Mission-driven habitability

Designing habitats to support mission-driven confinement,
TROLL Station Containers
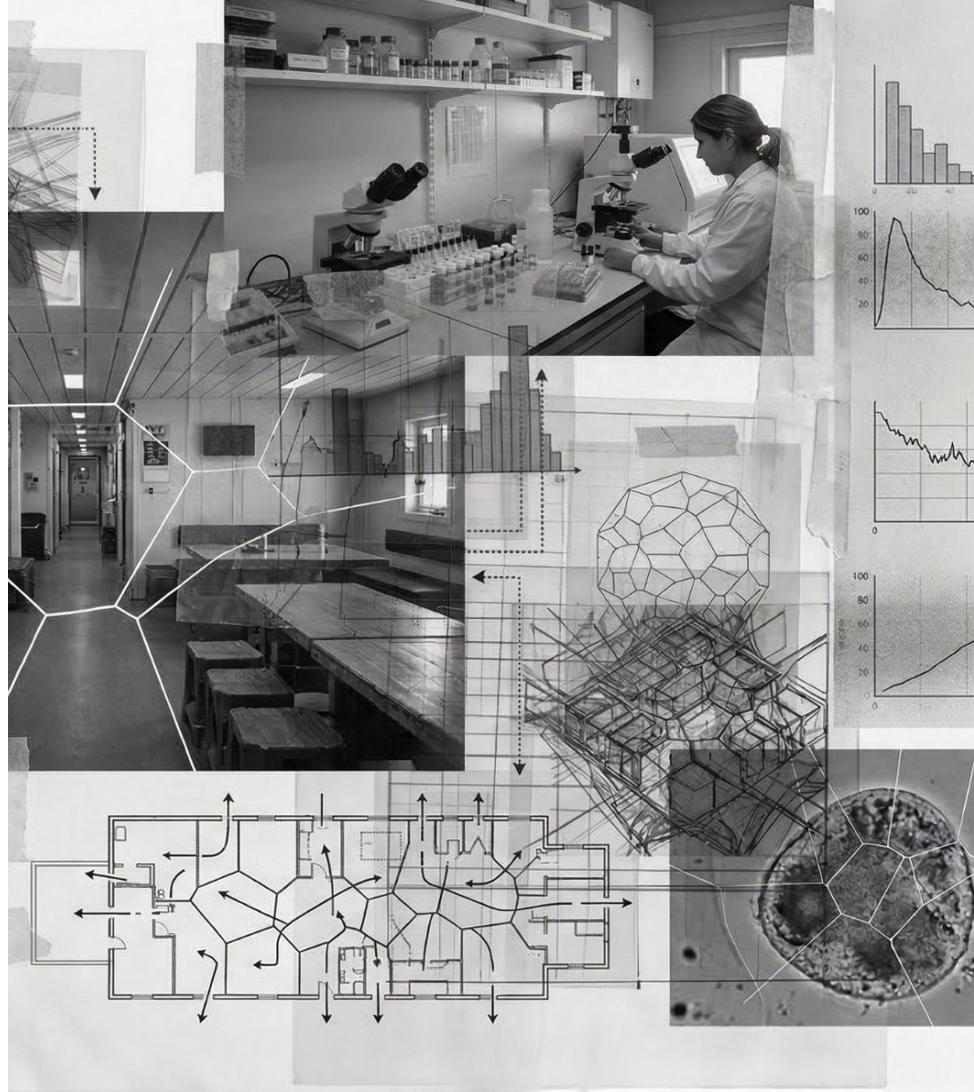
Group 2_ Brendan Exterkate, Gabriel Marks, Giorgia Vercelloni,
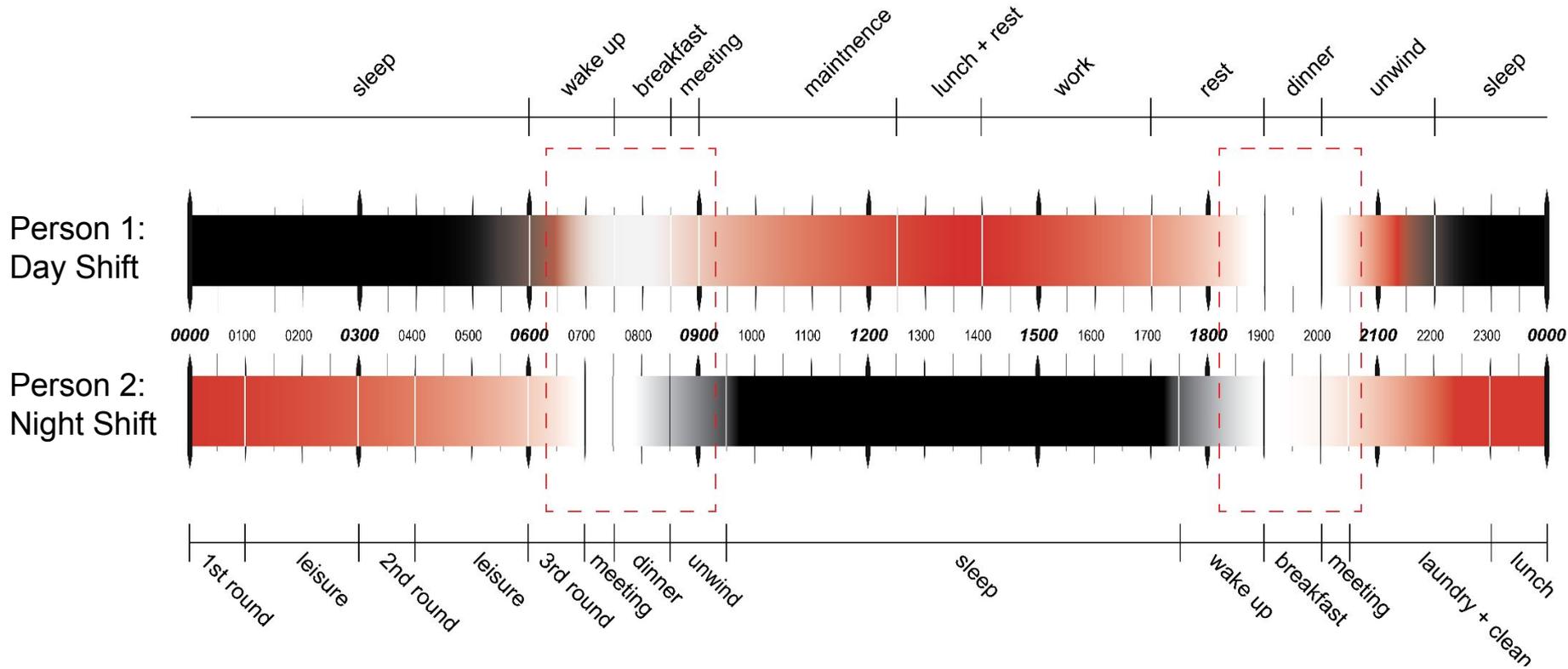Maciej Sachse, Ruxandra Florut, Zuzanna Schleifer, Long Ki

