B

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MEDICAL

CARBON DIOXIDE SENSOR

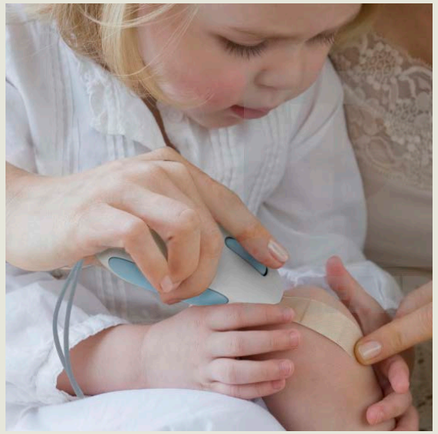
APPLICATION: INTERNSHIP EXPERIENCE

NAME: REALM PROJECT

DATE:	LENGTH:
2020	7 MONTHS

TEAM PROJECT
AMY ZHAO, LEO ZHANG, SITAI CHEN

HUMAN FACTORS STUDY



BANDAGE APPLICATOR

NAME: APPLICAID

DATE:	LENGTH:
2019	1 MONTH

PROTOTYPING

MOBILITY SET

NAME: ENCORE

DATE:	LENGTH:
2019	4 MONTHS

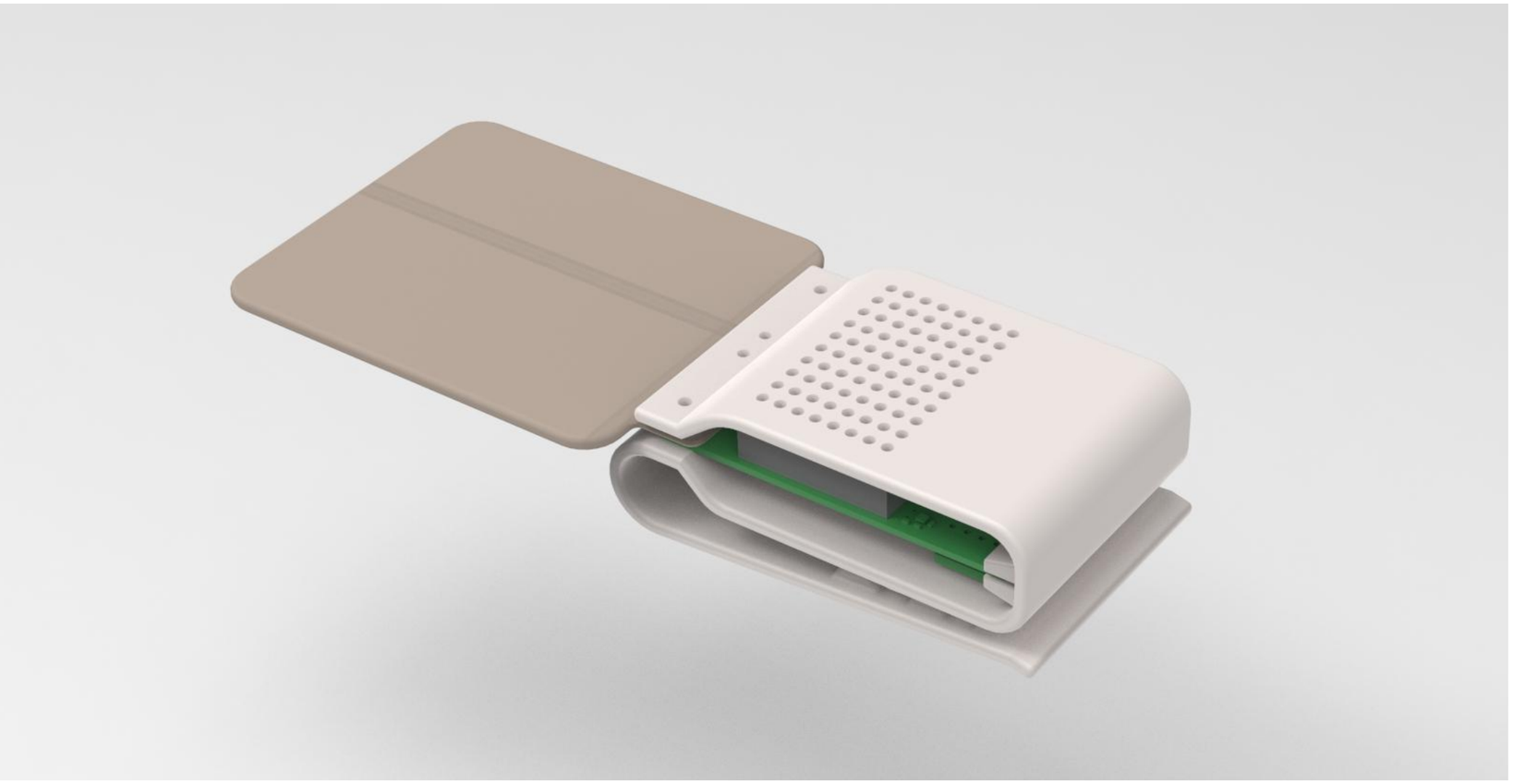
RESEARCH

AFFORDABLE ORTHOTIC

NAME: PREPARE

DATE:	LENGTH:
2019	4 MONTHS

MANUFACTURING



ENSURING ASTRONAUT HEALTH & PRODUCTIVITY

NAME:

REALM PROJECT

DESCRIPTION:

WEARABLE CARBON DIOXIDE SENSOR

COMPANY:

NASA JOHNSON SPACE CENTER

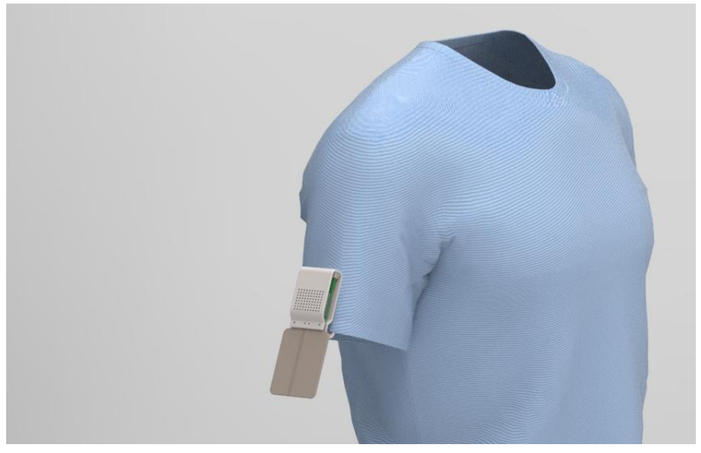
INTERNSHIP EXPERIENCE

TEAM PROJECT

AMY ZHAO, LEO ZHANG, SITAI CHEN

DATE:	LENGTH:
2020	7 MONTHS

PRESENTED AT 2020 WEARABLE TECHNOLOGIES WORKSHOP



MY ROLE:

TEAM LEADER & PRIMARY CORRESPONDANT

COLLECTIVE IDEATION, MODELING, TESTING, AND DATA VISUALIZATION

MENTOR:

NICHOLAS SCHLEIF

ELECTRICAL ENGINEER AT EV8 WIRELESS COMMUNICATION BRANCH AT NASA JOHNSON SPACE CENTER

SUPERVISED PROGRESS & RELAYED TECHNICAL FEEDBACK

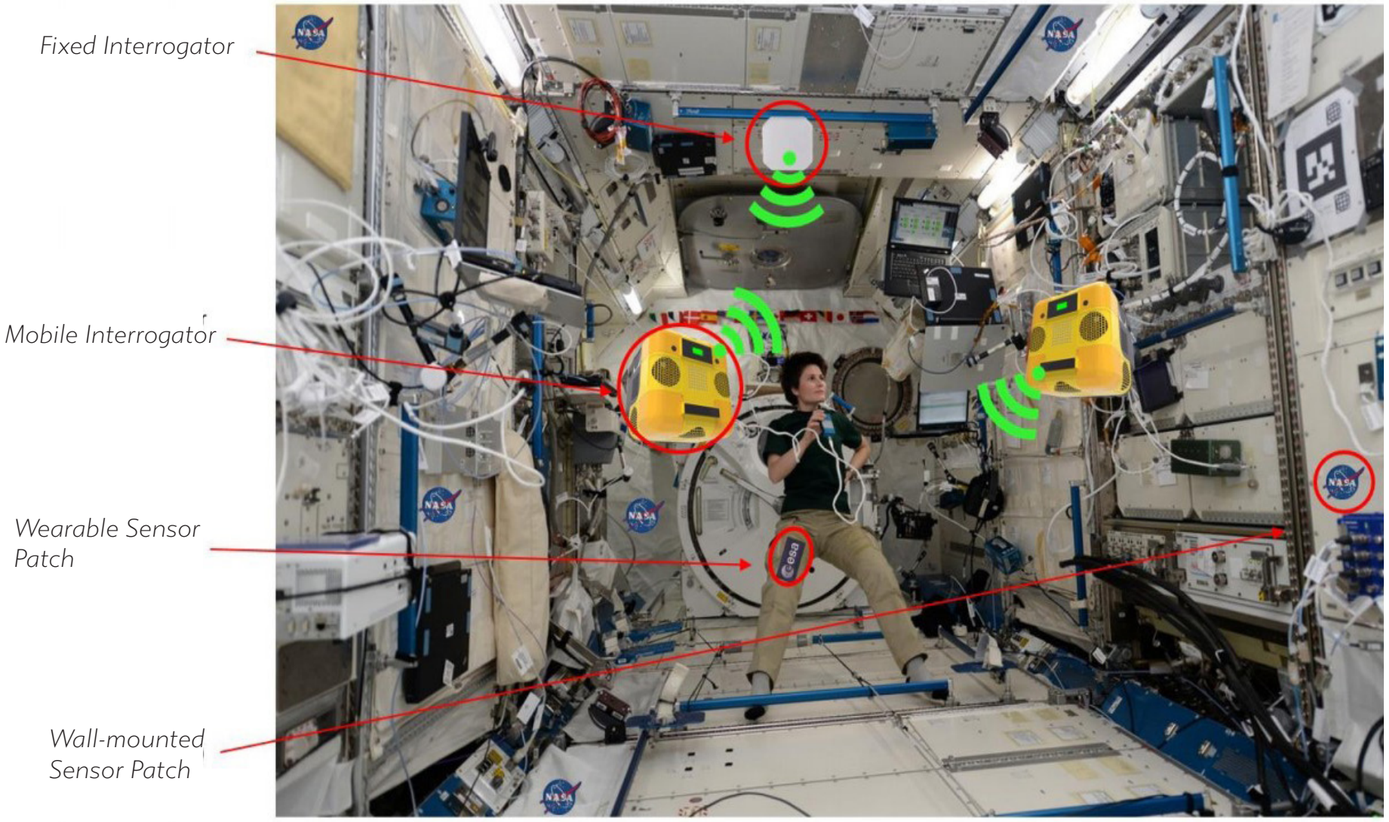
OUTCOME:

