1:1 Interactive Architecture Prototypes

Week 4

Group 3
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Content

- Conclusions of last week
  - How to go further
- Extended research
  - Materials -> conclude with decision how the structure is build up
  - Greenhouses as central space
  - Life Support Systems
  - Light
  - Minimal required spaces
  - Configuration of spaces using Grasshopper
- Final conclusions and how to continue further

Conclusions week 3

- Only use materials that are available on Mars
- Define some criteria and compare different materials
- Use artificial light in the habitation unit
- Scale down the space, design the space for 3 (to 5) users
- Define the functional requirements and assign areas to each
- Integrate the furniture within the structure

Materials

Comparative Analysis

	Martian Concrete	Biolith	Concrete	PLA	Silica aerogel	Silicon Dioxide
Strength	The strength is 2.5 times stronger than regular concrete, at 50 Mpa.	Average strength is 2.5-3.5 Mpa, which varies depending on the composition.	Between 17 Mpa - 28 MPa	Yes	No	NA
Precision	No	Fine 5mm definition	No	Yes	-	Yes
Curing Time	Curing time could be high as the mix needs to cool down to a temperature where sulfur is a solid.	Self adhesive properties, which makes it easier to bind and construct	Long time to gain full strength. Water will solidify to bind the mix.	Fast	-	NA
Contact with Humans	Not ideal due to presence of Sulphur as binding agent.	Uses bio material chitin mixed with regolith from Mars	Ideal due to the presence of water as binding agent	Yes	NA	Yes (considering properties similar to glass)
Availability on Mars	Yes	Yes, with chitin from earth	No	No	No	Yes
Recyclable / Sustainable	The concrete mix can be reheated until the sulfur melts, then the entire concrete block becomes malleable again. Hence, it is infinitely reusable.	Closed loop and zero waste solution, can be recycled in more forms.	Not reusable.	Yes	-	Yes

Materials

Comparative Analysis

	Martian Concrete	Biolith	Concrete	PLA	Silica aerogel	Silicon Dioxide
Strength	++	-	+-	+-	NA	+-
Precision	+-	+	+-	++	NA	++
Curing Time	+-	+-	-	+	NA	NA
Contact with Humans	--	+	++	++	+-	++
Availability on Mars	++	+	-	--	--	++
Recyclable / Sustainable	+	+	-	+	?	+
Purpose	*Structural Element*	*Finishing material on the interiors*	-	*Transparent Material where required*	*Insulation where required*	*Transparent Material where required*

Insulating Material

Silica Aerogel

- Efficient at warming, can obtain warming to 0°C or higher under Mars-like insulation levels using a 2-3 cm thick layer
- Strongly blocked UVA and UVB radiation (280-400 nm wavelengths) and nearly totally blocked the most hazardous UVC (220-275 nm) radiation
- Will transmit sufficient visible light for photosynthesis
- Very lightweight styrofoam like solid with 99% air
- Unsure if it can be 3d printed.
- Unsure if it can be manufactured in Mars

https://physicsworld.com/a/aerogel-insulation-could-help-in-regional-terraforming-on-mars/

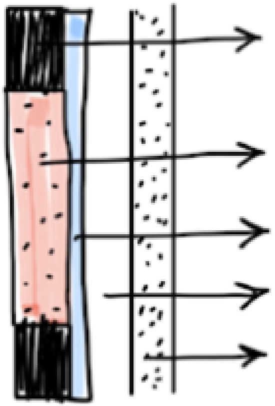
Materials

Conclusions

- Use **martian concrete** as structural material, as it offers high strength
- Use **biolith** as interior finishing material (which is in direct contact with humans)
- Use insulation of **silica aerogel** in areas which are exposed to the sun, such as the greenhouse area

Materials

Layers in Structure



Main Voronoi Structure
Martian Concrete

Martian Concrete

Insulation, Silica Aerogel

Air gap

Biolith

Greenhouses - Possibilities on Mars

Since the late 1980s, NASA plant scientists have been studying how to grow potatoes (such as the ones shown here) in hydroponic solutions, which are expected to be used on missions to Mars.
NASA

Astronauts on the International Space Station are ready to sample their harvest of a crop of "Outredgeous" red romaine lettuce from the Veggie plant growth system that tests hardware for growing vegetables and other plants in space.
Credits: NASA

NASA plans to grow food on future spacecraft and on other planets as a food supplement for astronauts. Fresh food, such as vegetables, provide essential vitamins and nutrients that will help enable sustainable deep space pioneering.
Credits: NASA

- Harsh conditions like extreme cold, lack of sunlight and water
- Experiments show that certain plants can grow on Martian soil, however this is difficult
- Better solution would be hydroponic or aeroponic systems
- Nutrient-laden water & higher density of plants possible
- Conducted experiments include growing potatoes and lettuce

Greenhouses - What systems would you need?

