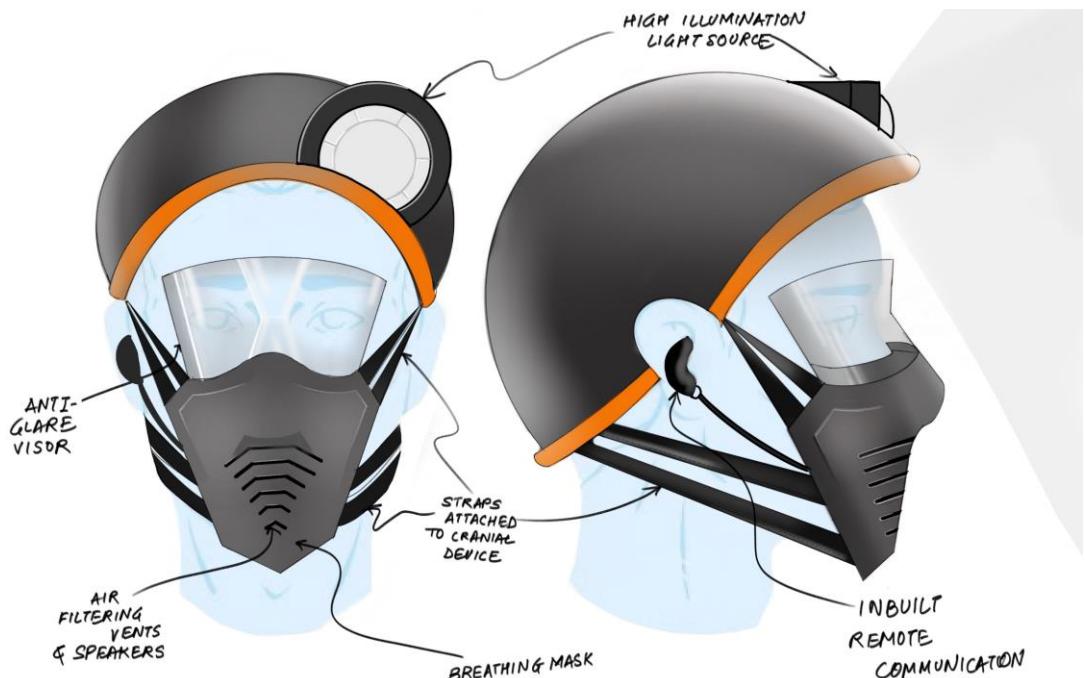


Firefighter's helmet

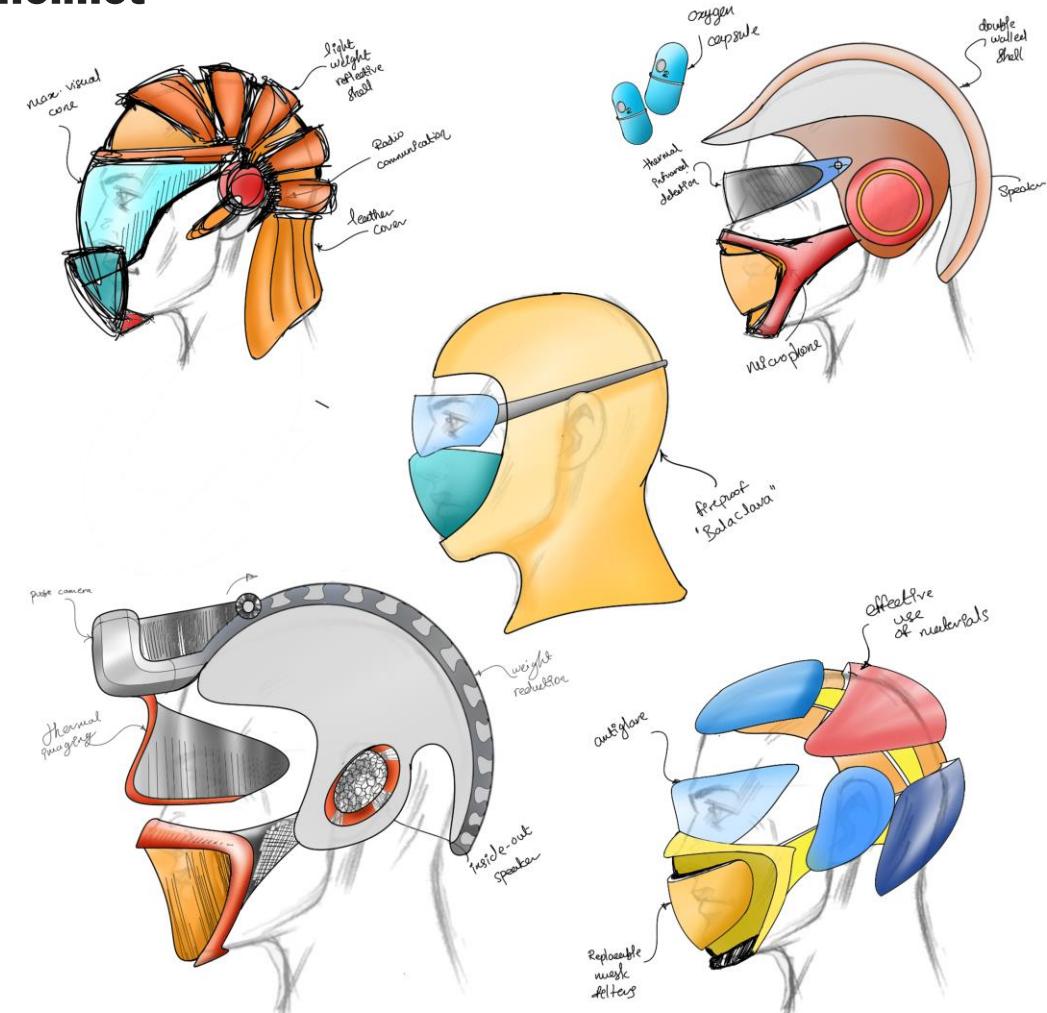


Stage 3: Concept Consolidation

Concept sketches



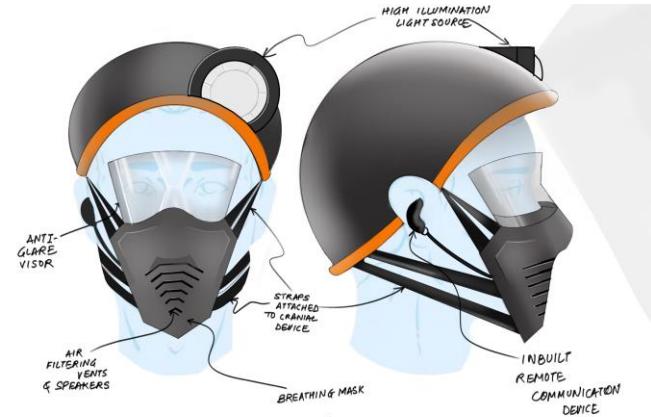
Firefighter's helmet



Stage 3: Concept Consolidation

Concept sketches

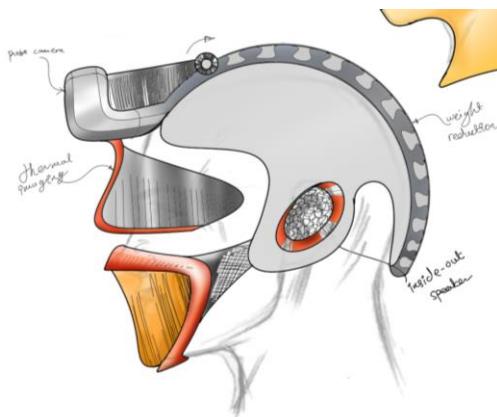
Concept 1



- **Helmet material-** GFRP
- **Solution for vision-** Powerful lighting with large anti glare visor
- **Communication solution-** Wireless transmitter
- **Breathing solution-** Air filter with vents

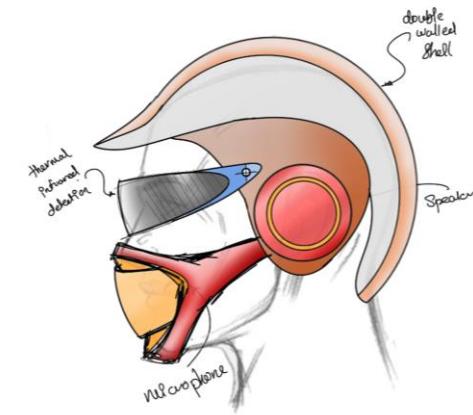
Firefighter's helmet

Concept 2



- **Helmet material-** ABS PC
- **Solution for vision-** IR Imaging camera
- **Communication solution-** Wireless transmitter and speaker
- **Breathing solution-** Replaceable mask

Concept 3



- **Helmet material-** ABS
- **Solution for vision-** Powerful lighting
- **Communication solution-** Wireless transmitter
- **Breathing solution-** Replaceable air filter patches with vents

Stage 3: Concept Consolidation

Concept prototypes

“A preliminary version of a final product and it can represent both aesthetic and functional features.”

