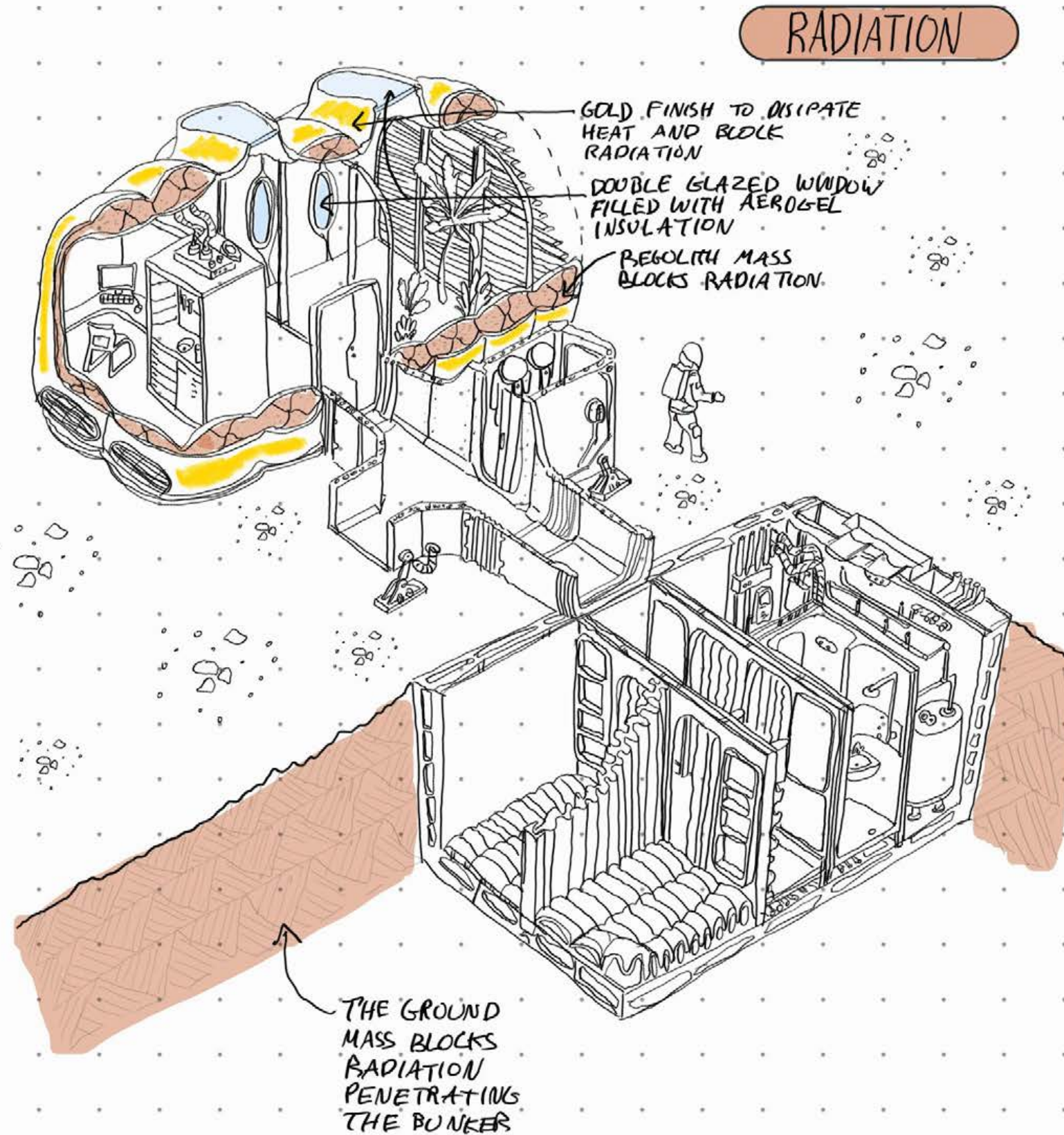


# HOW DOES EXTREME CLIMATE CONDITIONS IMPACT BUILDING ENVELOPE DESIGN?



## TDS - Assignment T6.1

Final Research Documentation/Esquisse

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DT175 04

09/05/2021



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## Shakleton HBA Talk 30/11/21

- Antarctica population: 2000.
- Temp. drops to  $-55^{\circ}\text{C}$ .
- Never above freezing.
- February - November: 105 days of darkness.
- Physiologically challenging.
- Halley III-IV designed to be buried.
- Belgium station = zero-carbon.
- Testing
  - Air tightness.
  - See if it could all fit together.
- Aerogel in glazing.
- Snow drift test
  - Model in water.
  - Set a current in water.
  - Pour sand in the water.
  - Take model out to see sand settlement.
- Blinds to block out 24 hr sun in the summer.

[Qs]

- Halley III?
- Hydroponics.
- Insulation?
- Used PIR foam for insulation.
- Stops water freezing within panel.
- Mars house?
- Water usage - recycled water.
- Aeronomics of social spaces.
- Exercise spaces.



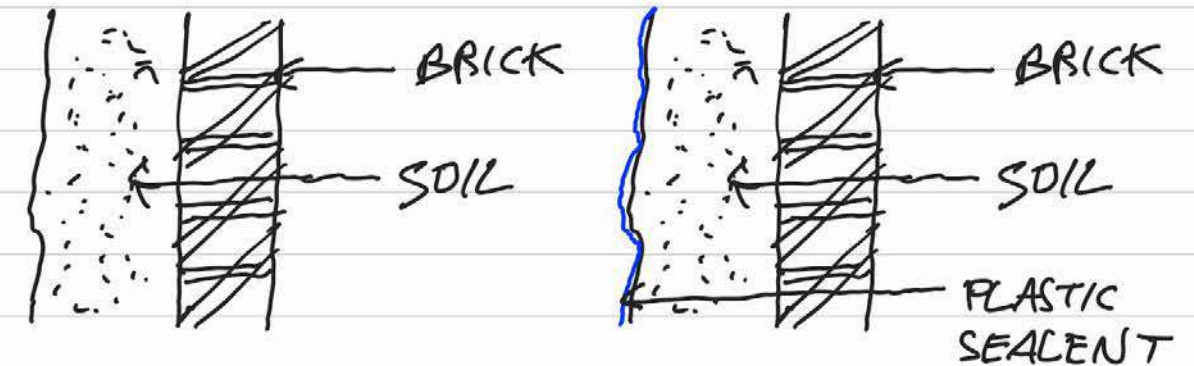
# Architecture Today

2/2/2021

- Tests
- One of
- 0-1 m<sup>3</sup> PA air tightness.
- Train carriage style connections between modules.
- Double glazed system filled with aerogel.
- Zinc corrodes slowly.
- First principals design.
- CHP provide heat and electricity.
- Some stations powered by wind turbine farm.
- Vacuum drainage.
- Low water using fittings.
- Management of recommended shower time.

# A Case for Mars

- Mars soil can be used to create bricks.
  - ↳ Contains iron, calcium, sulphur
- Brick vaults must be covered in soil to pressurise.
  - ↳ 2.5m deep
  - ↳ 1m may be enough.
- ↳ creates radiation shield.
- ↳ provides thermal insulation



- Potentially leak air
- Potentially slow down air leakage
- Mars dense atmosphere shields solar flares.
- Mars was once covered in water.
- Should position a base close to Northern polar cap.
  - ↳ 2,000,000 m<sup>3</sup> of water ice.
- In places soil is 40-60% water by weight.

- could freeze a brick instead of bake?

## Ice Station Notes 17/2/21

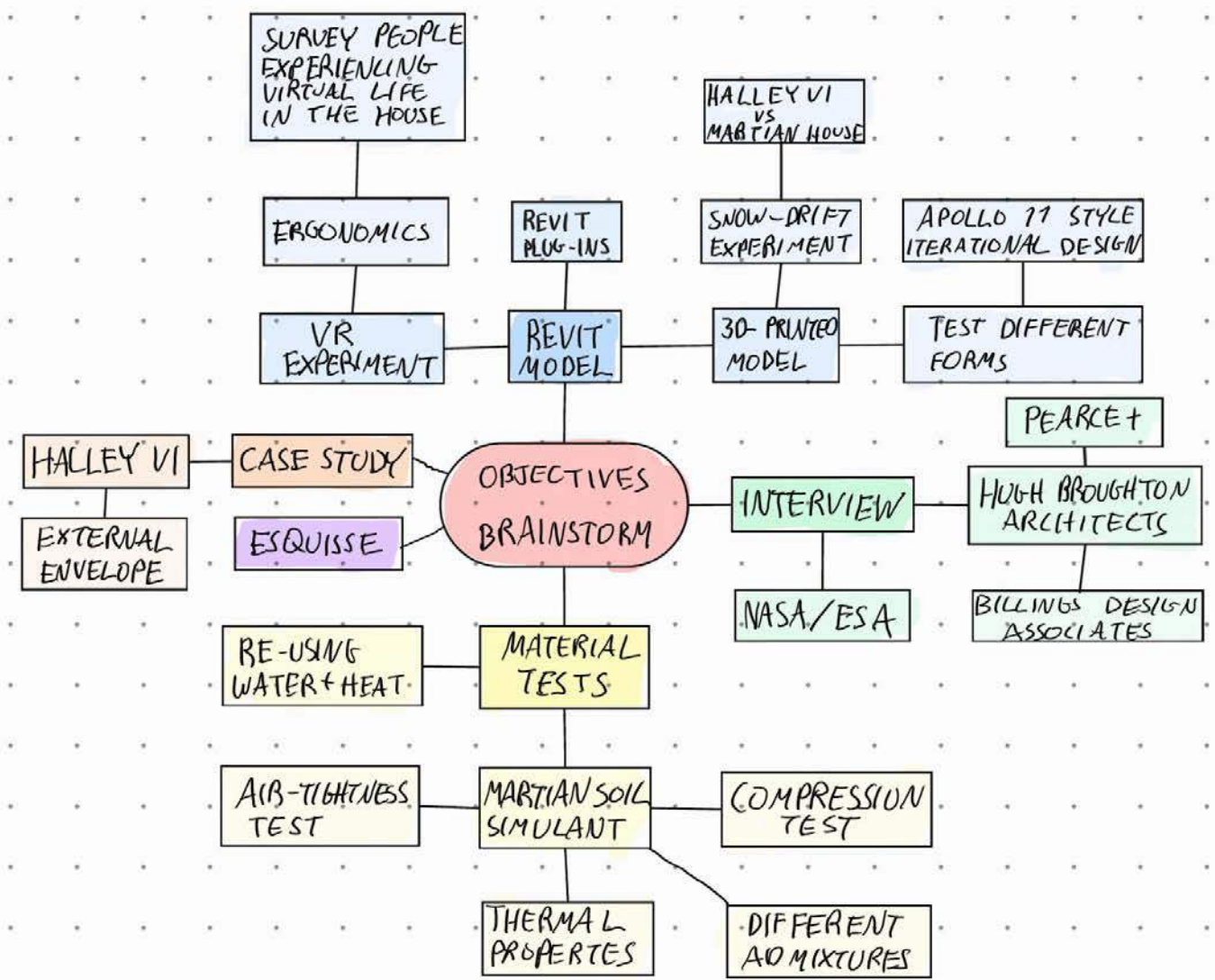
- Sits on a shifting ice shelf.
- Subject to high winds.
- Annual build-up of snow.
  - ↳ Buried previous stations.
- Months of light and dark.
  - ↳ lamp simulates daylight (closed windows).
- Ship arrives twice in the summer.
- Lowest temp in the winter on record:  $-55^{\circ}\text{C}$ .
- Snow never melts
  - ↳ Blown by prevailing winds.
  - ↳ Builds up against buildings.

Box is lined parallel to winds direction.
- 7-2m of snow per year.
- Legs jacks up building once a year during the summer.
- 106 days of darkness.
- Location is temporary
  - ↳ ice shelf moves and breaks into ice bergs.

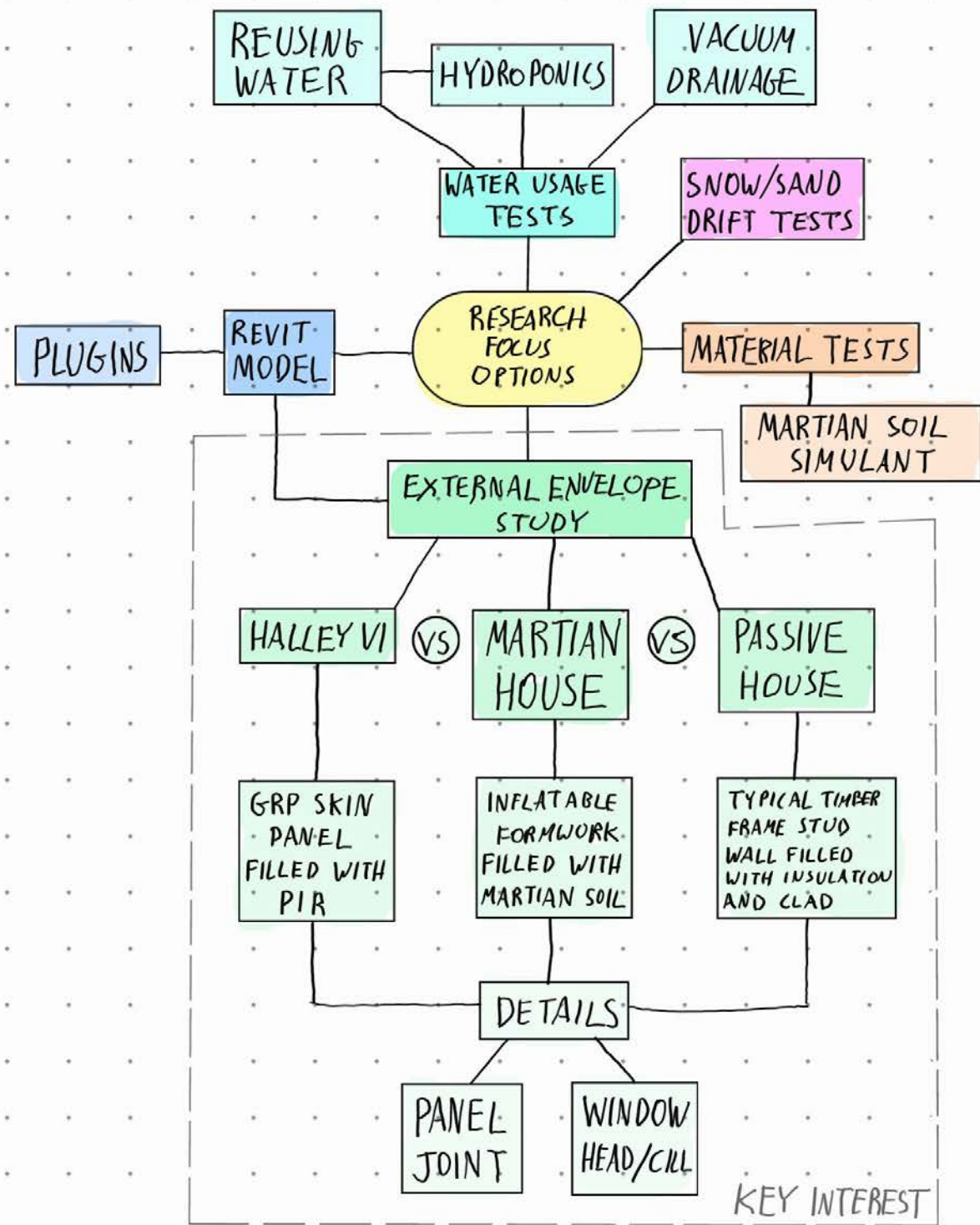


- Capacity :
  - Summer : 16
  - Winter : 52
- Modular construction - Prefabricated
  - ↳ 12 week summer construction period.
- Sledge tow max weight: 9.5 tonnes (3.5 tonnes is the sledge)
- Skis can lock in place or rotate.
- Hydraulic legs.
- Blue module erected in Cape Town to test hydraulics + air-tightness.
- 7.5% = average damage of materials on construction sites
  - ↳ Must account for this by bringing additional materials.
- Trelleborg connectors between modules.
- Water sourced by melting snow in a melt tank.