The basics necessary:

- A protected environment that is pressurised, heated and moisturized
- Seeds of certain crops/ plants
- Watering system (hydroponics)
- Multiwavelength LEDs augmenting sunlight

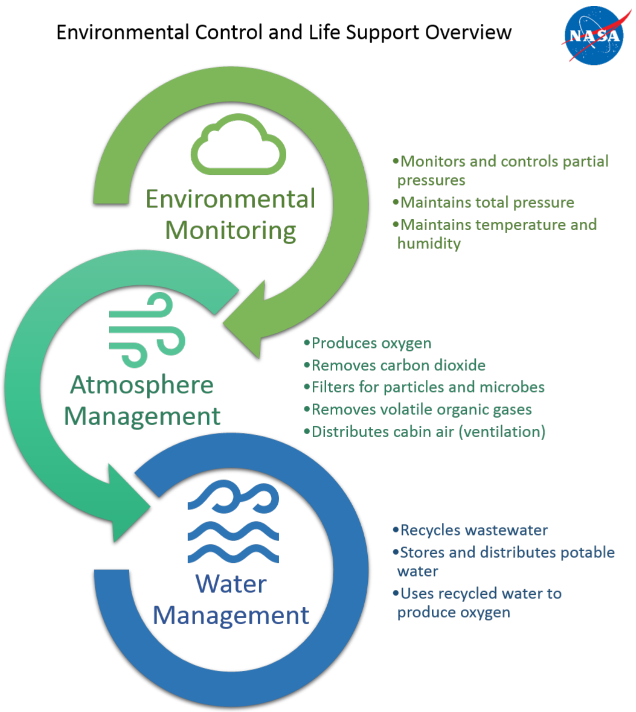
Greenhouses - Crops to grow

- Not suited for plants that require full sun like tomatoes, corn & many root plants
- Researchers found that dandelions flourish on Mars and have many benefits
- Other thriving plants included lettuce, spinach, peas, kale & onions.

Greenhouses - our project

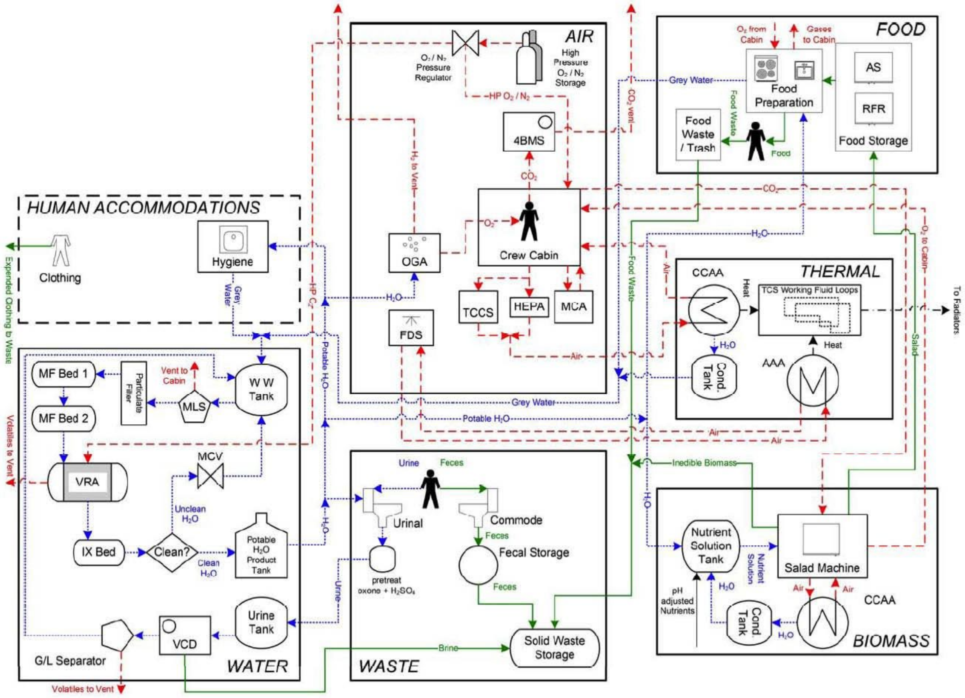
- Use of a hydroponic system
- Use of crops without much sunlight requirements like dandelions and lettuce
- Integration of the plants into the inner panels of the living room

Life support systems



- Three categories recognised by NASA
- **Environmental monitoring:** complex machines maintaining temperature and humidity
- **Atmosphere Management:** highest priority, This includes:
  - oxygen generation and recovery (3 possibilities)
  - removal of carbon dioxide
  - control of trace contaminants and particles.
- **Water management:** water recovery system

Life support systems - to conclude

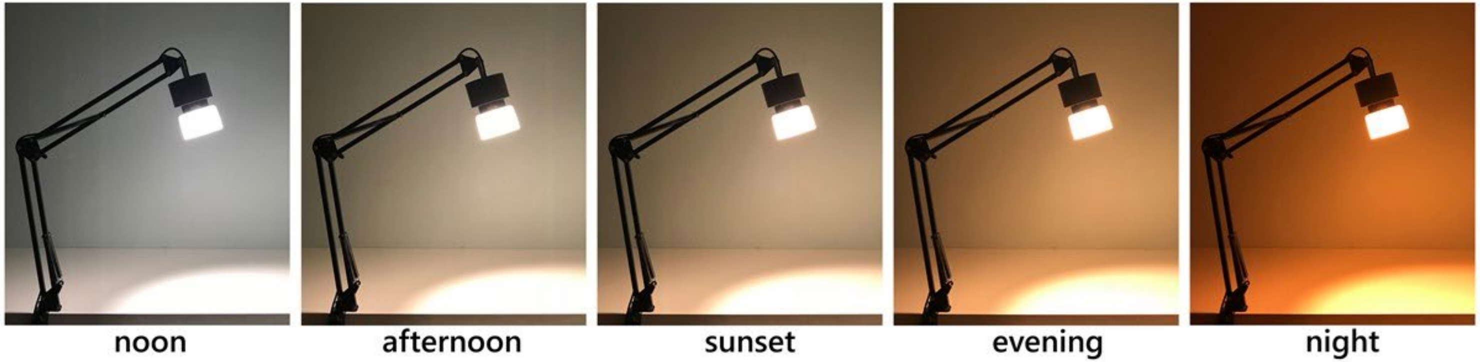


The importance of light

- Physical and Biological responses
- Biochemical and hormalar rhythm of the body are synchronized

