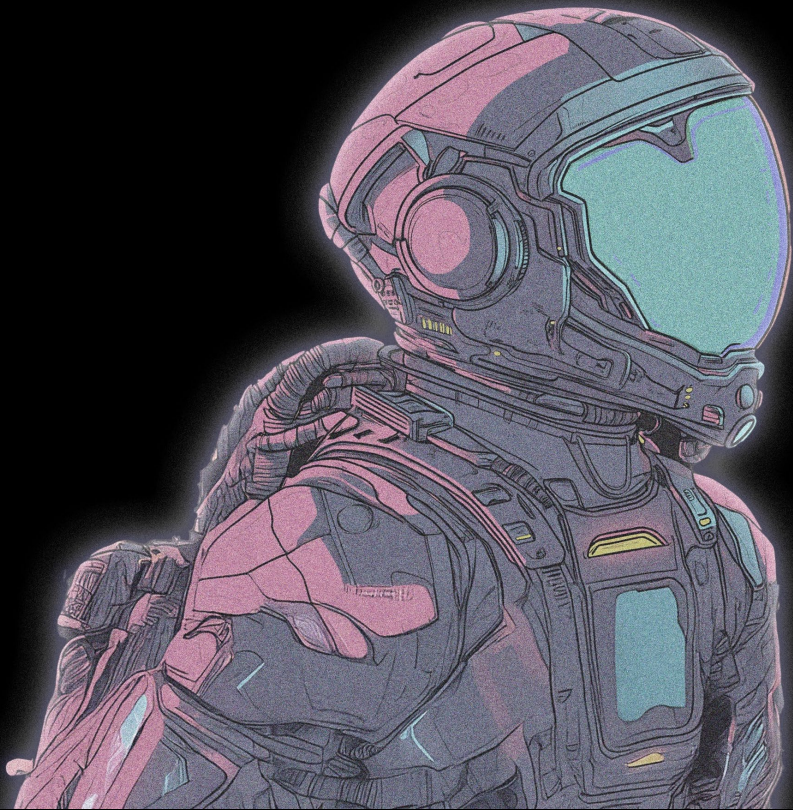


LUNAR PLAYSCAPE: CLIMBING CITY



living on the moon?

TO WORK?

TO PLAY?

TO COMMUNE?

LUNAR ARCHITECTURE & INFRASTRUCTURE

JONATHAN JONATHAN | P1 PRESENTATION

GRADUATION PROJECT 2024-2025 TU DELFT BK

TUTORS: HENRIETTE BIER, ARWIN HIDDING

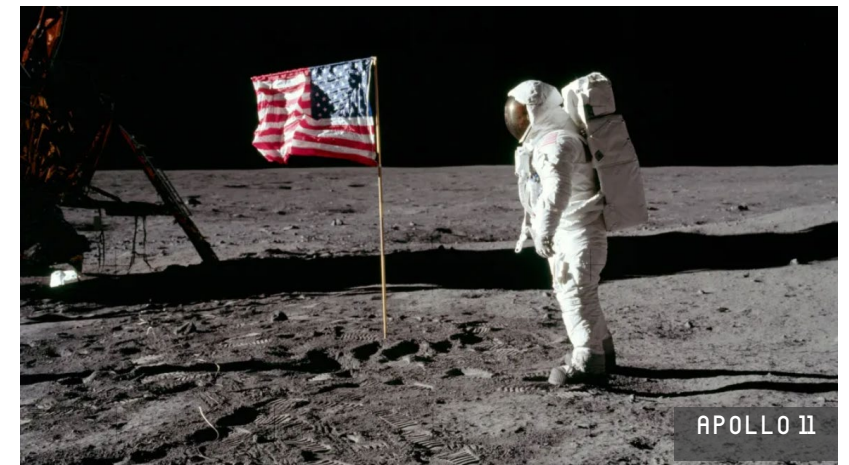
moon exploration
IN THE PAST



11

PERFORMED LUNAR LANDING AND RETURN TO EARTH

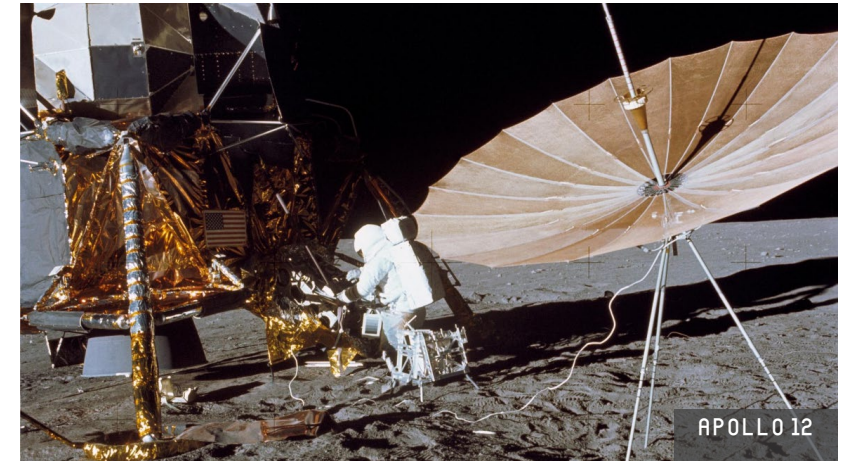
(NATIONAL GOAL BY PRESIDENT KENNEDY),
DEPLOYMENT OF A TELEVISION CAMERA TO TRANSMIT SIGNALS TO EARTH,
DEPLOYMENT OF A SOLAR WIND, SEISMIC EXPERIMENT PACKAGE AND A LASER RANGING RETROREFLECTOR,
GATHER SAMPLES OF LUNAR-SURFACE MATERIALS, PHOTOGRAPH THE LUNAR TERRAIN, DEPLOYED SCIENTIFIC
EQUIPMENT, LUNAR MODULE SPACECRAFT



12

**LUNAR EXPLORATION TASKS BY THE LUNAR MODULE,
DEPLOYMENT OF THE APOLLO LUNAR SURFACE EXPERIMENTS PACKAGE,**

SELENOLOGICAL INSPECTION,
SURVEYS AND SAMPLINGS IN LANDING AREAS,
DEVELOPMENT FOR PRECISION-LANDING CAPABILITIES,
FURTHER EVALUATIONS OF WORKING FOR LONG PERIOD, DEPLOYMENT AND RETRIEVAL OF OTHER SCIENTIFIC
EXPERIMENTS, PHOTOGRAPHY OF CANDIDATE EXPLORATION SITES FOR FUTURE MISSIONS



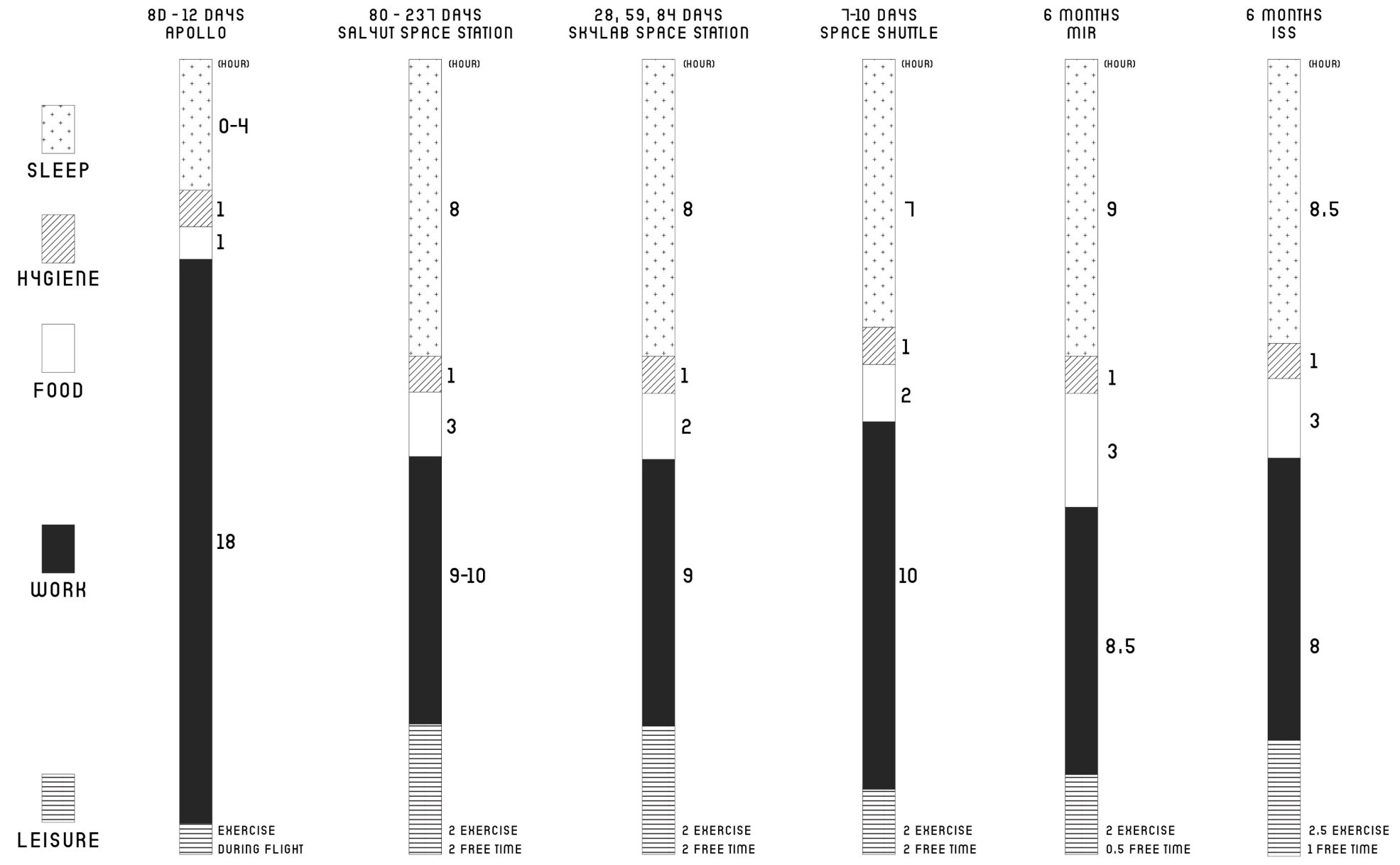
17

**GEOLOGICAL SURVEYING AND SAMPLING OF MATERIALS, DEPLOYING AND ACTIVATING
SURFACE EXPERIMENTS, CONDUCTING IN-FLIGHT EXPERIMENTS AND PHOTOGRAPHIC TASKS
DURING LUNAR ORBIT AND TRANS-EARTH COAST,**

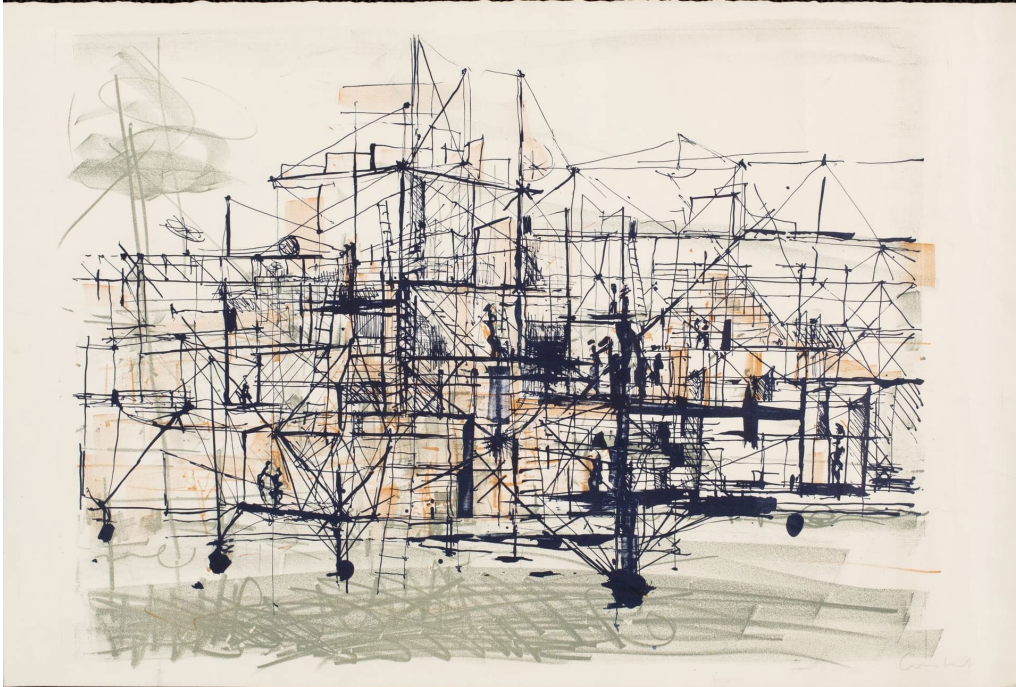
DEPLOYED EXPERIMENTS SUCH AS APOLLO LUNAR SURFACE EXPERIMENTS PACKAGE, WITH A HEAT FLOW
EXPERIMENT, LUNAR SEISMIC PROFILING, LUNAR SURFACE GRAVIMETER, LUNAR ATMOSPHERIC COMPOSITION
EXPERIMENT, LUNAR EJECTA AND METEORITES, LUNAR SAMPLING AND LUNAR ORBITAL EXPERIMENTS