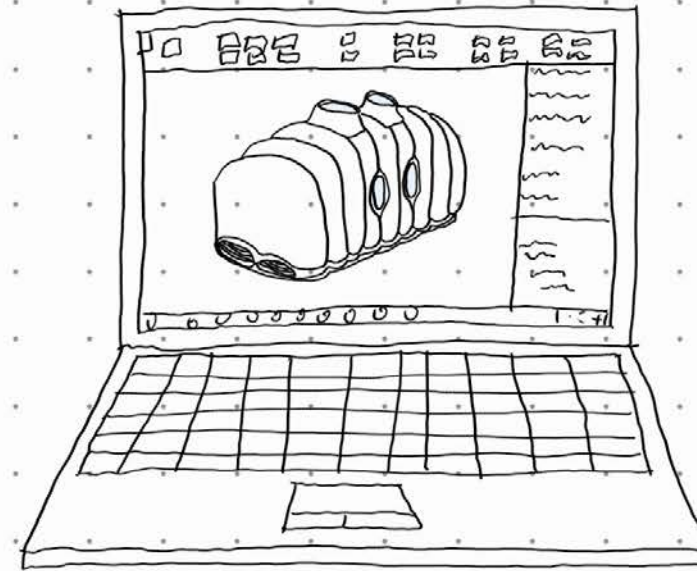
UK South Africa







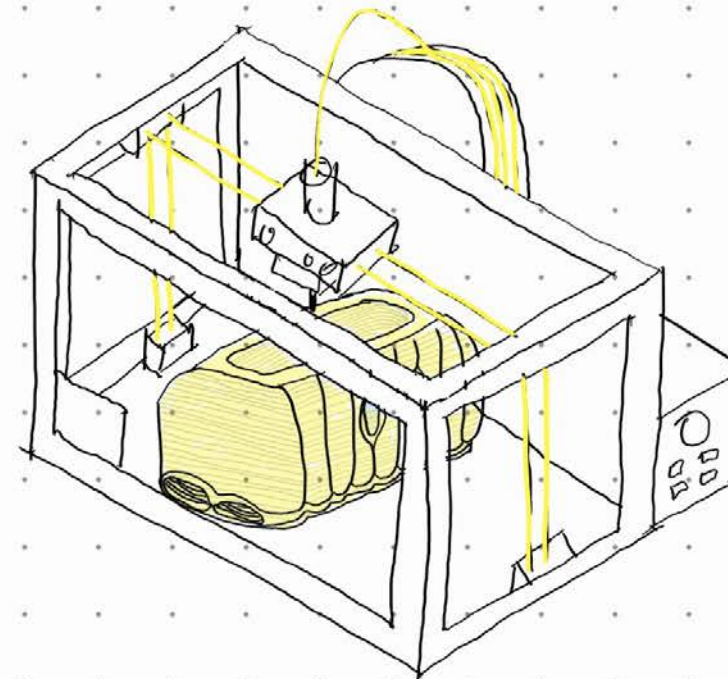
## REVIT MODEL



- PROS:**
- ACCESSIBLE
  - MANY PLUGINS AVAILABLE  
↳ VR
  - USED TO CREATE 3D PRINTED MODELS.

**CONS:**

## 3D PRINTED MODEL

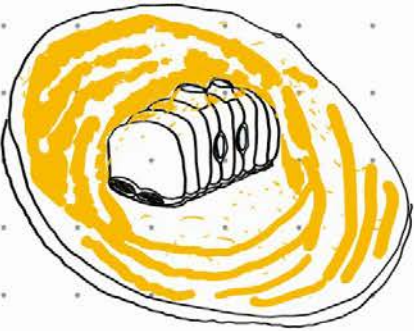
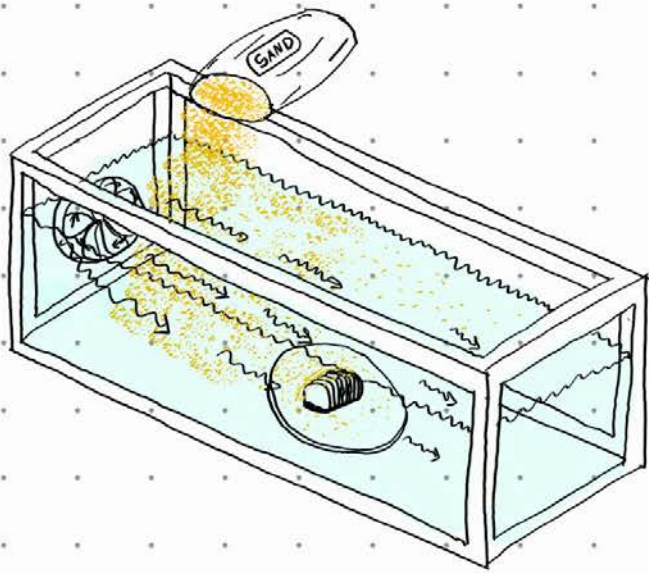


- PROS:**
- ACCESSIBLE
  - TEST DIFFERENT FORMS
  - PROVIDES ABILITY TO UNDERTAKE PHYSICAL TESTS ON A VIRTUAL MODEL

- CONS:**
- ONLY SMALL-SCALE MODELS
  - MADE OF PLA PLASTIC  
↳ NOT OF WHAT WILL BE USED FOR CONSTRUCTION ON MARS



# DUST DRIFT TEST

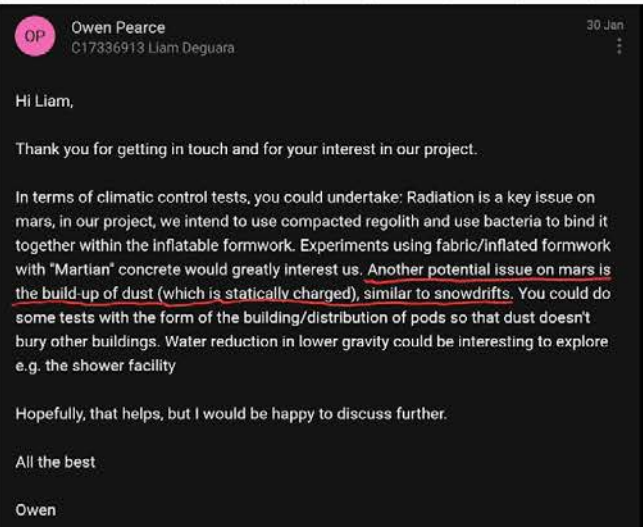


**PROS:**

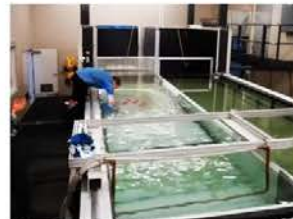
- TESTS A SCENARIO THE BUILDING WILL EXPERIENCE.
- APPROVED TESTING METHOD BY HUGH BROUGHTON ARCHITECTS.

**CONS:**

- LOTS OF EQUIPMENT
- DIFFICULT TO TOTALLY REPLICATE REAL WORLD SCENARIO



Snow modelling  
RWDI Laboratories, Canada



Water flume at RWDI laboratories



Calibration of flume using existing base model



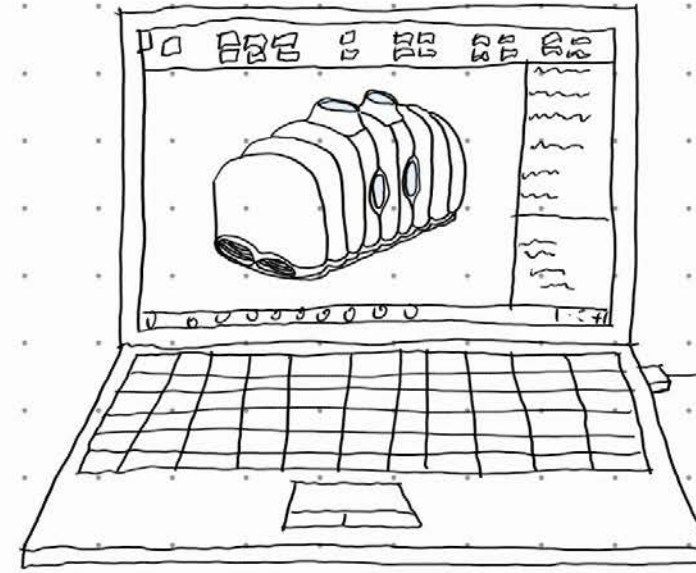
Option 1 model with constant grade topography



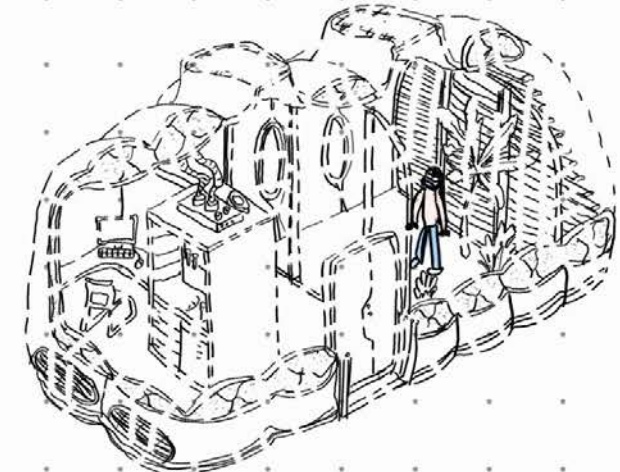
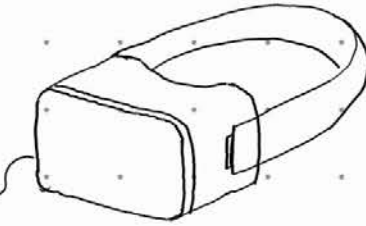
Option 2 model

HBA SNOW DRIFT TESTS ON MODELS

# VR EXPERIMENT



SURVEY	
D	1-10
S	1-10
D	1-10
S	1-10
D	1-10
S	1-10



**PROS:**

- ACCESSIBLE
- TESTS PEOPLES INTERACTIONS WITH A 1:1 SCALE VIRTUAL MODEL OF THE BUILDING.
- SURVEY PEOPLES EXPERIENCE TO MAKE DESIGN ITERATIONS.

↳ ERGONOMICS

"We look very carefully at the ergonomics of the social spaces to make sure that you could still provide space that people could be as a community but also on their own and very importantly on those missions where you are on very low gravity that you would be able to take lots of exercise to keep your muscles in shape" - Hugh Broughton

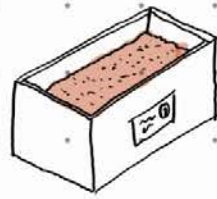
**CONS:**

- DOESNT REPLICATE LOW GRAVITY.
- ↳ HOWEVER A VR HEADSET COULD BE WORN BY AN INDIVIDUAL IN A LOW GRAVITY SIM OR ON BOARD THE ISS. →