Artificial lighting

- Space/activity independence
- Can be changed according to your mood
- It is always there (no rainy days)



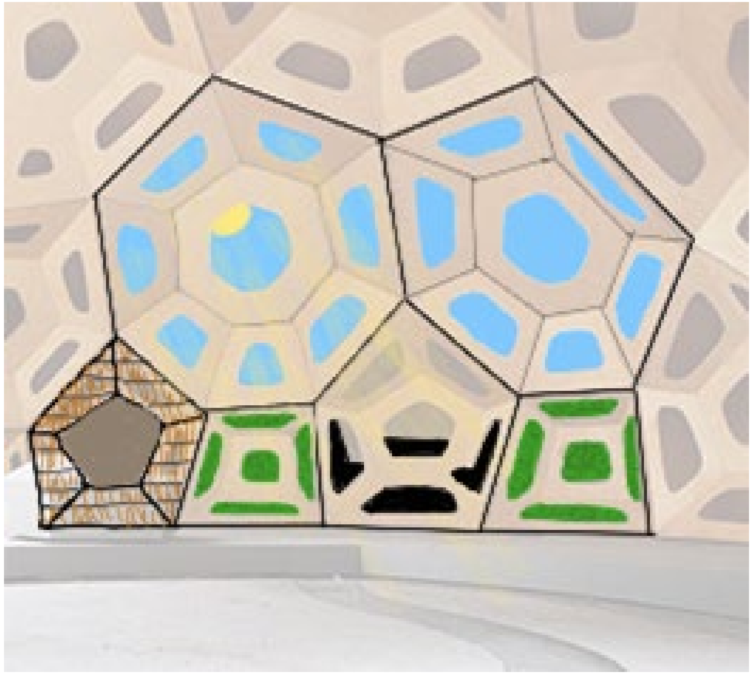
Smart lighting

Cleolux

Artificial window

Cleolux

Sketches panels integrated



Design decisions

The Planner:

- Identifies project location
- Creates boundaries
- Fits floorplans
- Creates spaces
- Plans digging