RESEARCH BACKGROUND | ACTIVITIES DISTRIBUTION

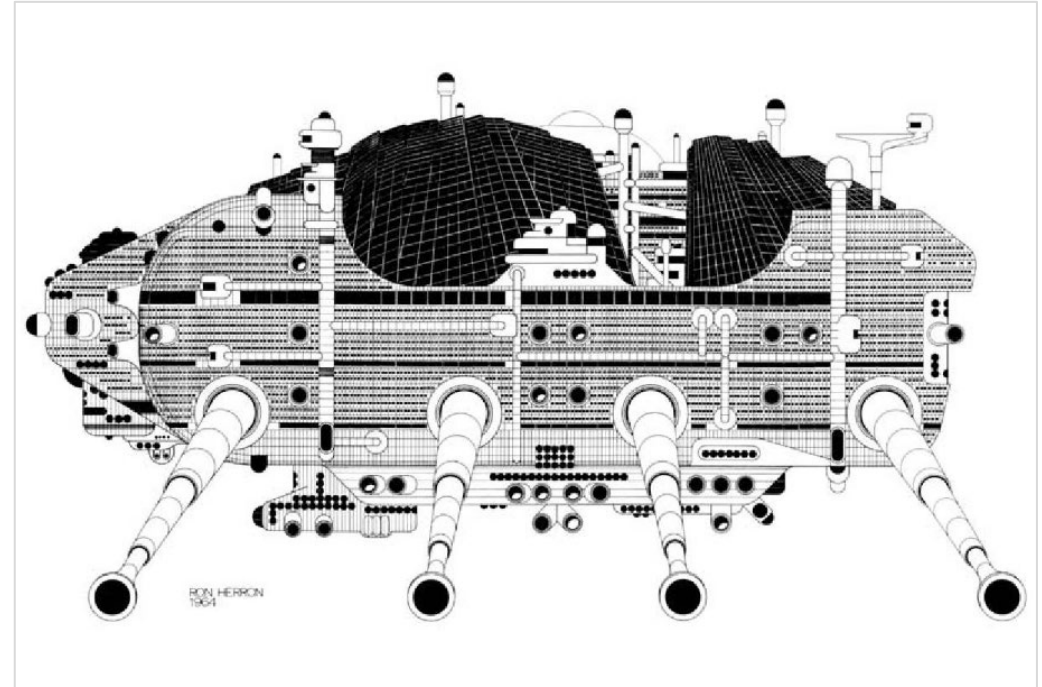


work lifestyle criticism



SOURCE: NIEUWE INSTITUUT

NEW BABYLON
BY CONSTANT



SOURCE: ARCHIGRAM (BOOK)

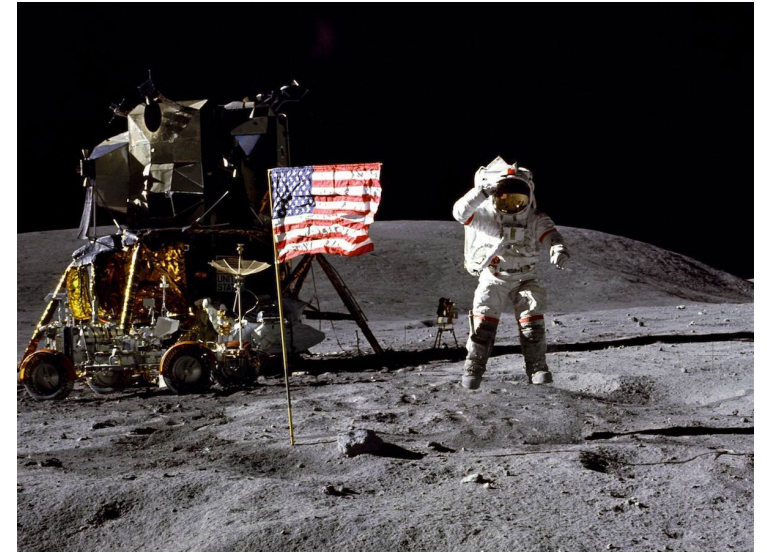
WALKING CITY
BY ARCHIGRAM



DAVID SCOTT (AP15)
HAMMER AND FEATHER



ALAN SHEPARD (AP14)
GOLF ON THE MOON



SOURCE: NASA.GOV

JOHN YOUNG (AP16)
MID-AIR SALUTE PHOTO

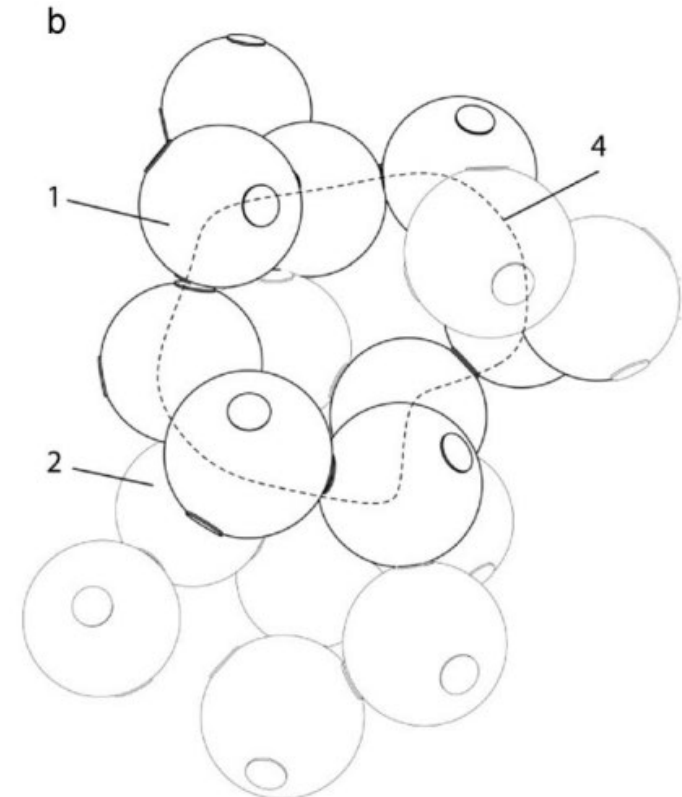
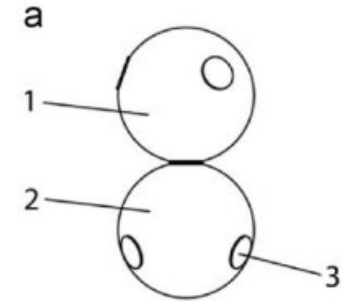
“TOWARDS THE END OF OUR STAY, **WE GOT EXCITED AND WE WERE GOING TO DO THE HIGH JUMP,**
AND I JUMPED AND FELL OVER BACKWARDS, THAT WAS A SCARY TIME,
BECAUSE IF THE BACKPACK GOT BROKEN, I WOULD HAVE HAD IT.”
-CHARLES DUKE, APOLLO 16”-

“SUBJECTED TO HIGH WORKLOADS UNDER A TIGHT SCHEDULE WITHIN A CONFINED ENVIRONMENT, ASTRONAUTS HAVE DRAWN ON **LEISURE ACTIVITIES IMPORTED MOSTLY FROM EARTH. POPULAR LEISURE ACTIVITIES DOCUMENTED TO-DATE HAVE CONCENTRATED ON PASSIVE PERUSAL OF MEDIA** LIKE RECORDS, AUDIO CASSETTES, NEWSPAPER, LETTERS, BOOKS, MAGAZINES, TELEVISION, AND MOVIES”



ARCHITECTURE FOR ASTRONAUTS P.281

GAME FOR SPACE
PROTOTYPE TESTED AT ISS



SOURCE: S. HAUPLIK-MEUSBURGER, ET AL., A GAME FOR SPACE, ACTA ASTRONAUTICA (2009), DOI: " 10.1016/J.ACTAASTRO.2009.07.017

-PROPOSAL-

lunar playscape



lunar playscape

REQUIREMENTS



1. physical

NEW WAY OF EXERCISE

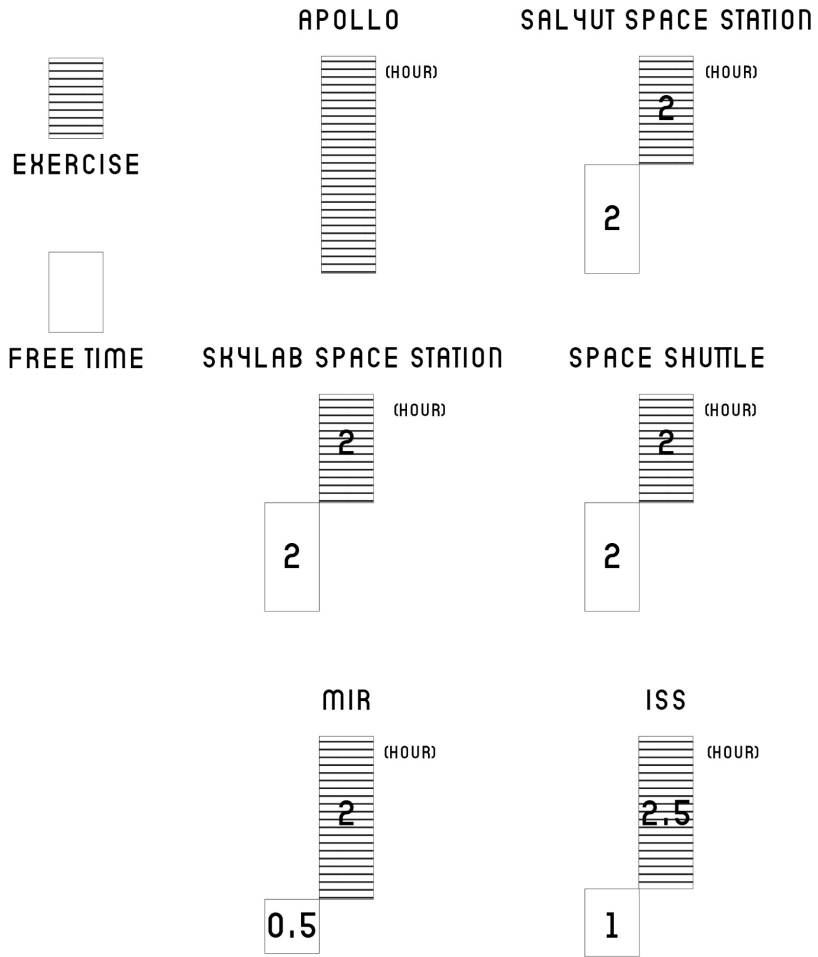
LONG-TERM HABITATION
IN
LOW LUNAR GRAVITY

↓
AFFECTS

BODY STRUCTURE
MUSCLE & BONE DENSITY



TREADMILLING IN THE MIR SPACE STATION
(SAMANTHA CRISTOFORETTI, ESA)



SOURCE: ARCHITECTURE FOR ASTRONAUTS (BOOK)

work out distribution

AVE. 2-HR DAILY WORK OUT

HAVING BREAKFAST

GOING TO MEETING

GOING TO GROUND SURFACE

SITTING IN LUNCH LECTURE

HAVING SOCIAL EVENING

GOING TO GYM

HEADING HOME

RESEARCH QUESTION | PHYSICAL REQUIREMENT

“...I DO GET A **SENSE OF SATISFACTION FROM WORKING OUT** THAT POSITIVELY LIFTS MY ATTITUDE. SO, FOR ME, EXERCISE IS NOT ONLY A CRITICAL PHYSICAL COMPONENT TO LIFE UP HERE, IT HAS **AN IMPORTANT PSYCHOLOGICAL COMPONENT** TOO.”

-PEGGY WHITSON, ISS-

“I COULD REALLY RUN (IN PLACE) AT DIFFERENT SPEEDS AND FOR **LONG DURATIONS**, AND THAT’S THE WAY I DID ALL MY EXERCISE.”