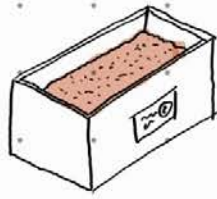




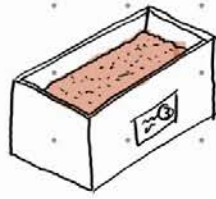
# MATERIAL TESTS



BINDING ADMIXTURE 1



BINDING ADMIXTURE 2



BINDING ADMIXTURE 3

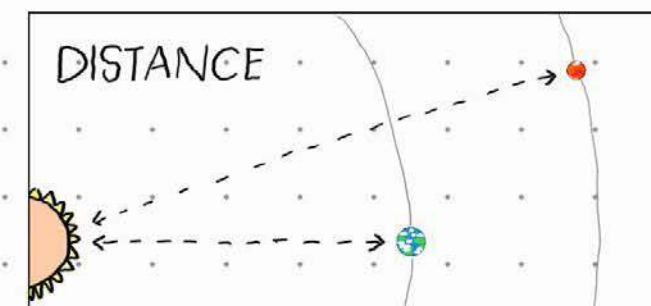
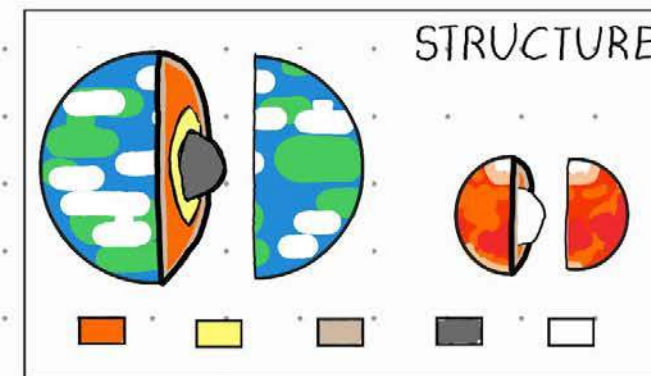
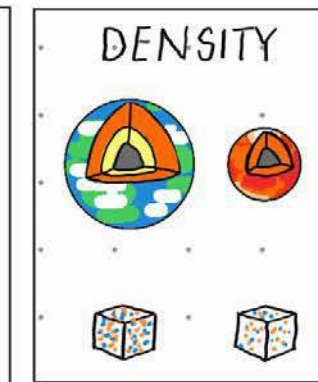
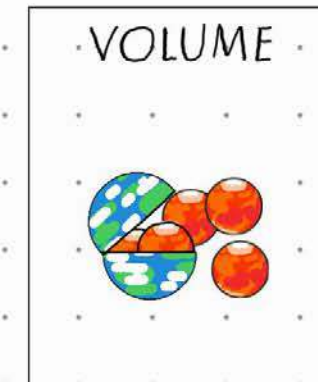
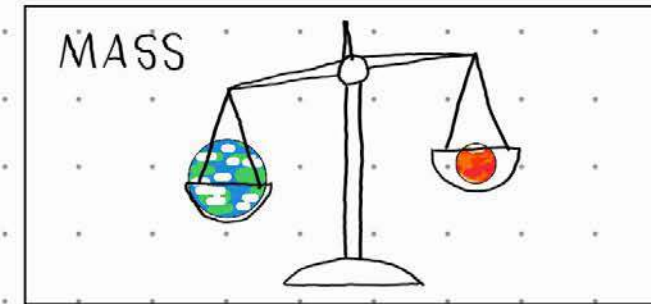
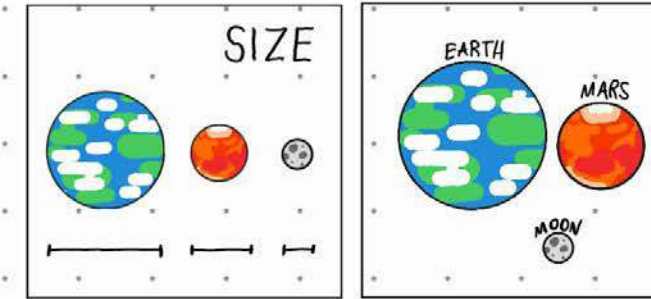
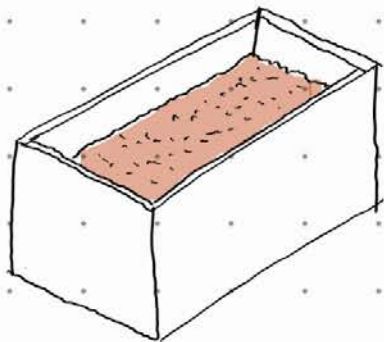
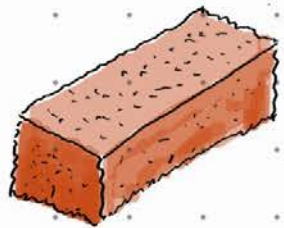
Element	Brown Powder, Weight %
Zirconium	0.275
Iron	29.193
Chromium	0.330
Vanadium	0.389
Titanium	2.926
Aluminium	9.705
Silicon	57.110

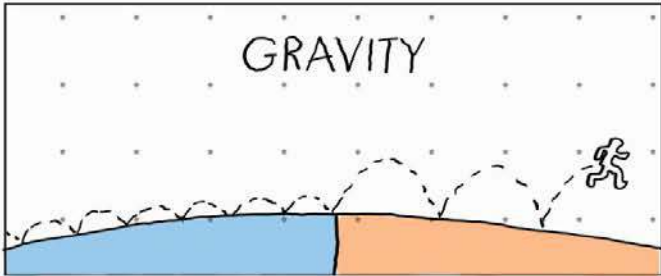
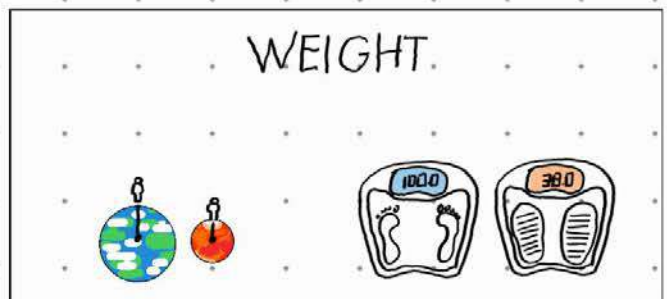
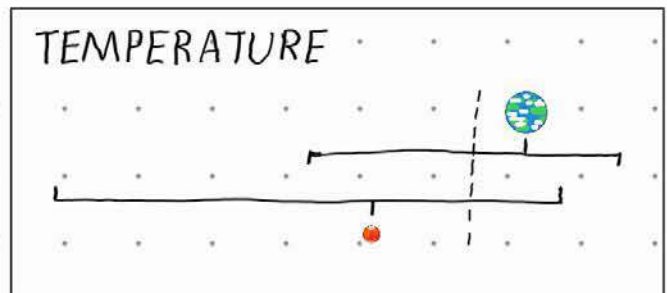
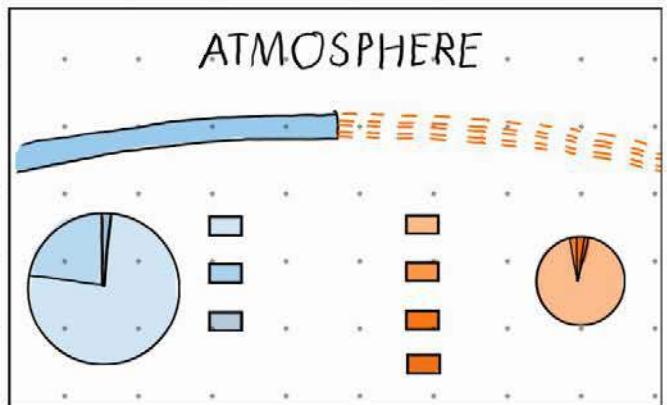
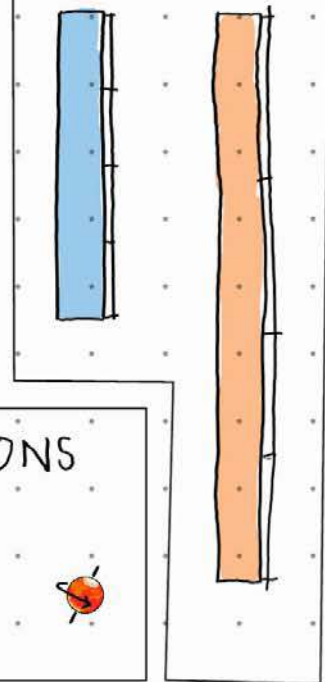
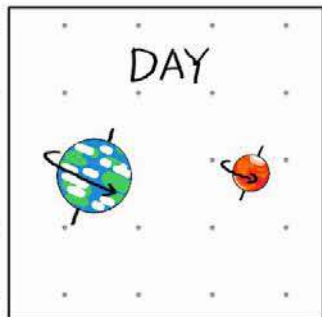
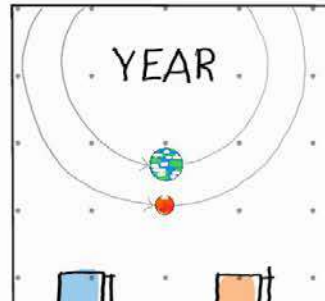
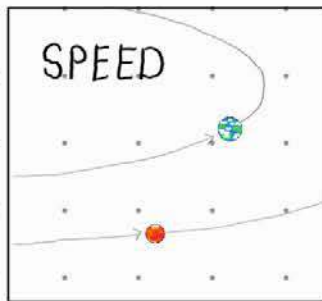
- CRUSHED BASALT FROM A QUARRY IN THE MOJAVE DESERT.

- PROS:**
- CLOSEST TEST THAT SIMULATES CONDITIONS ON MARS.
  - TESTS BUILDABILITY.
  - TESTS THERMAL PERFORMANCE.
  - TEST STRUCTURAL INTEGRITY.
  - TEST DIFFERENT BINDERS.

- CONS:**
- EXPENSIVE (€20 p/kg + €37 POSTAGE)
  - ↳ CAN ONLY CONSTRUCT SMALL SCALE PROTOTYPES.

Unlike the moon, no surface samples from Mars have been returned to Earth. But orbiters have recorded surface compositions across the entire planet, and robotic explorers have carried out deeper investigations at various sites. A major ingredient of much of the Martian surface is basalt, an iron-rich rock typically associated with volcanoes on Earth. So that's where NASA researchers go to look for appropriate Mars simulants. - NASA







# HALLEY VI



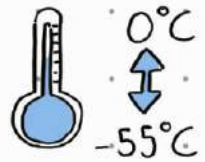
SNOW



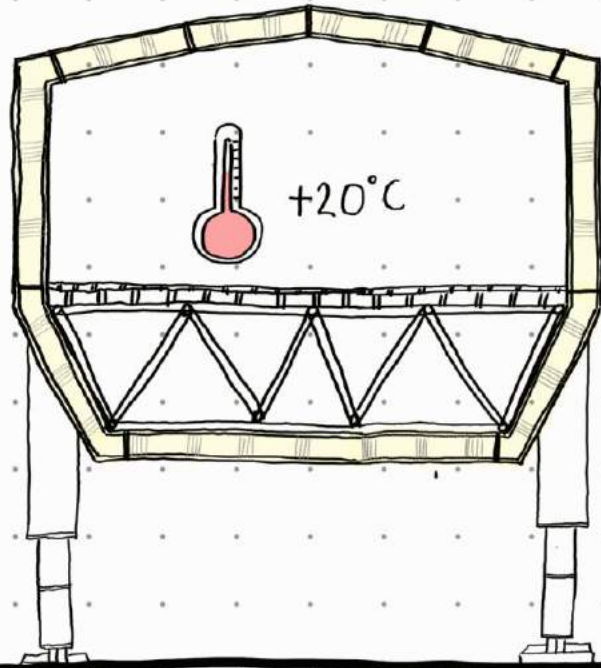
STRONG WIND



FREEZING TEMPERATURES



0°C  
-55°C



+20°C

DRY AIR

BRUNT ICE SHELF, ANTARCTICA  
 WEATHER DATA 27/02/2021 14:59 UTC:  
 TEMPERATURE: -7.0°C HUMIDITY: 95%  
 PRESSURE: 981.24 Pa  
 WIND SPEED: 7 kts  
 WIND DIRECTION: 107°  
 MAX GUST: 8.4 kts  
 IN LAST 10 MINS.

# MARTIAN HOUSE

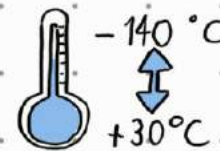


FLUCTUATING FREEZING TEMPERATURES

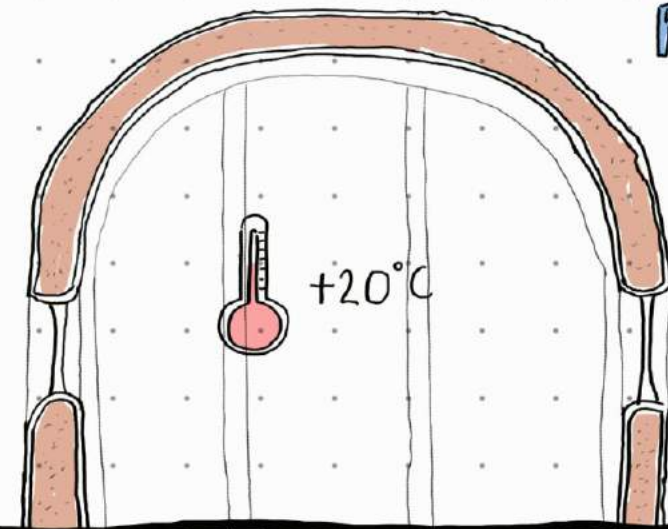


DUST STORMS

LOW PRESSURE



-140°C  
+30°C



+20°C

CURIOSITY ROVER:  
 WEATHER DATA 24/02/2021:  
 (SOL 3041)  
 TEMPERATURE: -13 - -73°C  
 PRESSURE: 828 Pa




# TYPICAL HOUSE




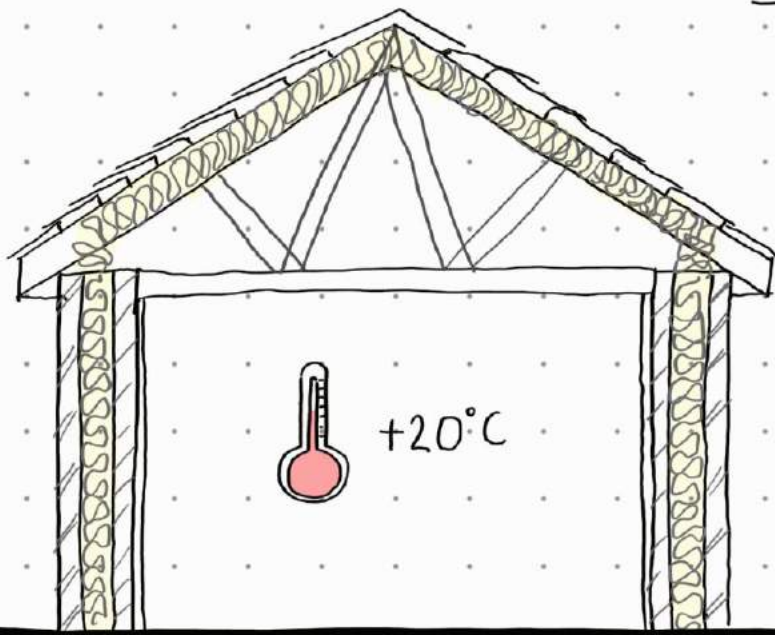
RAIN



COLD  HEAT  
FREEZE  $\leftrightarrow$  THAW

 WIND

 +20°C  
 $\updownarrow$   
+2°C



 +20°C

DUBLIN

WEATHER DATA 27/02/2021 15:00 GMT:

TEMPERATURE: 11.0°C HUMIDITY: 64%

PRESSURE: 1041 hPa

WIND SPEED: 3 kts

WIND DIRECTION: SW

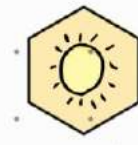
MAX GUST: -

(IN LAST 10 MINS)

# OSOYOOS DESERT CENTRE, CANADA




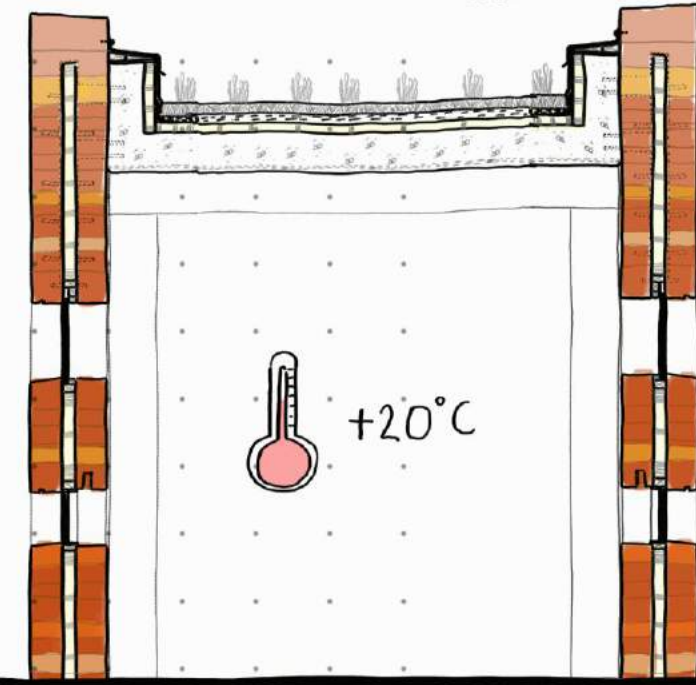
COLD WINTER  
TEMPERATURES




HOT SUMMER  
TEMPERATURES

 STRONG WIND

 +30°C  
 $\updownarrow$   
+1°C



 +20°C

OSOYOOS

WEATHER DATA 19/03/2021 10:00 GMT:

TEMPERATURE: 7.0°C HUMIDITY: 88%

PRESSURE: 101.2 kPa

WIND SPEED: 4 kph

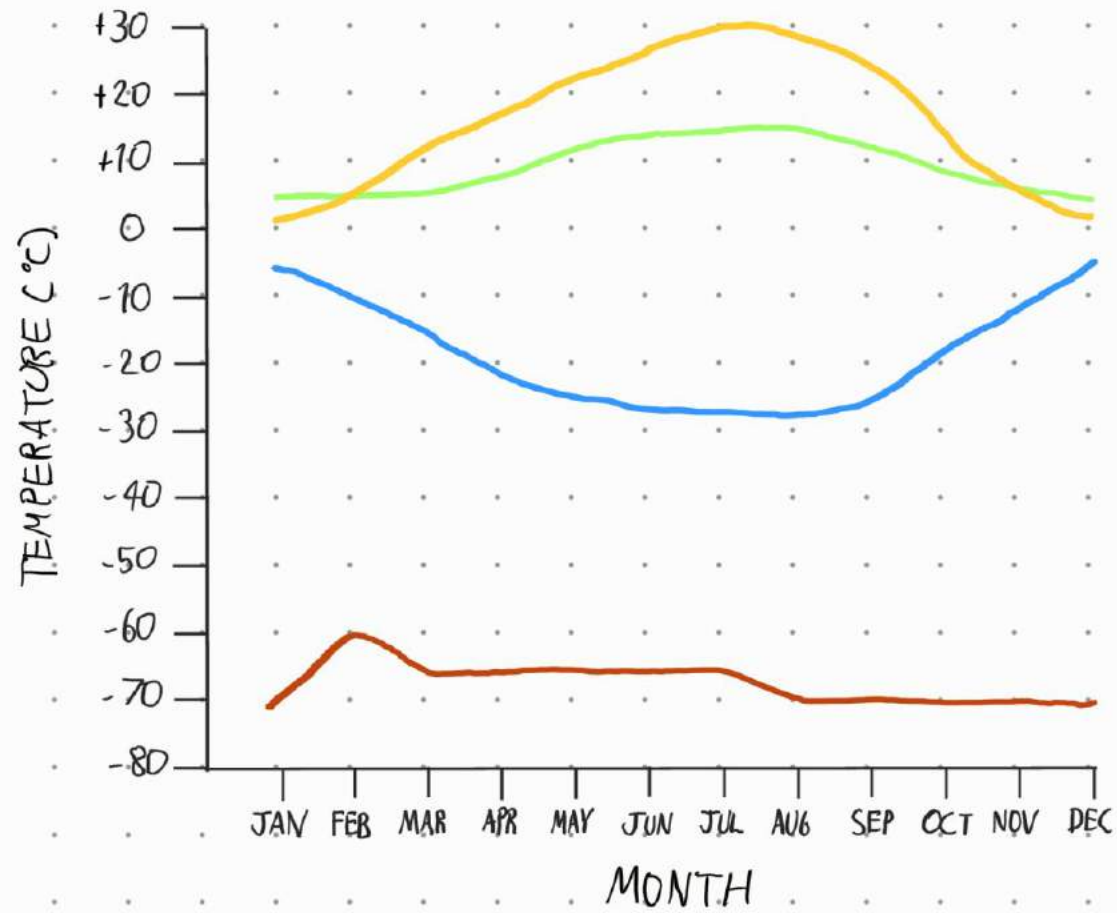
WIND DIRECTION: NW

MAX GUST: -

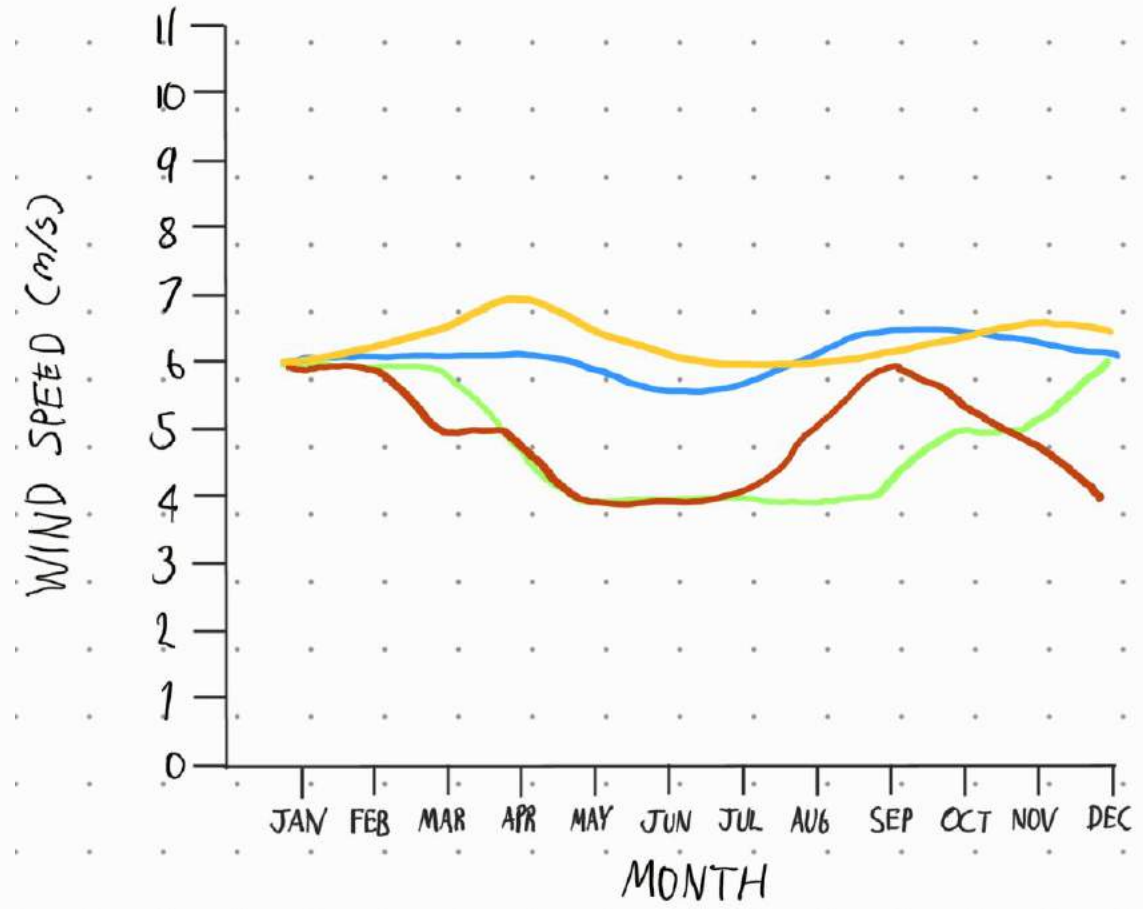
(IN LAST 10 MINS)



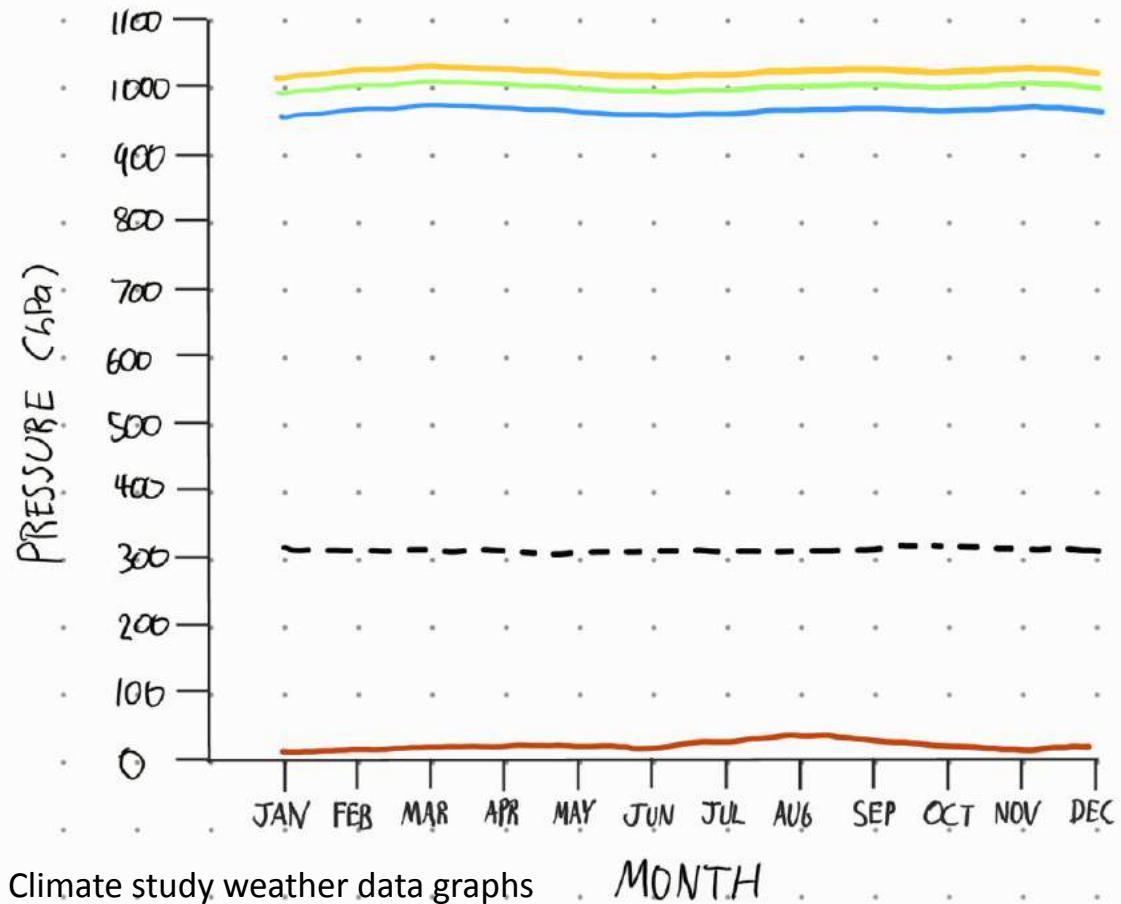
ANNUAL AVERAGE TEMPERATURE (2020)



ANNUAL AVERAGE WIND SPEED (2020)