“an approximation of the product along one or more dimensions of interest”

Purpose

- Learning
- Communication
- Demonstration
- Decision-making

Stage 3: Concept Consolidation

Concept prototypes



Paper



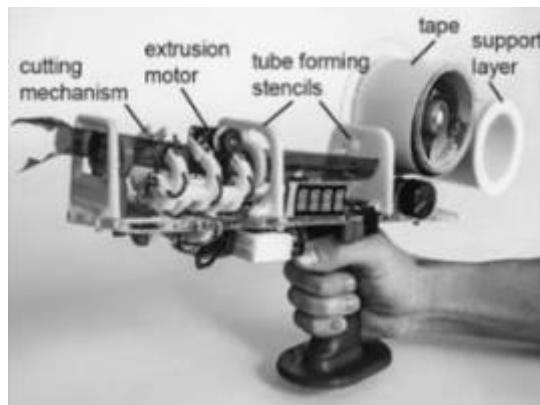
Foam



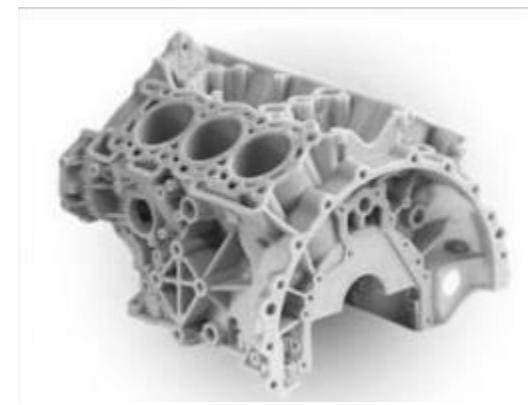
Cardboard



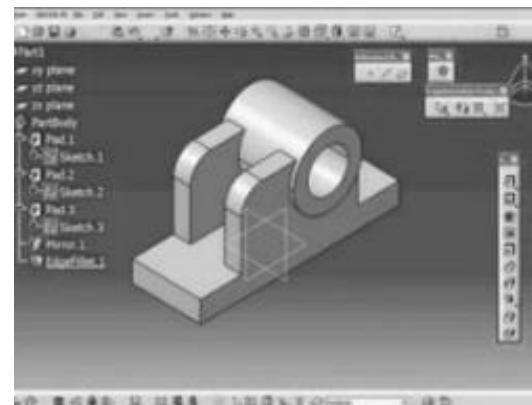
Scaled down



Functional



3D printed



CAD

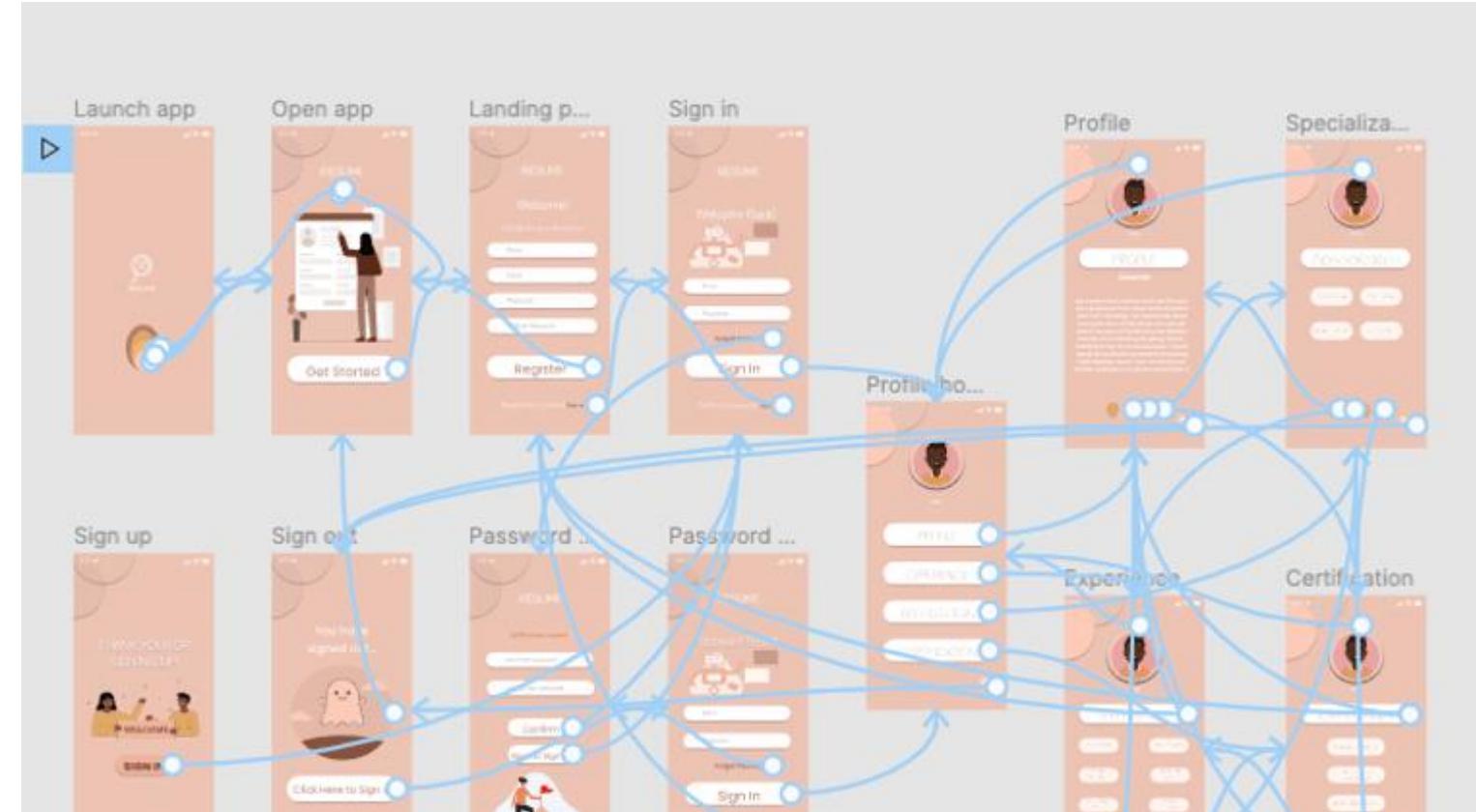


Augmented reality

Stage 3: Concept Consolidation

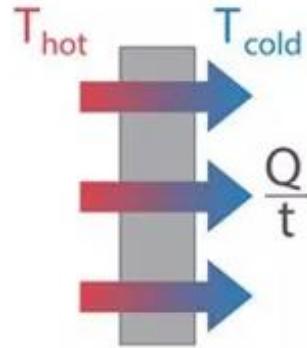
Concept prototypes

Figma



Stage 4: Concept Testing

Concept Analysis: Analytical method



$$\frac{Q}{A} = \frac{K (T_{hot} - T_{cold})}{d}$$

Firefighter's helmet

Q = Conduction heat transfer (W)

K = Materials thermal conductivity (W/mK)

A = Cross sectional area (m^2)

T_{Hot} = Higher temperature ($^{\circ}C$)

T_{Cold} = Colder temperature ($^{\circ}C$)

d = Material thickness (m)

Materials	Q/A [W/cm ²]	K [W/M*K]	T(hot) [K]	T(cold) [K]	T(hot)-T(cold)	d [cm]	d [mm]
ABS-PC	1	0.00192	523.15	310.15	213	0.40896	4mm
ABS		0.00209				0.44517	4.4mm
GFRP		0.00176				0.37488	3.7mm