-GENE CERNAN, APOLLO 17-

“I HATE OUR EXERCISES ... **BORING AND MONOTONOUS, AND HEAVY WORK ...**”

-B.J. BLUTH (SALYUT-

“SOMETIMES IT IS VERY HARD TO FORCE YOURSELF TO DO. WE LIKE THE TREADMILL THE MOST, BECAUSE **WE CAN DO SUCH A VARIETY OF EXERCISES ON IT**. IN FACT, WE’VE EVEN **MADE UP SOME NEW EXERCISES OF OUR OWN.**”

-LEBEDEV, SALYUT-

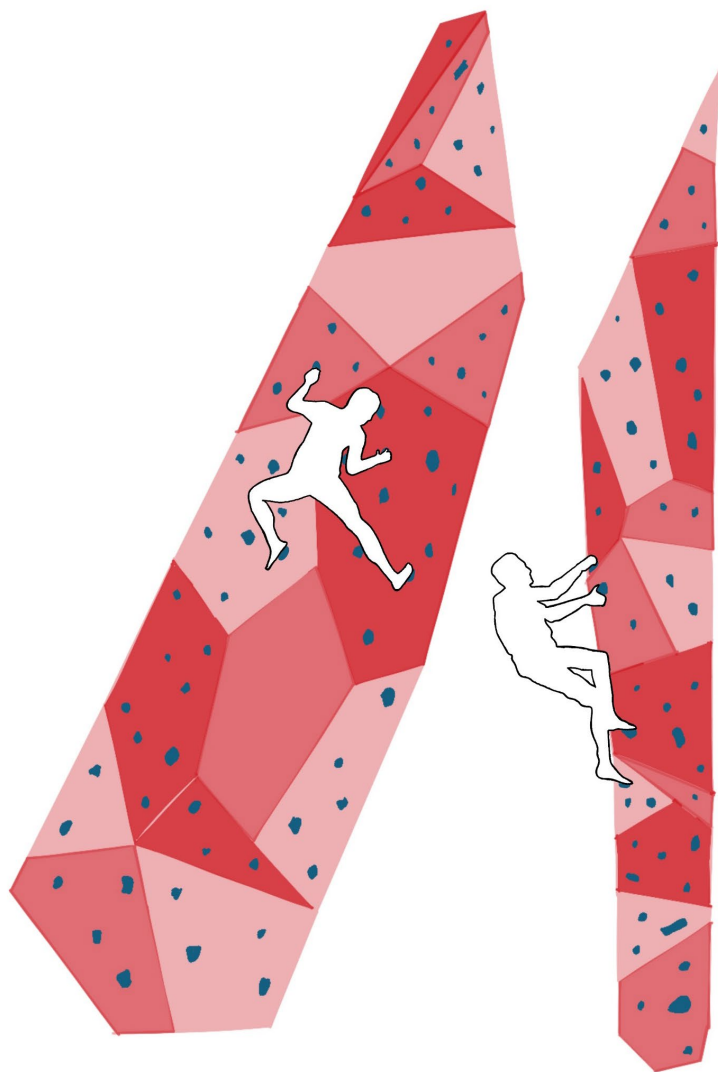
ARCHITECTURE FOR ASTRONAUTS (BOOK)



WINDOW AND CAMERA ARE ENTERTAINING ITEMS
(J. WILLIAMS, ASTRONAUT)

incorporating muscle work & architecture

PHYSICAL & SOCIAL WELL-BEING



climbing as an act of new normal

TO MOVE BY CLIMBING -> IMMERSIVE DIFFUSION INTO LUNAR CONDITIONS

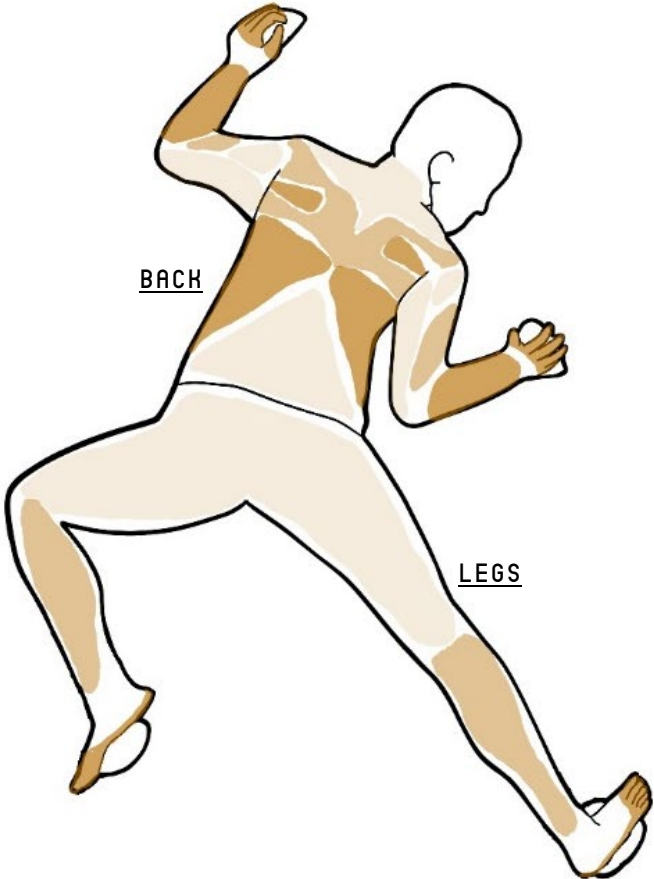
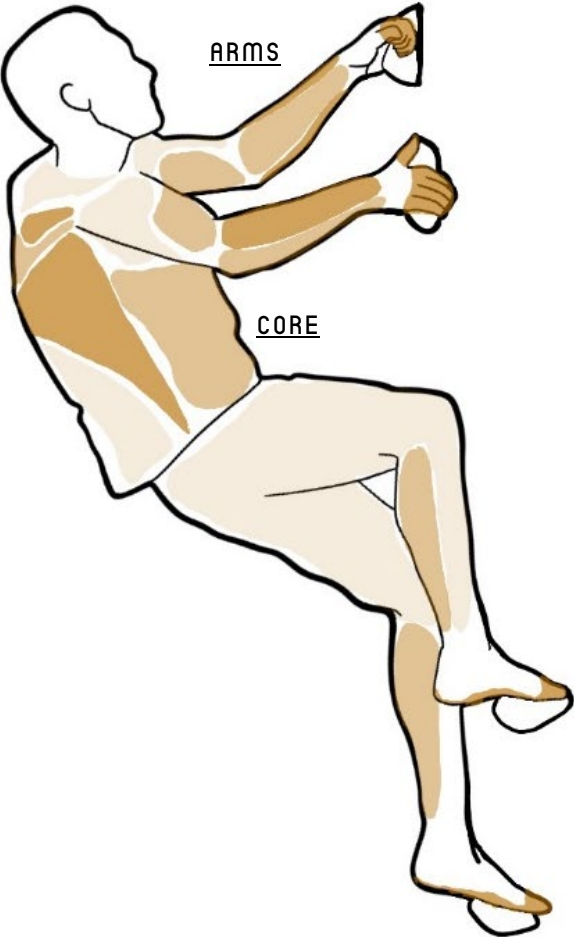
1/6 WEIGHT OF EARTH ->
LIGHTER BODY WEIGHT, HIGHER IMPACT-LESS FALL

FULL BODY MUSCLE USE

RICH ACTIVITY
DEVELOPMENT OPTIONS

TRIGGER OF ANOTHER
BODY MOVEMENTS
(GRIPPING, JUMPING, FALLING)

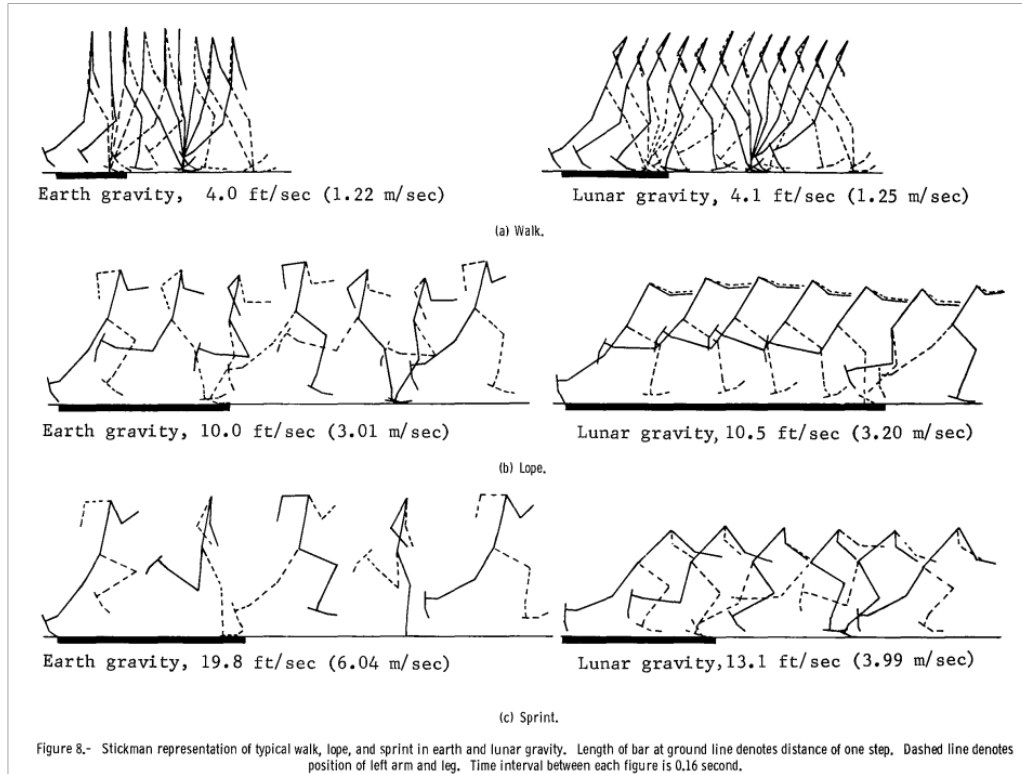
muscle activation



- 90-100% STRESSED
- 50-90% STRESSED
- LESS THAN 50% STRESSED

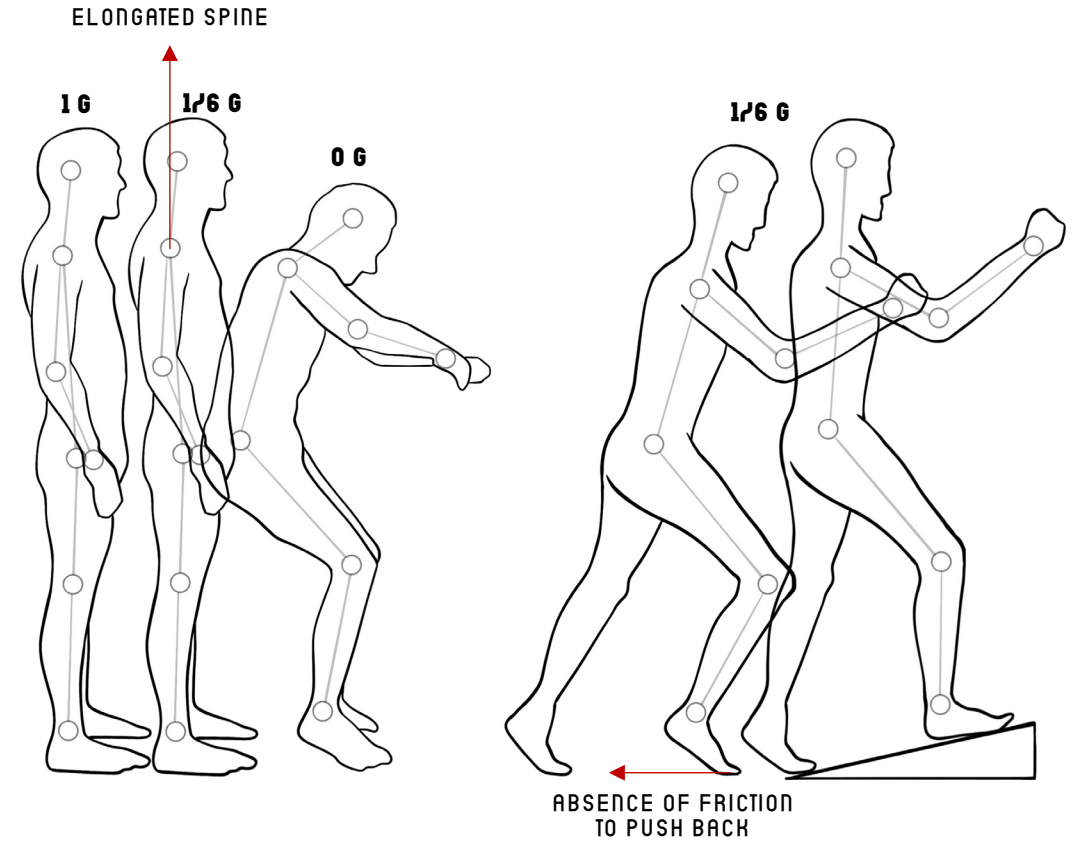
SOURCE: THE WANDERING CLIMBER

body movement against gravity



SOURCE: NASA

COMPARATIVE MEASUREMENTS OF WALKING AND RUNNING GAITS (1966)



NEUTRAL POSITION & START OF WALKING

fall and jump

G (m/s²)