The Digger

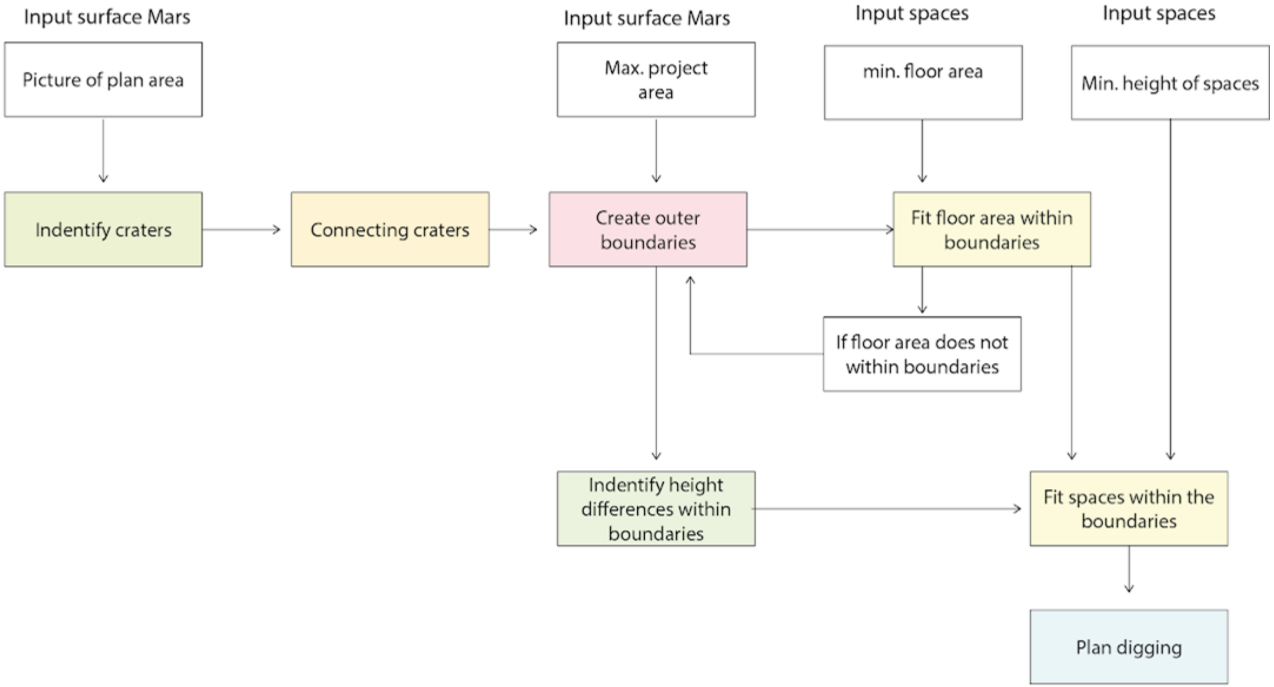
- Digs out underground spaces

The Printer

- Creates voronoi on inside surfaces
- Prints concrete structures

The Planner

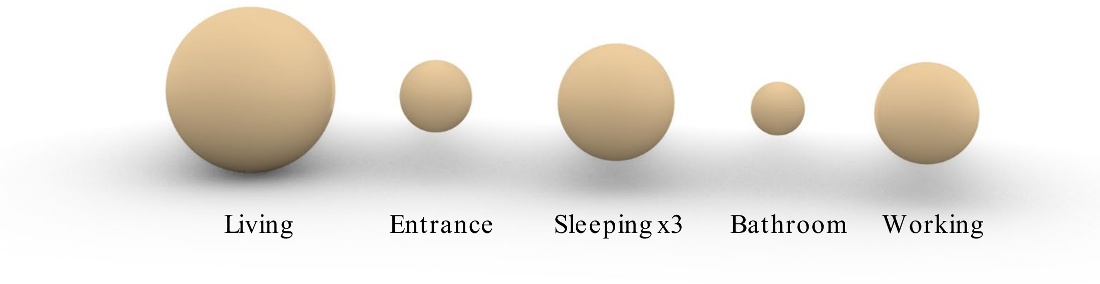
Flowchart Planner robot code



1.1 Input spaces: minimal floor area

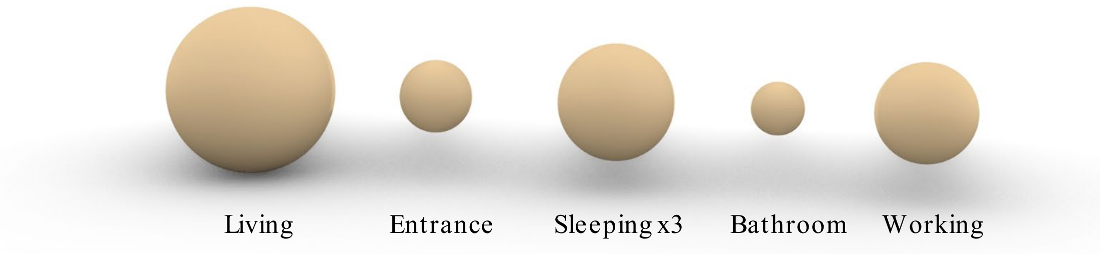
Based on the book 'De Menselijke Maat'

- Eating room 2.7x2.7m
  7 m2
- Kitchen 3x 2,4 m
  7 m2
- Sitting area 3.75x3.95m
  8 m2
- **Together as a living room: 22 m2**
- Entrance
  4 m2
- Sleeping area 3.35x3.30m **3 x 10 m2**
- Bathroom 1.8x0.9m
  2 m2

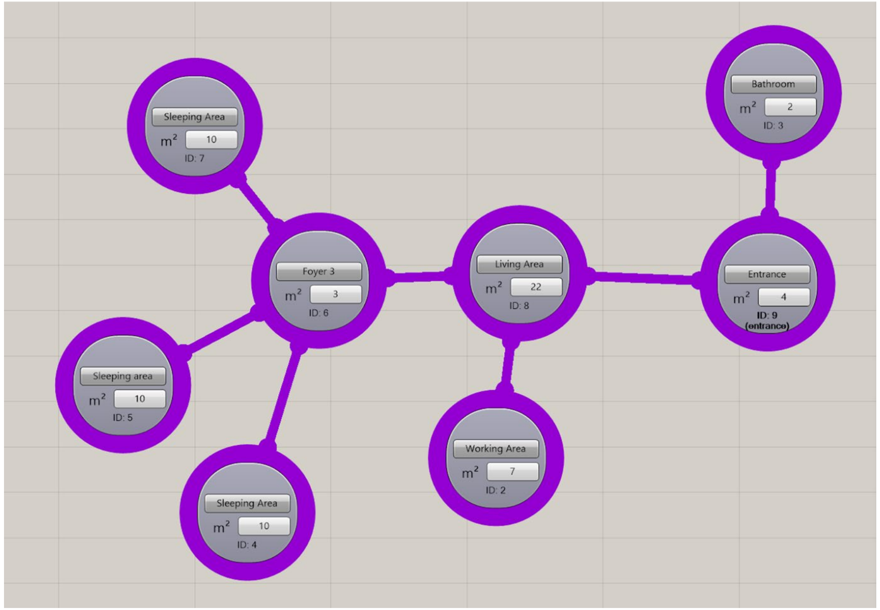


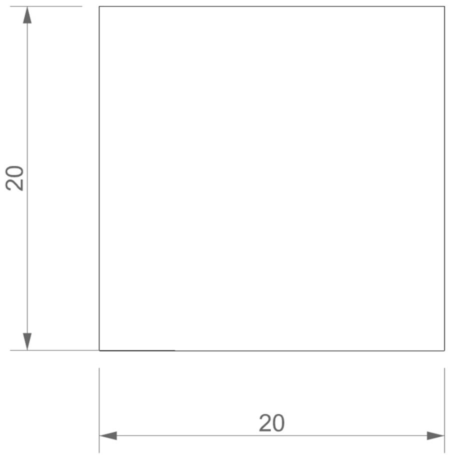
1.2 Input spaces: minimal height of spaces

