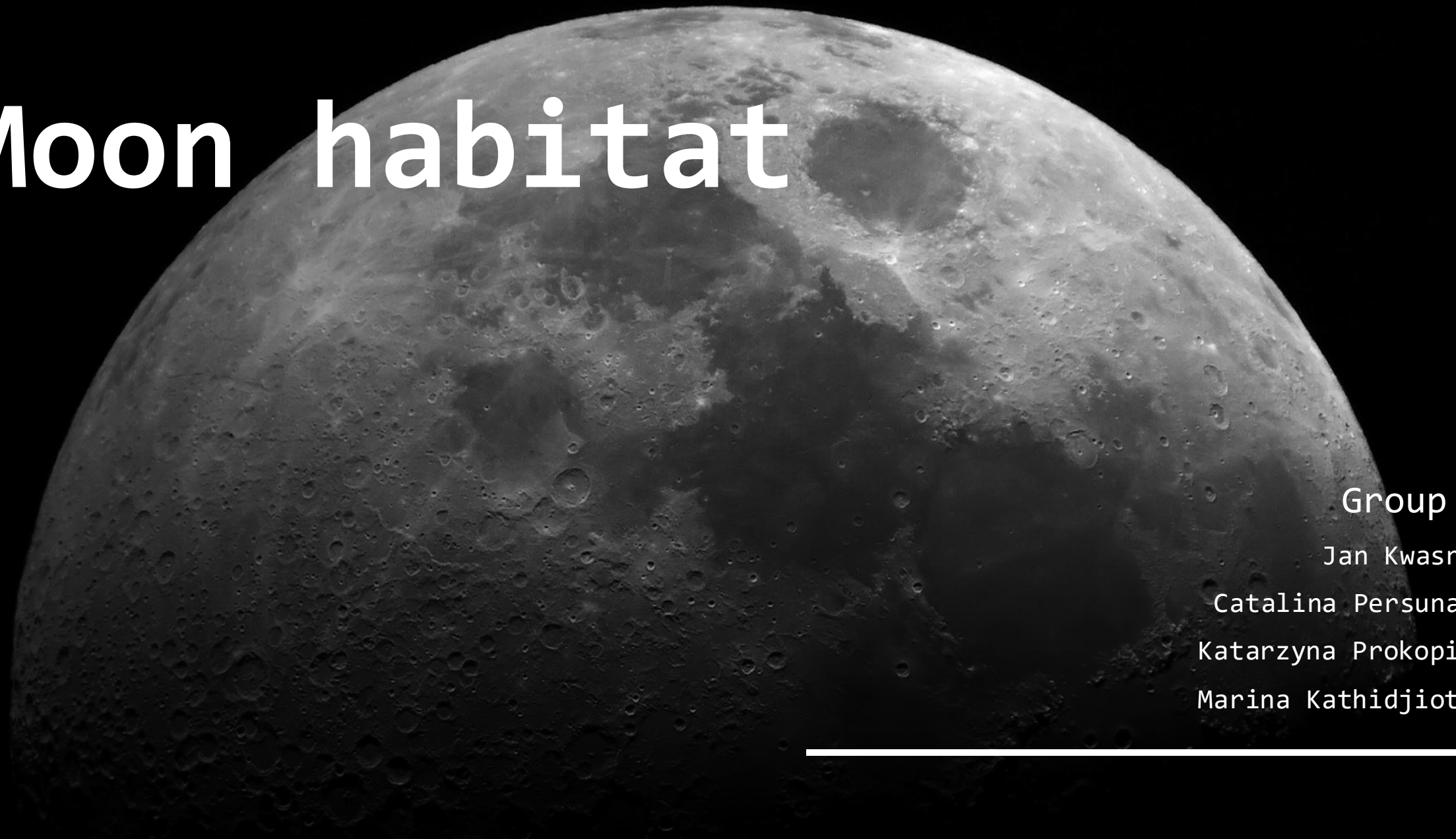
Moon habitat



Group 2

Jan Kwasnik

Catalina Persunaru

Katarzyna Prokopiuk

Marina Kathidjiotis

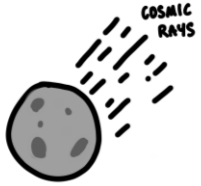
Context

One lunar day is equivalent to **29.53 Earth days**

Moon's surface gravity is **1.62 m/s²**, 1/6 of the Earth's one

Drastic temperature differences from day to night. The temperature of a surface also varies when in sunlight or shadow

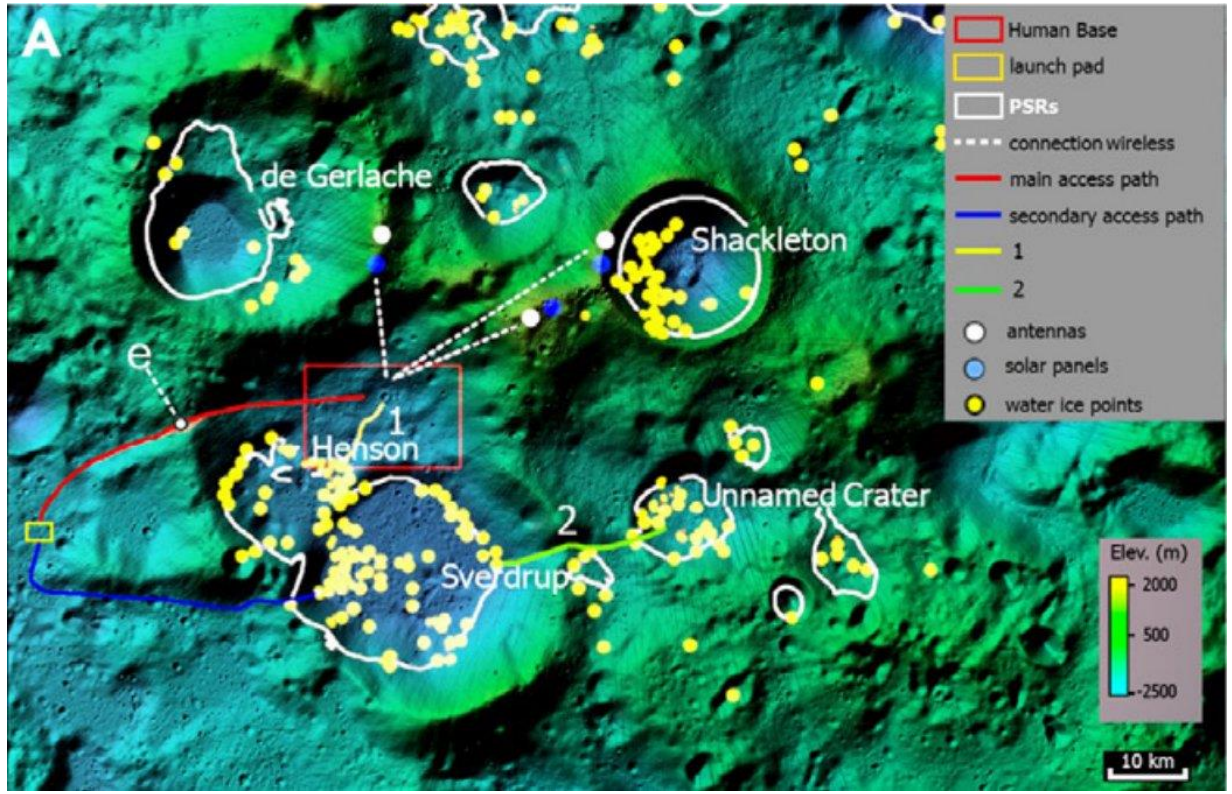
The Moon's atmosphere is nearly **vacuum**