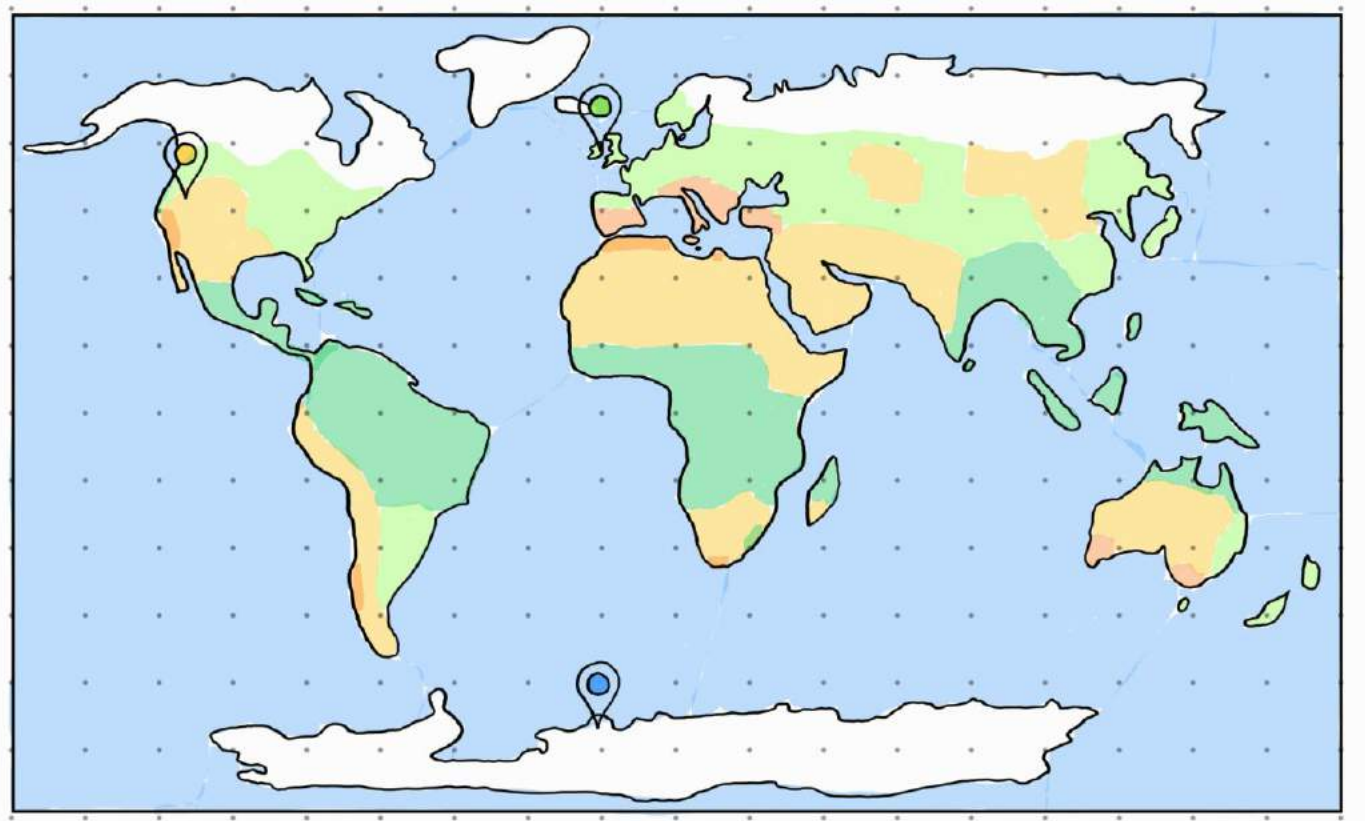
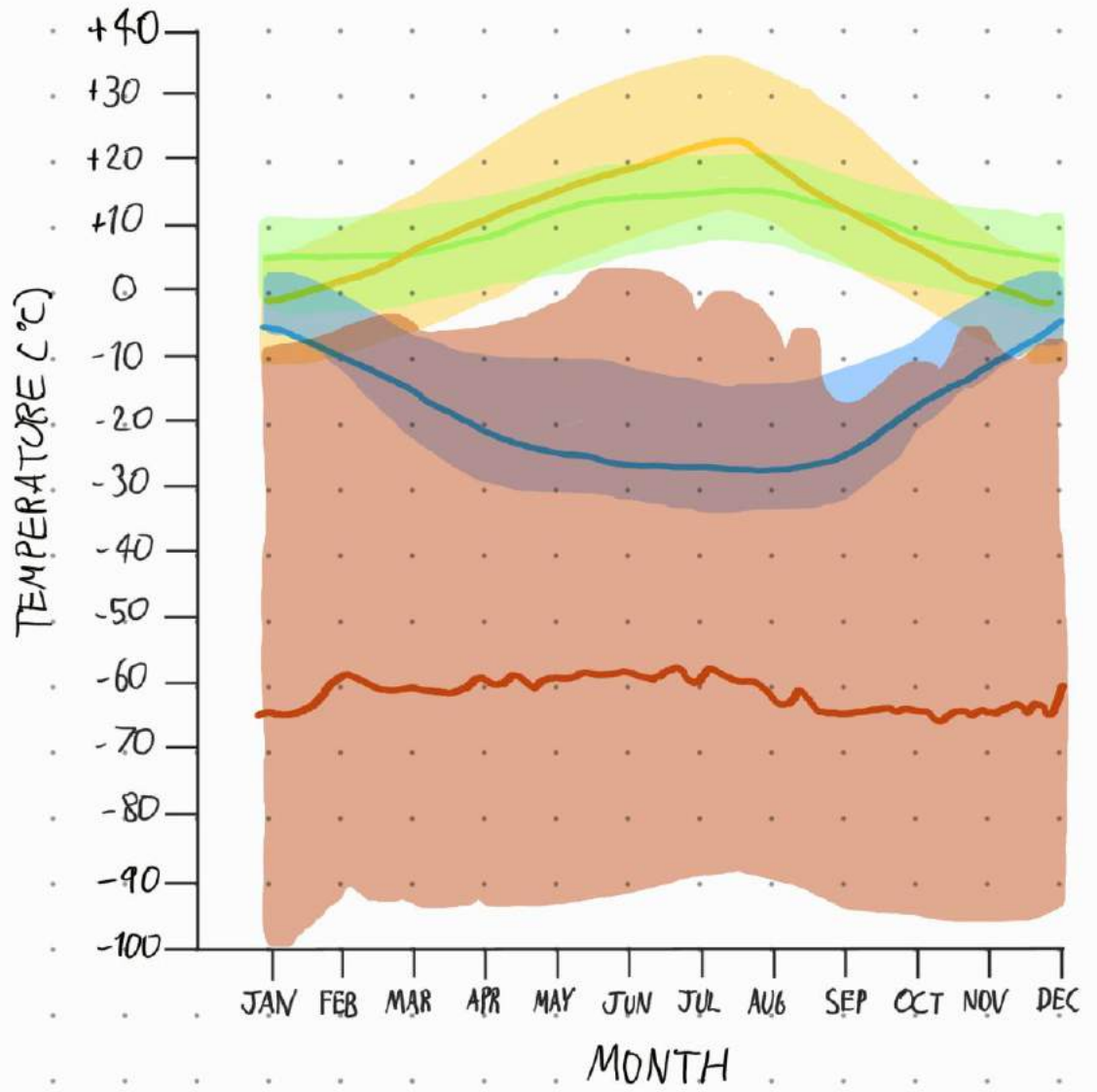


ANNUAL AVERAGE PRESSURE (2020)



- OSOYDOS DESERT
- DUBLIN
- ANTARCTICA
- MARS
- - - MOUNT EVEREST

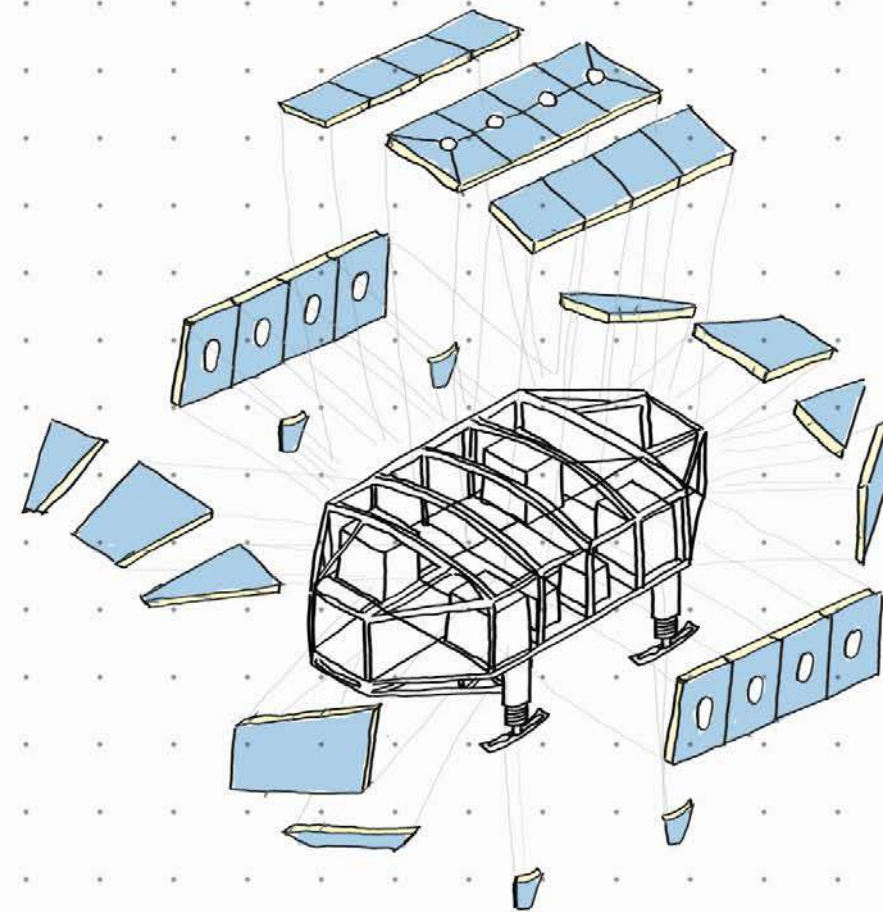
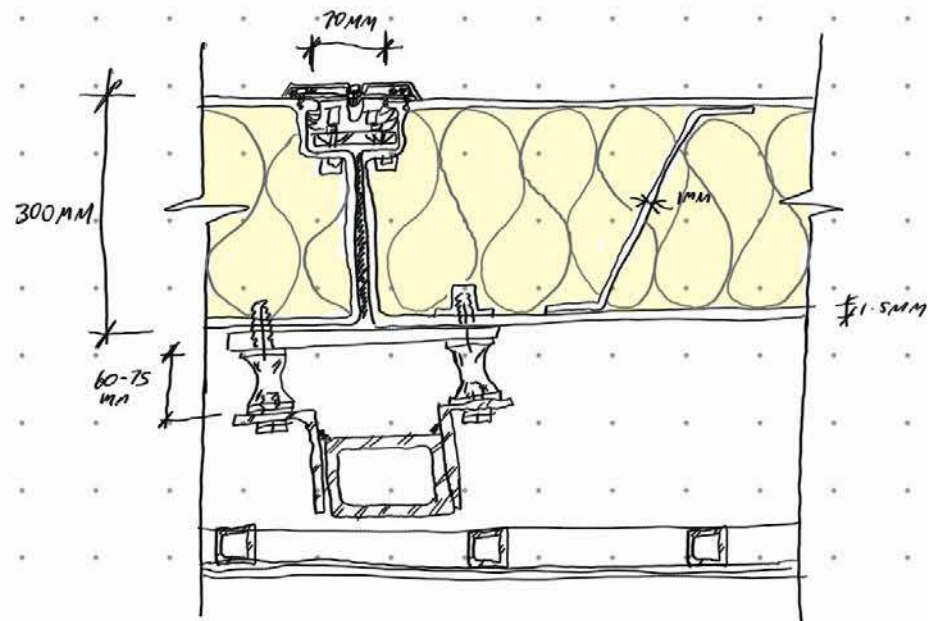
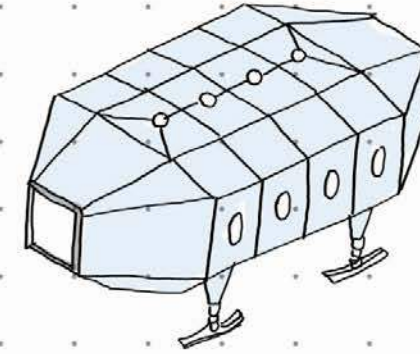
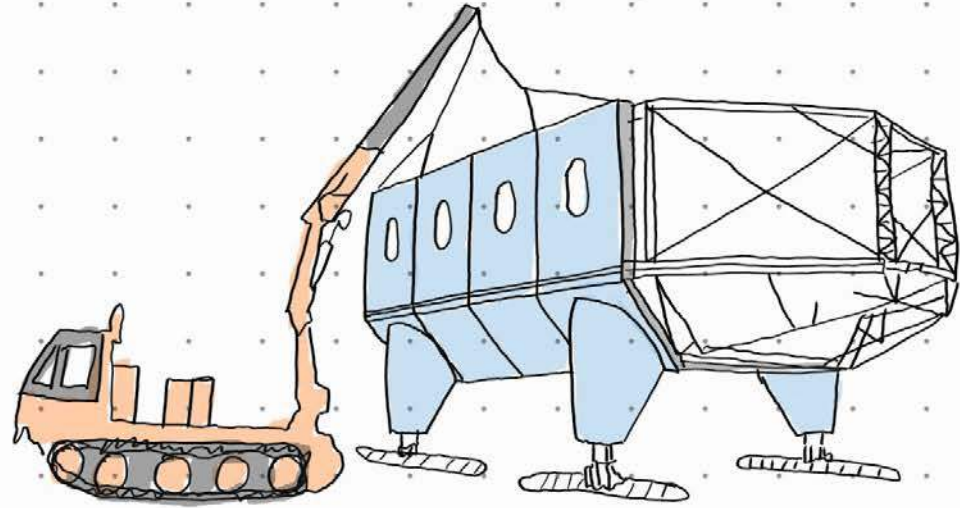
AVERAGE ANNUAL TEMPERATURE

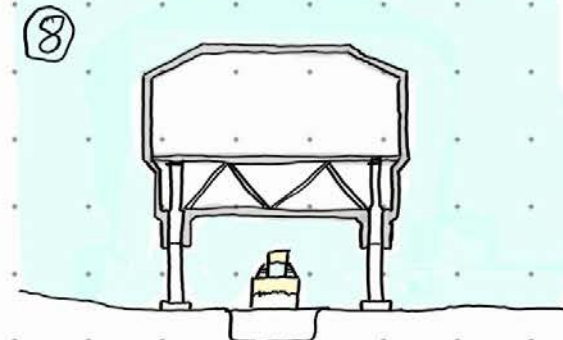
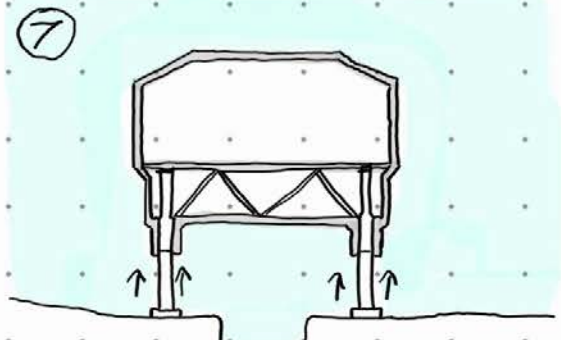
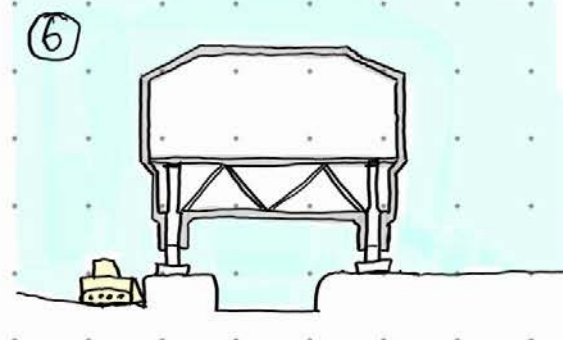
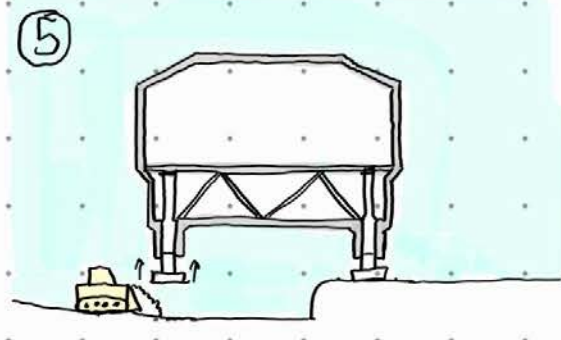
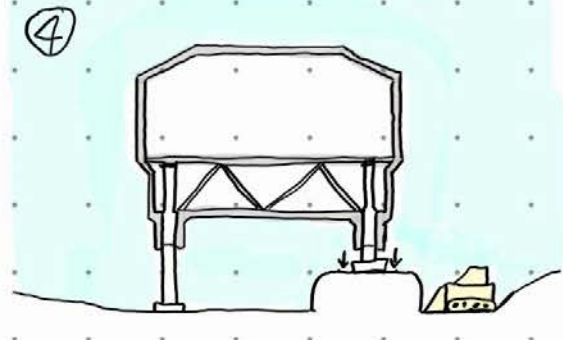
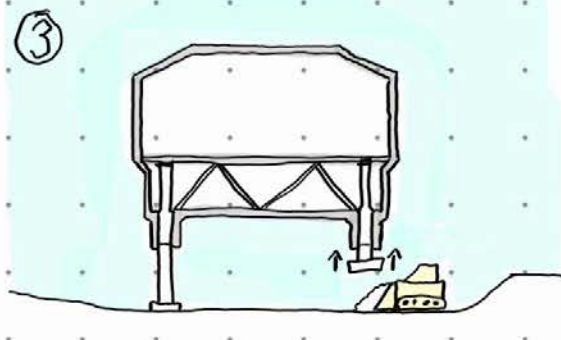
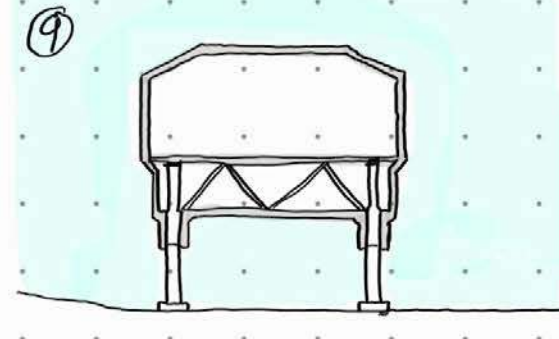
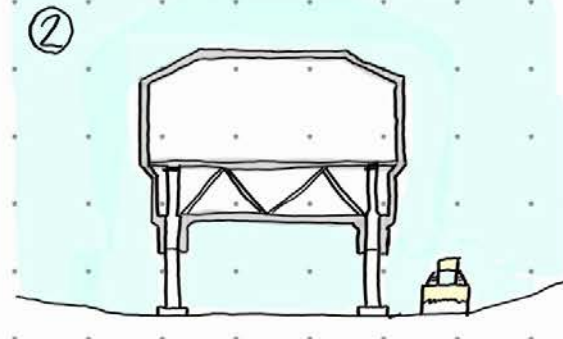
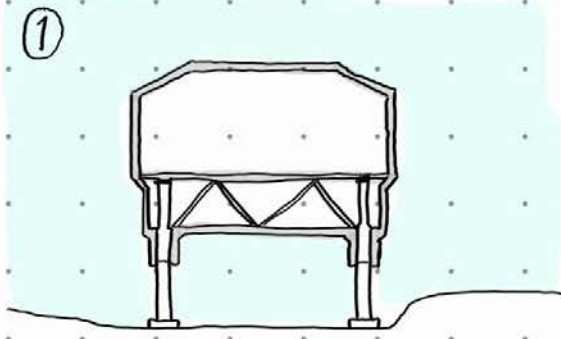