- **Living room:**
  3 m
- Entrance
  4 m
- Sleeping area 3.35x3.30m **3 m**
- Bathroom 1.8x0.9m
  3 m
- Working area 2.7x2.7
  7 m
- Life Support Systems
  - Greenhouse
    10 m
  - Heating system
    4 m

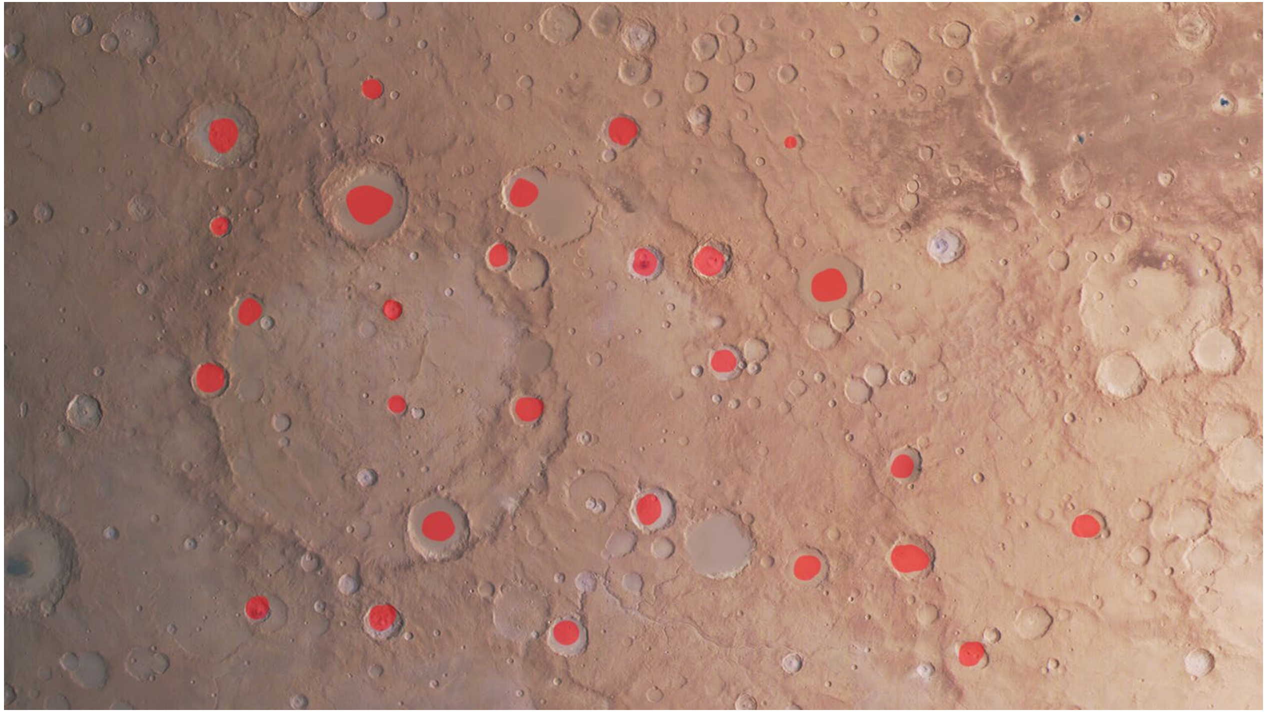