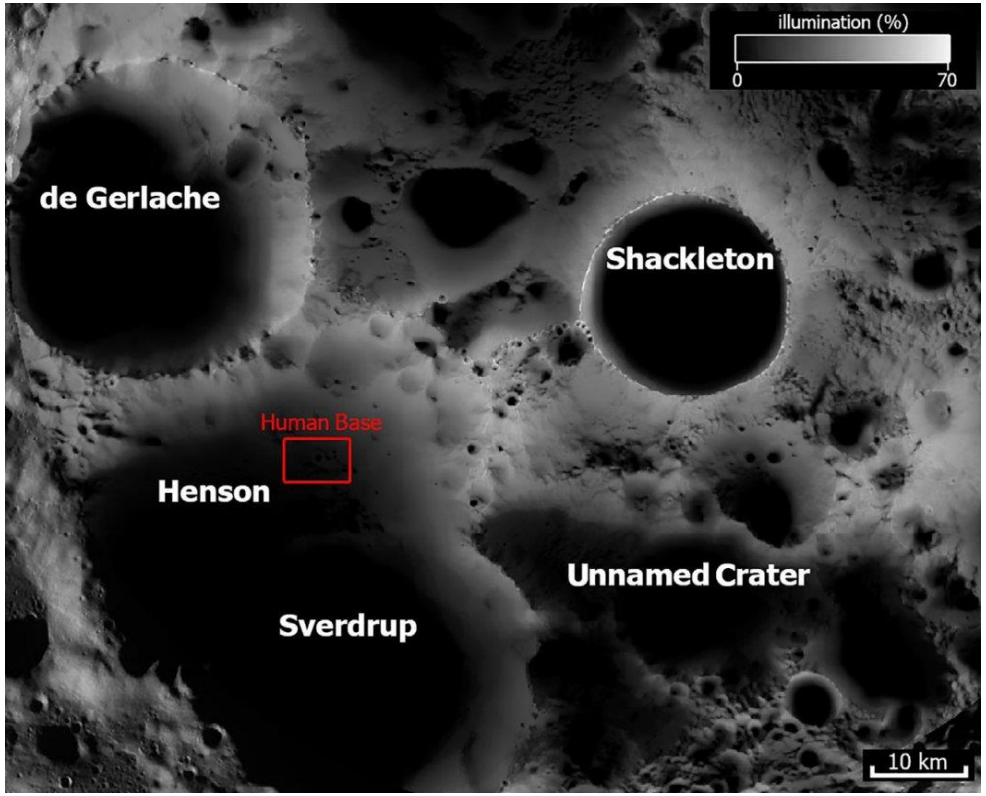
Ionizing radiation from cosmic rays is **200 times more** than on Earth's surface

A permanent **dust cloud** exists around the Moon that sticks to the suits of the astronauts. If carried in their quarters while it can cause health issues

Site selection



The chosen **location on the lunar South Pole**: multiple water ice points, variable resources, (semi) continuous visibility of Earth, constant daylight

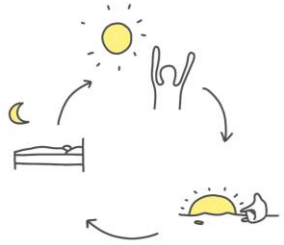


Optimal **sunlight exposure** – possibility of power generation without excessive radiation

(Leone et al., 2023)

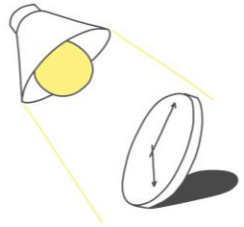
Circadian rhythms

Circadian rhythms are 24-hour cycles that are part of the body's internal clock, running in the background to carry out essential functions and processes. One of the most important and well-known circadian rhythms is the sleep-wake cycle.



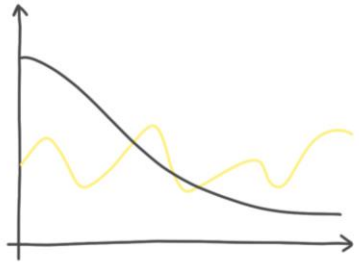
They prepare our bodies for **expected changes in the environment**.

Darkness at night is as important as brightness during the day.



Bright light regulates **hormones production** and **sleep-wake cycles.**

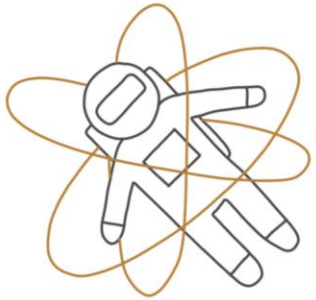
It is important to have a **variety of stimuli**.



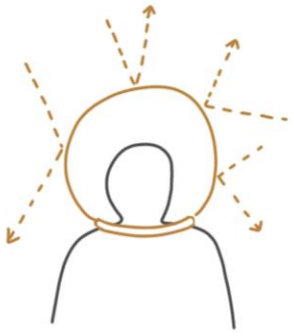
Disruptions affect psychiatric health, metabolism, and possibly the immune system.

(van den Wymelenberg, 2014; *Module 2. Circadian Rhythms Have an Important Purpose | NIOSH | CDC*, n.d.-b; Suni & Singh, 2023b)

Psychological effects of spending time in space



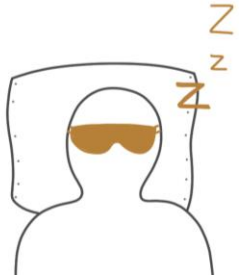
Multiple aspects that cause **changes in circadian rhythms**.



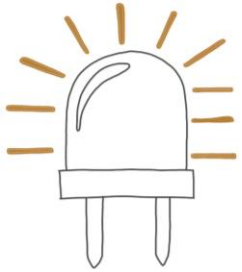
Senses become numb because of monotonous stimuli.

Ionizing radiation can cause visible **flashes of light**.

Human factor is the biggest unknown in space.



Astronauts need to get **enough sleep**.



Space infrastructures mostly use **artificial LED lights**.

(Turner, 2019; Arone et al., 2021b; Guo et al., 2014)

Maintaining circadian rhythms for mental wellbeing

- On the ISS (International Space Station) a **24-hour day** is simulated using Universal Coordinated Time.
- There are **LED systems that help to maintain the circadian rhythms**. They use stronger blue light in the morning, and more red light before sleep.
- It is beneficial to **simulate the changing sky throughout 24 hours**: dawn, sunrise, daylight, sunset, dusk.
- **Variation from day-to-day** to better mimic the variable nature of natural lighting found on Earth.
- Astronauts need **private sleeping quarters** to limit disturbances.