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Designing habitats to **support** mission-driven confinement

Mission-driven confinement is a condition of necessity; our task is to transform it into a space that can still feel human, familiar, and supportive of everyday life.
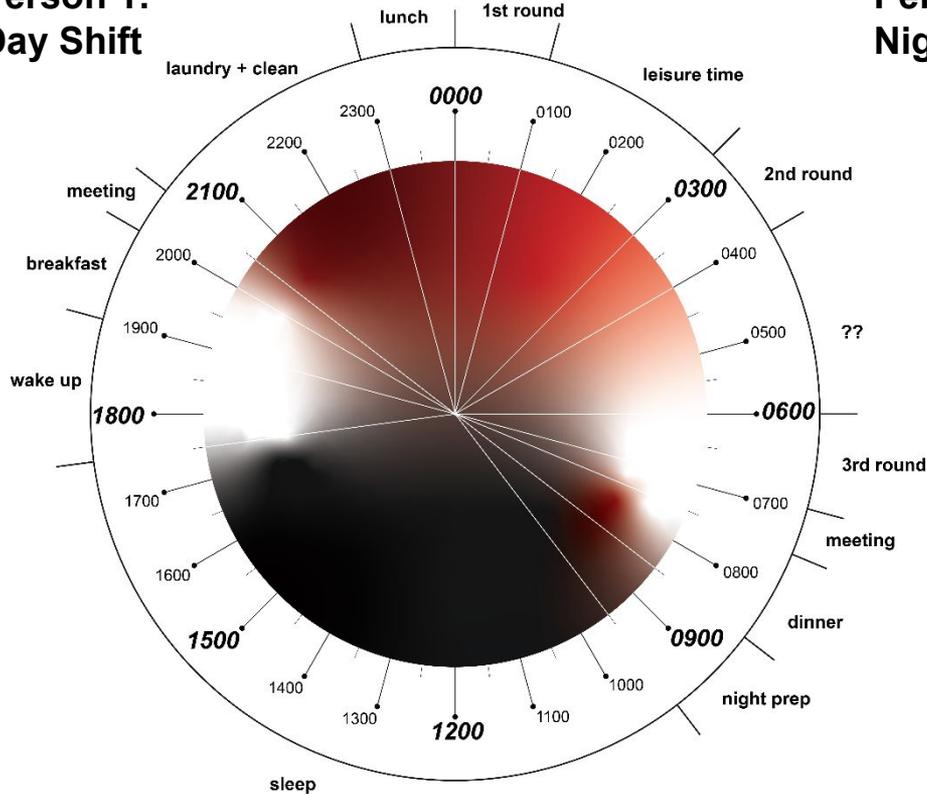
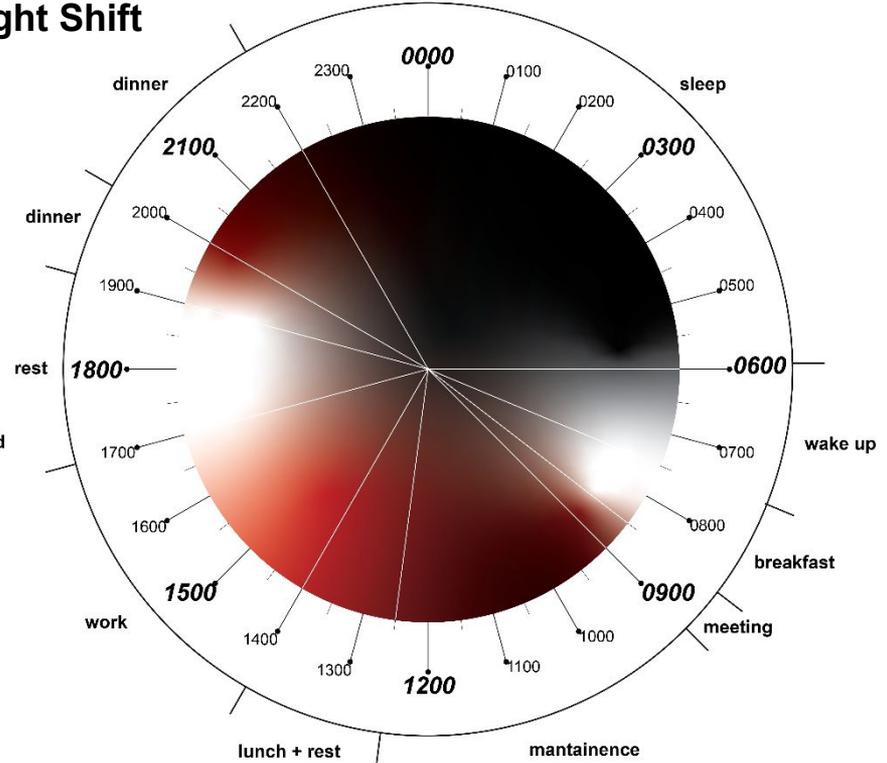# Cohabiting when schedules collide