1.3 Input: maximum workspace

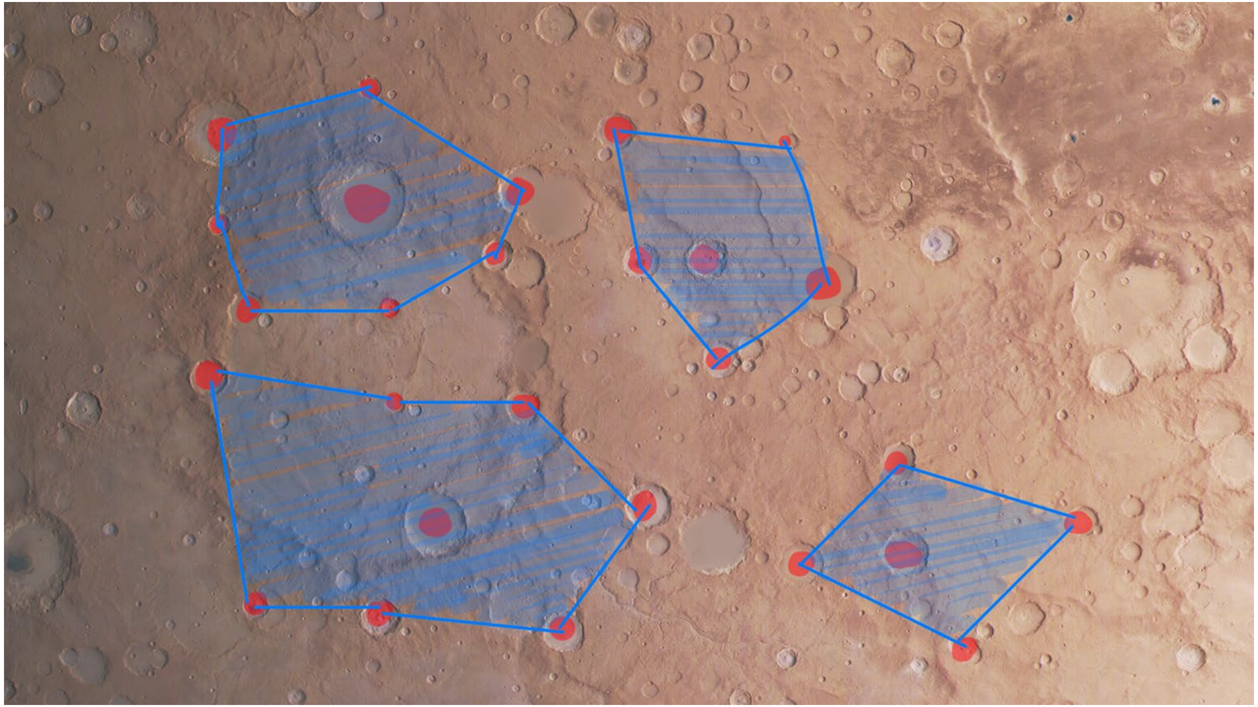




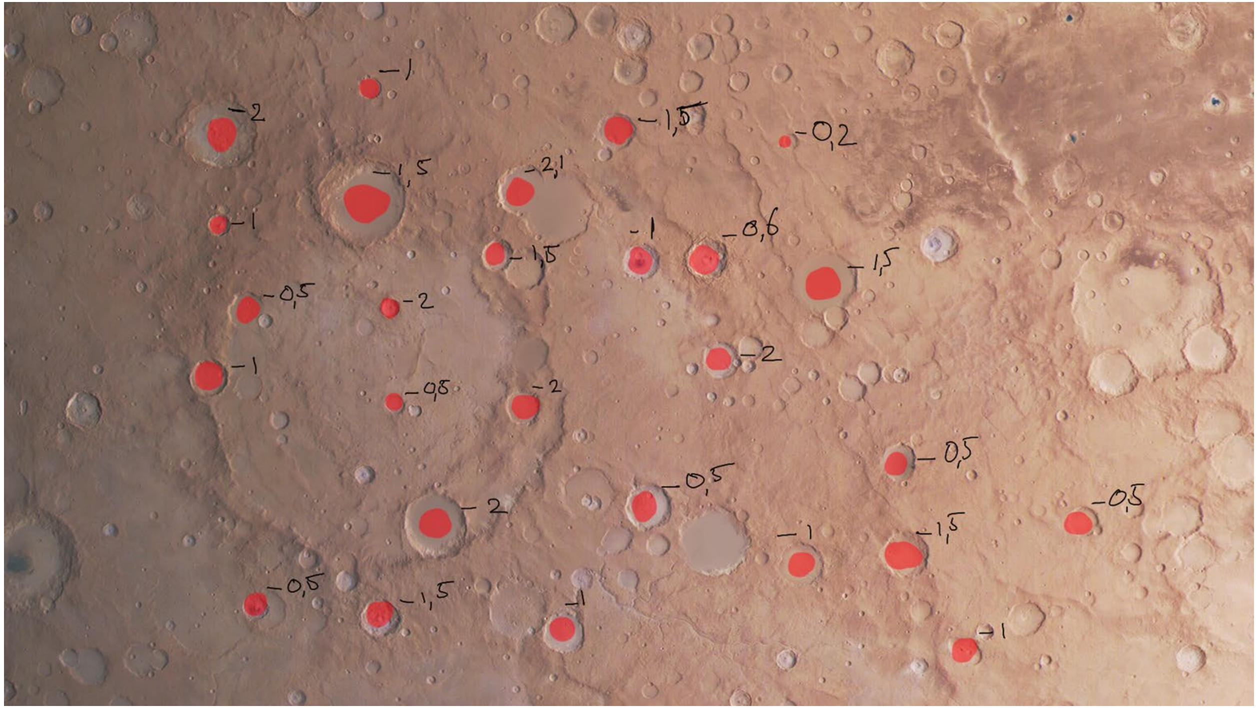
2) Identifying craters



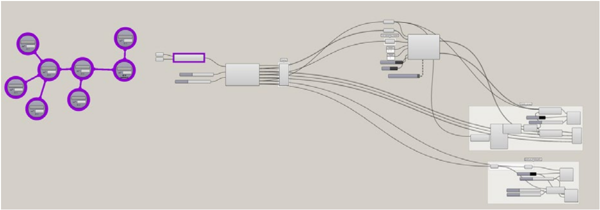
3) Connecting craters as outer boundaries