The Circadian Lights – a project by SAGA Architects

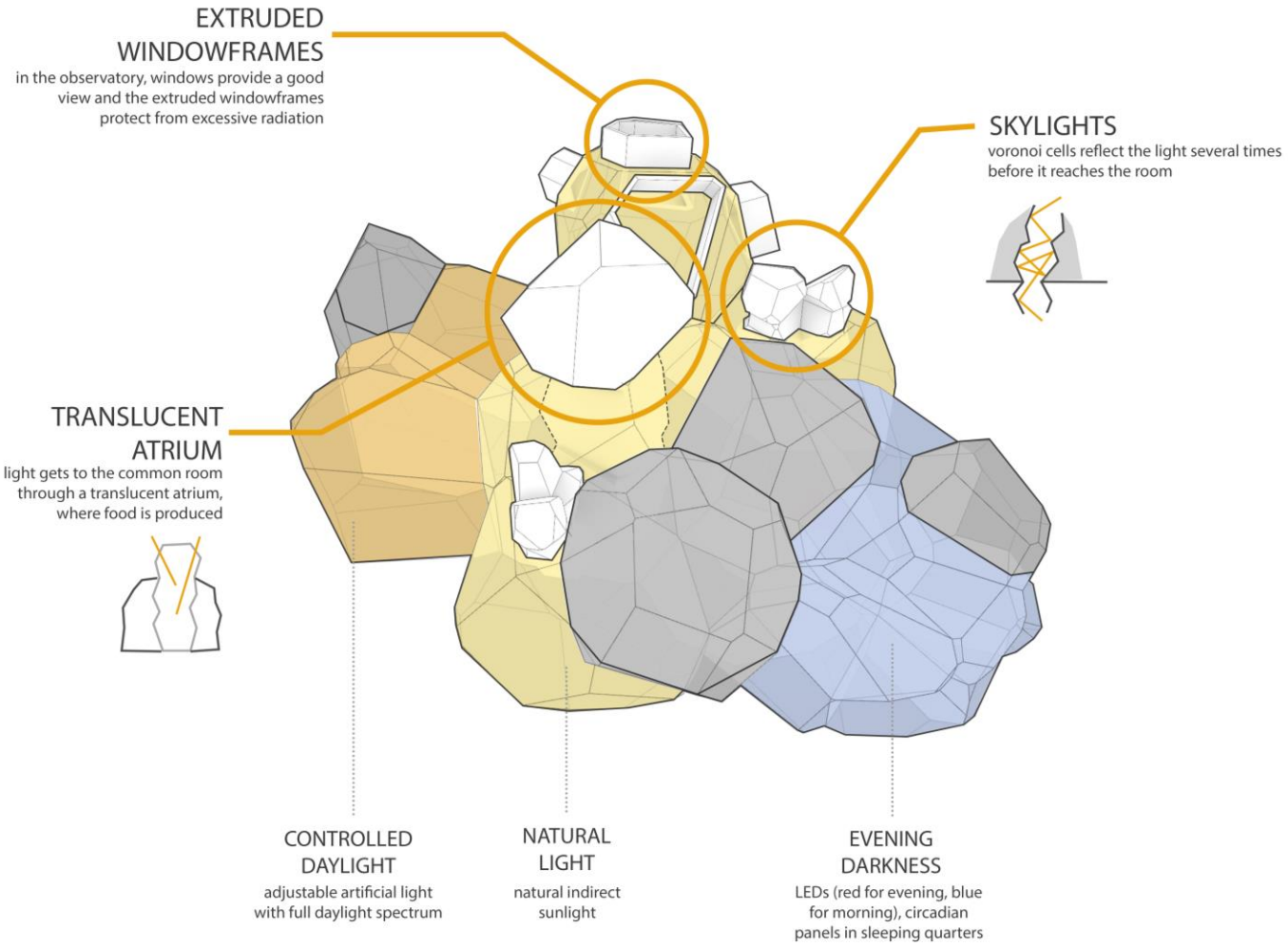
(*What Life on the International Space Station Can Tell Us About the Circadian Clock.*, n.d.; Designboom, 2023)

Simulating the Earth day cycle

Our project explores the idea of circadian rhythms in relation to spending time in space. The design follows the idea of creating spaces in the building which help to maintain a healthy internal clock. This effect is achieved through zoning the station into parts dedicated to activities usually associated with specific parts of the day.

Lighting strategies

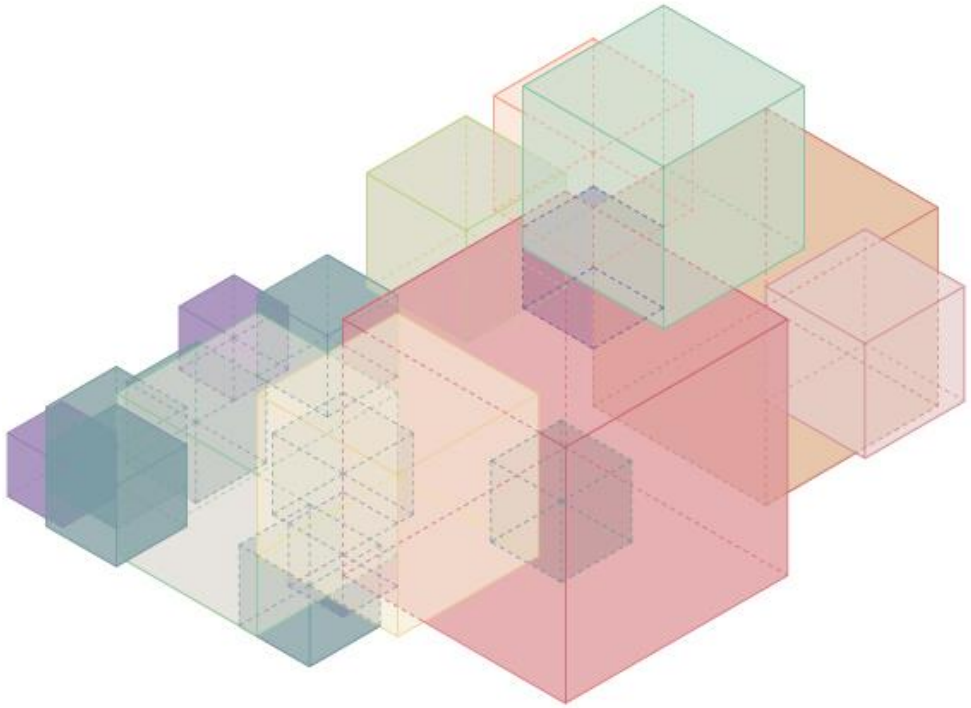
A factor that is crucial for maintaining the circadian rhythms is light. In the design, we implement various lighting strategies that simulate different times of the day. By combining guiding natural light with architectural elements and smart artificial lighting, the design breaks the monotony of outer space and helps the astronauts to stay healthy and rested.