Cohabiting when schedules collide

Person 1: Day Shift

1st round
lunch
leisure time
laundry + clean
2nd round
meeting
??
breakfast
3rd round
wake up
meeting
dinner
night prep
sleep

0000, 0100, 0200, 0300, 0400, 0500, 0600, 0700, 0800, 0900, 1000, 1100, 1200, 1300, 1400, 1500, 1600, 1700, 1800, 1900, 2000, 2100, 2200, 2300

Person 2: Night Shift

dinner
sleep
dinner
rest
wake up
work
breakfast
meeting
lunch + rest
mantainence

0000, 0100, 0200, 0300, 0400, 0500, 0600, 0700, 0800, 0900, 1000, 1100, 1200, 1300, 1400, 1500, 1600, 1700, 1800, 1900, 2000, 2100, 2200, 2300

Different case scenarios

24H ACTIVITIES MAPPING & schedules collisions
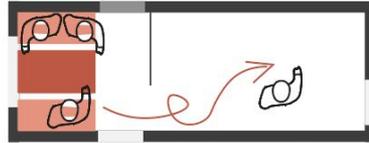
WORK SETTINGS

group work discussion

working together

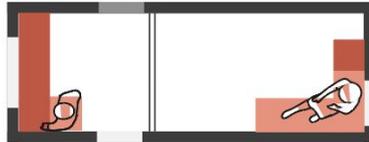working in focus
parting two spaces

LEISURE SETTINGS

socialising *one person can always part the space and go e.g. to sleep*

two people socialising separately
parting two spaces

one person working and the other resting
parting two spaces

*PARTITION OF AREAS
INTO SLEEPING AND
WORKING/LEISURE AREA*

*In general we think that social interations
are valuable in working in arctic conditions
and permanent parting of areas in two
wouldn't be the best decision
but we give the possibility for parting
into two areas when in need for alone time*

work/
leisure

sleeping/
rest

Different case scenarios

24H ACTIVITIES MAPPING & schedules collisions

DIFFERENT SLEEPING SCHEDULES
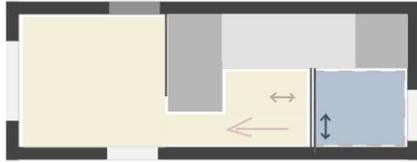
night time for higher bed movable partition

elevation with closing beds and changing areas
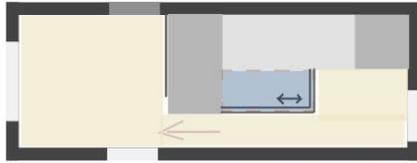
night time for lower bed movable partition

elevation with closing beds and changing areas

plan with opened separations
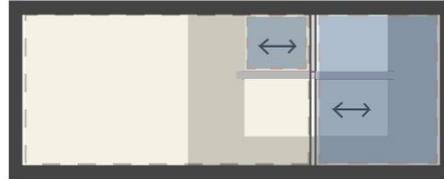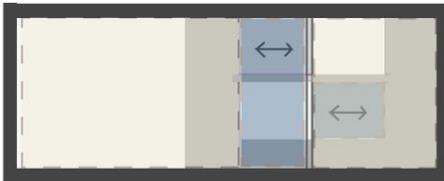
elevation with open beds
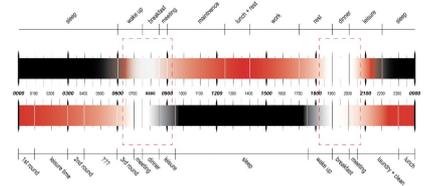
Adaptive lighting system