Q/A = 1 W/cm² as per NFPA standards

Stage 4: Concept Testing

Simulations: Numerical method

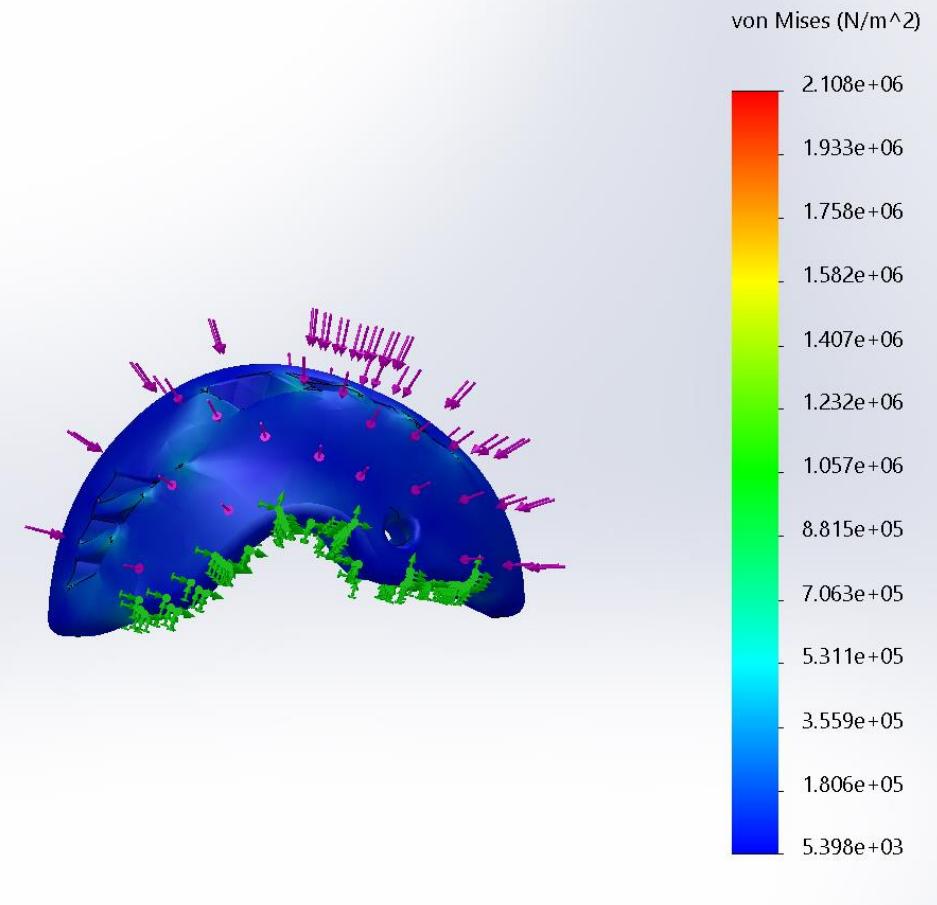
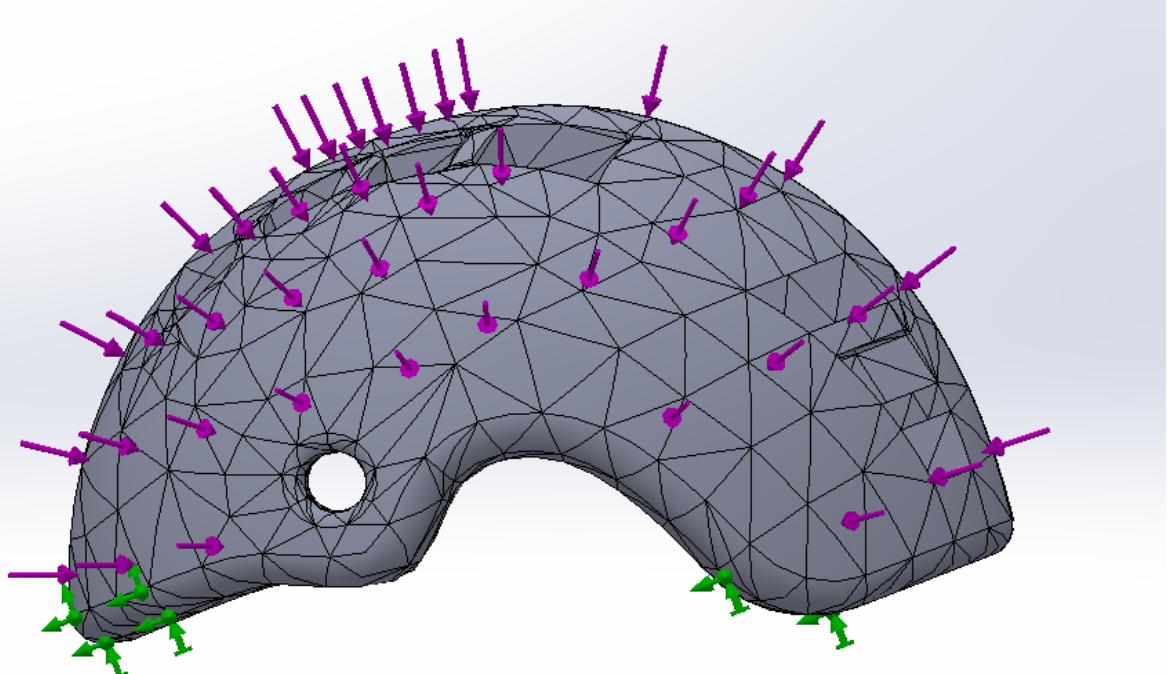
Firefighter's helmet