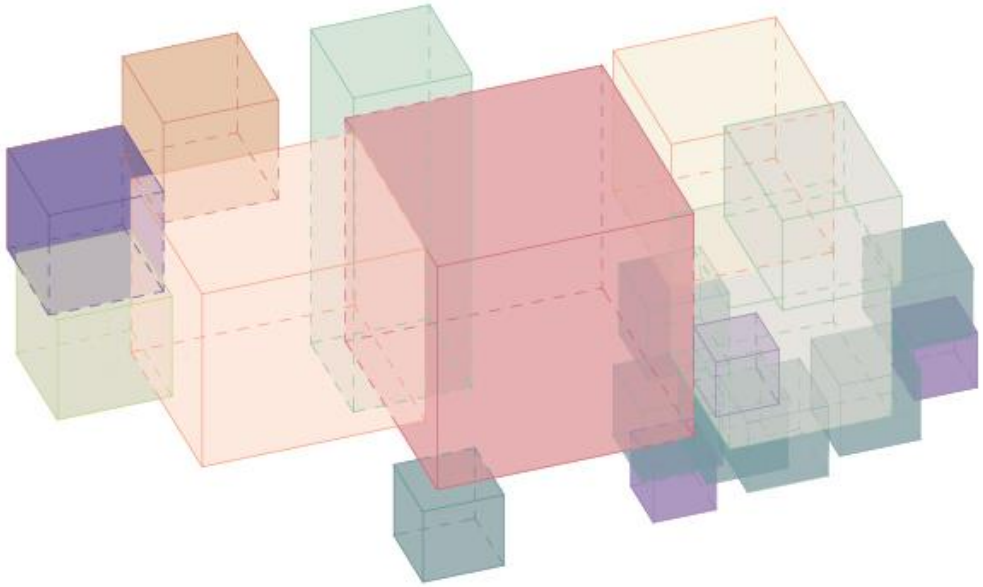
Revised program

- **Entrance space**
- **Emergency exits**
- **Bedrooms (6 x 10m2)**
  Plain yet comfortable bedrooms. Since the day cycles on moon do not follow the day cycles of earth there is possibly no need for windows in the living quarters.
- **Common Hall (58m2)**
  Multifunctional space for food preparation and consumption + a hub for social interaction
- **Food production (50m2)**
- **Control Room (Environmental Control and Life Support System) (46m2)**
  Space to host complex control equipment for maintaining the internal environment of the Habitat.
- **Gym (30m2)**
  Space to accommodate gym equipment for daily exercise
- **Laboratories (60m2)**
  The research areas should be close to the entrance and exit areas to facilitate the transport of samples into the station
- **Observatory (50m2)**
- **Rover Hub (40m2)**
  The connection hub between the station and rovers for mobility. In this space one can enter in rovers safely and find all the necessary elements for the rovers' maintenance
- **3D printing room (30m2)**
  should be accessed from both inside and outside
- **Meditation room with VR+AR (20m2)**
  should be accessed from both inside and outside
- **Unisex toilets + bathrooms + medical care (38m2)**
  Combined units
- **Lounge (40m2)**
- **Computer room (25m2)**
- A place filled with computers which store the information gatehered there and help you communicate with the people on Earth

Design – iteration 1-2

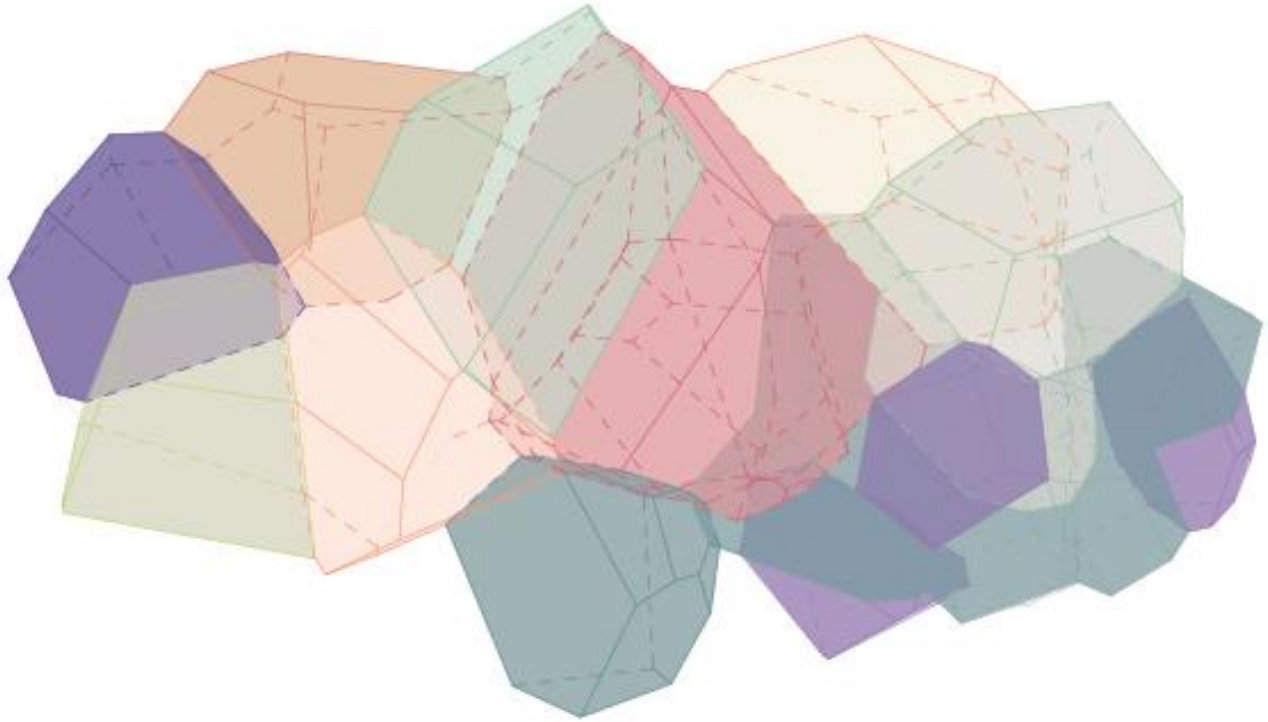


The **program** of the building and its correspondent **area are revised** and **rearranged**.



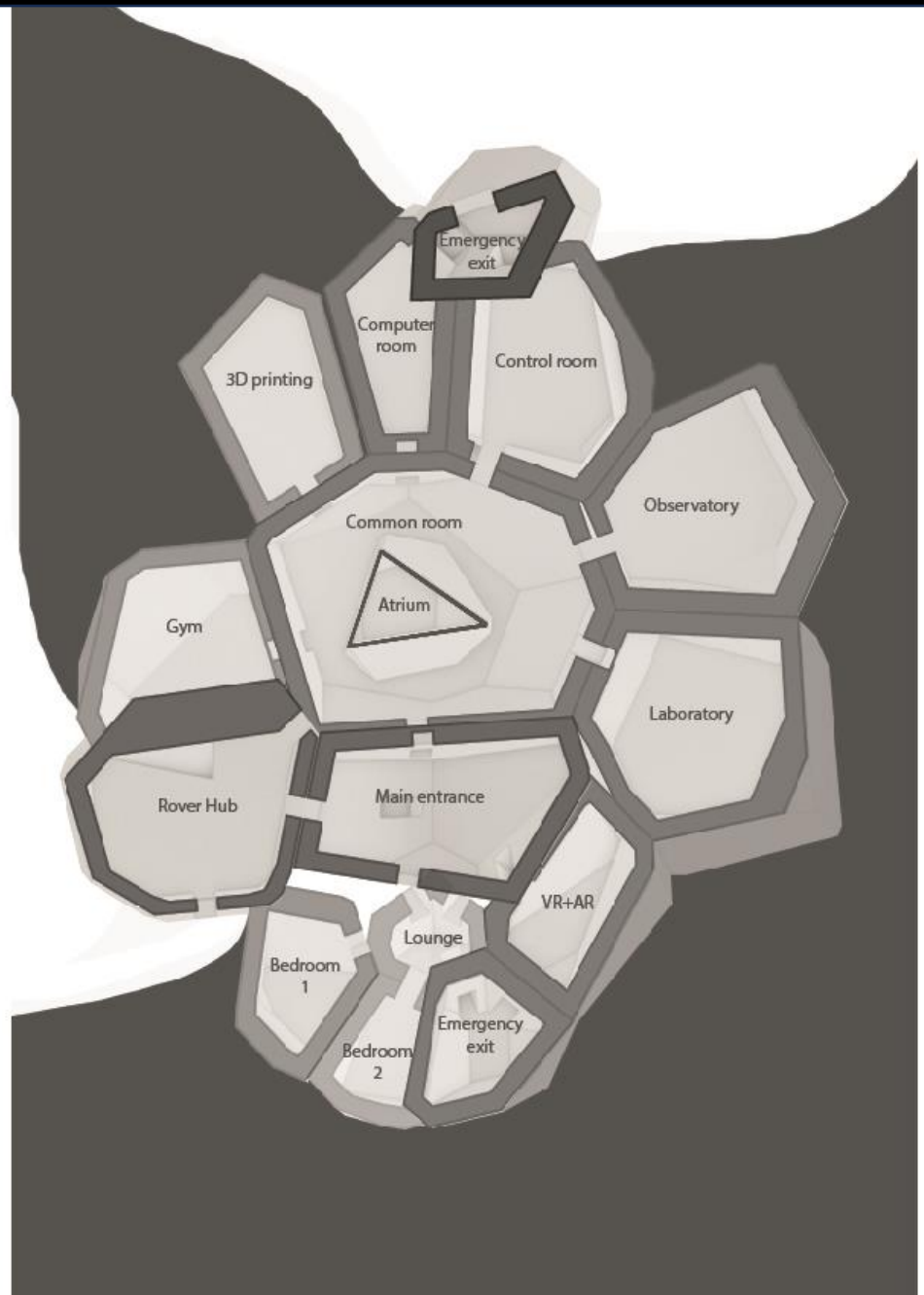
The **volumes' position** in plan and section is **rearranged according to the site**.