_Morning_sunrise light_
Exposure to cool light tones
(high temperatures > 5000K, 10000lux)
with increasing intensity after awakening

_Evening_sunset light_
1.5 hour (at least one hour) before sleep
Transition to warmer tones (<2700K)
With decreasing intensity
Eliminating blue frequencies > for rising
melatonin levels

01_ _Personalised circadian cycle_
For rebalancing the sleep cycle with: light, light tone and timing

INPUT:
_personalised schedule
_time of day
_CCT
_illuminance
_HAR (movement)
_ heartbeat

Adaptive lighting system

**Stress management**
Biodata feedback (e.g. smart watch)
Input: _heart rate_respiratory rate

**Focus mode**
Personalised schedule and needs
Input: blink rate_heart rate_respiratory rate

**Recovery**
Personalised schedule and needs
Input: blink rate_heart rate_respiratory rate_Human Action Recognition
Red light 630-850K

**Mood boost**
Personalised needs
Input: respiratory rate_facial expression

02_Personalised functional lighting
For helping with stress focus and recovery

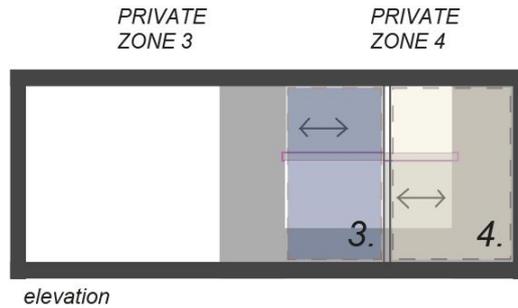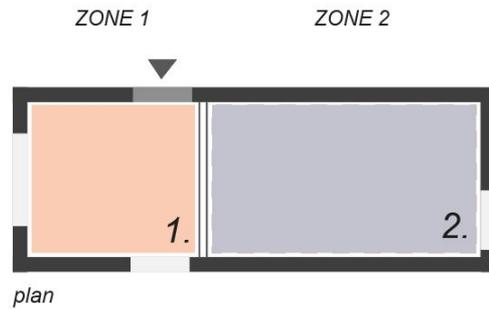*INPUT (biodata feedback) :*
_heart rate
_movement (HAR)
__blink rate
_respiratory rate
_facial emotions :)

24h activities mapping

WITH LIGHTING CONSIDERATION

ZONE 1   ZONE 2

PRIVATE   PRIVATE
ZONE 3   ZONE 4

1.   2.

3.   4.

plan

elevation

_LIGHT ZONES
With possibility of personalised lighting
according to personal preferences

_01 MAIN ZONES
_02 PERSONAL SPACES

24h activities mapping
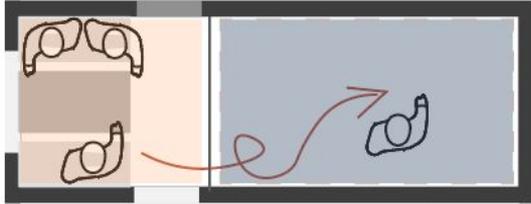
WITH LIGHTING CONSIDERATION

*one person can always part the space
and go e.g. to sleep*

SCENARIO 1
socialising / sleeping

SCENARIO 3
two people socialising separately

SCENARIO 2
working / family call
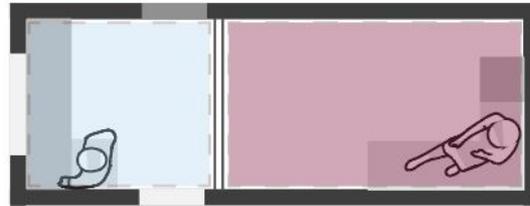
SCENARIO 4
working / relaxing
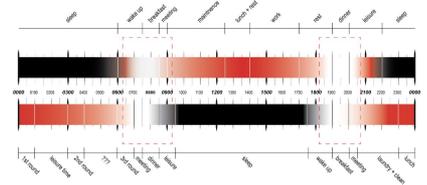
24h activities mapping