CARBON DIOXIDE SENSOR INCOPORATING OUR DESIGN
ANTICIPATED TO LAUNCH INTO SPACE IN LATE 2021

PROBLEM:

In space, **carbon dioxide forms air pockets that displace oxygen** and impact astronaut health and productivity.

Prototypes of 6 Sensor-Antenna Combinations used in Human Factors Study



Existing RFID Infrastructure on the International Space Station

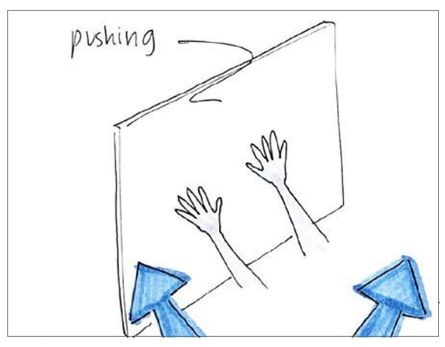
OBJECTIVE:

Conduct a **human factors study** and design a **thousing and attachment method** of a custom wireless on-body sensing system.

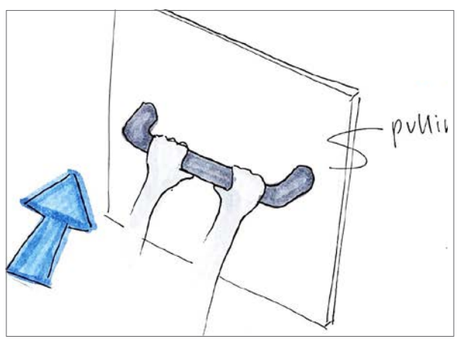
HUMAN FACTORS STUDY IDEATION

MOVEMENT IDENTIFICATION

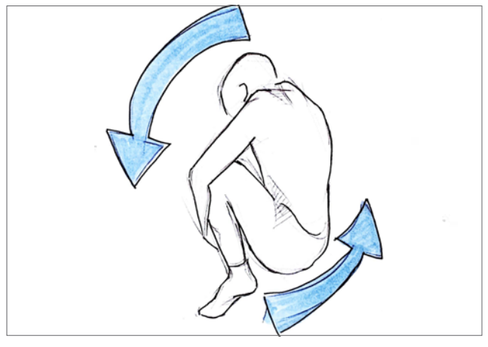
sketches by Amy Zhao



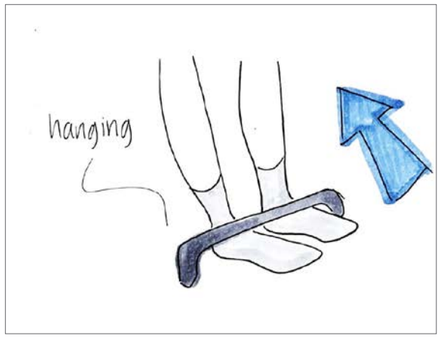
Pushing: to move the body in the opposite direction of the push



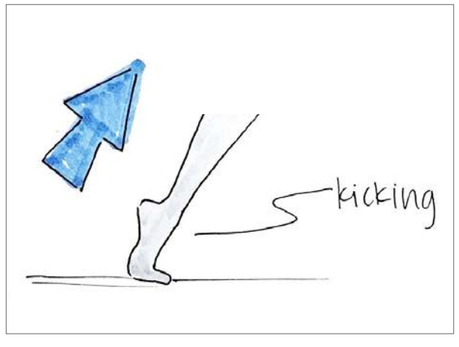
Pulling: to move the body sideways in relation to the bar.



Spinning: To change the direction of movement



Hanging: to maintain the body's position relative to the ISS

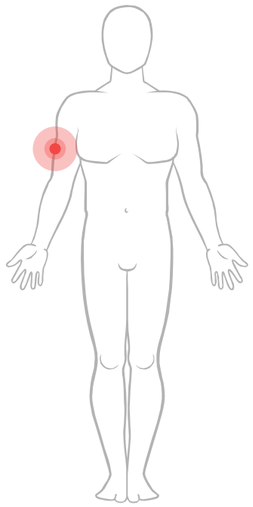


Kicking: to push the body in the opposite direction of the kick

Astronaut movements in space were observed and 5 key movements were identified. During the **human factors test**, participants will be asked to **wear the sensor packages**, **perform these representitive tasks,** and **evaluate the comfort and restrictiveness** of the sensor packages.

HUMAN FACTORS STUDY

TESTING EXAMPLE: ARM LOCATION



ABOUT THE TEST

VARIABLES:

6 SENSOR-ANTENNA COMBINATIONS
4 BODY LOCATIONS
arm, thigh, chest, back

SAMPLE:

15 PEOPLE FOR EACH BODY LOCATION
carefully selected based on wide demographic including gender, height, and age

TASK:

PERFORM REPRESENTATIVE TASKS WHILE SUSPENDED
pulling, pushing, kicking, hanging

MEASUREMENT:

RATE COMFORTABILITY AND RESTRICTIVENESS ON A SCALE OF 1-5
5 being the most comfortable and least restrictive

Two Samples of Arm Human Factors Study

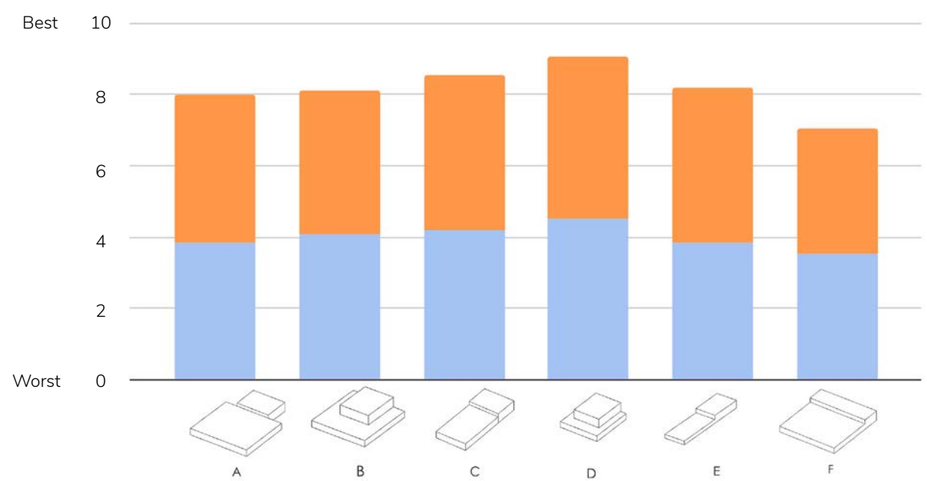
Test Subject	Restrictiveness							Comfort					
	A	B	C	D	E	F		A	B	C	D	E	F
	5	4	5	5	4	2		5	3	5	5	4	1

Test Subject	Restrictiveness							Comfort					
	A	B	C	D	E	F		A	B	C	D	E	F
	4	5	5	5	3	2		4	4	5	5	3	2

Compiled Data

	A	B	C	D	E	F
Average Restrictiveness	3.867	4.067	4.200	4.533	3.867	3.533
Average Comfort	4.133	4.067	4.333	4.533	4.333	3.533
Combined Average	8.000	8.133	8.533	9.067	8.200	7.067

Compiled Data Visualized



RESULT:

The results of the data are combined to **determine the overall best sensor** for the arm location, which is determined to be **sensor package D**.