Design – iteration 3

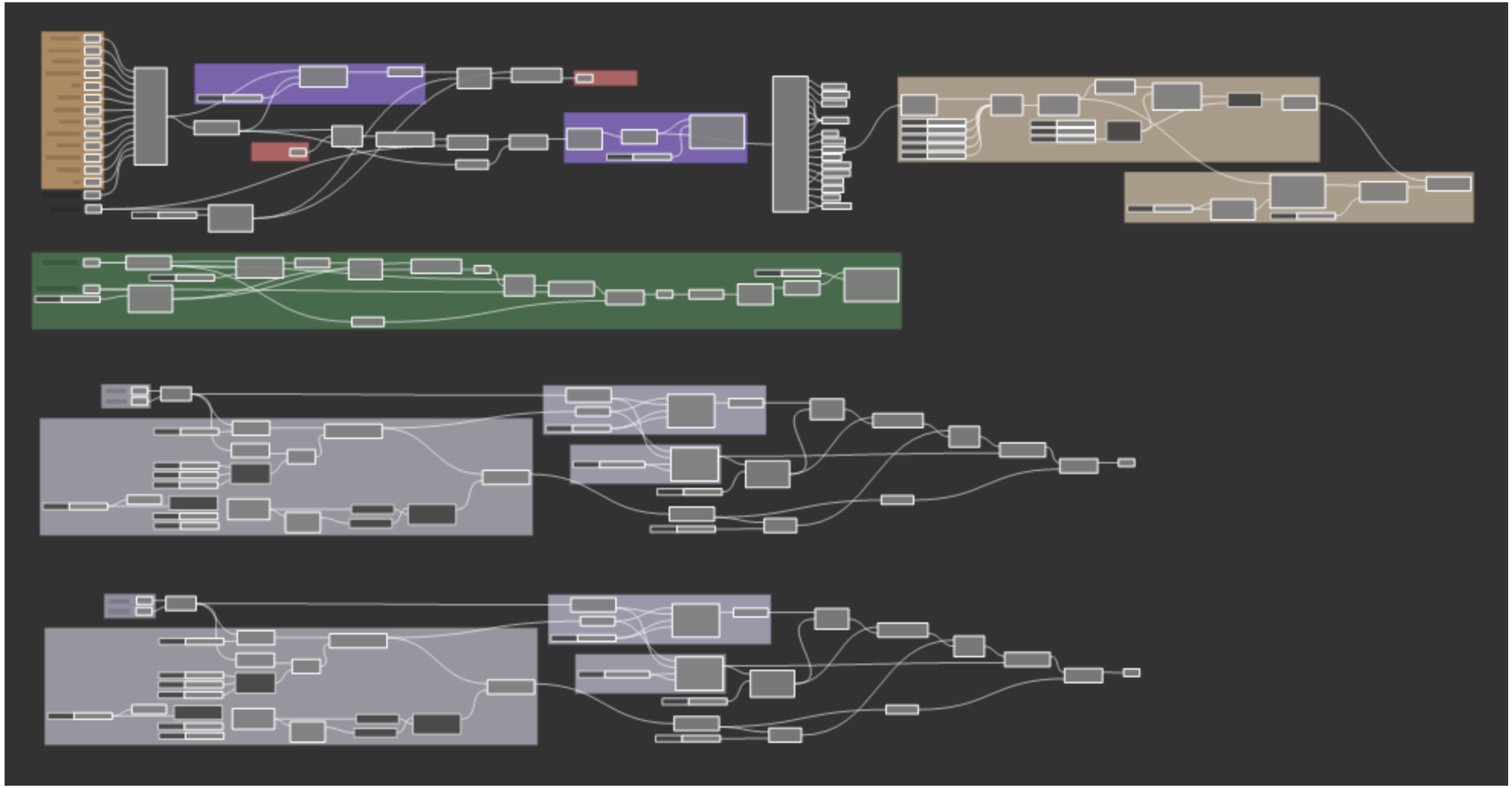


The **reference cubes** are
transformed into **voronoi volumes**.

Plan

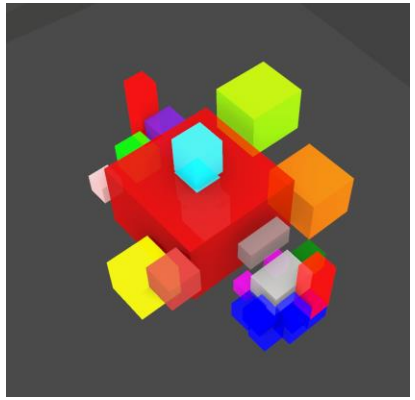

Emergency exit
Computer room
Control room
3D printing
Observatory
Common room
Atrium
Gym
Laboratory
Rover Hub
Main entrance
VR+AR
Lounge
Bedroom 1
Emergency exit
Bedroom 2

The algorithm



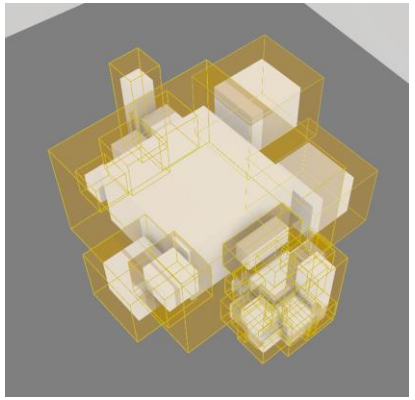
Algorithm - building

1



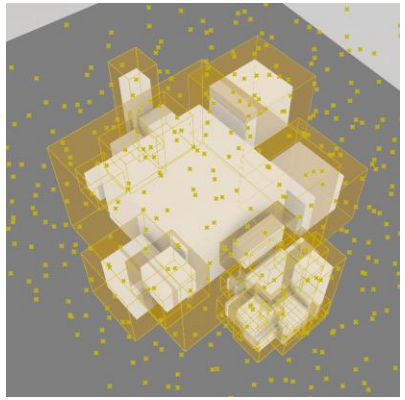
Input: boxes representing each function

2



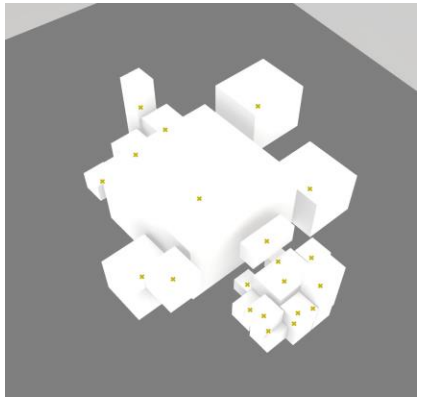
Offset the volumes to restrict possible points