WITH SCHEDULE COMPARISON AND LIGHTING CONSIDERATION
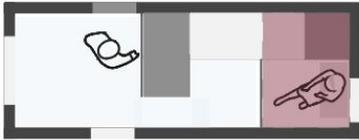
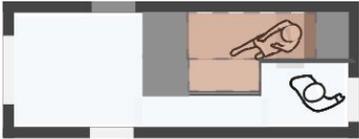*SCENARIO 1*
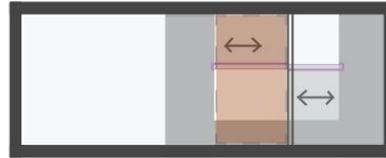getting ready for a day / getting ready for bed

elevation

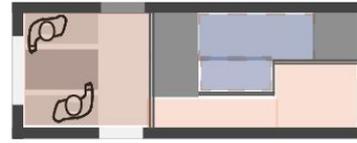*SCENARIO 3*
focus work / wake up and getting ready
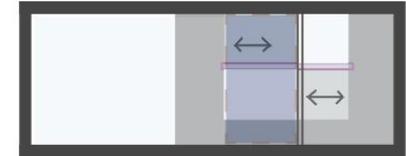
elevation

SCENARIO 2
stress management (relax) / get ready for work
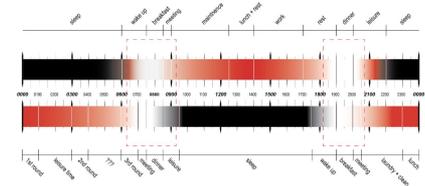
elevation

SCENARIO 4
sleep / leisure activities

elevation

Dynamic design, 2D and 3D approach to Voronoi
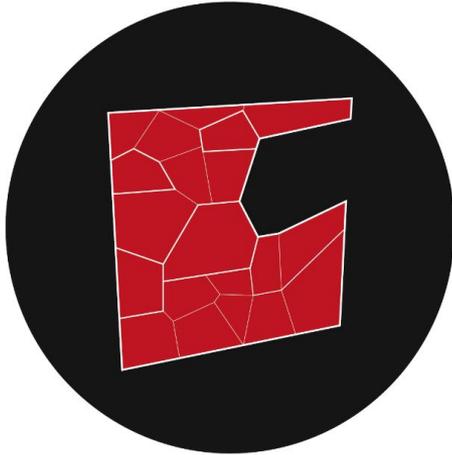
"Functionalized wall"

Approaching voronoi geometries in *two dimensions*
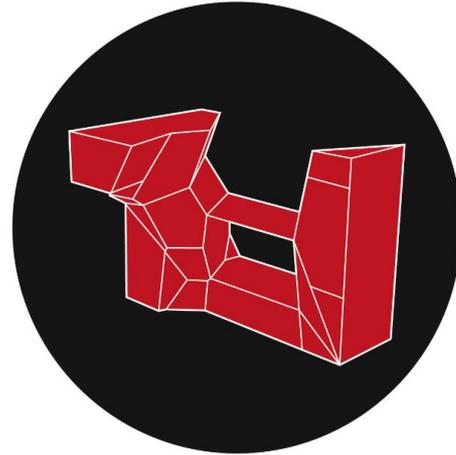
"Main habitat element"

Approaching voronoi geometries in *three dimensions*

Dynamic design
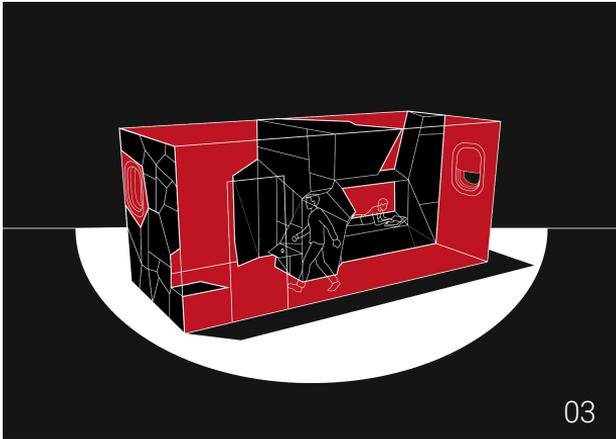
01_ *Work + Leisure*
02_ *Eating together*
03_ *Rest + Getting ready*
04_ *Sleeping*

Lighting integration

Boarders
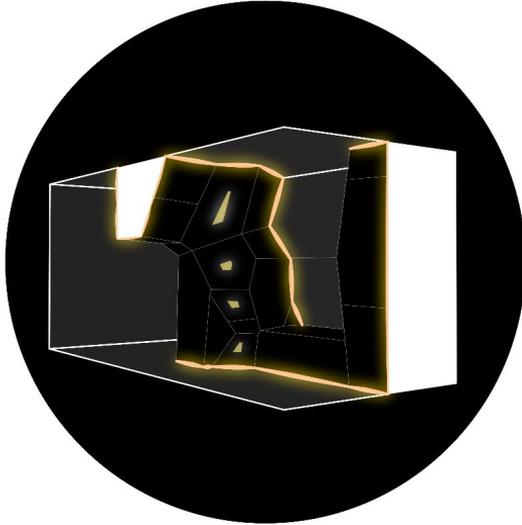
1. Easy integration
2. Act as elegant 'skirting' solution
3. Even lighting across surfaces