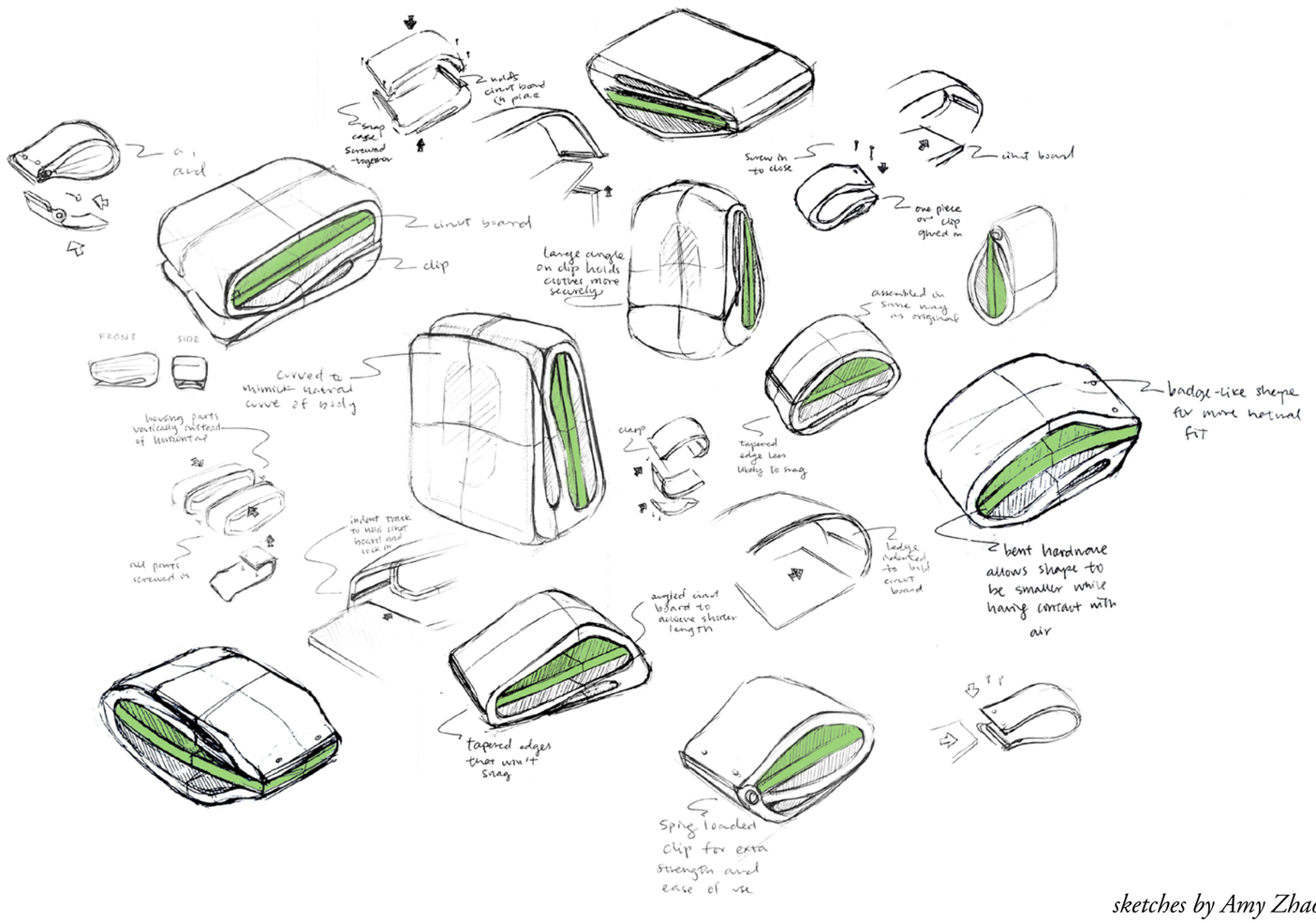
HOUSING IDEATION

FORM EXPLORATION

CONSIDERATIONS:

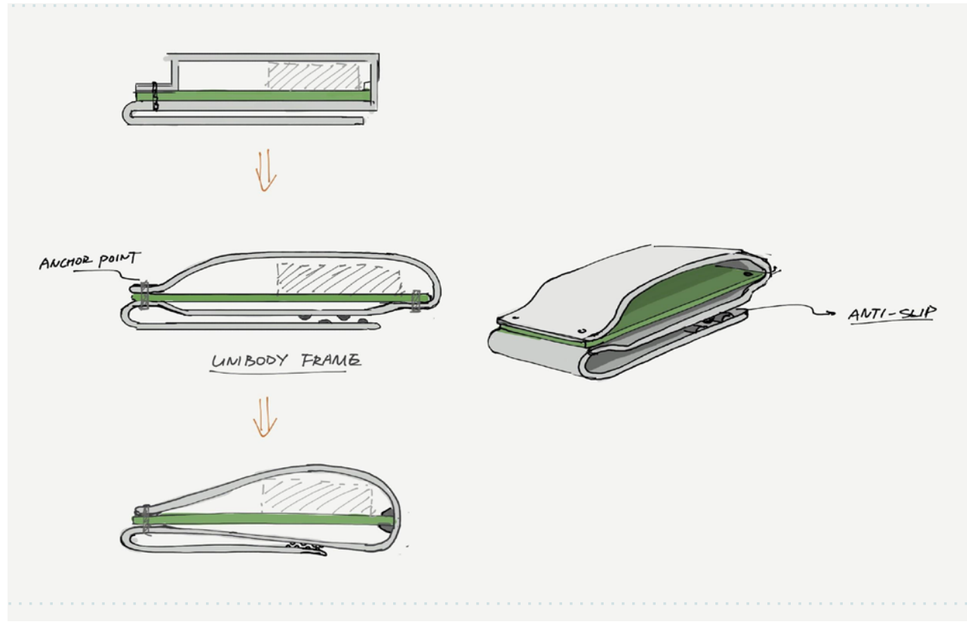
The following work was done 4 months later after the team from NASA **finalized the dimensions of the sensor-antenna** package. The sensor-antenna package **must be protected by a rigid housing** that is open on the sides and **incorporate an attachment method**. It must be **comfortable, ergonomic, nonrestrictive, and stay on astronaut clothing**.