EARTH	MOON
9.8	1.6

FALL FROM 1M

0.45 SEC	1.1 SEC
<u>U= 4.4m/s</u>	<u>U= 1.8m/s</u>

↙

U= 1.8m/s
0.17M

FALL FROM 2M

0.64 SEC	1.6 SEC
<u>U= 6.26m/s</u>	<u>U= 2.5m/s</u>

↙

U= 2.5m/s
0.32M

FALL FROM 3M

0.78 SEC	1.9 SEC
<u>U= 7.7m/s</u>	<u>U= 3.1m/s</u>

↙

U= 3.1m/s
0.49M

FALL FROM 5M

1 SEC	2.5 SEC
<u>U= 9.9m/s</u>	<u>U= 4m/s</u>

↙

U= 4m/s
0.82M

FALL FROM 10M

1.43 SEC	3.54 SEC
<u>U= 14m/s</u>	<u>U= 5.6m/s</u>

↙

U= 5.6m/s
1.6M

JUMP FROM GROUND

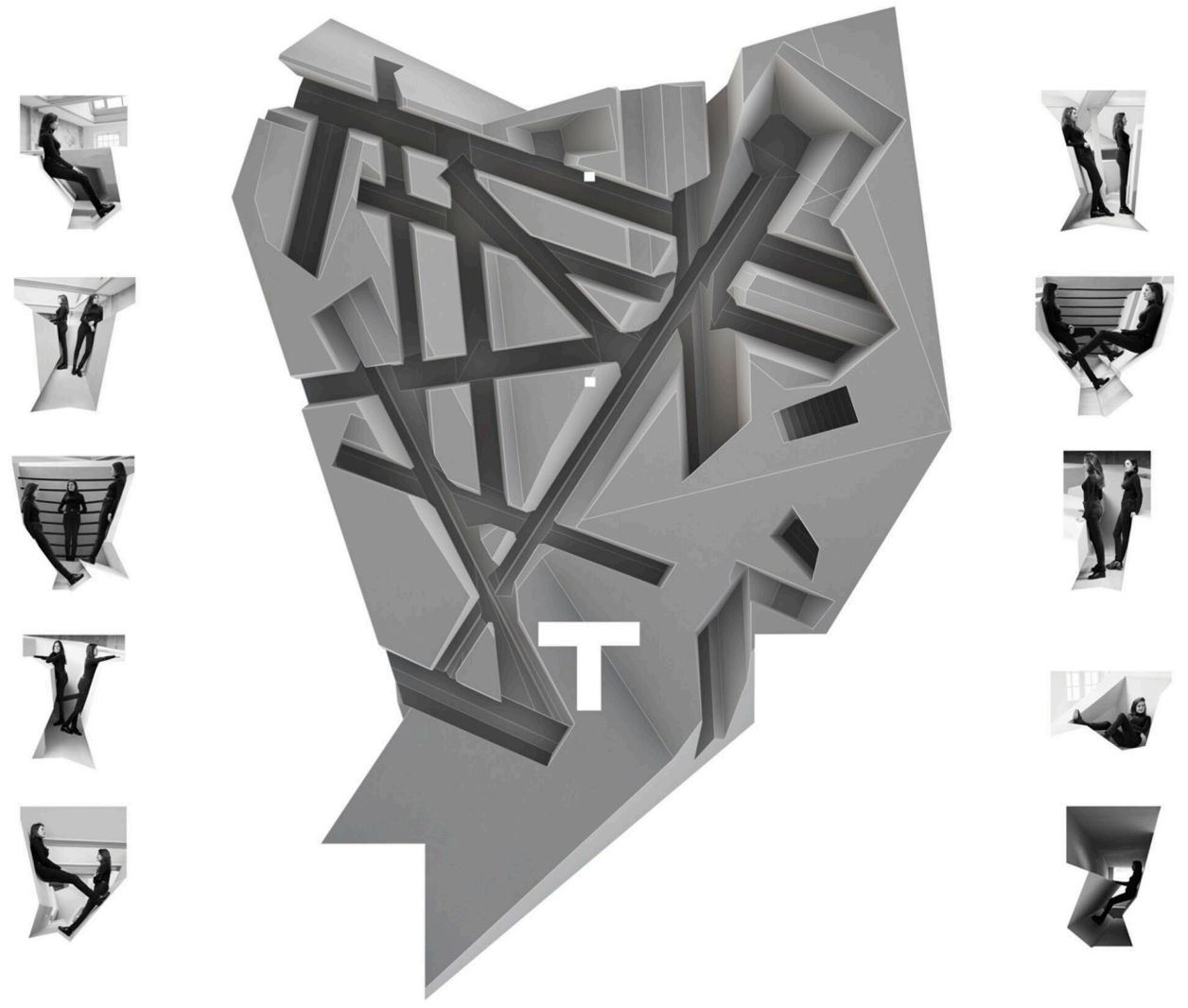
0.5 m → 2.7 m

work ergonomics criticism



SOURCE: RAAAF.NL

THE END OF SITTING BY RAAAF



2. social

NEW RITUAL NEW LIFESTYLE

INCREASING MOONERS
POPULATION



A QUERY IN
COMMUNITY CREATION



SPACE STATION WARDROOM TABLE FOR SKYLAB,
AMERICA'S FIRST EXPERIMENTAL SPACE STATION

social life in previous spaceship

VERY LOW IN PRIORITY

"HAVING DINNER IS A SOCIAL ACTIVITY SHARED BY MANY CULTURES AND IS ONE OF THE HABITUAL SOCIAL CUSTOMS THAT PEOPLE CARRY INTO SPACE ... ON SKYLAB MISSIONS, **CREWS REFUSED TO FLOAT OVER THE TABLE ... THEY HAD FOR THE FIRST TIME A LARGE DEDICATED AREA FOR FOOD** PREPARATION AND DINING AND WERE EATING TOGETHER ON A SPECIALLY DESIGNED TABLE, EATING WITH KNIVES, FORKS AND SPOONS

SPACE ARCHITECTURE EDUCATION FOR ARCHITECTS AND ENGINEERS P.131

**CLIMBING COULD BE UTILISED
AS MEANS OF CONTROL OF COMMUNITY CREATION**

SOURCE: SPACE ARCHITECTURE EDUCATION FOR ARCHITECTS AND ENGINEERS P.77



SPACE STATION WARDROOM TABLE FOR SKYLAB,
AMERICA'S FIRST EXPERIMENTAL SPACE STATION

AN EFFECTIVE SOCIAL BONDING TOOL



RESEARCH QUESTION

how is **playscape** designed under benefits of lunar environment
to foster work productivity and social interaction
during long-term lunar habitation?

DESIGN DIRECTION

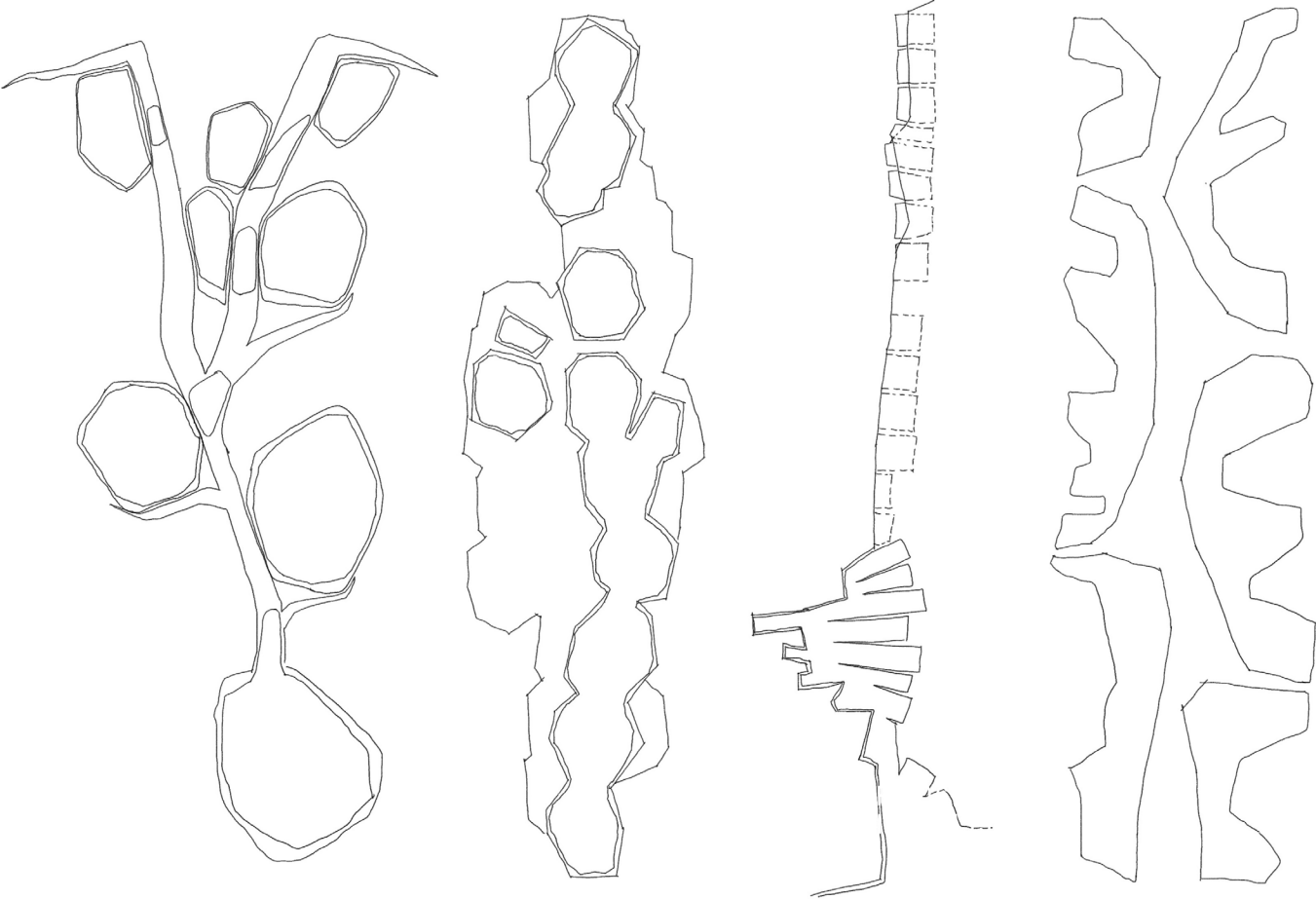
climbing city ->
to create interactive, adaptive and engaging
environment, space and furniture