Boxes
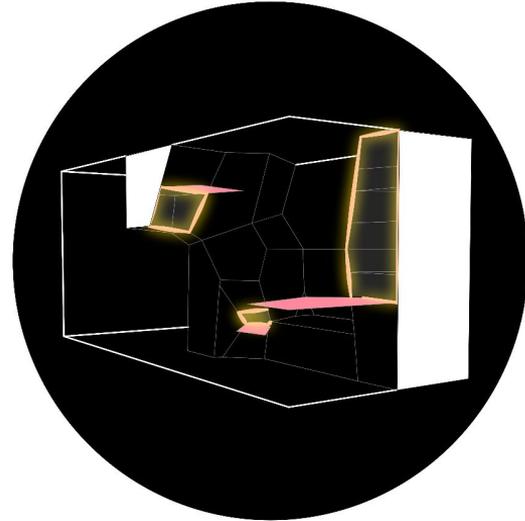
1. Task lighting
2. Responds to user activity

Voronoi pattern,   zoom in

Visualisation of the panel inside the container
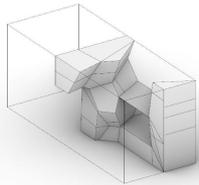
Starting geometry
Habitat for two
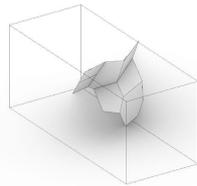
Extracted surfaces
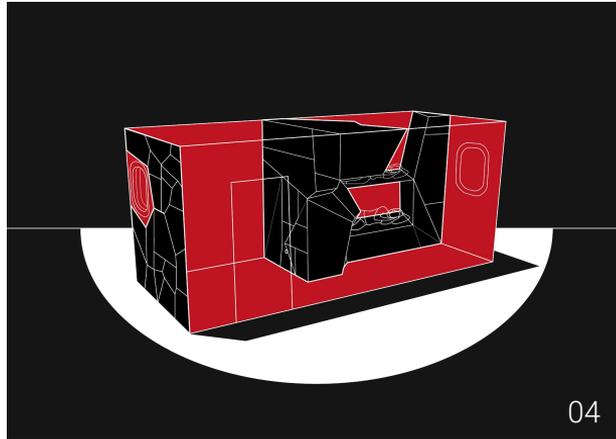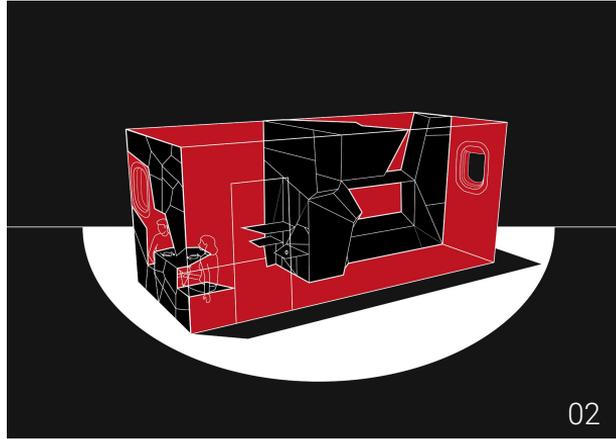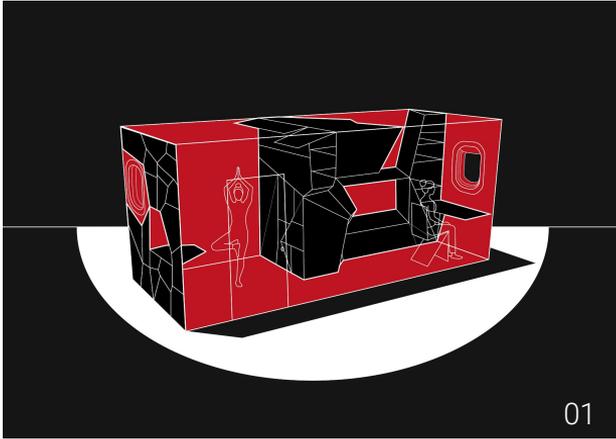*Habitat for two*
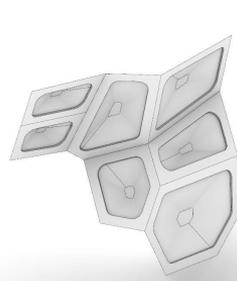
General Geometry

Starting surfaces are divided into 2 elements. Light surface and structural surface.
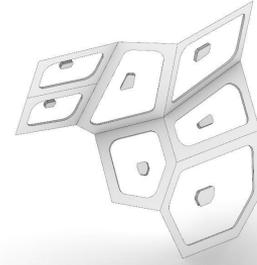
Structure + Light Points

Based on the Arwins tutorial the structural optimisation is run on the edges of the panels that are shown above.

Version 3.0

A seamless fusion of light and texture: these waved panels double as acoustic cushions, providing both visual depth and enhanced auditory comfort.