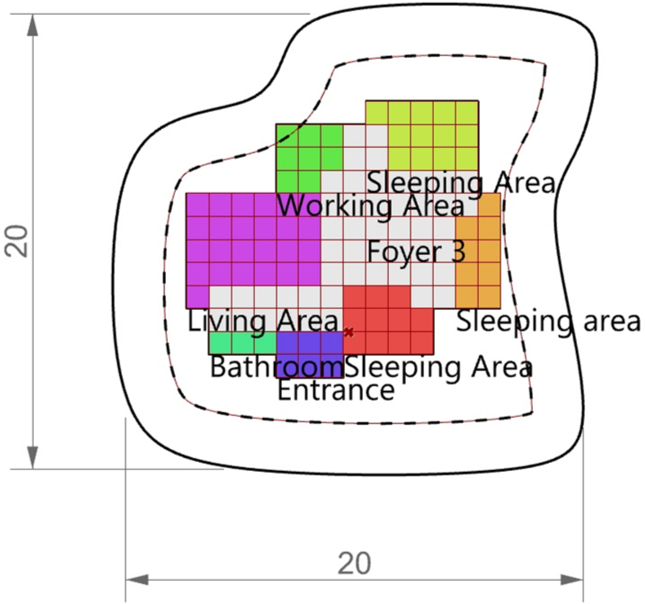


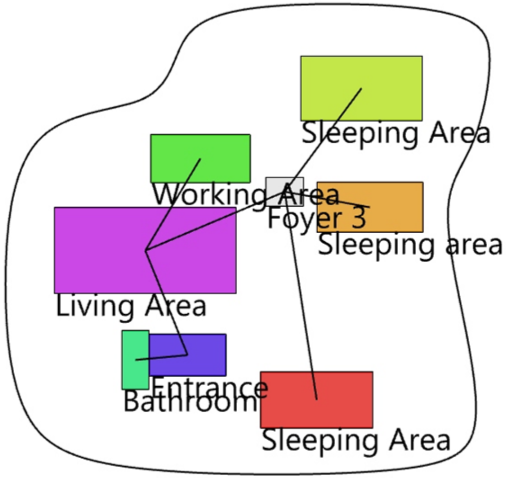
4) Identify height differences within the boundaries