architectural application

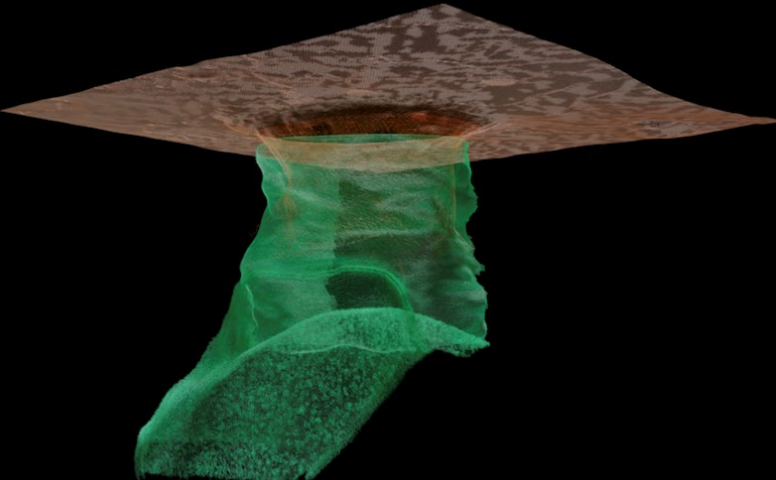
COMPONENTS



vertical configuration

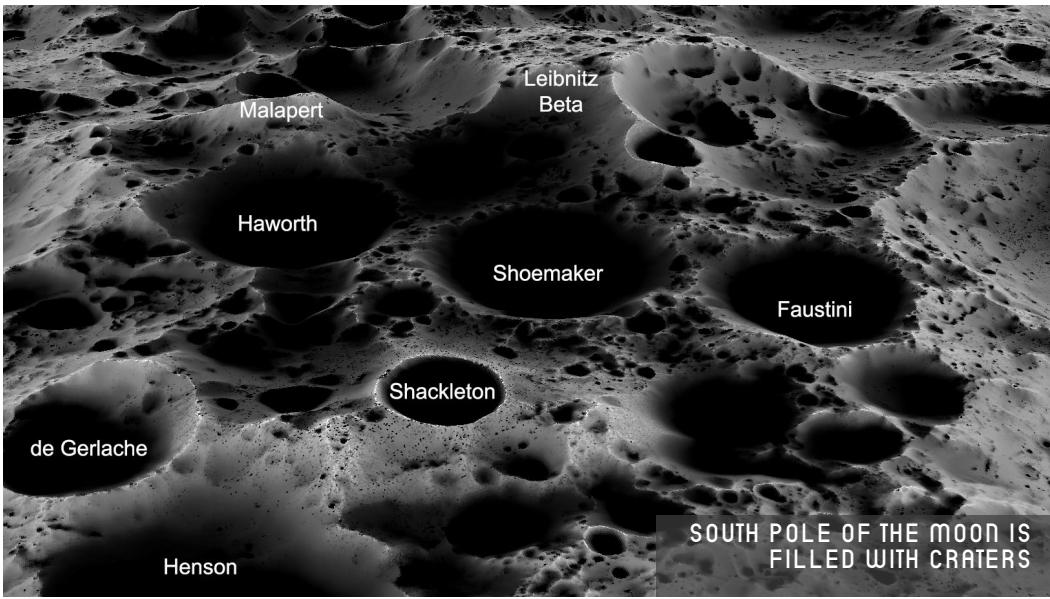


VERTICAL ITERATION - INITIAL SKETCHES



ASSUMPTIVE MODEL OF LUNAR LAVA TUBE

site



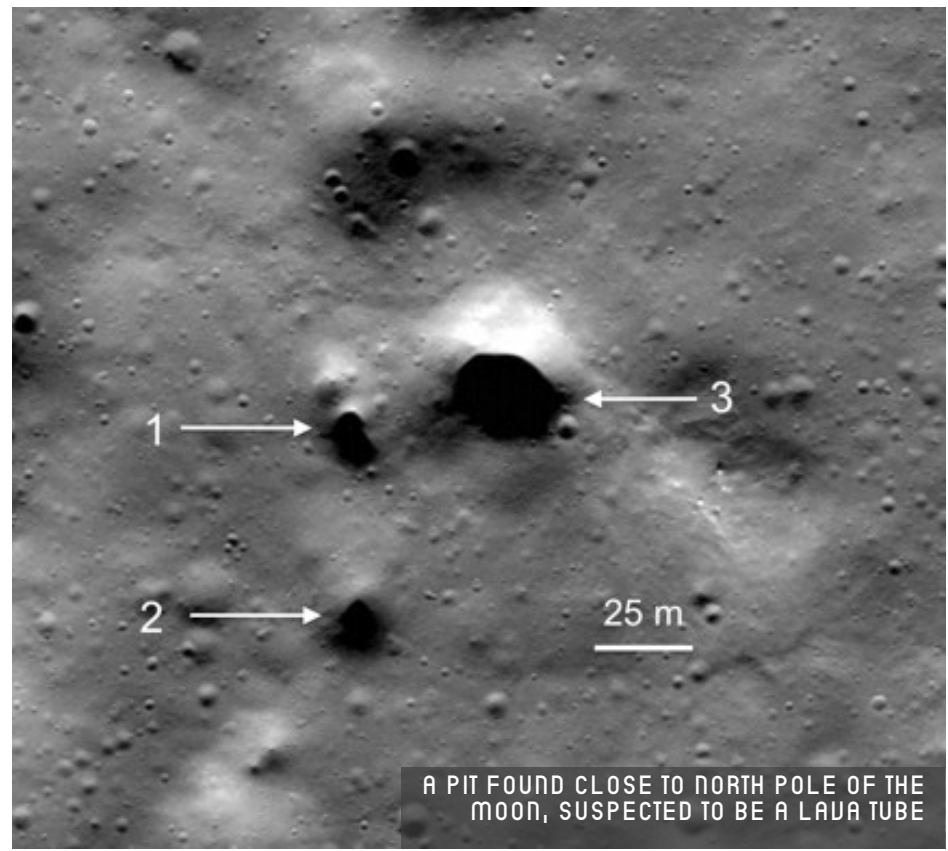
SOURCE: LPI.USRA.EDU

SOUTH POLE OF MOON

RESOURCES

WATER (ICE) -> CRATER BASE

SUN POWER -> CRATER RIM



SOURCE: SETI INSTITUTE

LUNAR LAVA TUBE

DIAMETER VARIES FROM 5-900M

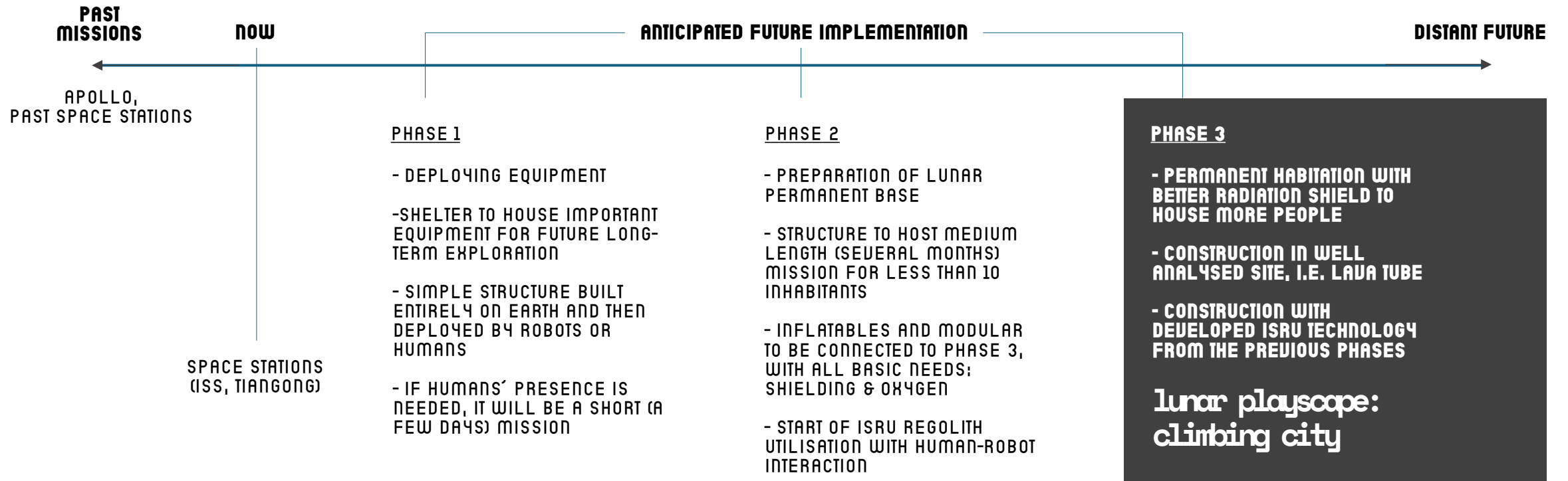
PROTECTION

RADIATION

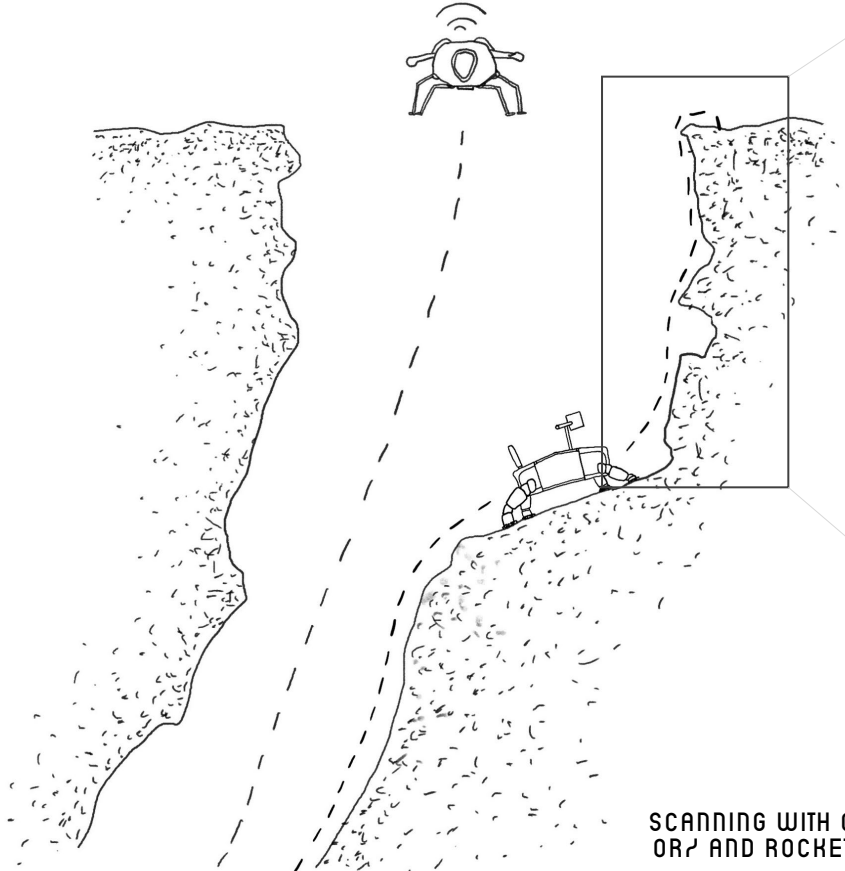
TEMPERATURE FLUCTUATIONS

METEORITE SHOWER

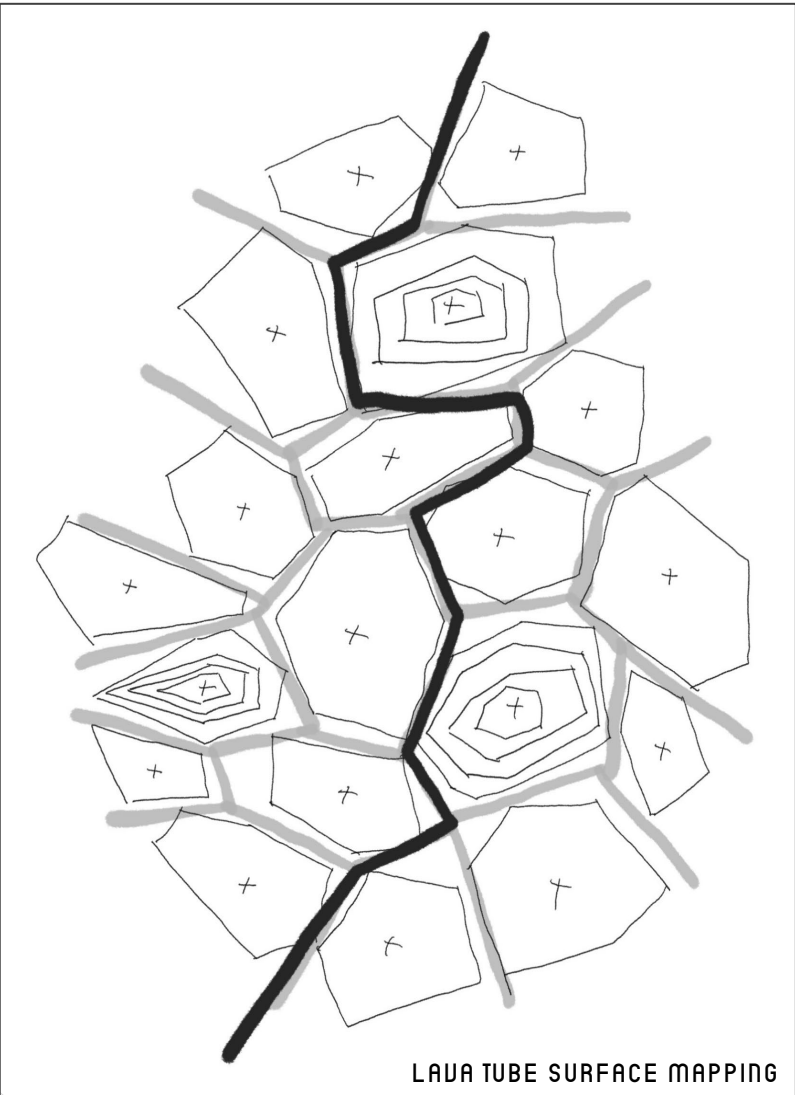
project timeline



main structure orientation



SCANNING WITH CLIMBING ROBOT OR? AND ROCKET-ENGINE DRONE

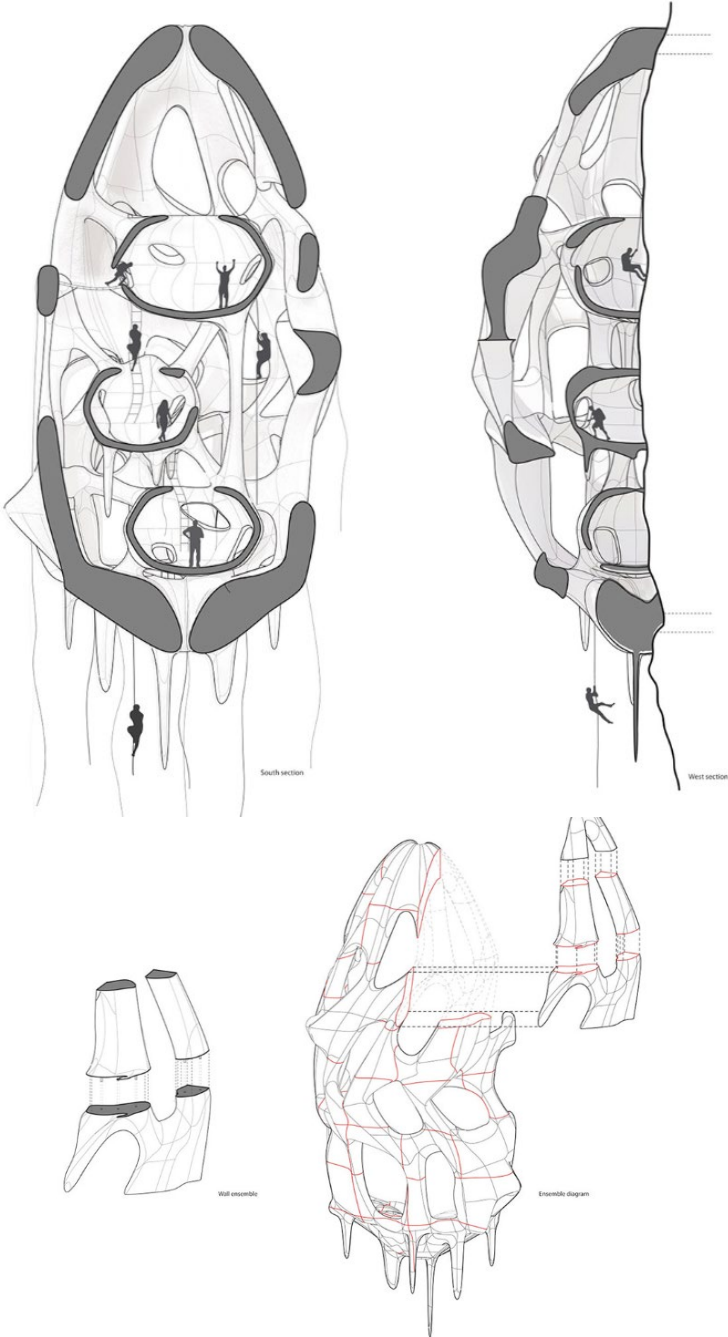


LAVA TUBE SURFACE MAPPING



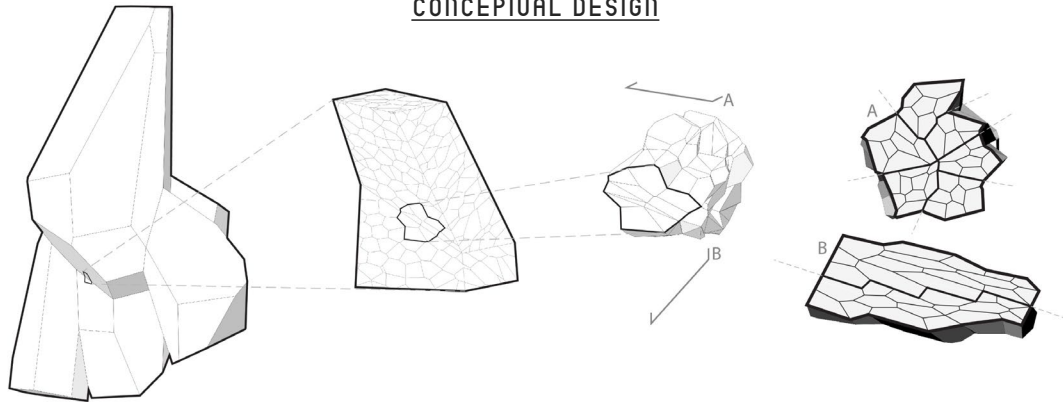