Structural optimisation of the panel

To minimze the use of the material and also the weight of the panels structural optimisation have been used only on the edges of the panels.
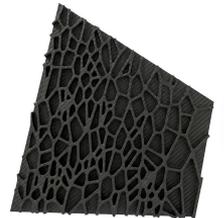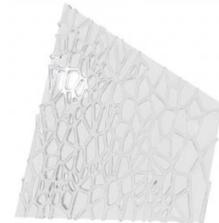
Implementing Artificial Intelligence

```
#Remove or add features to the weather and physiological features List here usein the All Feature and Label Options List above as reference, you can ru

#Weather Features
weather_data = ['direct_normal_illumination', 'diffuse_horizontal_illumination', 'total_sky_cover','infrared_radiation','direct_normal_radiation']

#Physiological featrues
physiological_data = ['heart_rate_bpm','hrv_rmssd_ms', 'skin_conductance_uS','respiratory_rate_bpm',]

#Label Options
illuminance = 'illuminance_lux'
cct = 'cct_kelvin'
```

Filtering inputs to better fit our vision of the project

```
# Import train_test_split function
from sklearn.model_selection import train_test_split

# Split dataset into training set and test set
X_2_train, X_2_test, y_2_train, y_2_test = train_test_split(X_2_norm, y_2, test_size=0.3,random_state=42) # 70% training and 30% test
X_21_train, X_21_test, y_21_train, y_21_test = train_test_split(X_2_norm, y_21, test_size=0.3,random_state=42)

#Train a regression model using the MLPRegressor function
#https://scikit-Learn.org/stable/modules/generated/sklearn.neural_network.MLPRegressor.html#sklearn.neural_network.MLPRegressor

from sklearn.neural_network import MLPRegressor

mlp_2 = MLPRegressor(hidden_layer_sizes=(50, 50, 50, 50), activation='relu', solver='adam', max_iter=300)
mlp_2.fit(X_2_train, y_2_train)

mlp_21 = MLPRegressor(hidden_layer_sizes=(50, 50, 50, 50), activation='relu', solver='adam', max_iter=300)
mlp_21.fit(X_21_train, y_21_train)

predict_train_2 = mlp_2.predict(X_2_train)
y_pred_2 = mlp_2.predict(X_2_test)

predict_train_21 = mlp_21.predict(X_21_train)
y_pred_21 = mlp_21.predict(X_21_test)

print('training complete')
```

Splitting the data into training and testing data for both CCT and Illuminance

Training models

Implementing Artificial Intelligence

```python
results = X_2_test.copy()
results["Actual_Illuminance_Lux"] = y_2_test.values
results["Predicted_Illuminance_Lux"] = y_pred_2

print(results.head())
results.to_csv("illuminance_predictions.csv", index=True)

results21 = X_21_test.copy()
results21["Actual_CCT_K"] = y_21_test.values
results21["Predicted_CCT_K"] = y_pred_21

print(results21.head())
results21.to_csv("cct_predictions.csv", index=True)
```

← *Compare the training data and result to check accuracy and extract data into CSV file*

```
Performance of the Illuminance model trained with adjusted features
r-squared is  0.9333259968738368
root mean squared error is  152.1492655044463
mean absolute error is  119.47095324590482
Performance of the CCT model trained with adjusted features
r-squared is  0.8029481465160725
root mean squared error is  397.0765252120407
mean absolute error is  292.5108196711489
```