- POLAR
- TROPICAL
- TEMPERATE
- MEDITERRANEAN
- ARID
- HALLEY VI, ANTARCTICA
- OSOYDOS DESERT, CANADA
- DUBLIN

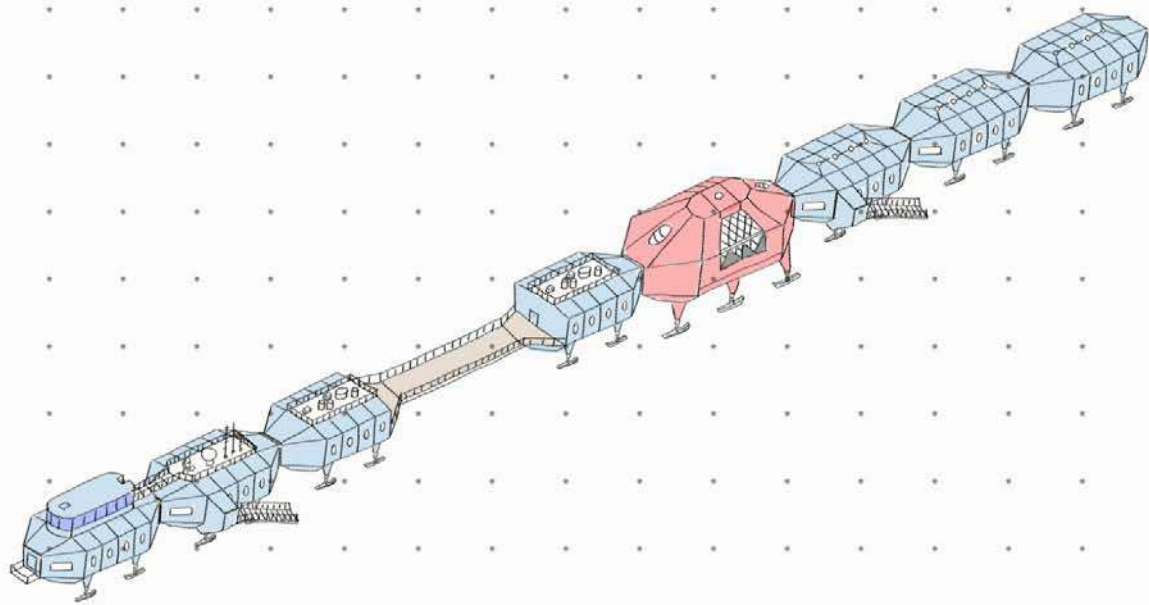


# HALLEY VI

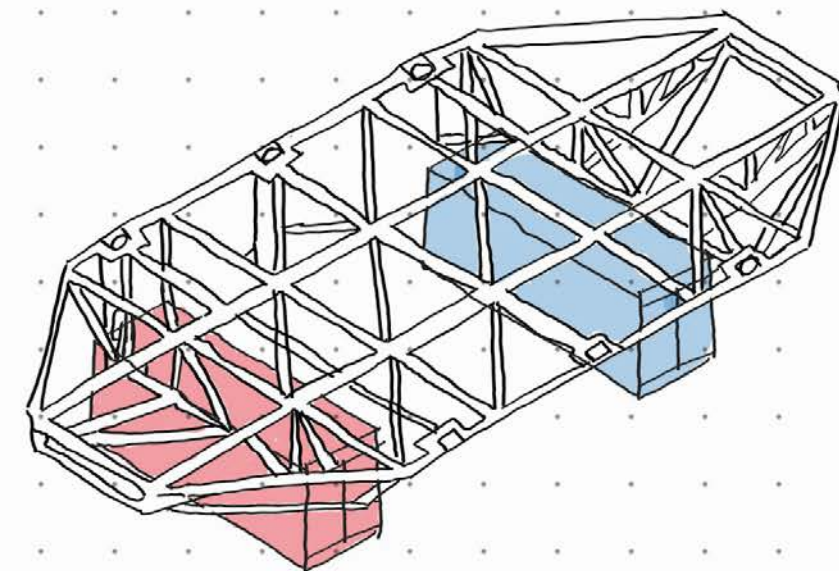
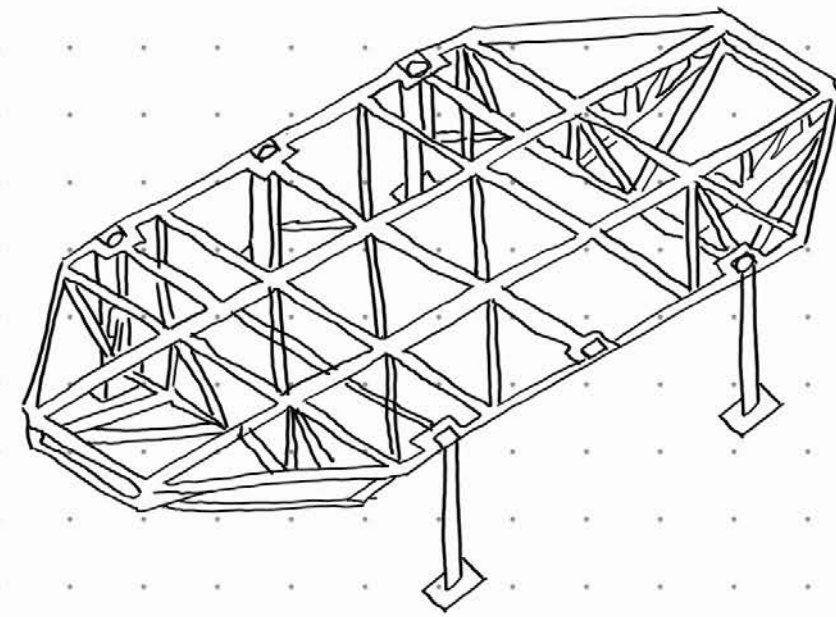




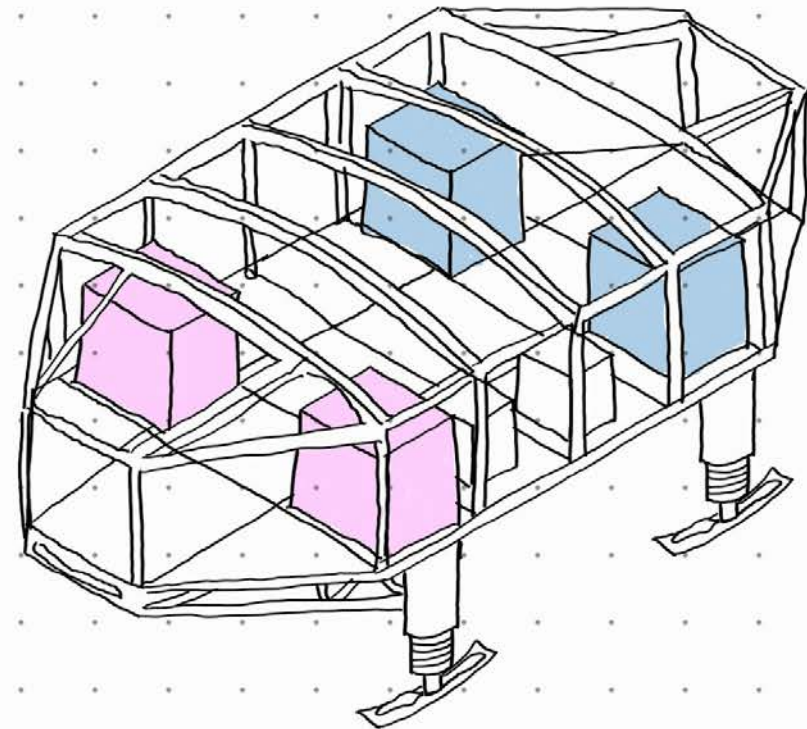
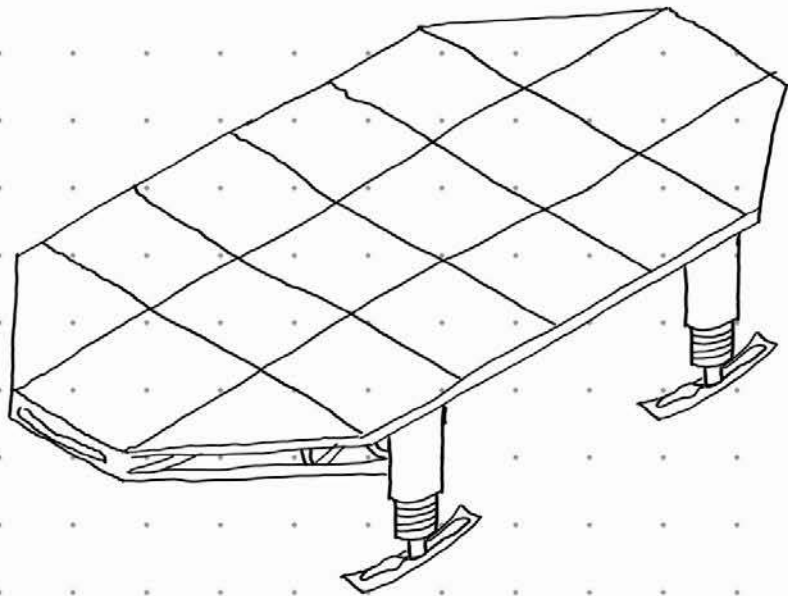
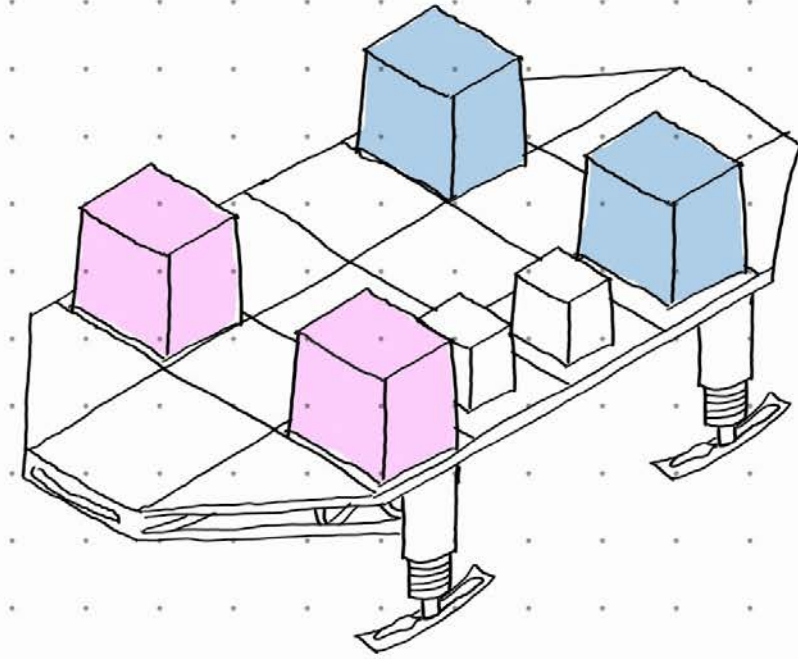
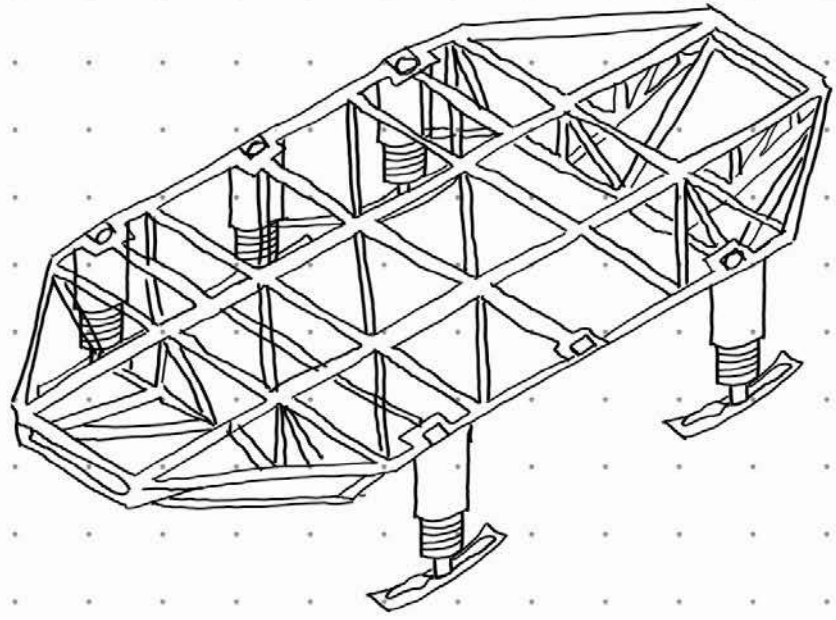