Housing Ideation

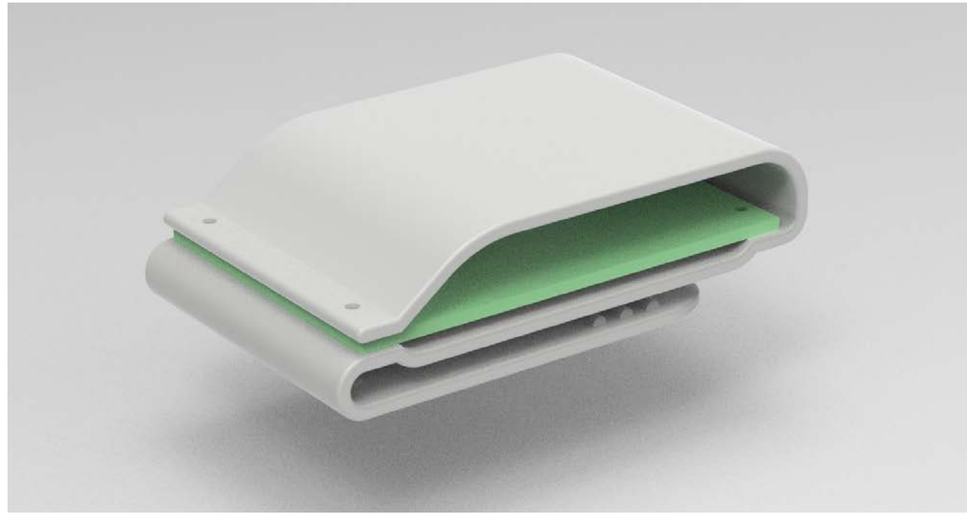


sketches by Amy Zhao

Ideation Revised after Technical Feedback



Rendered Preliminary Housing

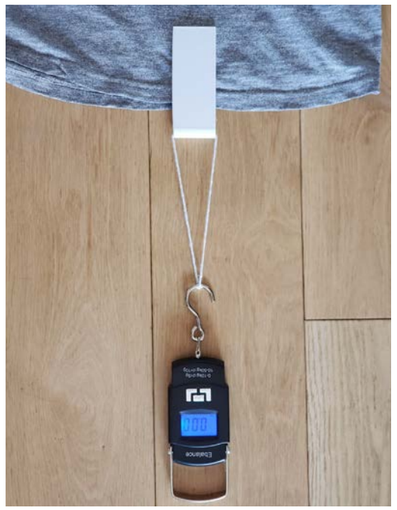


ATTACHMENT PROTOTYPING

MODELING & TESTING FOR SECURE GRIP

Grip Prototypes

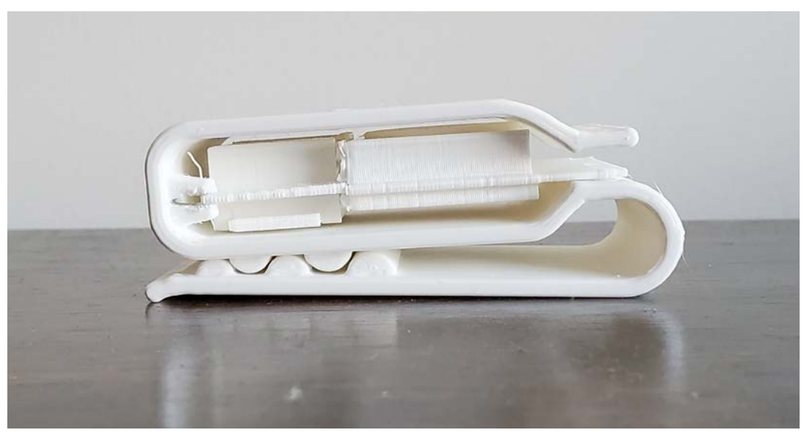
WeightTest



Movement Test

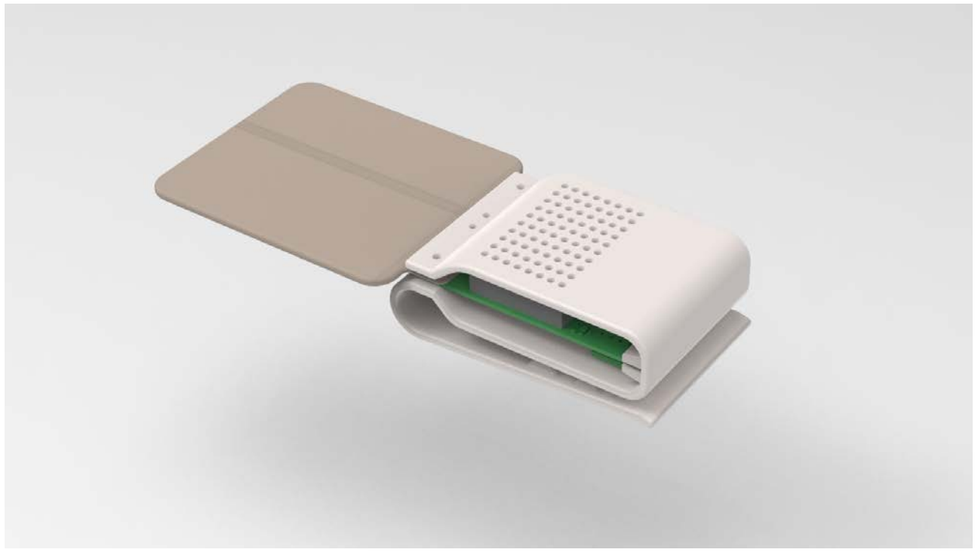
Housing and Attachment Prototype

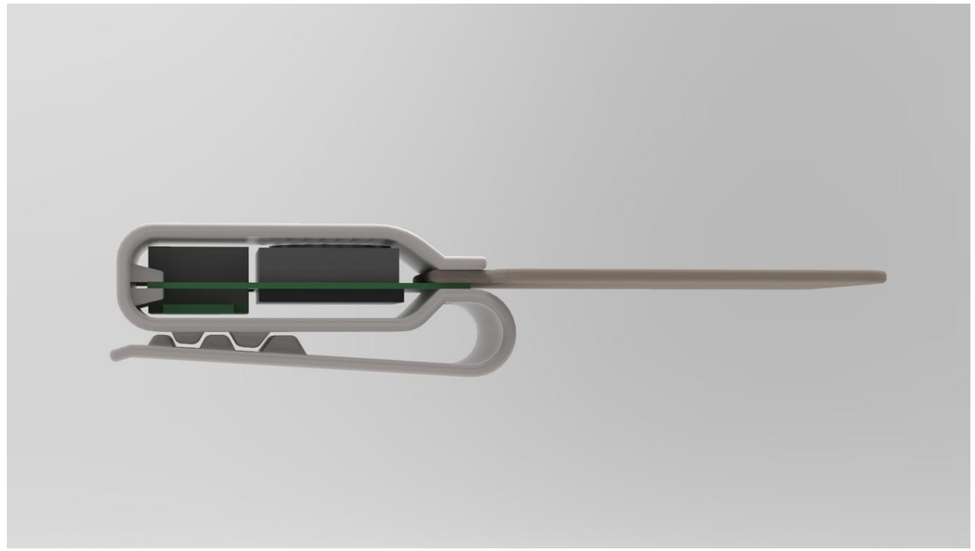
Final Sensor Package, Housing, and Attachment Prototype

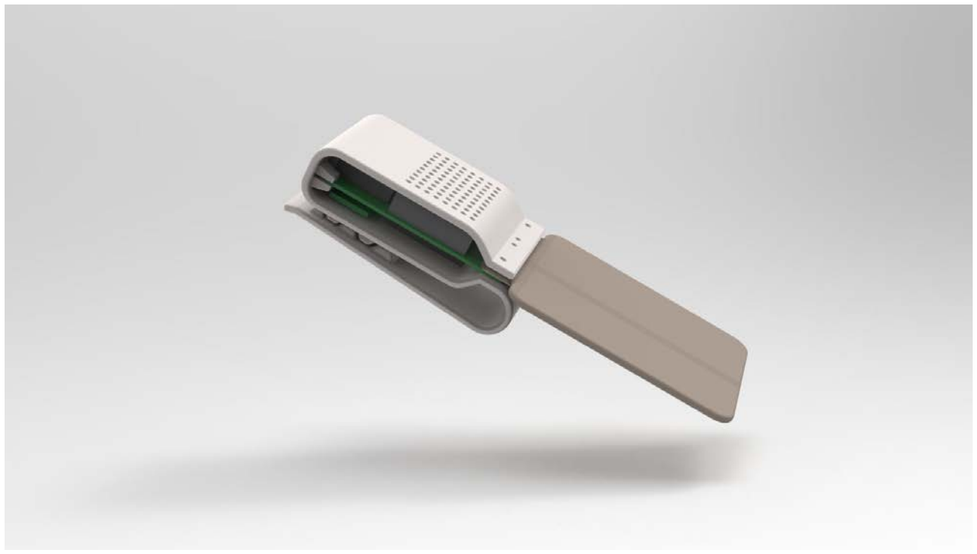


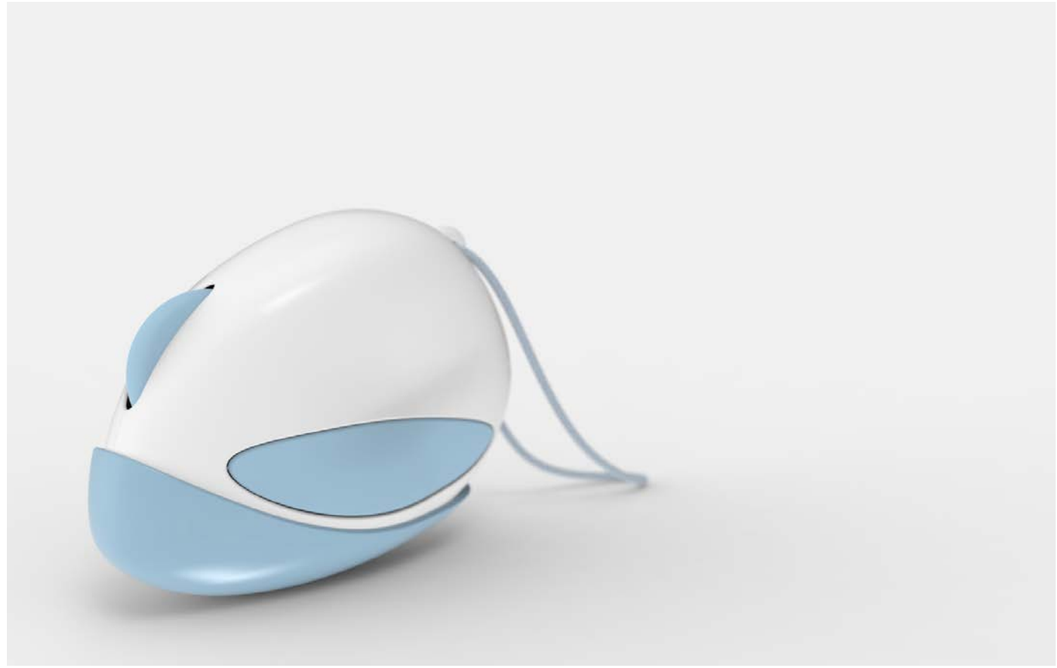
FINAL RENDERINGS

FINAL HOUSING & ATTACHMENT



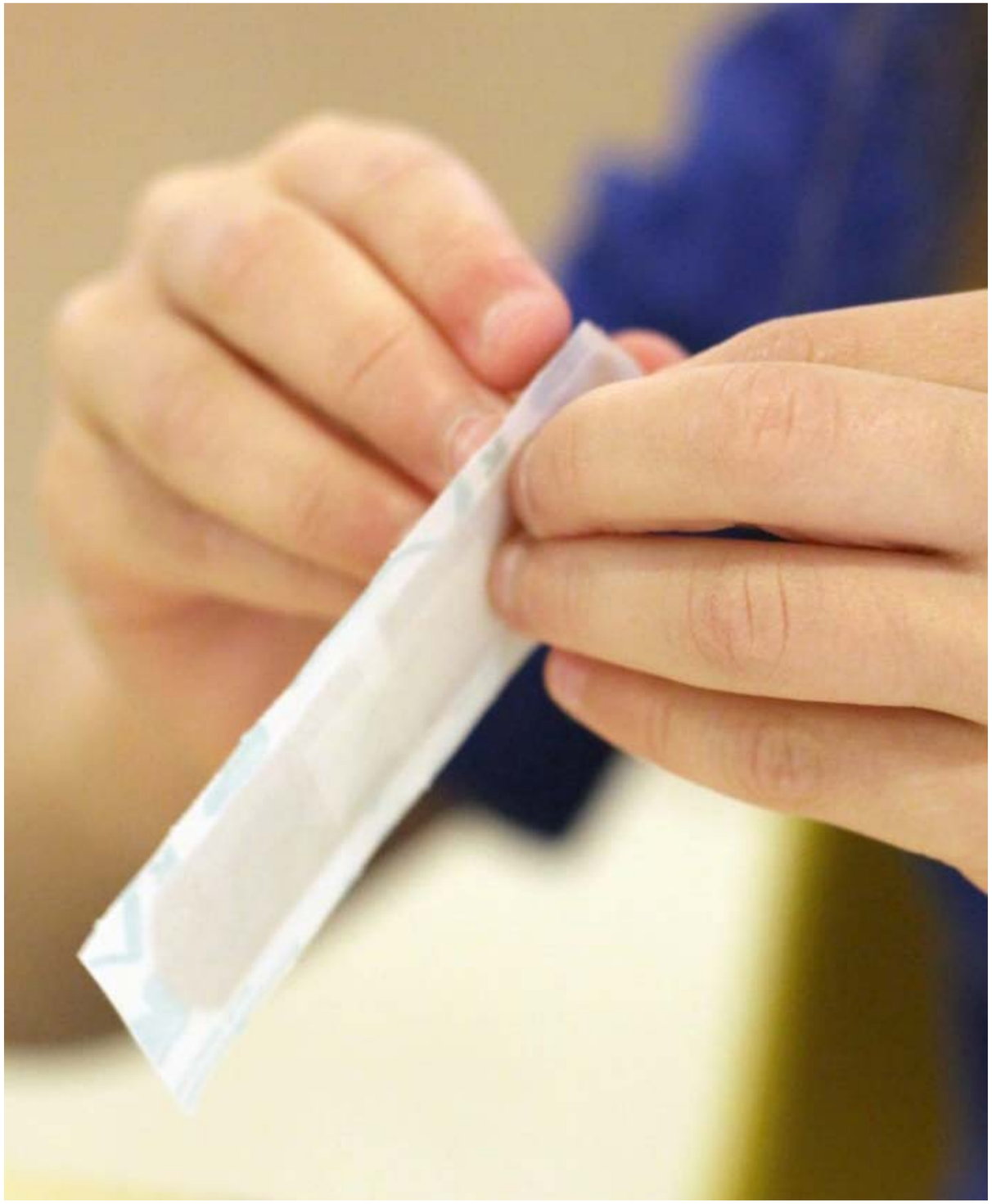






UNIVERSAL ACCESSIBILITY TO FIRST-AID

NAME: *APPLICAID*	
DESCRIPTION: **BANDAGE APPLICATOR FOR LIMITED HAND MOBILITY**	
DATE: 2019	LENGTH: 1 MONTH



PROBLEM:

Adhesive bandage **packaging marginalizes those with limited hand mobility,** presenting difficulty to those including:

amputees or the partially paralyzed

patients with stiff hands (arthritis, diabetes, etc.)

those without immediate access to soap and water

OBJECTIVE:

Simplify the process of applying a band-aid by providing an **ergonomic and universal design** able to be used with one hand and minimal gripping pressure that is also better for storage

RESEARCH

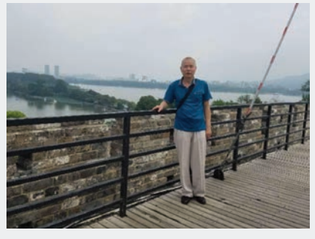
PRELIMINARY ISSUES EXPLORATION

Most Common Complaints for Adhesive Bandages*

*data acquired from 100 of the most recent one star reviews of the top 4 adhesive bandages on Amazon

Interviews

20 interviews were conducted with members of the general population to find any difficulties they may have noticed with adhesive bandages.

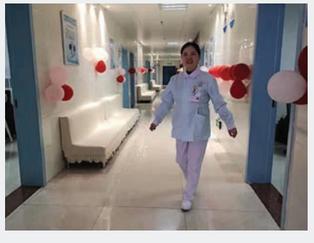


"I am having a harder time bending my fingers as I get older. I cannot grip as tightly as I used to and have a difficult time holding small or thin things."

Shiyin Zhao, 84, has arthritis

"Many patients with arthritis also suffer from hand tremors and have a difficult time with detailed work. "

Deping Zhao, 46, nurse



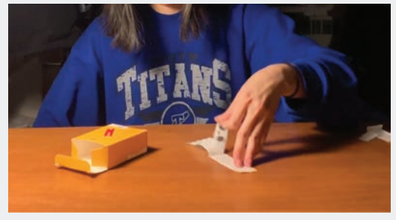
Difficulty of Applying an Adhesive Bandage Using One Hand

Sample: 20 adults

Task: Apply an adhesive bandage with both hands and rate its difficulty, repeat again using one hand

Scale: 1 to 10 with 1 = easy and 10 = hard

Average Time: 21 seconds
Average Difficulty Rating: 2.7



Average Time: 49 seconds
Average Difficulty Rating: 7.3

Results: Participants found that it was nearly 3X more difficult to apply an adhesive bandage with one hand and it took 2X longer.