3



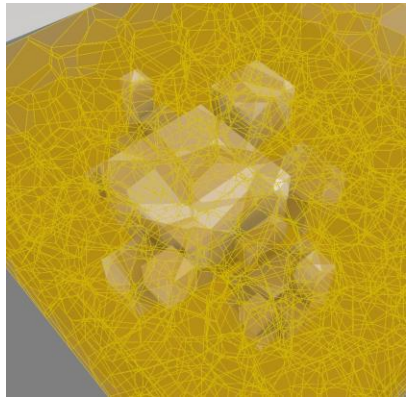
Populate box with points outside offset volumes

4



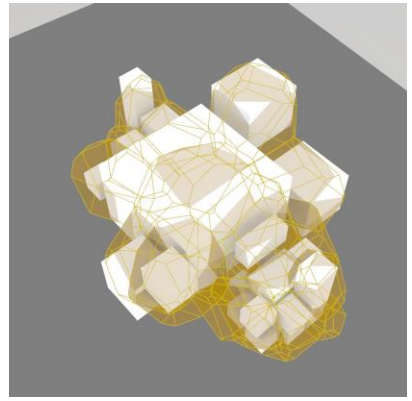
Find centers of each box and merge with other points

5



Voronoi 3d

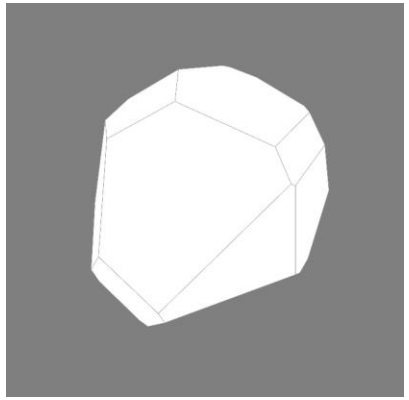
6



Select the cells with the same centers as the boxes

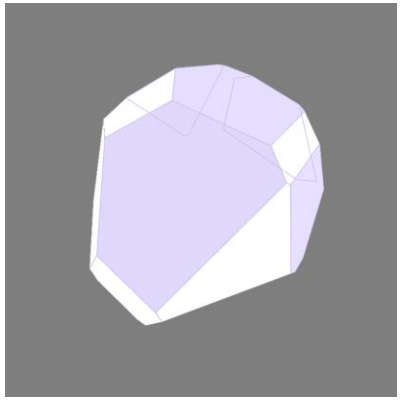
Algorithm - observatory

1



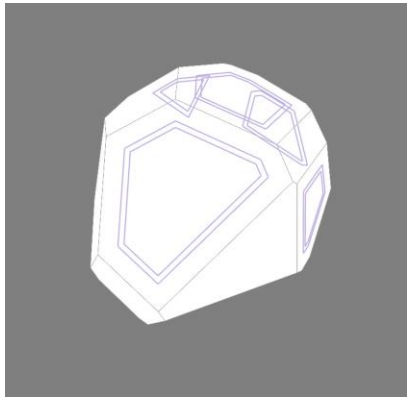
Input: selected cell representing the observatory

2



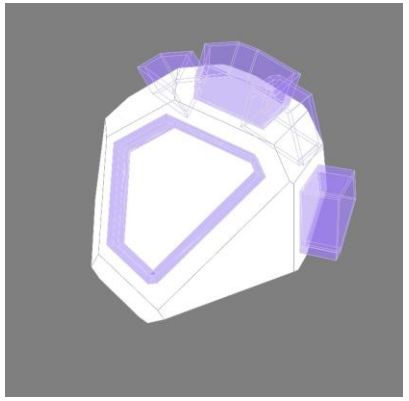
Select the faces that will have windows on them

3



Offset the edge curve of the surface twice to create thickness

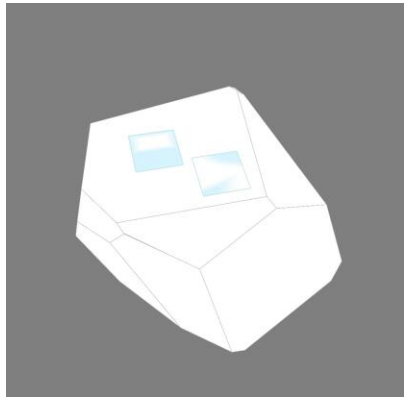
4



Loft the curves and extrude the surfaces to make window frames

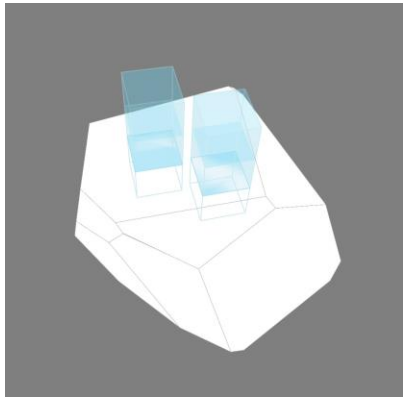
Algorithm - skylight

1



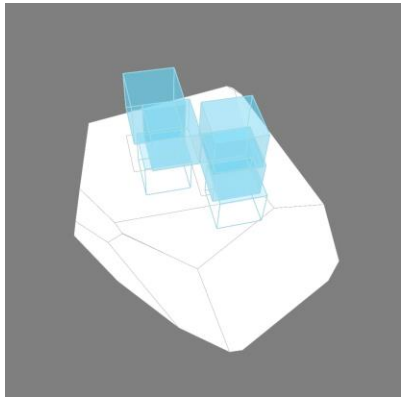
Input: rectangles drawn as the base of the skylight

2



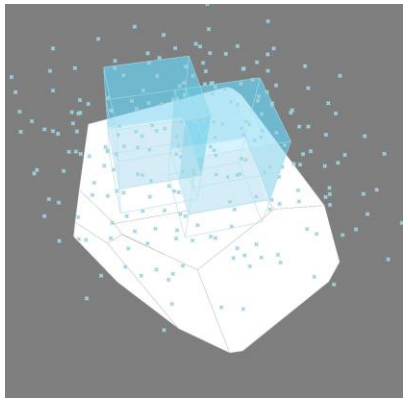
Three boxes on top of each other, one inside the cell

3



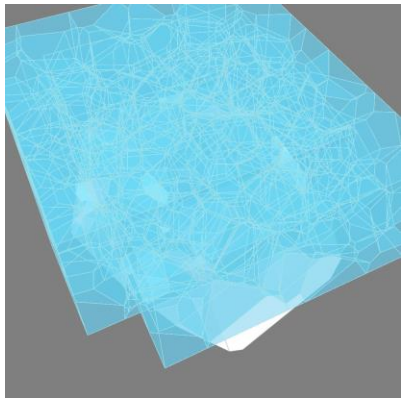
Slightly move the boxes by a random vector for irregularity

4



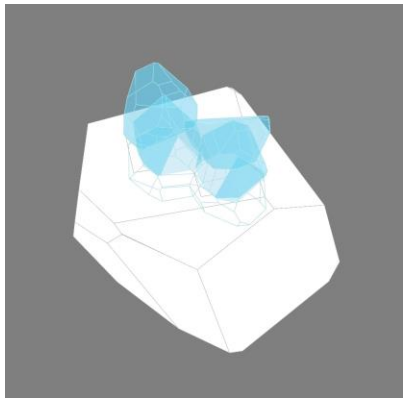
Offset the boxes and populate the volume outside of them