SOURCE: BEHANCE.NET

THE SANCTUARY BY ARTHUR NESTERENKO

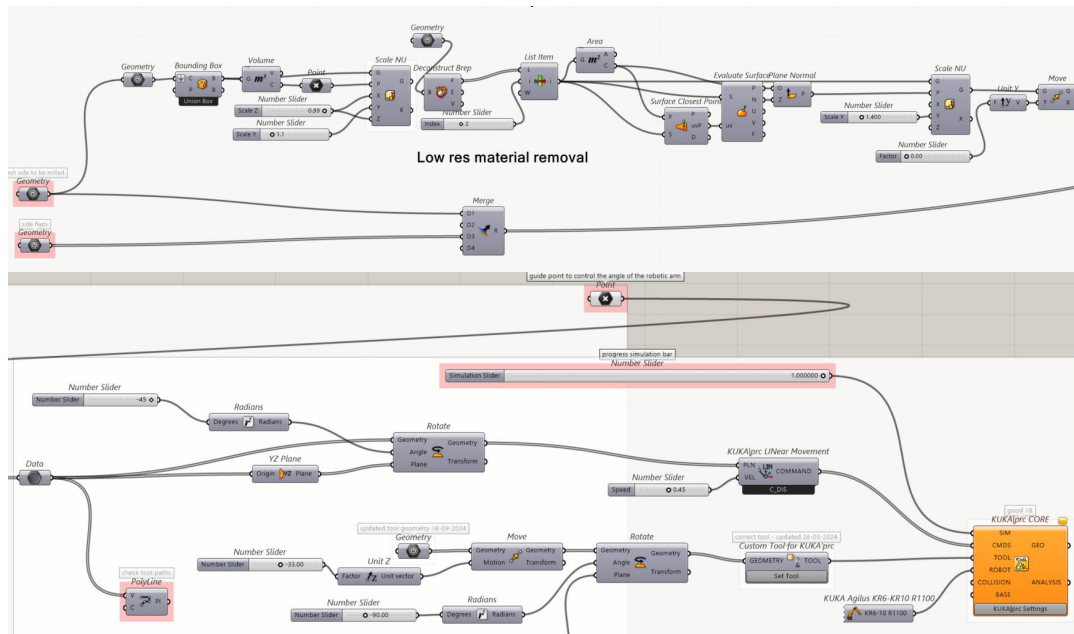


WORKSHOP 1 - WEEK 1.3

CONCEPTUAL DESIGN



FABRICATION DESIGN



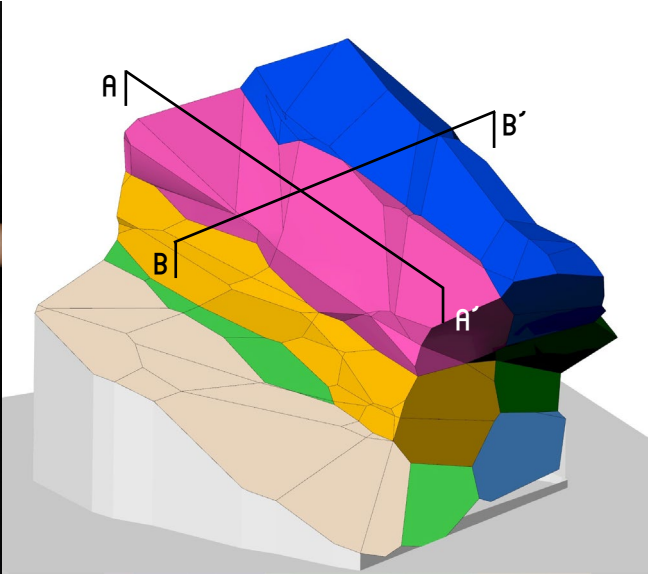
1:1 SCALE FABRICATION



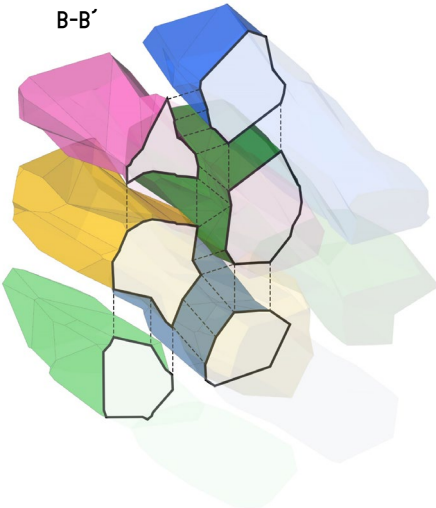
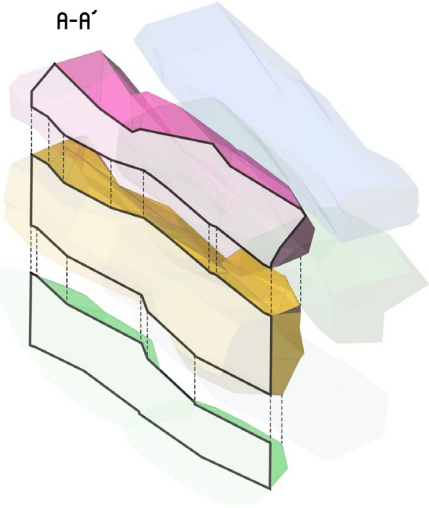
INTUITIVE DESIGN EXERCISE
 BASIC LUNAR CONDITIONS RESEARCH
 —
 CONSTRUCTION LOGIC KNOWLEDGE
 EXISTING TECHNOLOGY KNOWLEDGE
 —
 LIMITATIONS
 (I.E. ACCURACY TOLERANCE)
 —
 PICTURE TO ANOTHER TECHNOLOGIES

INTERLOCKING LOGIC

ADDITIVE METHOD

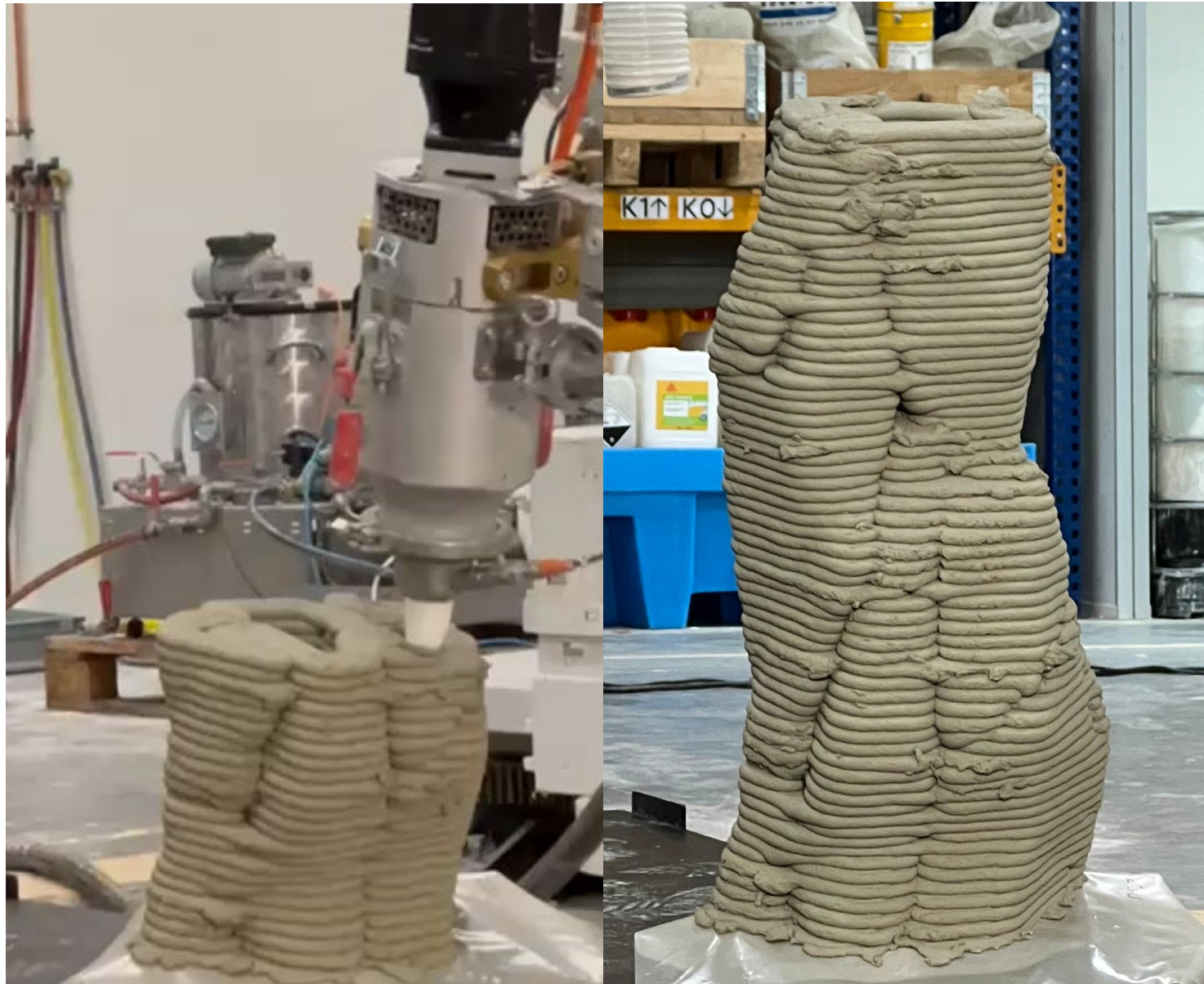


STACKING GESTURE



3-DIMENSIONAL INTERLOCKING EDGES

INTUITIVE DESIGN EXERCISE
BASIC LUNAR CONDITIONS RESEARCH
—
CONSTRUCTION LOGIC KNOWLEDGE
EXISTING TECHNOLOGY KNOWLEDGE
LIMITATIONS
(I.E. ACCURACY TOLERANCE)
PICTURE TO ANOTHER TECHNOLOGIES
—
INTERLOCKING LOGIC
ADDITIVE METHOD