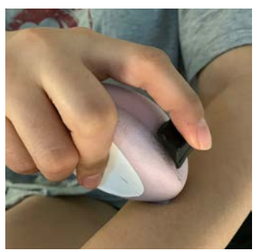
PROTOTYPING & USER TESTING

DEVELOPMENT

Directions for User Testing

Prototypes

User Testing

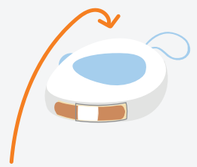


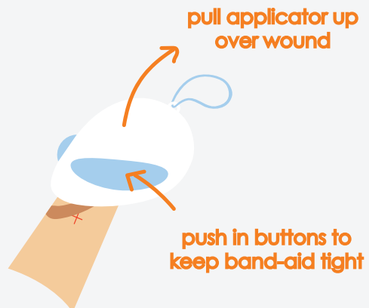
Final Model

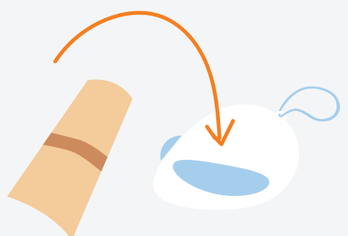
PRESENTATION

GRAPHICS

Instructions

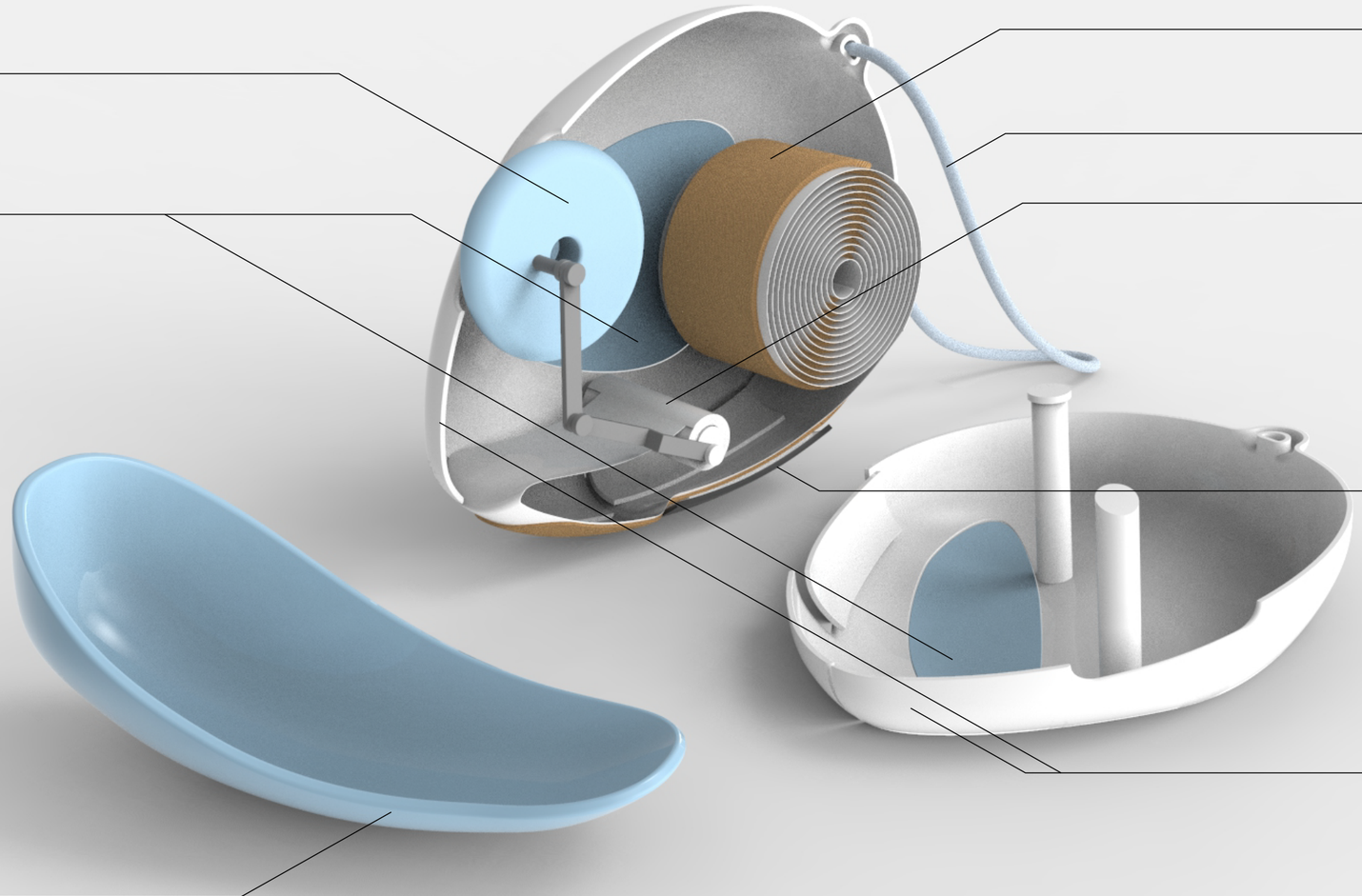






FINAL MODEL

INTERIOR



bandage advance wheel
moves bandages forward/backwards during applicaation

bandage advance wheel
moves bandages forward/backwards during applicaation

waterproof magnetic lid

replaceable bandage roll
contains up to 50 adhesive bandages

string

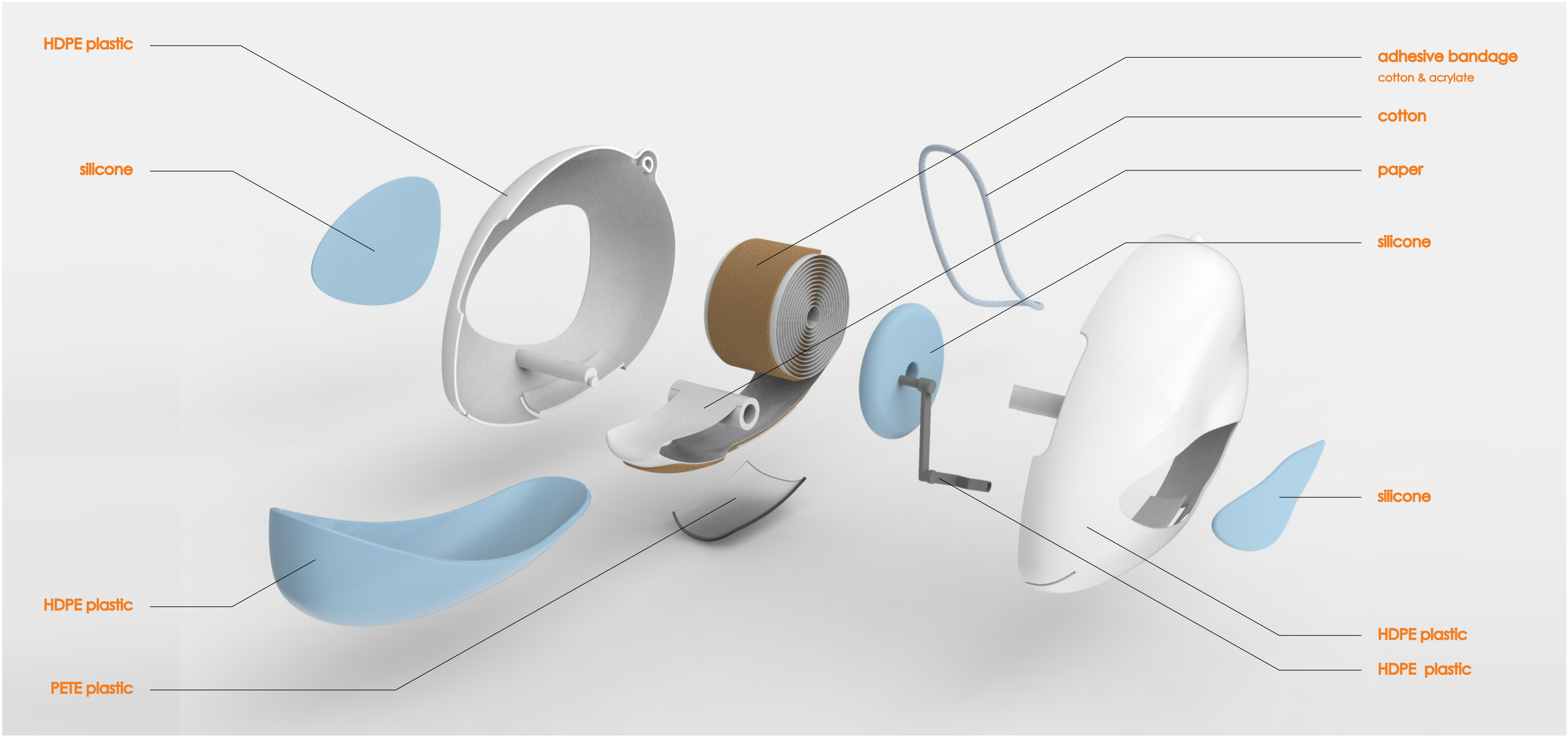
biodegradable paper
easier disposal

clear bandage protector
keeps bandages sterile but visible during application

detachable plastic casing
reusable and recyclable

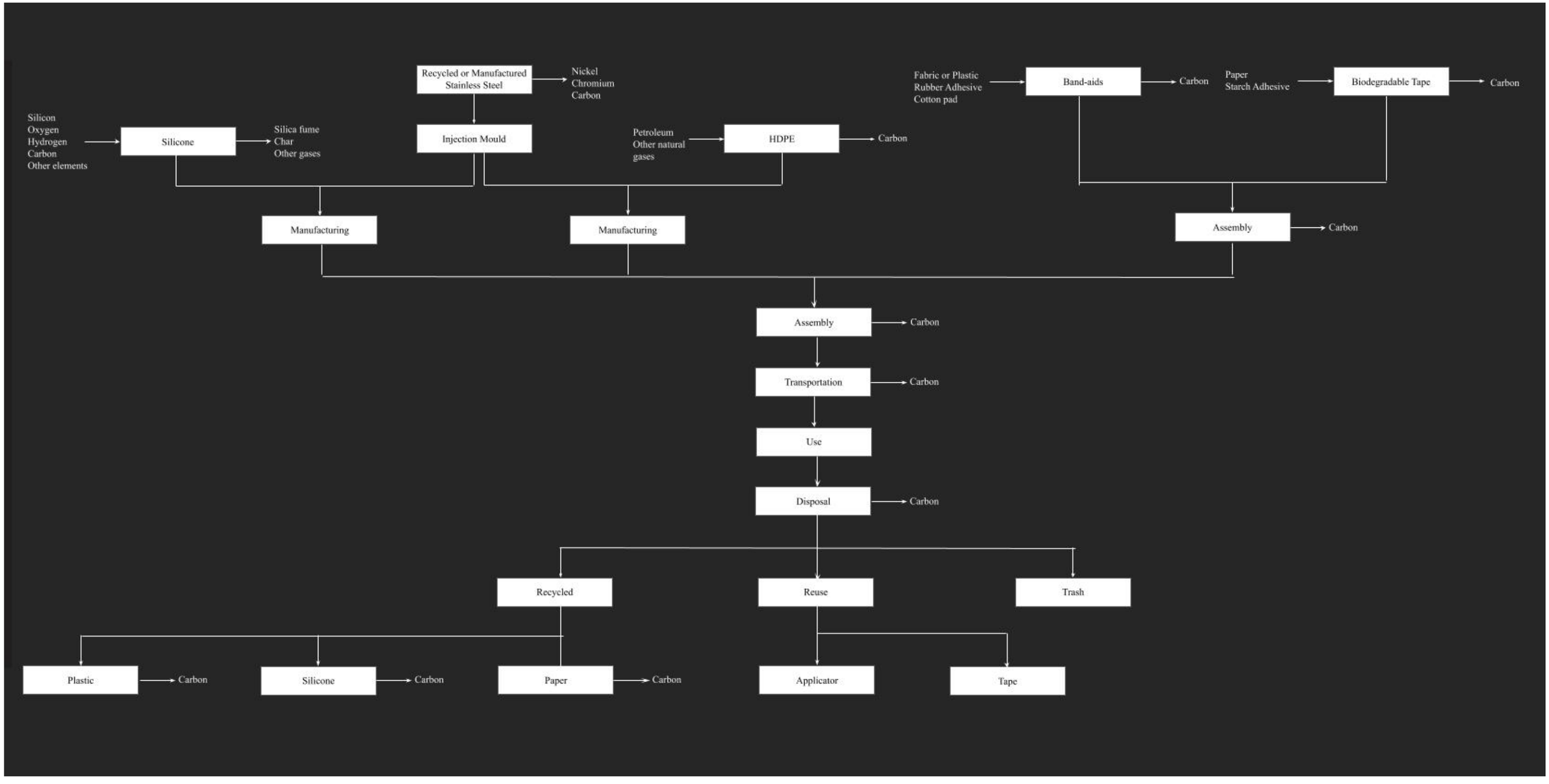
FINAL MODEL

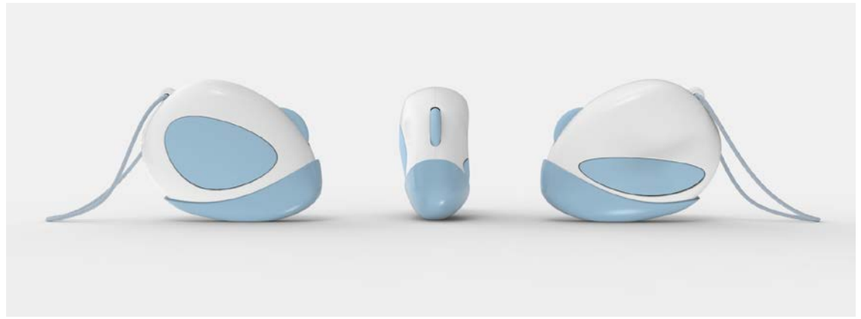
MATERIALS

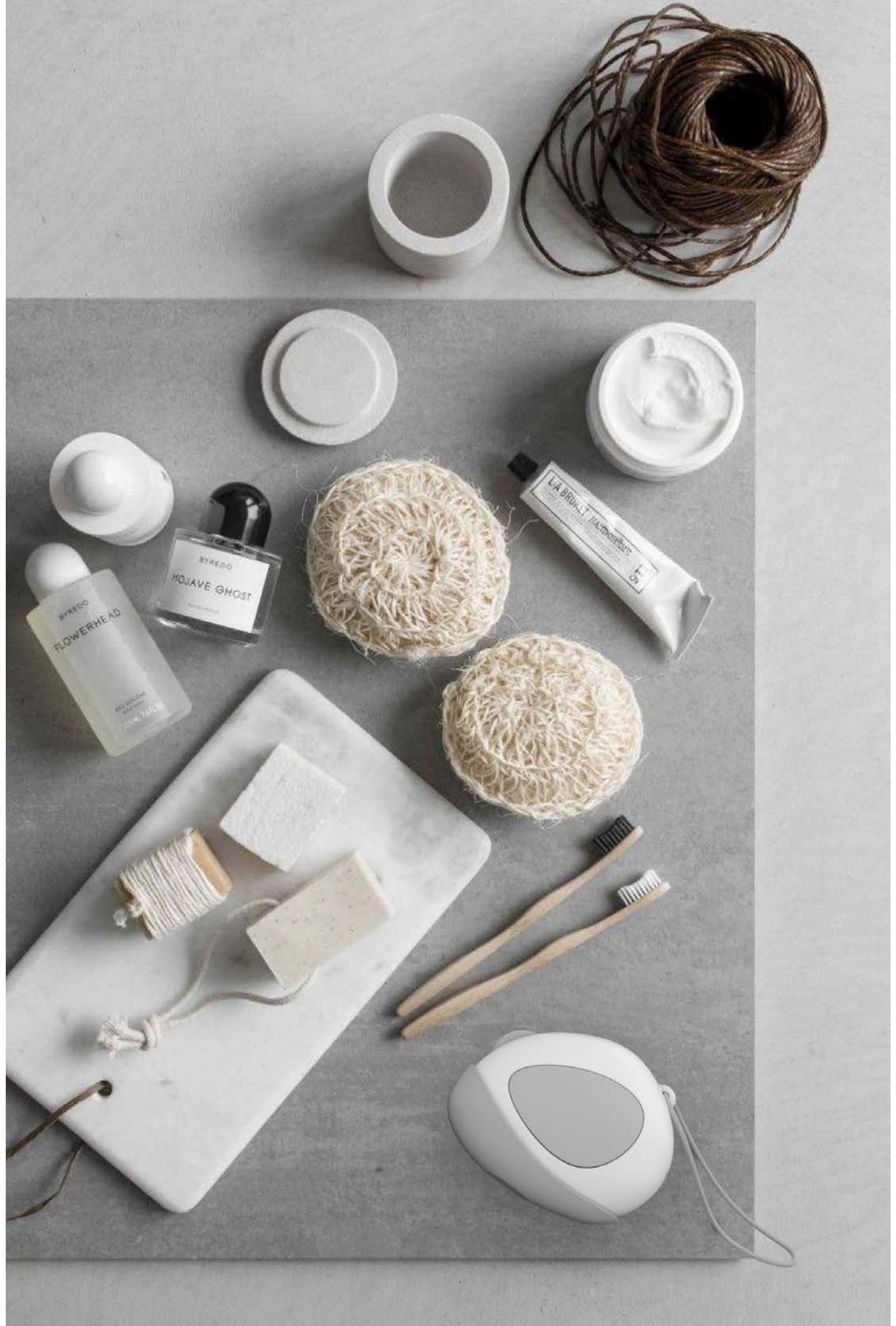


MANUFACTURING RESEARCH

PROCESS GRAPH






BYREDO
MOJAVE GHOST
BYREDO
FLOWERHEAD

DESTIGMATIZING PREVENTATIVE CARE

NAME: *ENCORE*	
DESCRIPTION: **ATHLETIC & MOBILITY SET FOR EARLY-ONSET ARTHRITIS**	
DATE: 2020	LENGTH: 4 MONTHS

PROBLEM:

The stigma of aging prevents many with early onset arthritis **from preventative care resulting in injuries**.

OBJECTIVE:

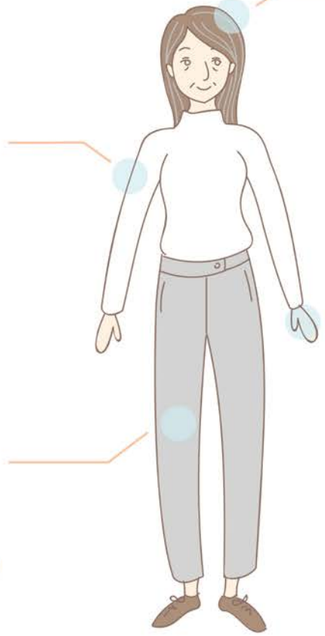
Create a mobility aid and exercise device patients suffering from weakness or pain and for athletic users prone to overuse injury **that offers therapeutic care and engages the body**.

RESEARCH

TARGET USER

Target User

+statistics



most likely middle-aged or elderly

arthritis affects:
- 1 in 3 people ages 18-64
- 1 in 2 men 65 or over
- 2 in 3 women 65 or over

arthritis is projected to increase by 49% by 2040

leads a stationary lifestyle and doesn't exercise regularly

arthritis is:
- 7% more common in overweight individuals
- 16% more common in obese individuals
- 40% less debilitating with increased physical activity

beginning to experience joint pain or weakness

1 in 4 of adults with arthritis report sever joiint pain

44% of those with arthritis report being physically imited by arthritis in their daily lives

want to reverse the signs of aging by taking the power back into their own hands

1 in 3 of adults with arthritis report experiencing depression or anxiety in relationship to their condition

18% of adults with arthiritis experience major depression due to feelings stemming from functional limitation

anxiety is twice as common as depression for those with arthritis

RESEARCH

ADDRESSING CONCERNS

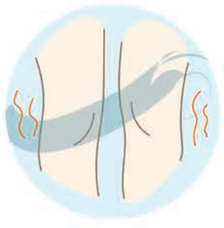
Key Issues

joint pain

joint pain is the primary symptom of arthritis and is the most debilitating factor. there is no cure for arthritis and medical care focuses mainly on pain relief through medication or surgery, which is not recommended unless there are no other options.

muscle weakness

a majority of those suffering from arthritis live sedentary lifestyles. many are afraid of overtaxing their bodies and do not exercise enough, but adequate exercise is crucial to those with arthritis. strong muscles can support the joints and lessen their loads, letting the body do the same amount with less effort.