Model Name: helmet1

Study name: Static 1(-Default-)

Plot type: Static nodal stress Stress1

Deformation scale: 2,180.36



Learning from the Analysis

Firefighter's helmet

	<u>ABS PC</u>	<u>ABS</u>	<u>GRP</u>
Deformation	3	1	2
Stress Concentration	1	3	2
Weight	low	low	high
Impact Resistance	average	average	high
Thermal resistivity	0.00192 W/mK	0.00209 W/mK	0.00176 W/mK
Min. Material thickness (Based on Thermal Conductivity)	4 mm	4.4 mm	3.7 mm

Stage 4: Concept Testing

PoCs

Firefighter's helmet

Concept 1



Concept 2



Concept 3



Stage 4: Concept Testing

Weighted objectives method
(Selection)

Firefighter's helmet

	Objective 1	Objective 2	Objective 3	...	Objective N	Sum
Weightage	X %	Y %	Z %	... %	... %	
Concept 1	0-10	0-10	0-10	0-10	0-10	...
Concept 2	0-10	0-10	0-10	0-10	0-10	...
Concept ...	0-10	0-10	0-10	0-10	0-10	...
Concept M	0-10	0-10	0-10	0-10	0-10	...

Stage 4: Concept Testing

Weighted objectives method
(Selection)

Firefighter's helmet

	C1 High visibility in smoke	C2 High breathability	C3 High heat resistance	C4 High impact resistance	C5 Low power consumption	C6 Low weight	Sum
Ki	16	30	30	7	7	10	
Concept 1	7	8	9	9	5	4	= 760
Concept 2							
Concept 3							

Stage 4: Concept Testing

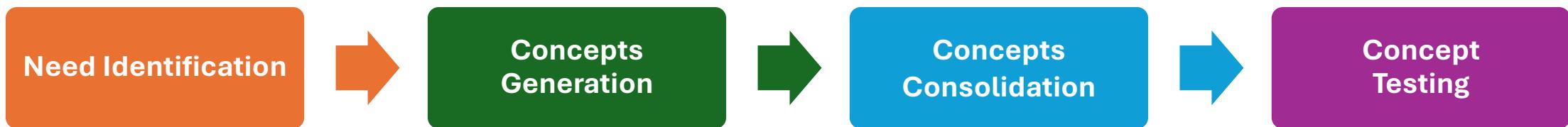
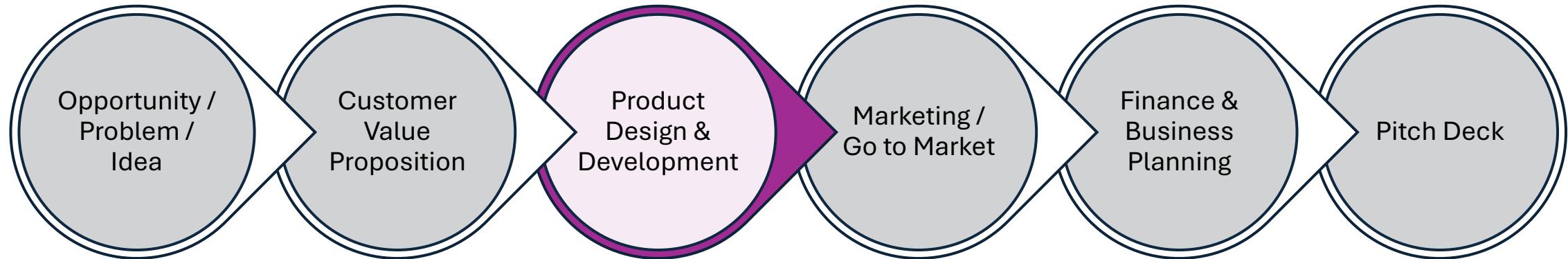
Weighted objectives method
(Selection)

Firefighter's helmet

	C1 High visibility in smoke	C2 High breathability	C3 High heat resistance	C4 High impact resistance	C5 Low power consumption	C6 Low weight	Sum
Ki	16	30	30	7	7	10	
Concept 1	7	8	9	9	5	4	760
Concept 2	9	4	6	7	4	8	601
Concept 3	3	5	4	5	9	8	496

Best alternative- Concept 1

Product Design Process: Activity view



- Observation
- Interaction
- Experience

- Ideation
- Inspiration
- Syntheses

- Sketching
- Prototyping

- Analysis
- Evaluation
- Selection