← *Check performance*

Implementing Artificial Intelligence

Data cleaning and extraction of relevant data in separate CSV

Changing CCT based on AI Data

Changing Illuminance based on AI Data
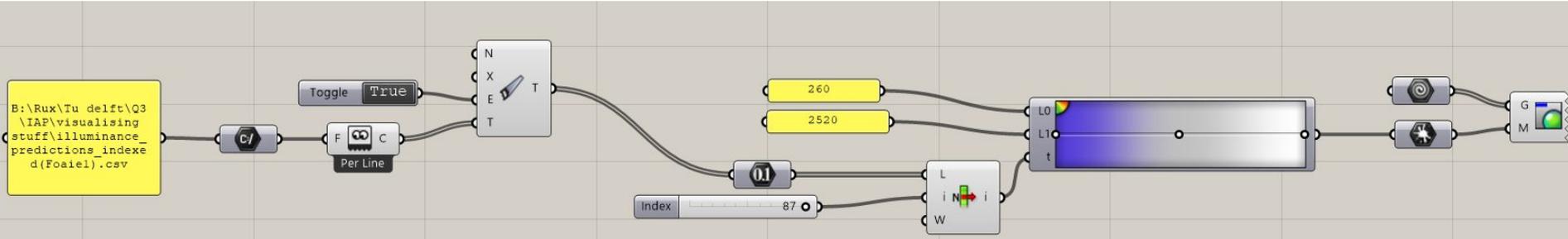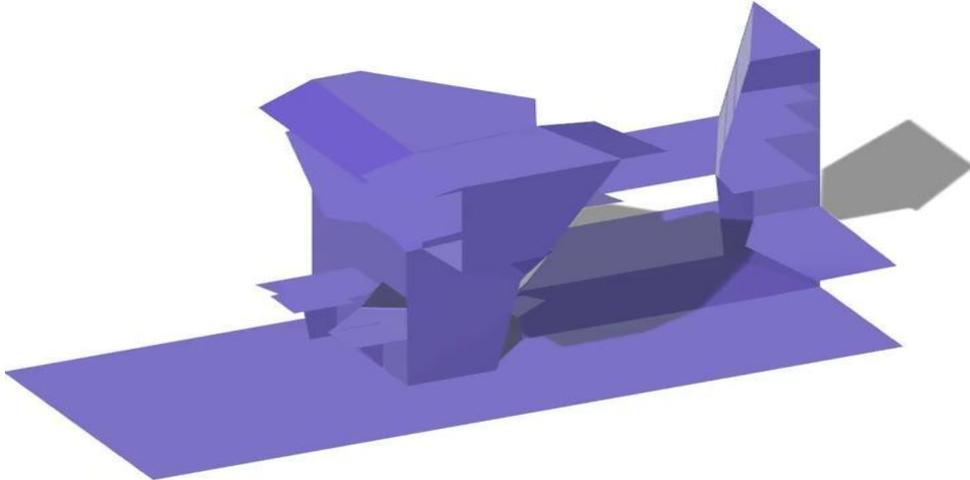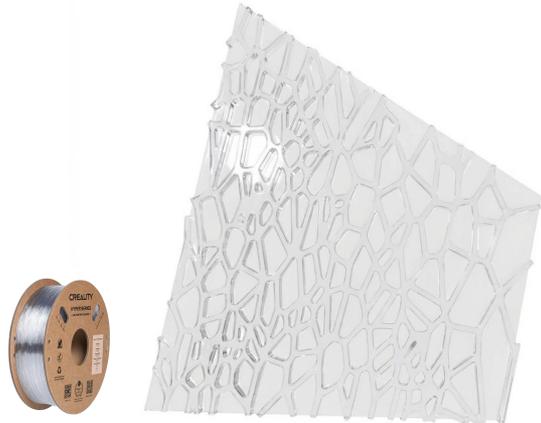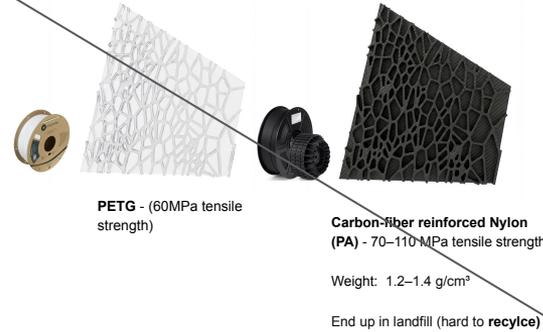
Material performance

Requirement:
Temperature range: -30°C to +25°C
(Jutulsessen indoor)
Static load: 150kg (safety factor 1.5×)
Dynamic load: 200kg (impact from sitting down)

PETG - (60MPa tensile strength)

Carbon-fiber reinforced Nylon (PA) - 70–110 MPa tensile strength

Weight: 1.2–1.4 g/cm³

End up in landfill (hard to **recylce**)

Polycarbonate (PC)

Specifications:

Tensile strength: 60-70 MPa

Flexural modulus: 2,300 MPa

Impact resistance: -30°C

Recycle: Mechanical Recycling

Recycling process
1. **COLLECTION**
2. **SORTING & IDENTIFICATION**
3. **CLEANING / WASHING**
4. **SIZE REDUCTION** (Shredding into flakes)
5. **SEPARATION OF CONTAMINANTS**
6. **DRYING**
7. **MELT EXTRUSION / REPROCESSING**
8. **PELLETIZING** (Cutting into pellets)
9. **REMANUFACTURING**
(Injection molding, extrusion, thermoforming)
END: NEW PC PRODUCTS
(Electronic components, sheets, automotive parts)

Material transportation
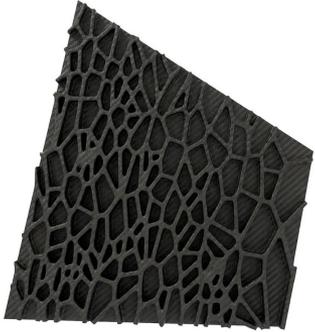
3D print

Packed the piece in **vacuum bags**

Transfer by plane

Combine together on site

Material Prototype

Prototyping material: PLA

- easy to print
- low cost
- suitable for geometry and concept testing

Final manufacturing material: Polycarbonate PC

- stronger and tougher than PLA
- better heat resistance
- more suitable for functional parts

For the robotic arm prototype case study, we use PLA because it is simple and cost-effective for testing geometry. For future manufacturing, polycarbonate could be a better option due to its higher mechanical strength and heat resistance.