insulation

arthritis makes the joints more sensitve to the cold and wind, making it difficult to dress for the weather. when dressing for the joints, it is often too hot for the rest of the body and vice versa.

stairs

stairs present difficulty for those suffering from arthritis. when the joints are tender, it is difficult to walk in the correct posture, making it is easy to slip and get injured.

Resolution

TENS treatment

transcutaneous electrical nerve stimulation (TENS) is a pre-existing technology that delivers small electrical impulses that flood the nervous system, reducing its ability to transmit pain signals to the spinal cord and brain and stimulate the body to produce natural pain relievers (endorphins). it is shown to be successful in relieving joint pain.

EMS treatment

electrical muscle stimulation (EMS) is a pre-existing technology that delivers small electrical impulses that illicit muscle contractions, stimulating muscle growth and blood flow which result in improved muscle density, strength, and quick recovery from overuse or injury.

heat therapy

regular joint and muscle pain are shown to be rimproved by protecting problem areas from the cold and the occasional use of additional heat therapy. by incoporating heating pads to the ankles, knees, and waist, users are able to not only use heat therapy when in pain but also have additional insulation when not in use.

engaged core

inspired by the use of the elliptical machine, which minimizes the impact on joints while exercising, encore makes walking up and down stairs easier by engaging more of the core and upper body. users will feel that it is much easier to get up and down and less tired as a result, but receive the same amount of health benefits from exercising as they would normally as they are still doing the same amount of work.

RESEARCH

DEVELOPMENT

Inspiration: Elliptical

- made for runners with achy joints and overuse injuries
- lower perceived rate of exertion → feels easier to accomplish tasks
  - ➢ heavier use of core muscles lessens load on extremities
  - ➢ has the same rate of exertion as walking/running normally
- weight-bearing exercise strengthens bones and improves balance

Incorporating the Theory

- simulate benefits of elliptical by transferring lower body load to upper body and core
- have more control over amount of muscle exertion
- decreased amount of leg muscle strain and joint reliance

Point of Connection

Above the Knee
lifts leg with least effort

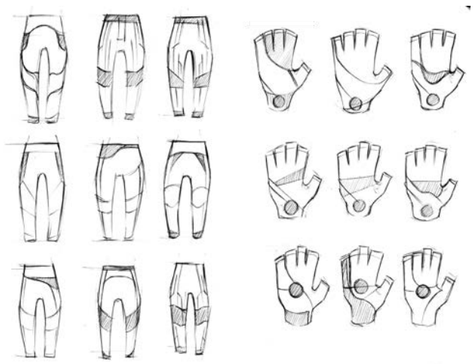
Under the Knee
most stable grip

Around the Ankle
control over foot placement

IDEATION & PROTOTYPE

DEVELOPMENT

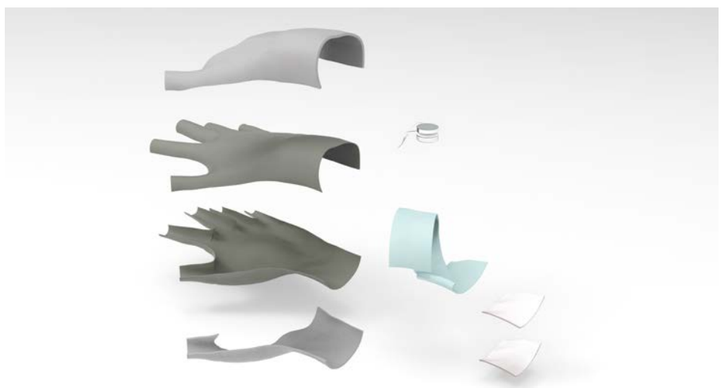
Sketches



Semi-Final Model

Labelled Rendering

Exploded Rendering



PRESENTATION

STORYBOARD & FINAL MODEL

IMPROVING ACCESSIBILITY FOR DIABETICS

NAME: *PREPARE*	
DESCRIPTION: AFFORDABLE ORTHOTIC FOR PEDIATRIC NEUROPATHY	
DATE: 2020	LENGTH: 4 MONTHS

PROBLEM:

Pediatric neuropathy is the **leading cause of lower body amputations** but **care is costly and inaccessible** to many.

OBJECTIVE:

Lower the cost of custom orthotics by **simplifying the process of manufacturing**.