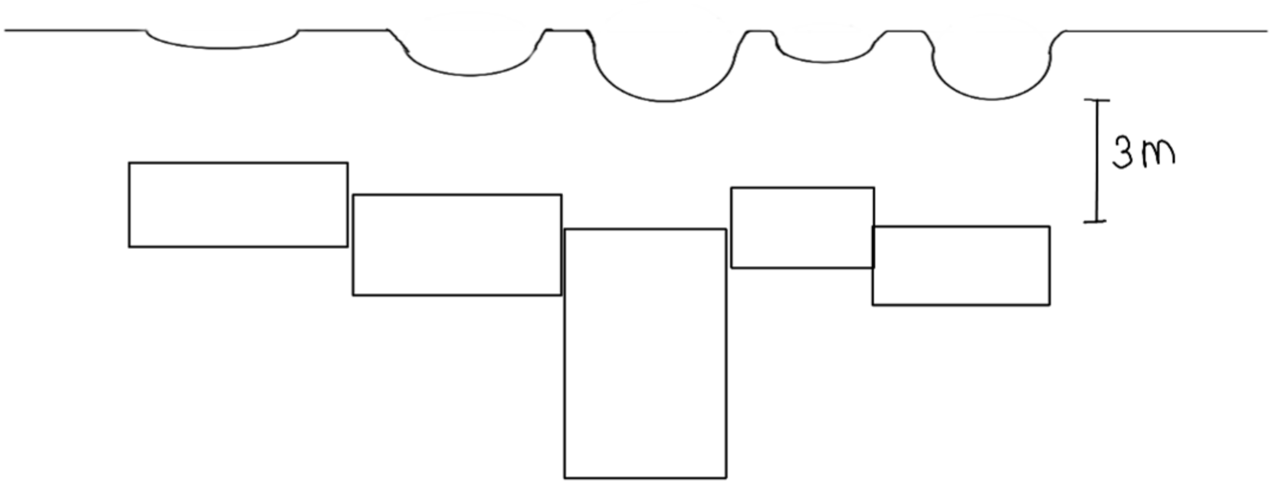
5) Fit floor area within the boundaries



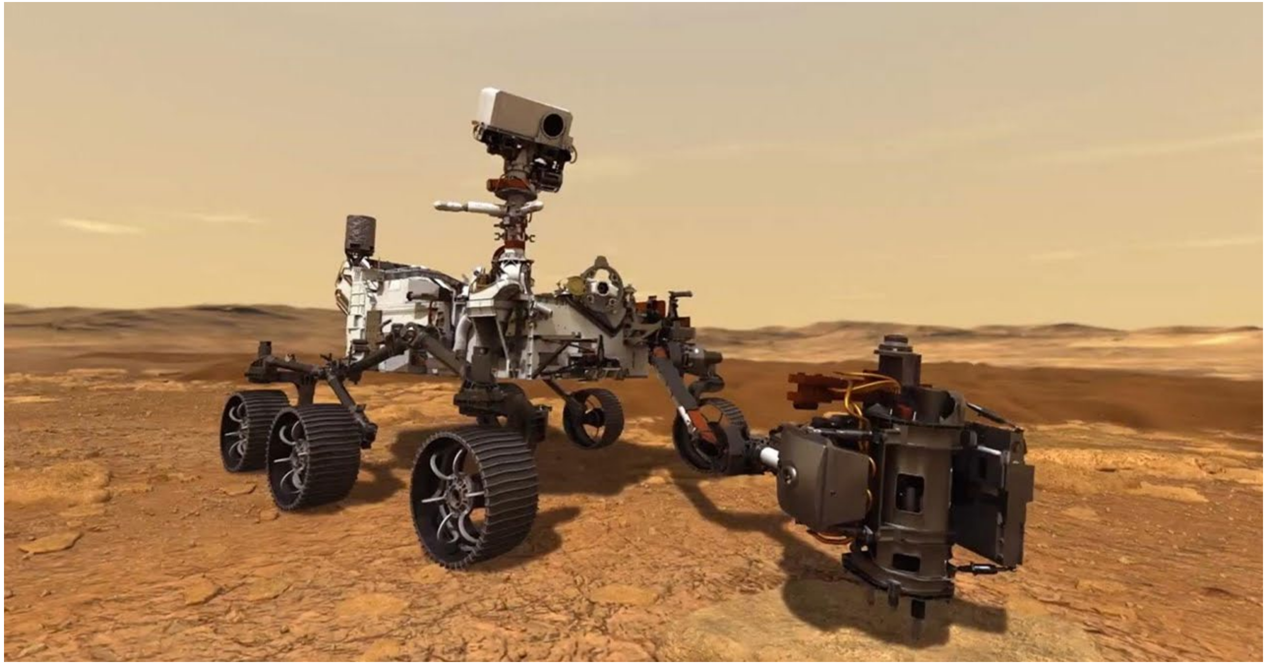




6) Fit in minimal height of spaces

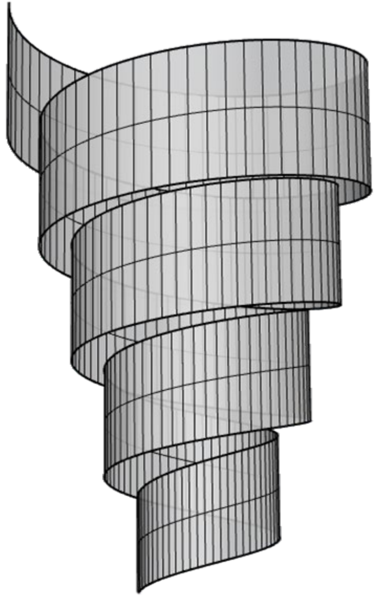


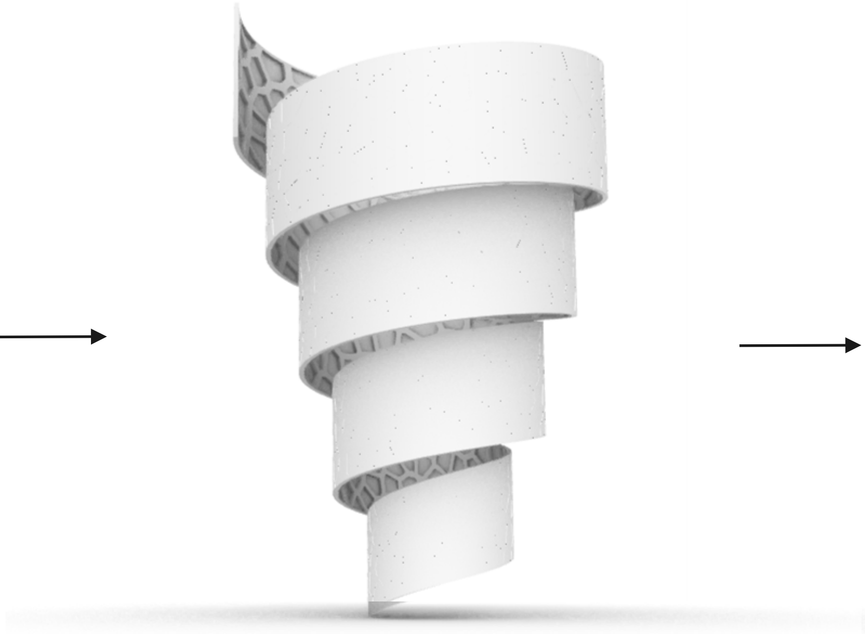
7) Plan digging structure/ points

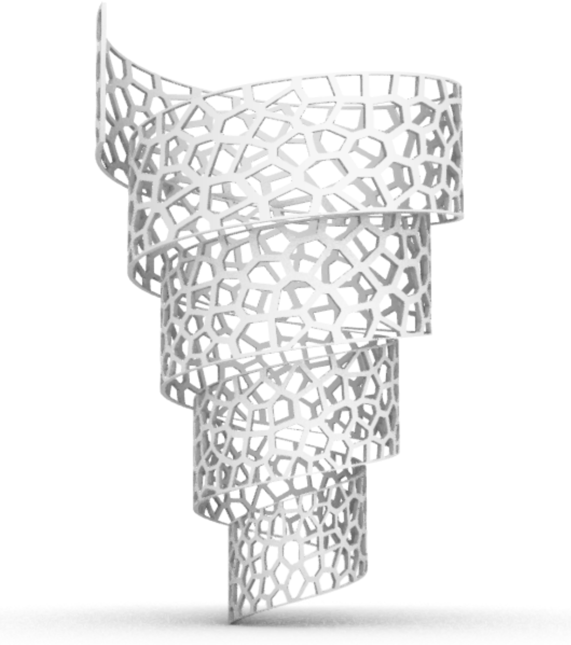


The Printer

Martial concrete structure







1) Identify space surface

2) Create voronoi on space surface

2) Print voronoi structure

Conclusions week 4

- Material use: biolith, martial concrete, and silica aerogel
- Artificial light in the habitation unit
- Defined the functional requirements and assigned areas to each
- Create floor plans using magnetiser plug-in
- Create spaces using Termite plug-in
- Create voronoi using Kangaroo plug-in

How to continue week 5

- Artificial lighting
- Integration of furniture within the structure
- Finish floor plan algorithm
- Create spacing algorithm
- Finish voronoi algorithm
- Integrated sensors