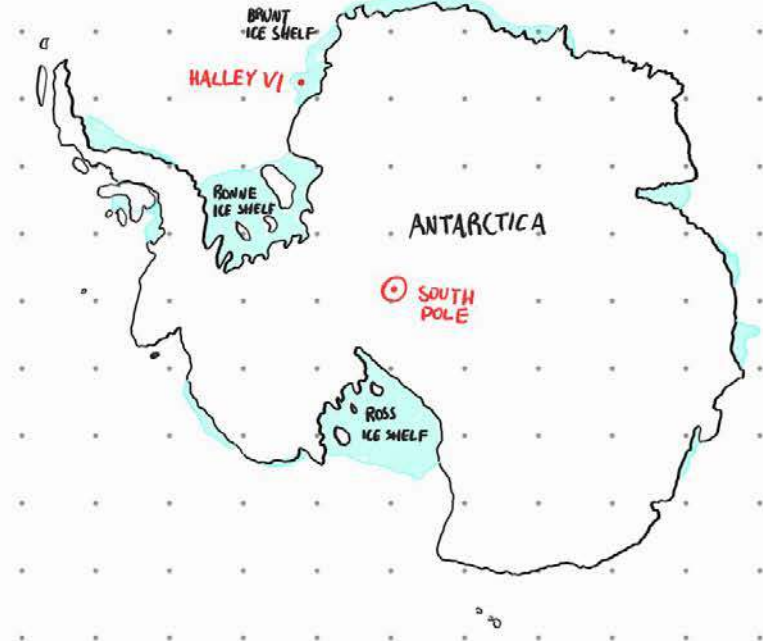
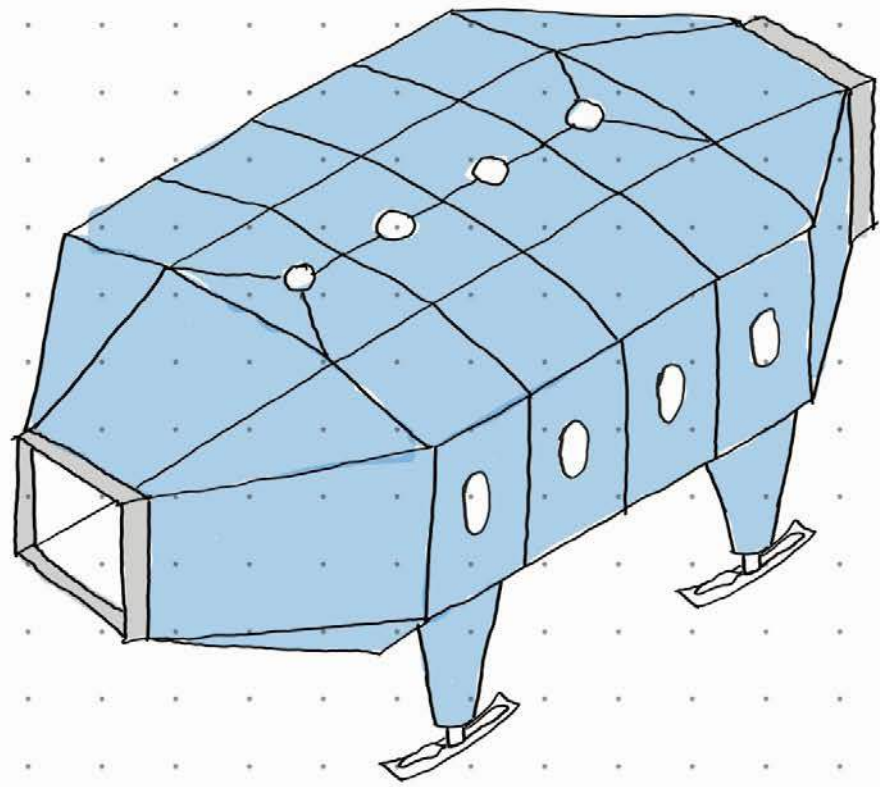
Halley VI connected modules 3D sketch

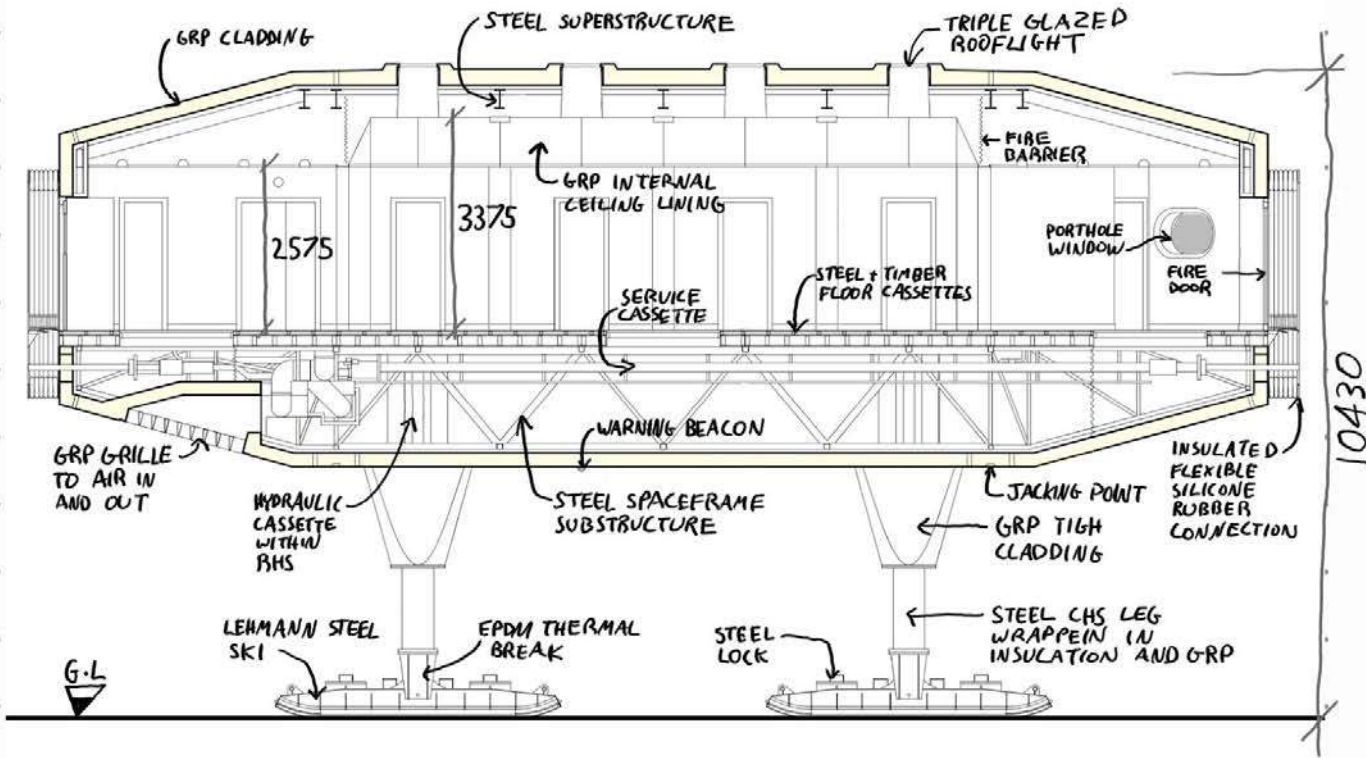
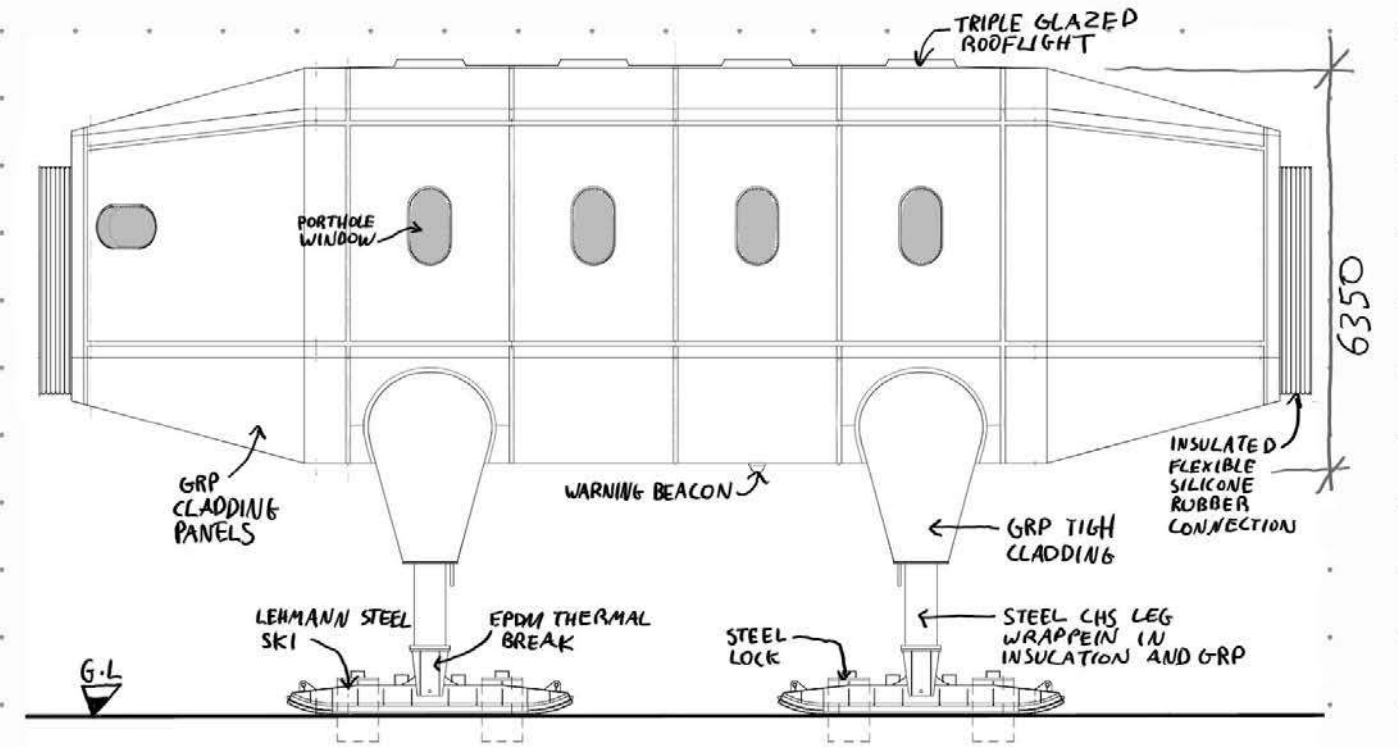
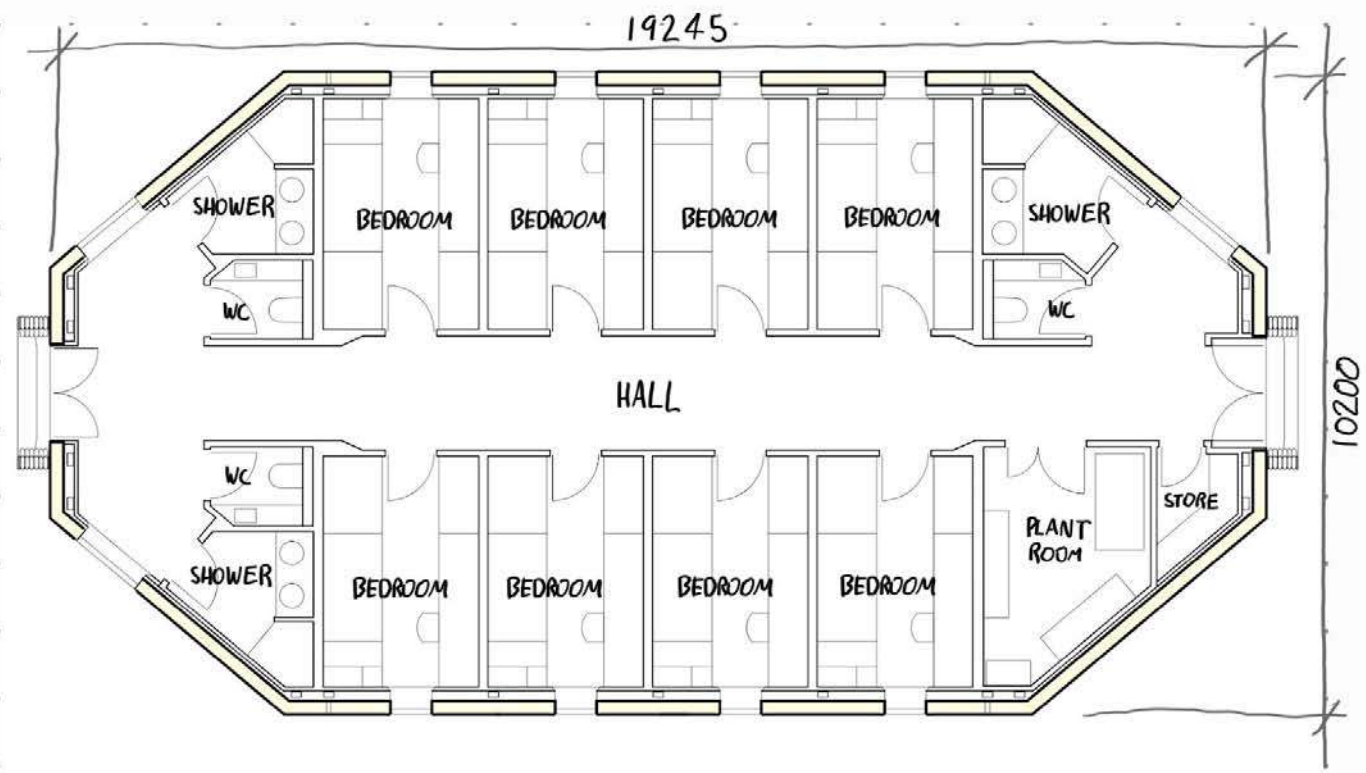