5

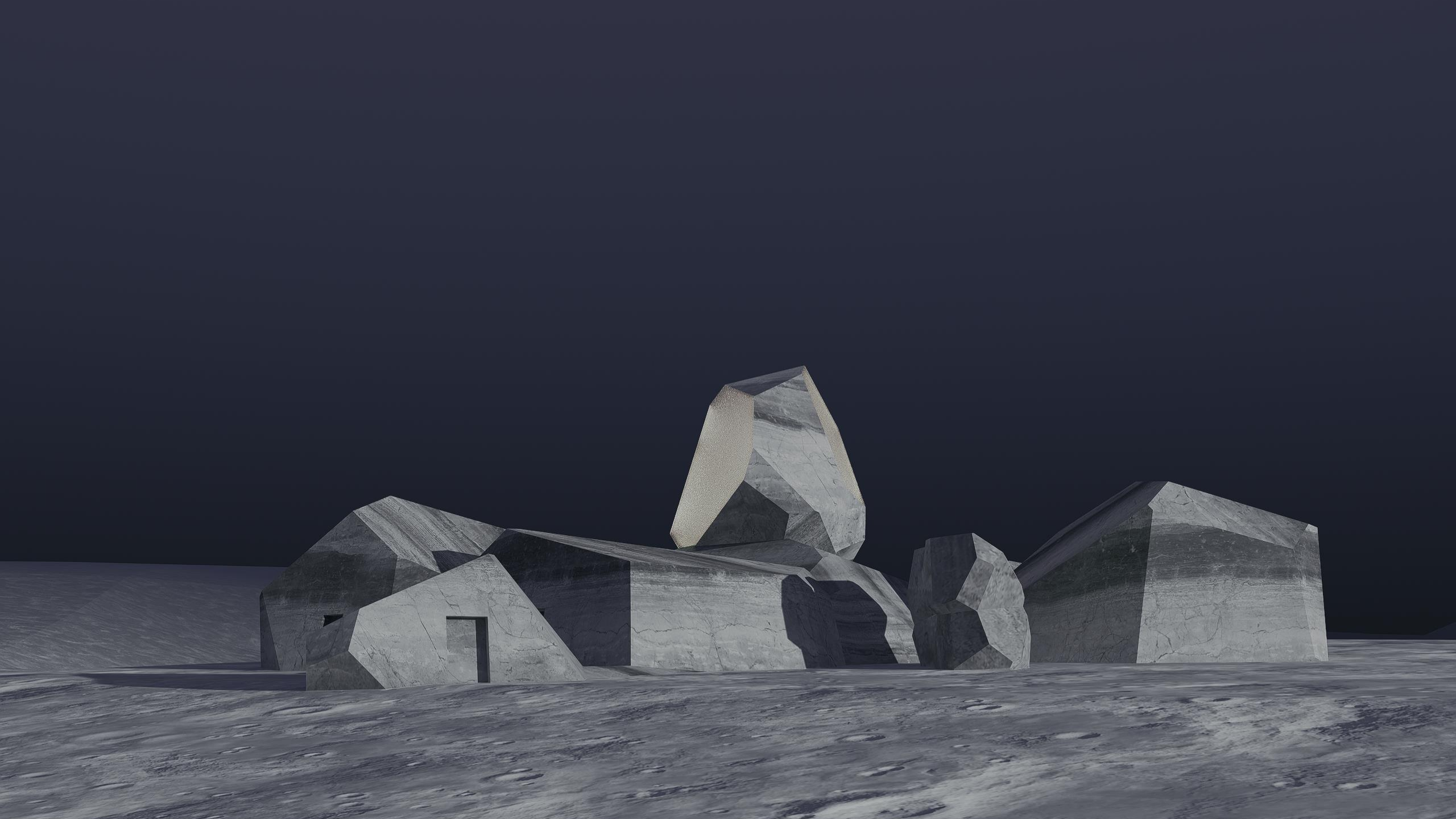


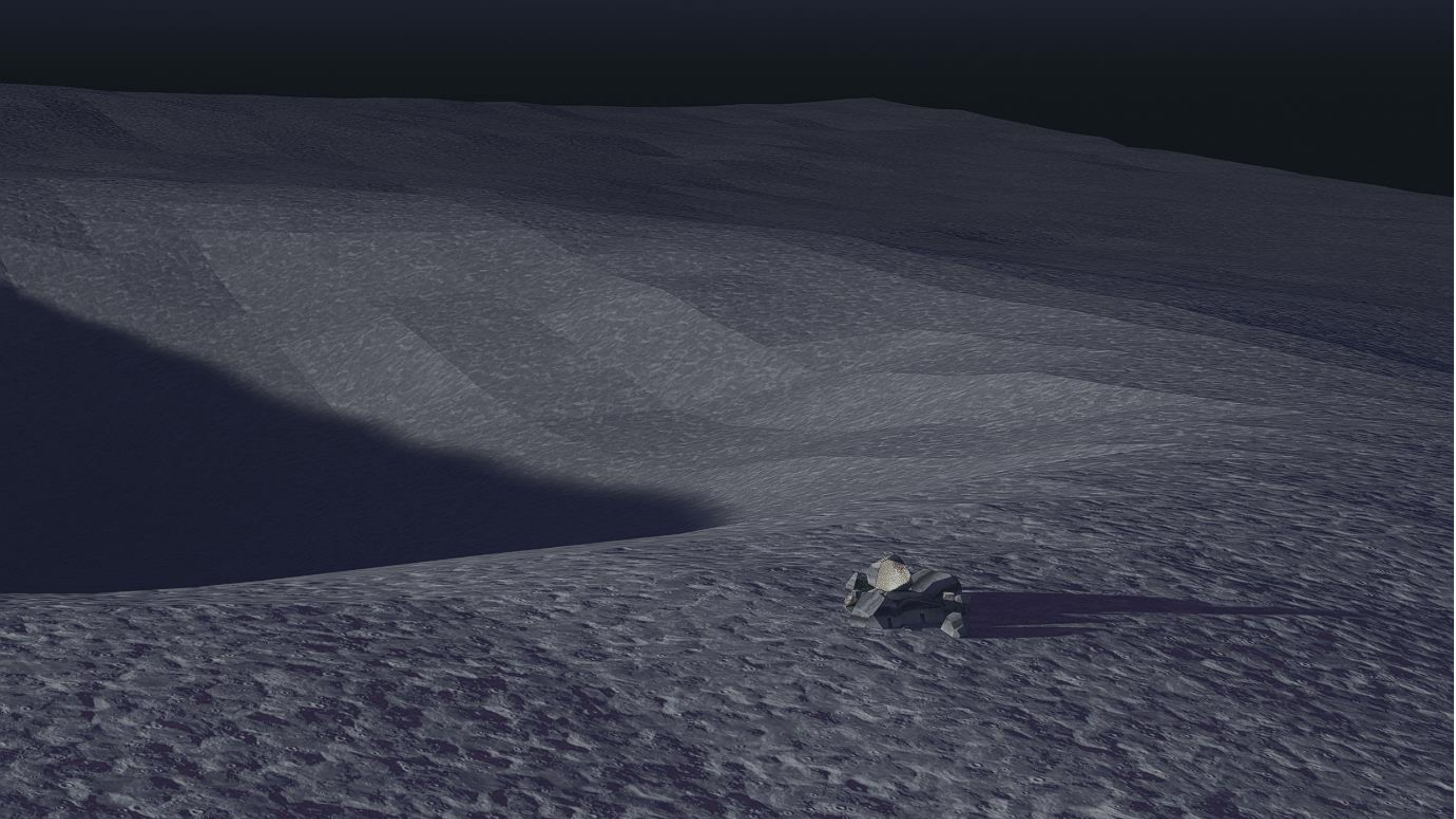
Voronoi 3d

6

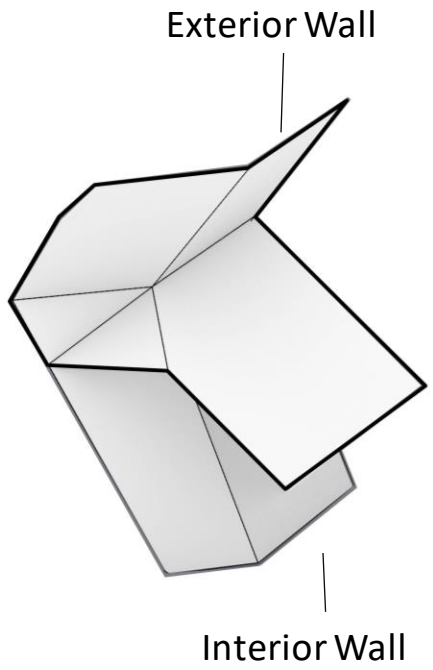


Select cells with the same centers as the initial boxes

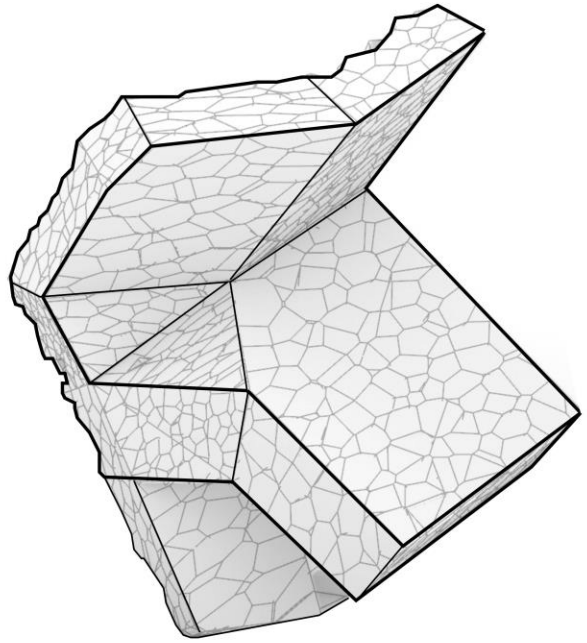




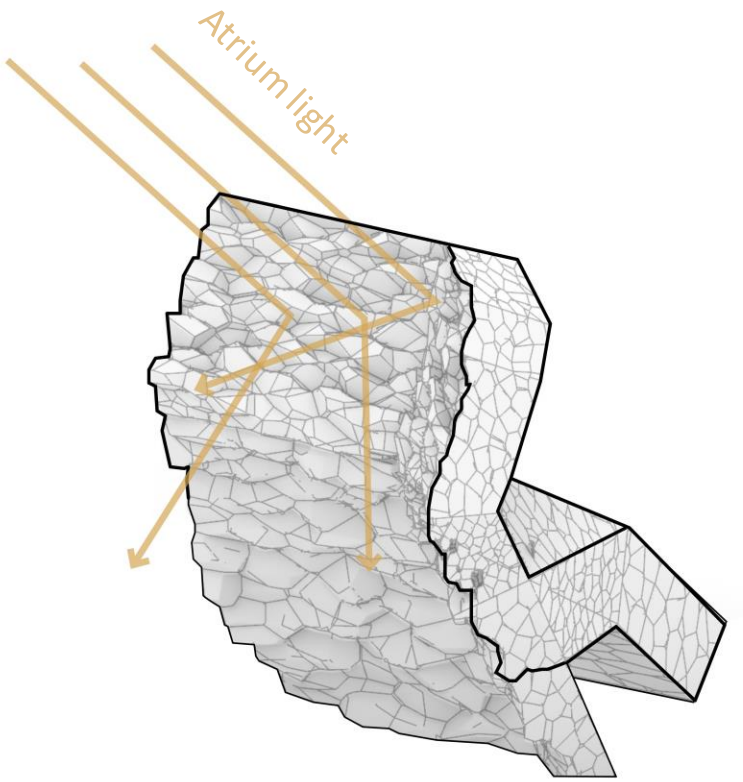
Fragment



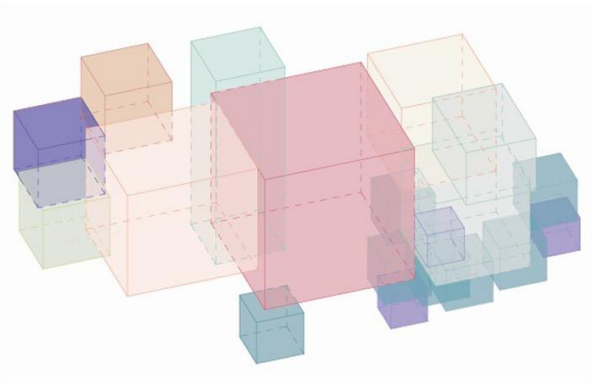
Fragment

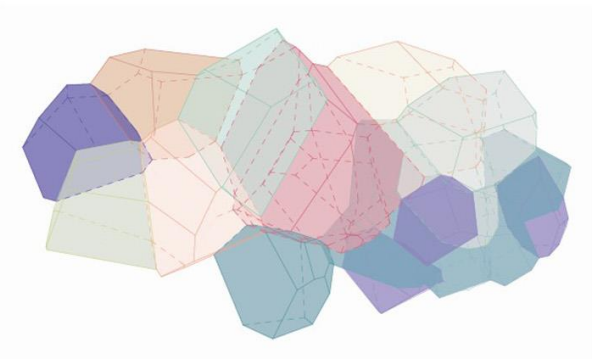


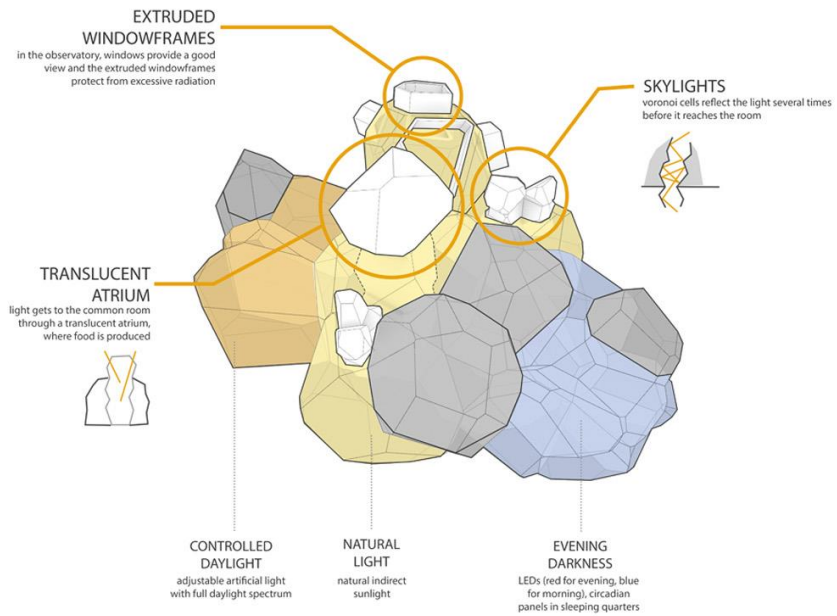
External faces are smooth to avoid debris collection on the façade of the building



Internal faces follow the voronoi patterns of the bricks to diffuse atrium light as






EXTRUDED WINDOWFRAMES
in the observatory, windows provide a good view and the extruded windowframes protect from excessive radiation
SKYLIGHTS
voronoi cells reflect the light several times before it reaches the room
TRANSLUCENT ATRIUM
light gets to the common room through a translucent atrium, where food is produced
CONTROLLED DAYLIGHT
adjustable artificial light with full daylight spectrum
NATURAL LIGHT
natural indirect sunlight
EVENING DARKNESS
LEDs (red for evening, blue for morning), circadian panels in sleeping quarters