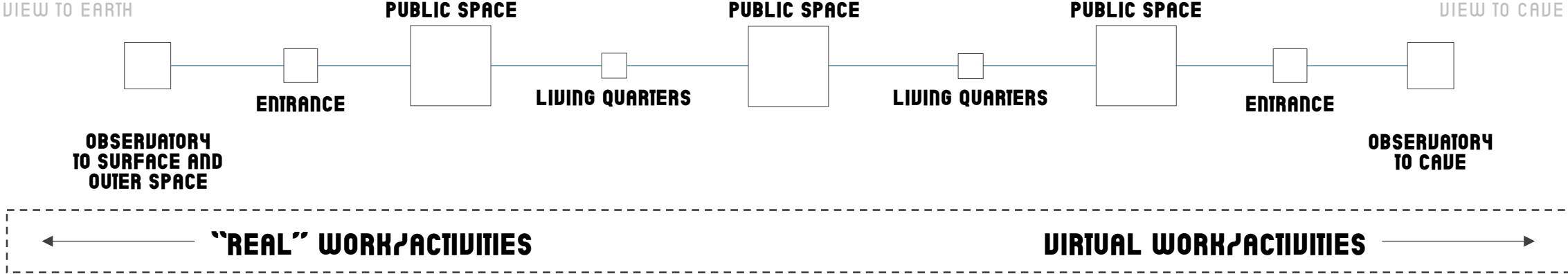


ADDITIVE PROCESS AND RESULT (CONCRETE 3D PRINTING AT VERTICO, EINDHOVEN)

interfaces and spatial experiences

GROUND SURFACE

UNDERGROUND

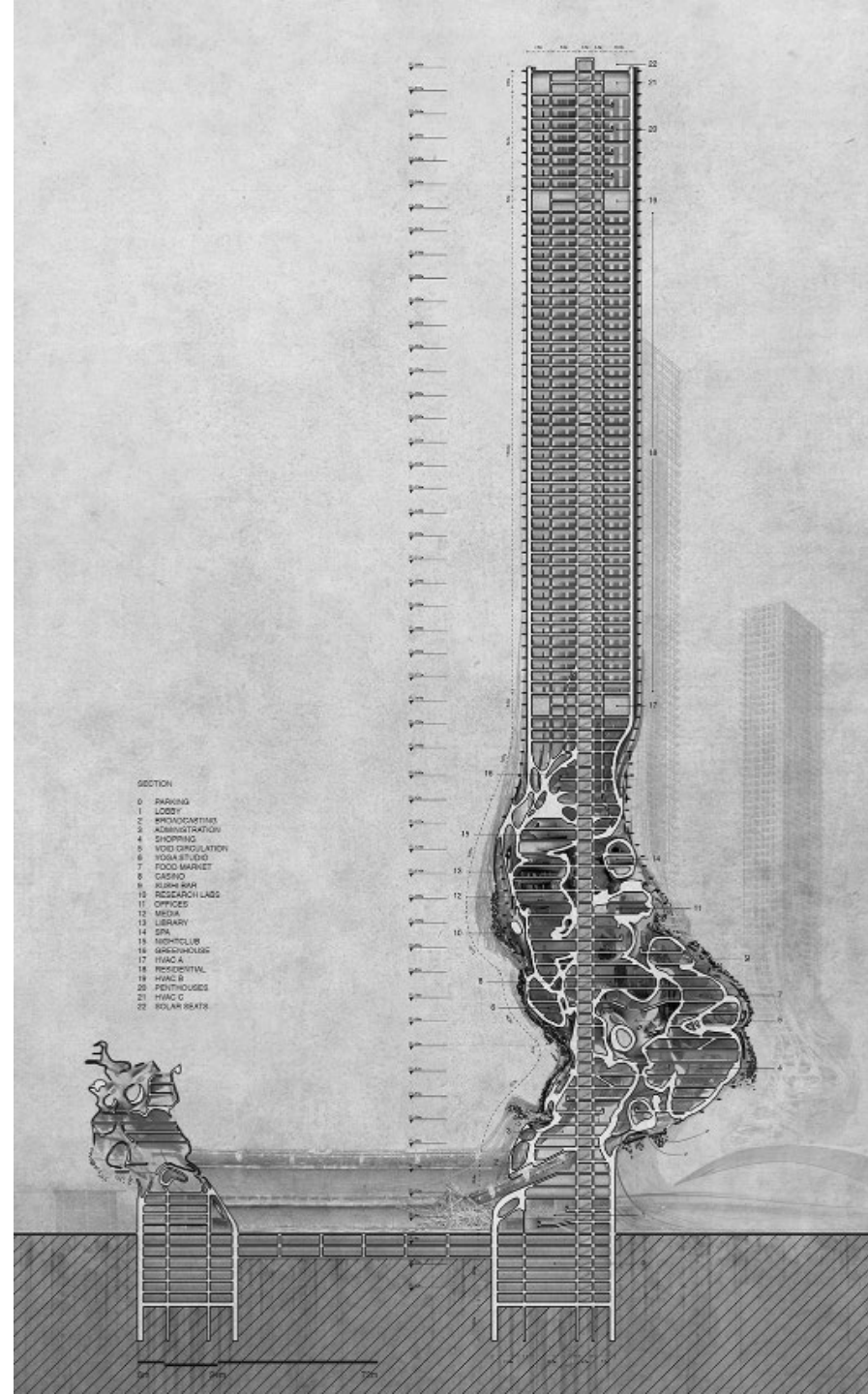


DESIGN COMPONENTS | PROJECT REFERENCE

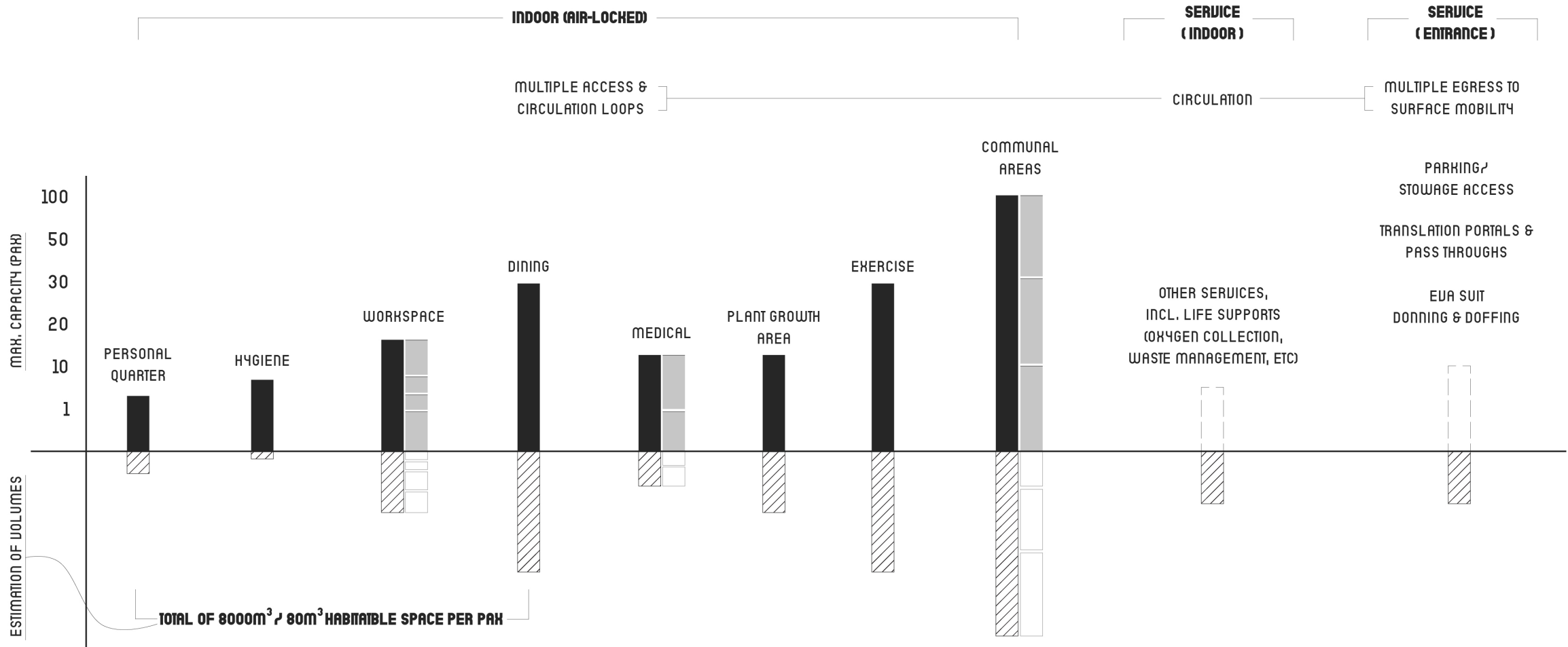


SOURCE: BEHANCE.NET

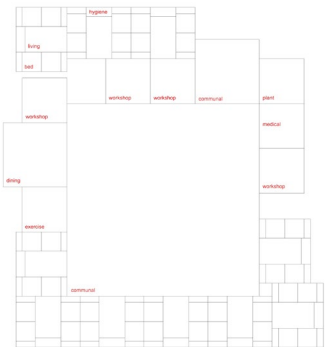
OLYMPHINGS BY RYAN COOK



program specification

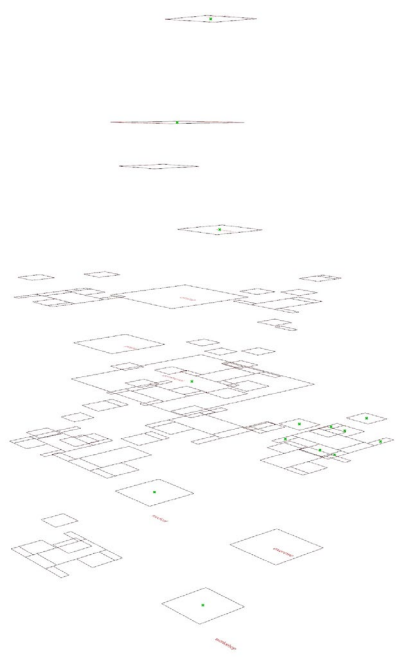


spatial arrangement trial



PLAN VIEW (ALIGNED VS DISTRIBUTED)

- WORKSPACE
- HALL/EVENT AREAS
- DINING
- BEDROOM
- HYGIENE
- EXERCISE
- MEDICAL
- PLANT GROWING



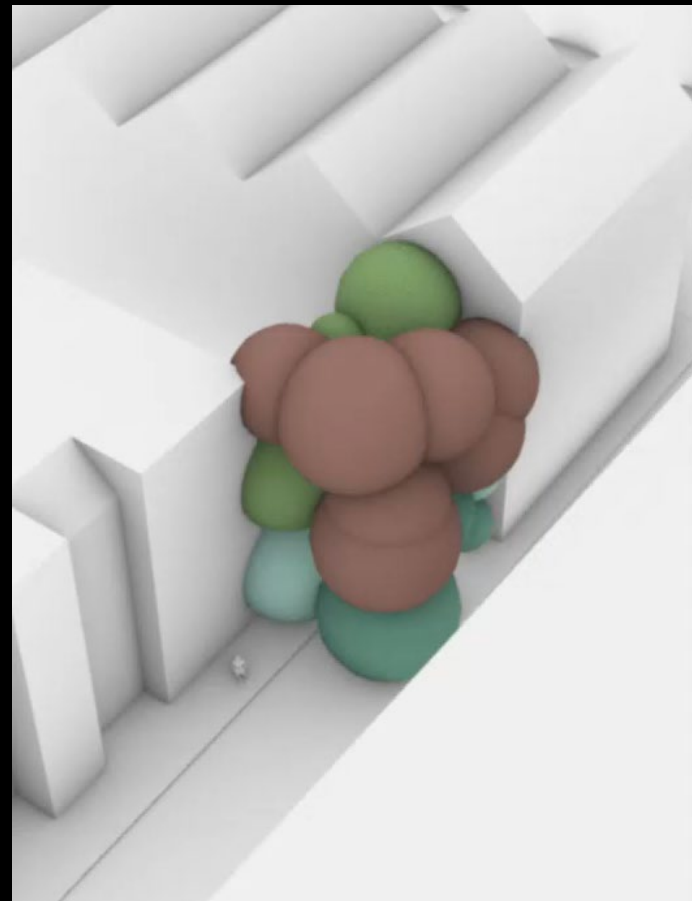
SPACES ARE VERTICALLY DISTRIBUTED



FRONT VIEW

BACK VIEW

COMPUTATIONAL DESIGN GOAL



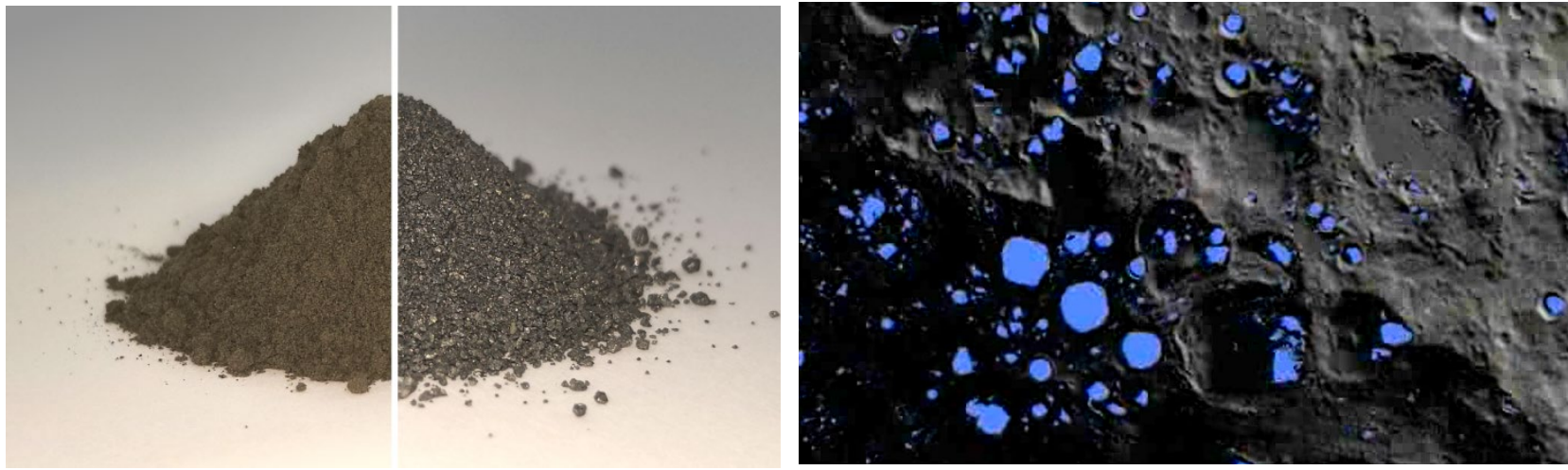
THE CONSTRUCTION INDUSTRY OF TOMORROW IMPLEMENTED TODAY
THESIS BY THIJS HOELEMANN (2020)

materialisation



exterior

IN-SITU RESOURCE UTILISATION (ISRU) & 3D PRINTING



SOURCE: ESA

REGOLITH



SHAPED TO ACCOMMODATE
STRUCTURAL SHELLS
FOR CLIMBING

METAL



LARGE OPENING COVER
RADIATION SHIELD
FOR OPEN VERTICAL ATRIUM

ICE



APOLLO	DURATION (TOTAL)	DURATION (LUNAR SURFACE)	AUE. RADIATION
11	8D 3H 13M	21H 38M	1.8 MSU
12	10D 4H 31M	31H 31M	5.8 MSU
14	9D 1M	33H 31M	11.4 MSU
15	10D 1H 11M	66H 54M	3.0 MSU
16	11D 1H 51M	71H 2M	5.1 MSU
17	12D 13H 51M	74H 59M	5.5 MSU