Halley VI construction sequence





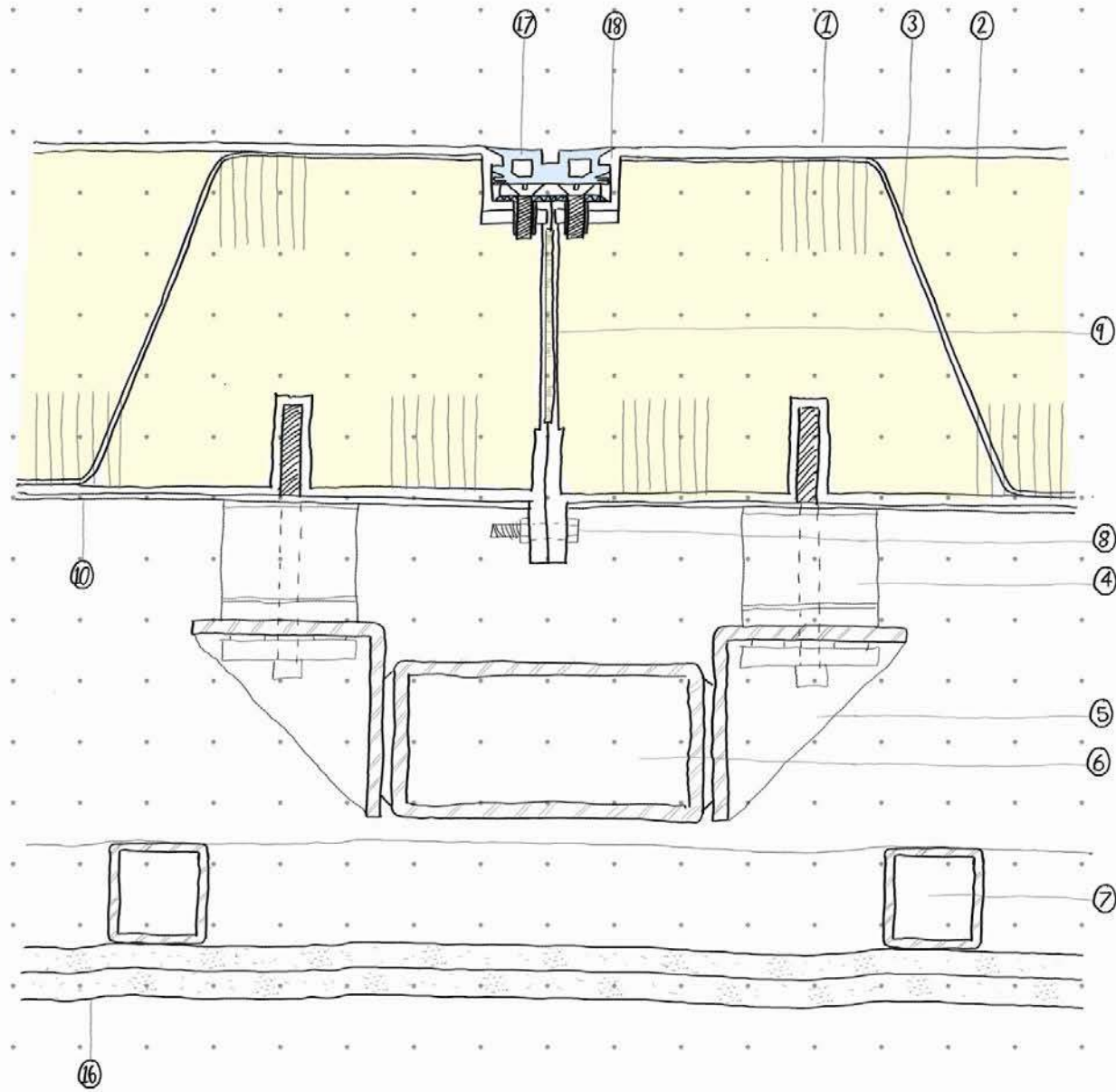




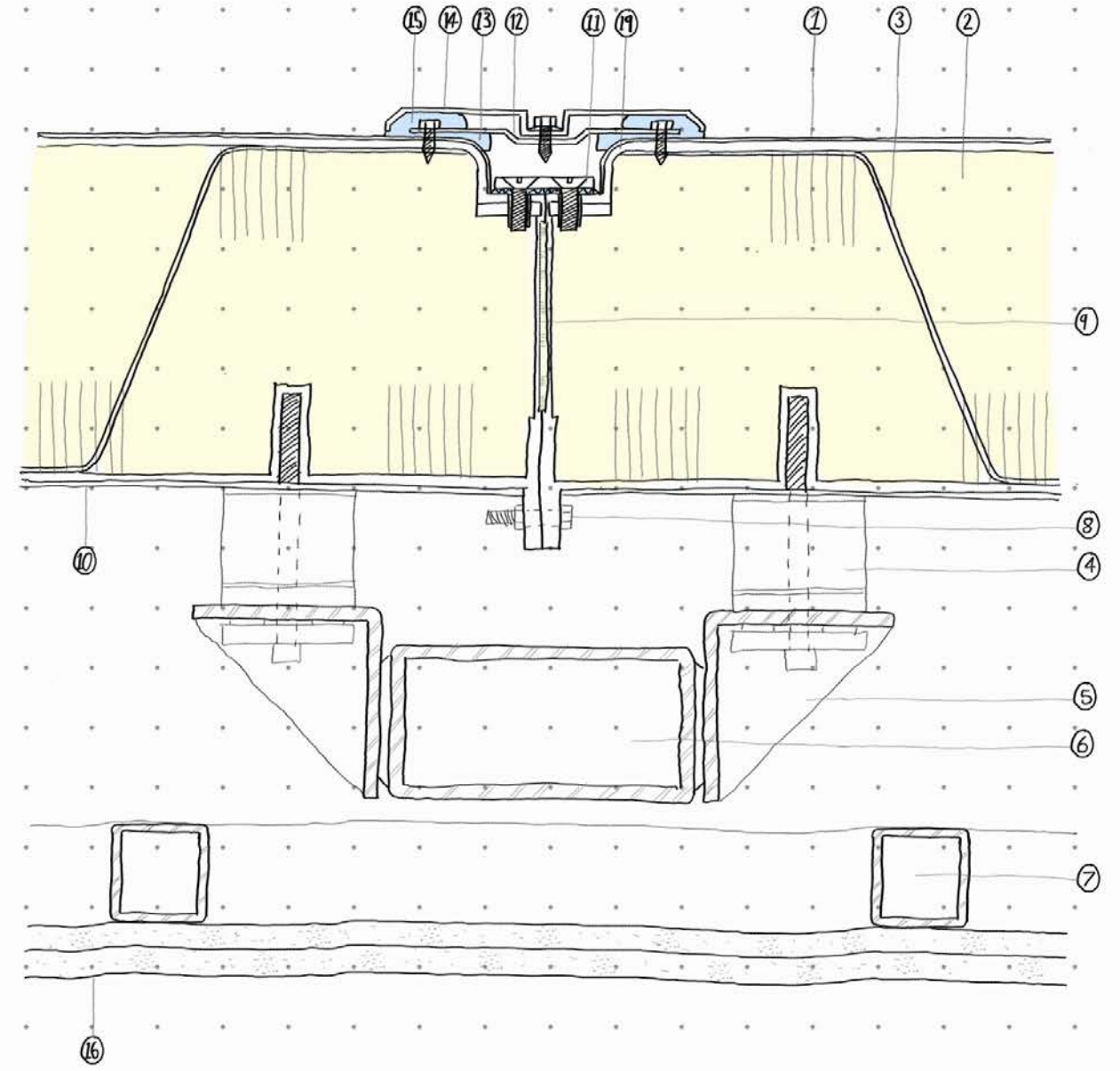
Halley VI bedroom module plan & section

Halley VI bedroom module elevation

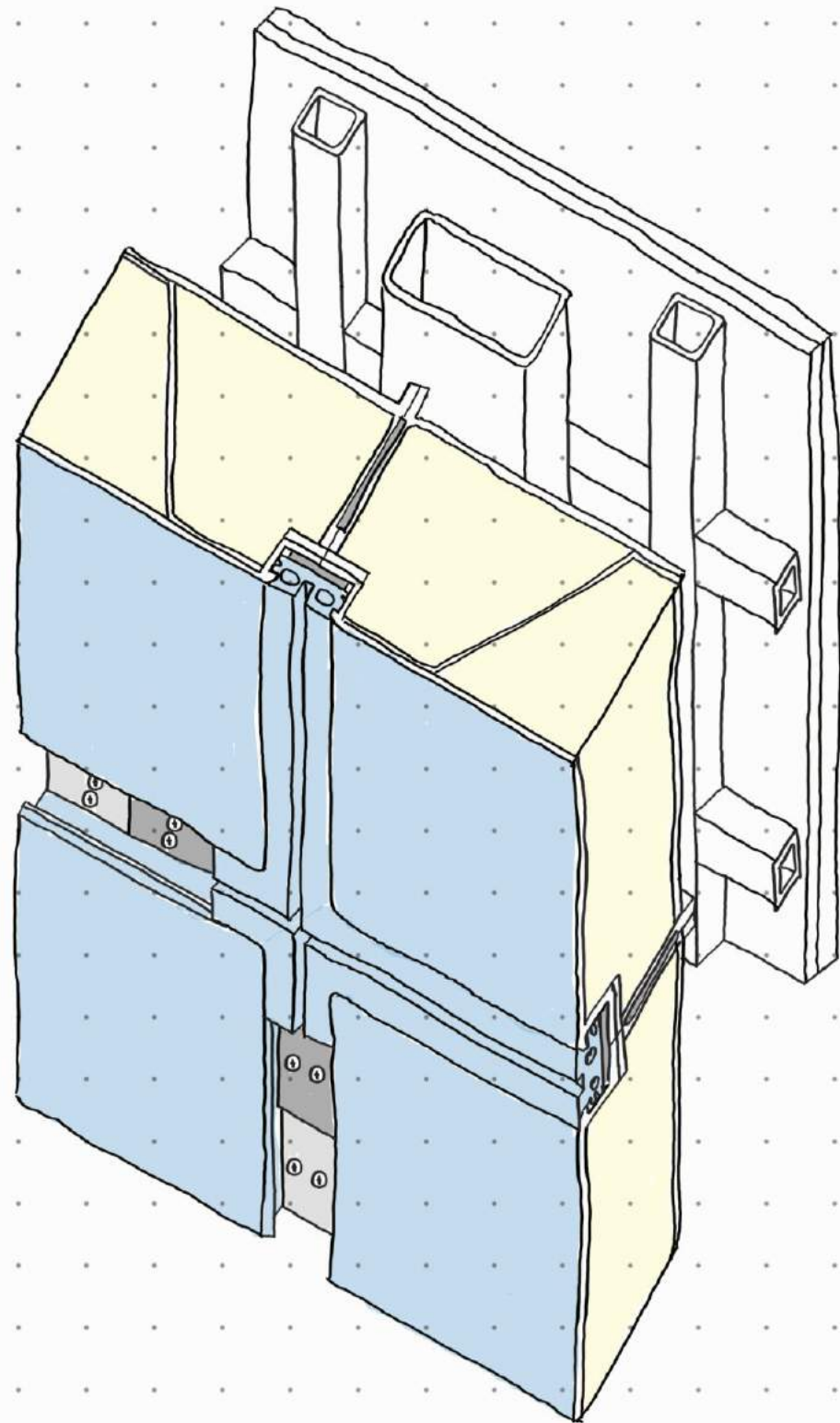




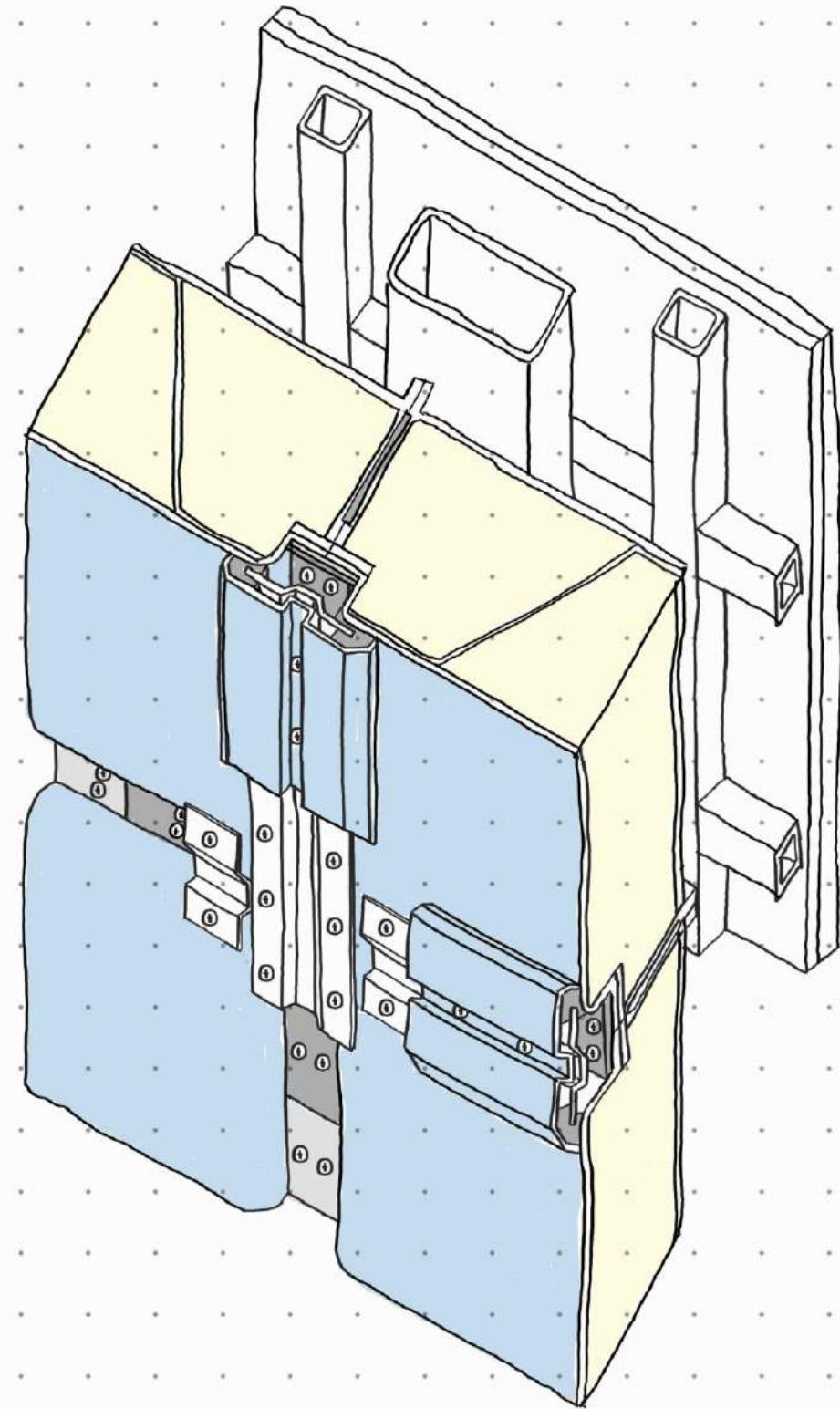
Halley VI defective panel joint detail



Halley VI amended panel joint detail



Halley VI defective panel joint detail 3D cutaway



Halley VI amended panel joint detail 3D cutaway