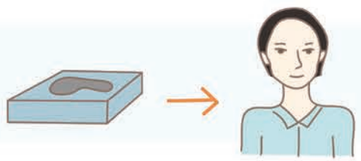
RESEARCH

TRADITIONAL MANUFACTURING PROCESS (PART 1)

visit a podiatrist

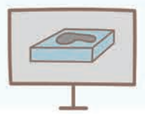
get a motion test, muscle exam, and gait exam

podiatrist takes mold of foot

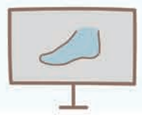


cast is sent to a pedorthist

cast is scanned to create digital model



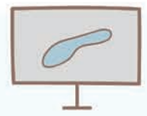
digital model is altered to correct posture
based on the podiatrist's prescription



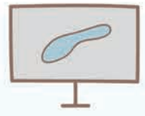
digital positive mold is created

podiatrist makes a foot scan

scan is sent to a pedorthist



scan is cleaned and alterned
based on the podiatrist's prescription



digital insole is created

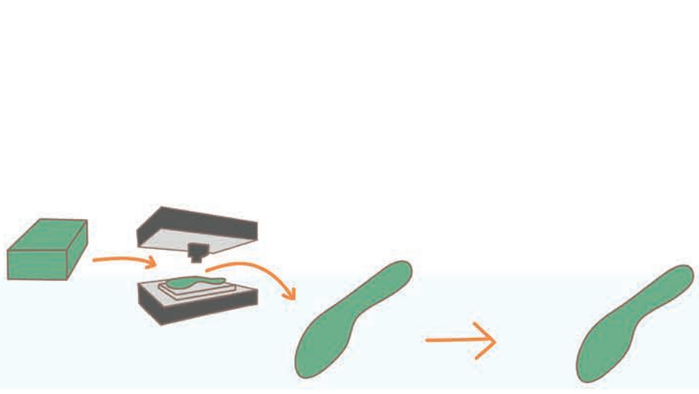
RESEARCH

TRADITIONAL MANUFACTURING PROCESS (PART 2)

positive of foot model is milled

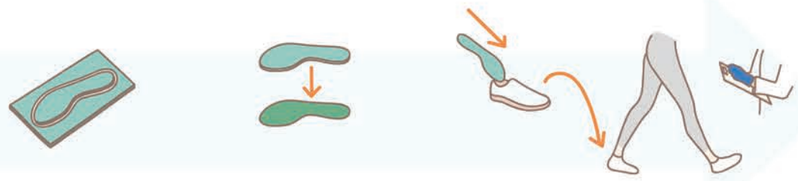
part is cleaned

insole is vacuum formed and cut



insole is milled

part is cleaned



cut cushioning material

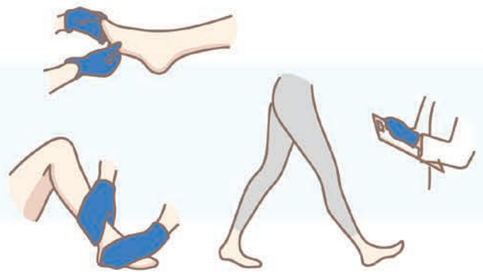
glue cushioning material to orthotic

orthotic is fitted and any adjustments are made

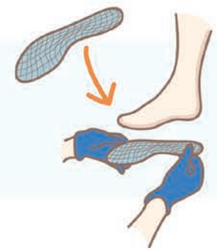
PROPOSED PROCESS

STORYBOARD & PROTOTYPING

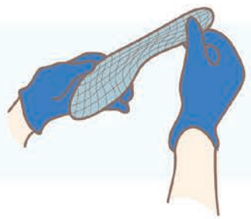
visit a podiatrist



get a motion test, muscle exam, and gait exam

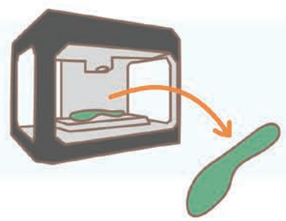


podiatrist adjusts wireframe to fit foot



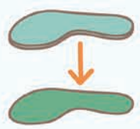
podiatrist adjusts wireframe to correct posture

connect wireframe to construct digital model

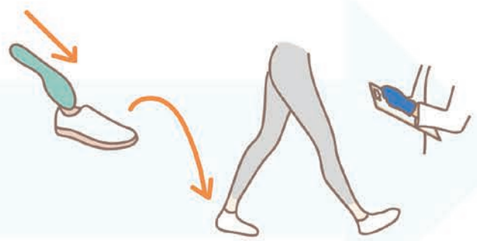


structural orthotic is 3D printed

cut cushioning material



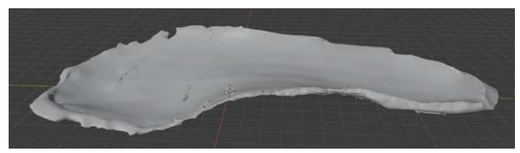
glue cushioning material to orthotic



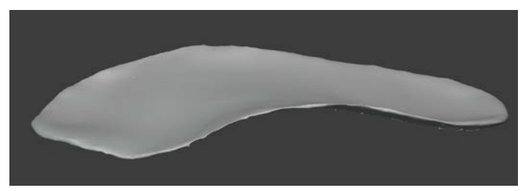
orthotic is fitted and any adjustments are made

WIREFRAME MODEL

SCANNED MODEL



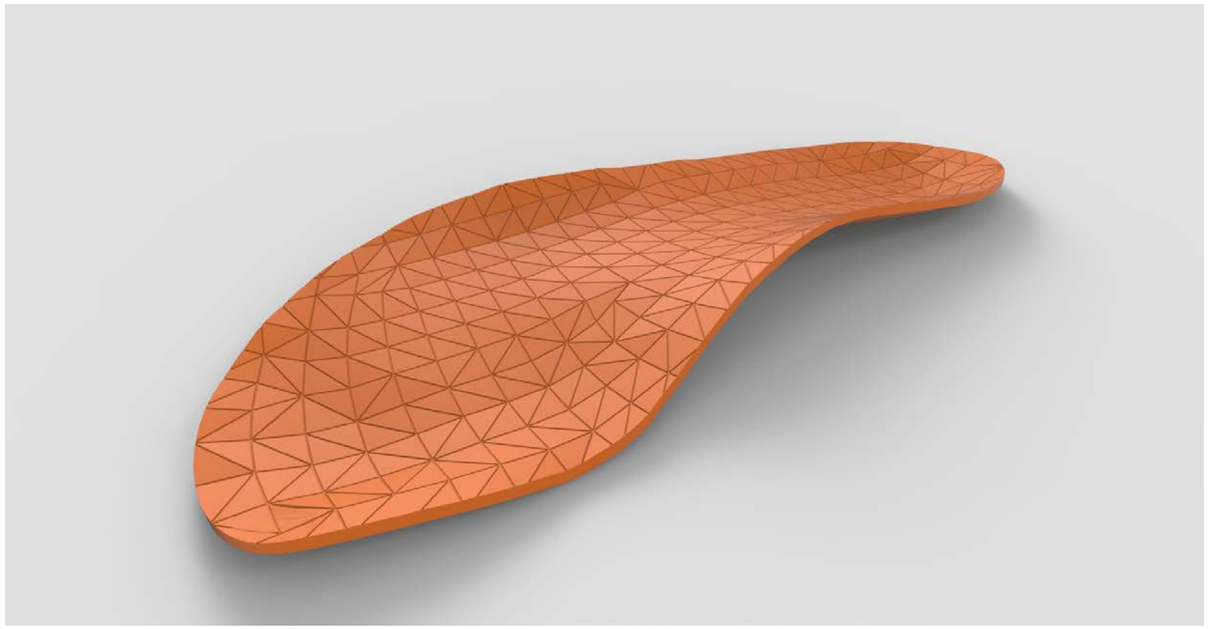
SIMPLIFIED MODEL



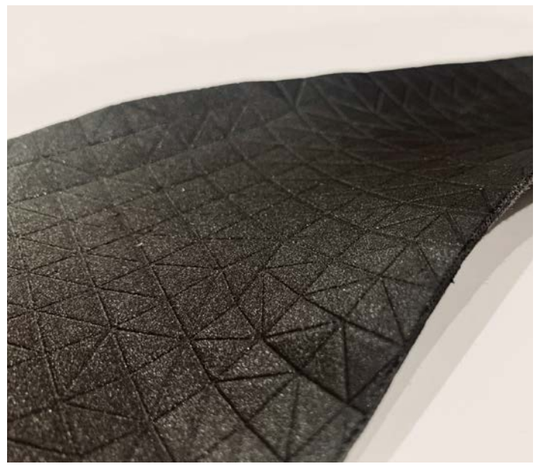
PROTOTYPING

PROCESS

Rendered Model



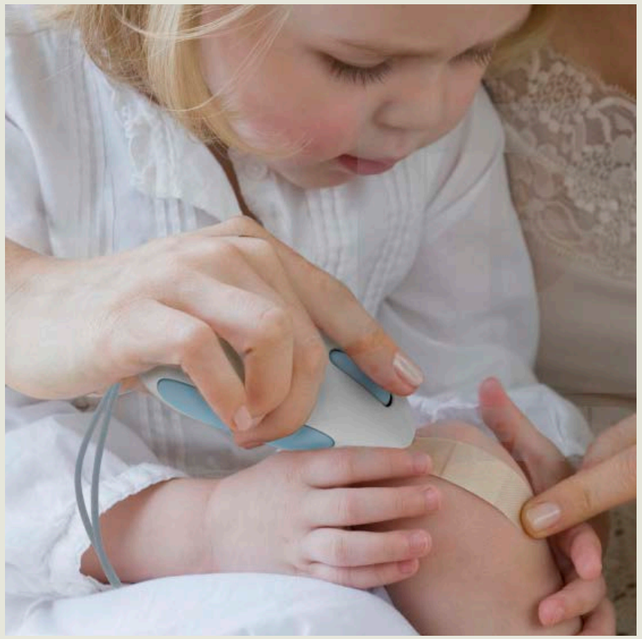
3D Printed Model



FINAL MODEL

IN CONTEXT

AMY ZHAO



contact: xxamyzhao@gmail.com 732.778.3578

THANK YOU





SEE MORE AT:

xamyzhao.com