CAREER EXPOSURE LIMITS (NASA)				
AGE	25	35	45	55
MALE	1,500 MSU	2,500 MSU	3,250 MSU	4,000 MSU
FEMALE	1,000 MSU	1,750 MSU	2,500 MSU	3,000 MSU

mooners cycle

RADIATION EXPOSURE LIMIT = 700-2000 DAYS

ANNUAL CYCLE OF NEW MOONERS



material impression = contrast

EXTERIOR -> MONUMENTAL, PERMANENT

LIVING IN INTERIOR -> LIGHTING, CONNECTION TO OUTSIDE, **PHYSICAL IMMERSIVE-NESS**

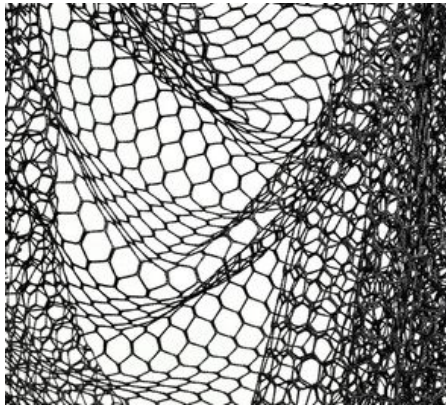
INTERIOR -> (PARTIALLY) FLEXIBLE

SENSE OF FREEDOM / PERSONALITY



interior

IN-SITU RESOURCE UTILISATION (ISRU) & 3D PRINTING



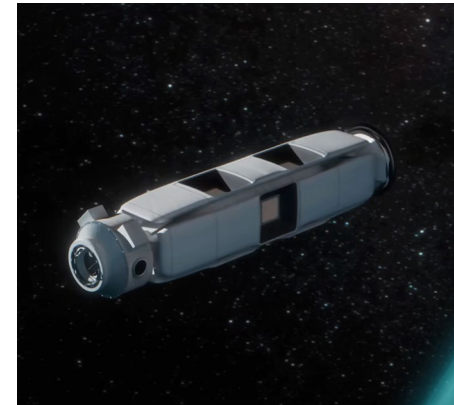
SOURCE: DAZIAN.COM

NETS



SOURCE: ESA

MODULAR & POROUS
DESIGNED
REGOLITH BLOCKS



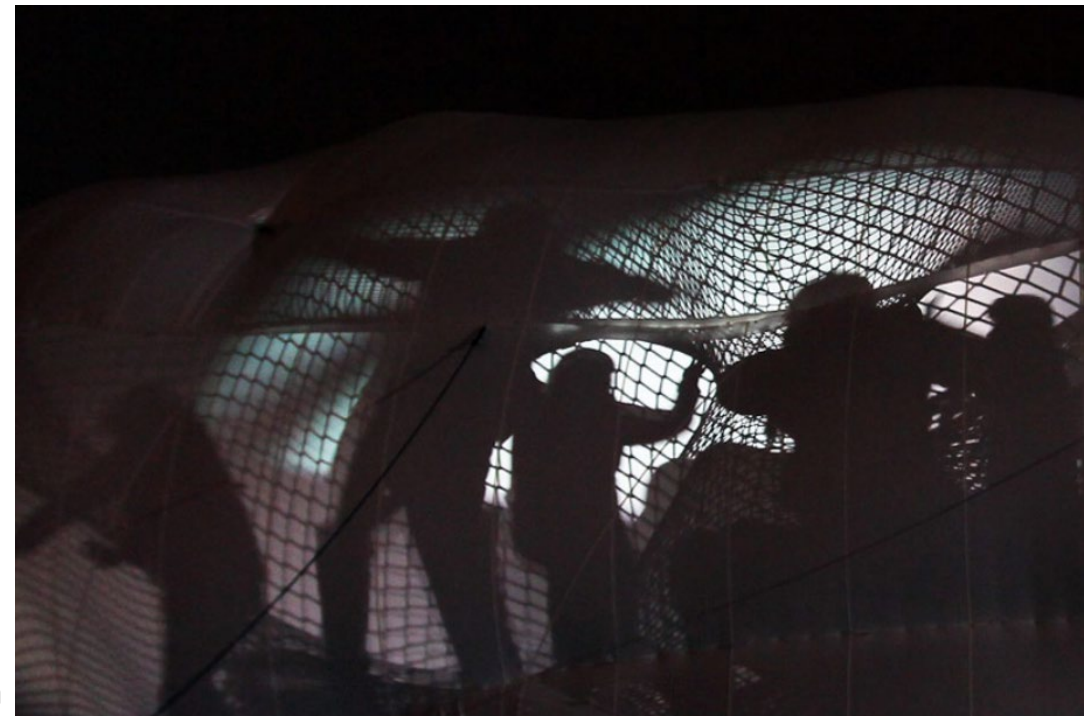
SOURCE: SIERRA NEVADA & NASA

INFLATABLES

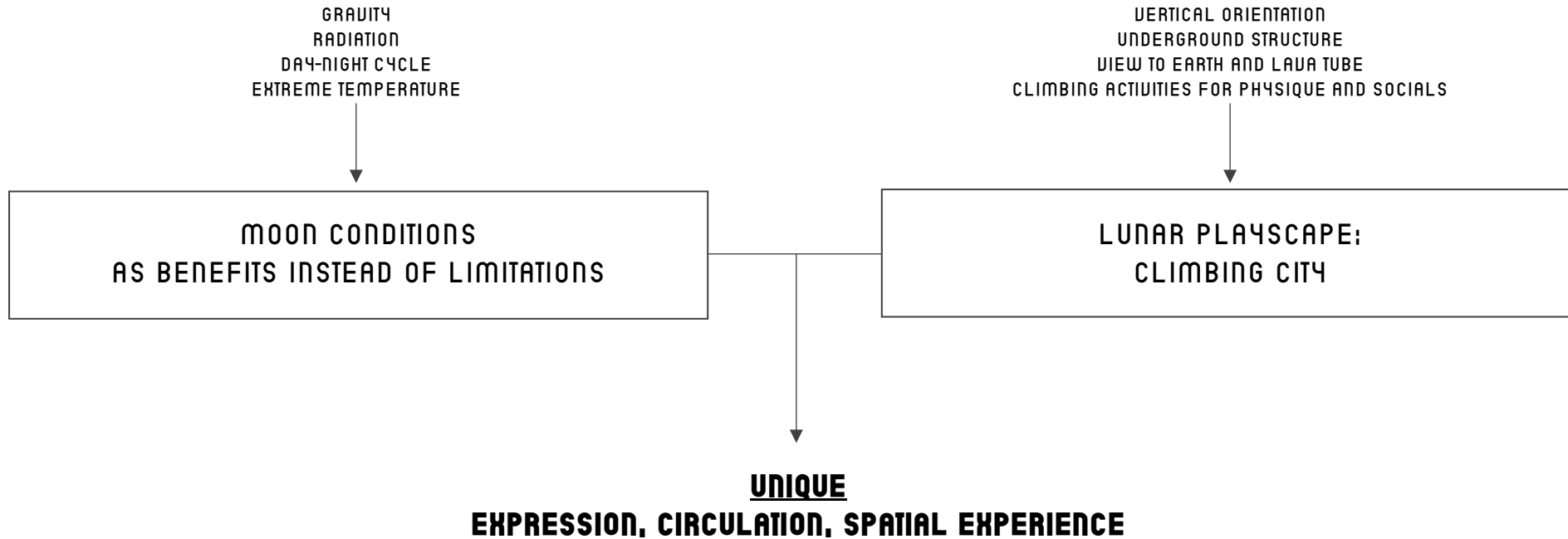


INTERACTIVE NET BLOW-UP IN YOKOHAMA BY NUMEN/ FOR USE

NETS AS MATERIAL
STRONG, LIGHT, RECONFIGURE-ABLE,
OFFER GRIP FOR CLIMBING,
PLEASANT CONTRASTING AESTHETIC WITH HARD STRUCTURE



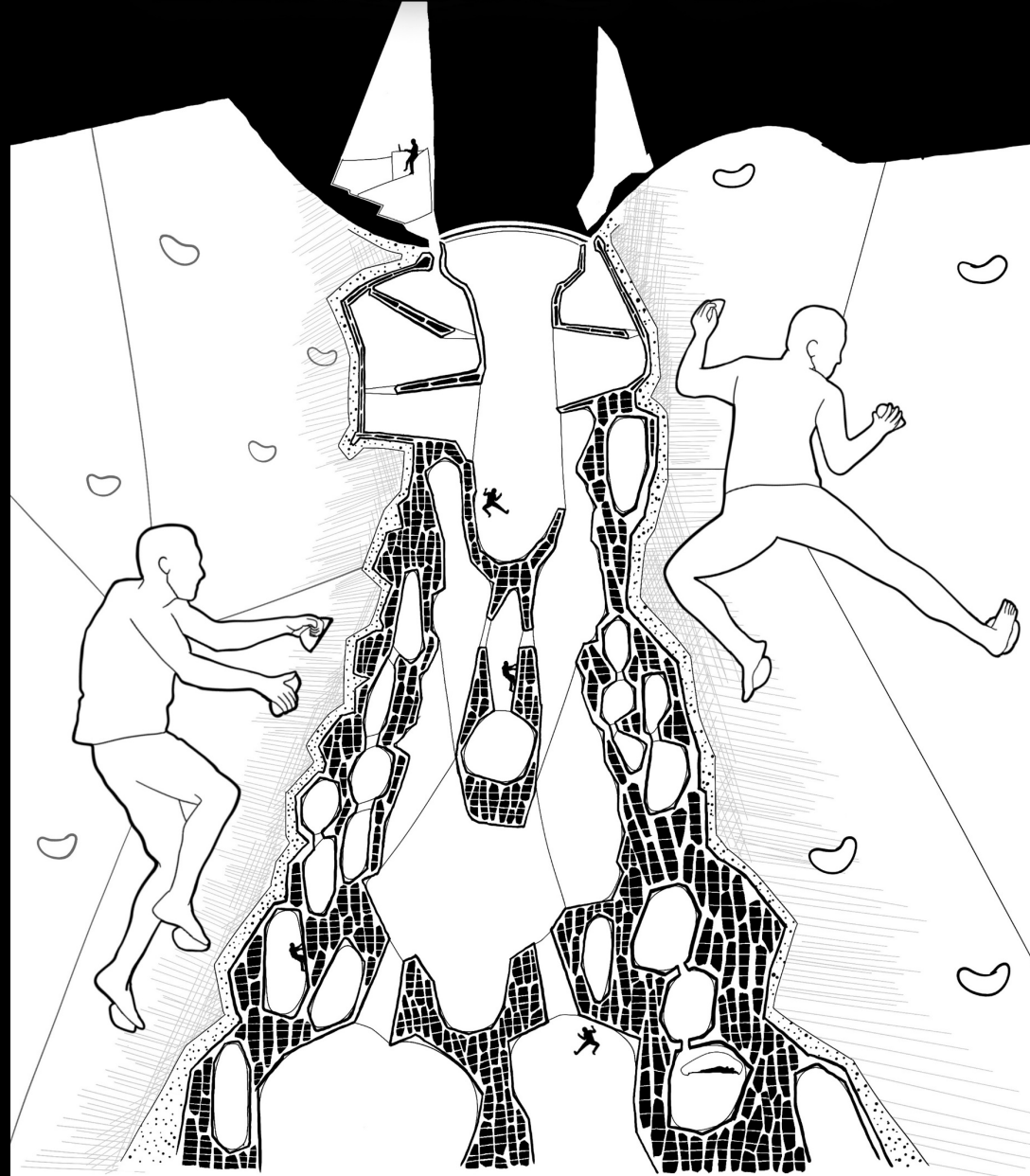
CONCLUSION



being on the moon is the perfect time to **re-feel our body**
by engaging with new gravity & new architecture around us

LUNAR PLAYSCAPE

CLIMBING CITY



IMPRESSION POSTER IN PROGRESS