EYES OF EDEN

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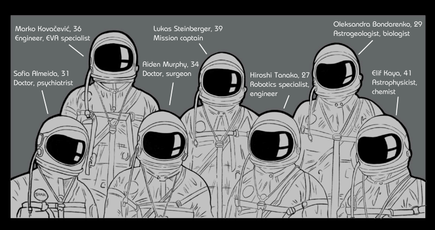
TU Wien | WS25 | 253.036 Entwerfen Humans on Mars – Architectural Implications

Ever since the traces of water were found on Mars, scientists have been driven by two fundamental questions: "Is there life on Mars?" and "Can humans live there?" These questions form the core objectives of the Eyes of Eden project. Life within the settlement revolves around a greenhouse located at the center. Like in a biblical legend in which God places first people in the Garden of Eden to live and strive there. Surrounding it, inflatable modules of varying sizes are arranged according to their specific functions. For added protection, the structure is reinforced with 3D-printed regolith walls. The Martian habitat is designed to support a wide range of scientific research activities and EVA missions. In addition, parts of the facility can be utilized by private companies engaged in space-related industries, encouraging further innovation and contribution to space exploration.

I.



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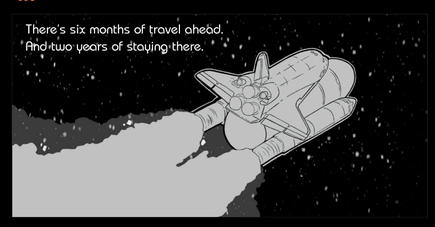

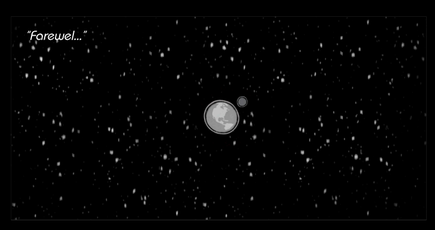

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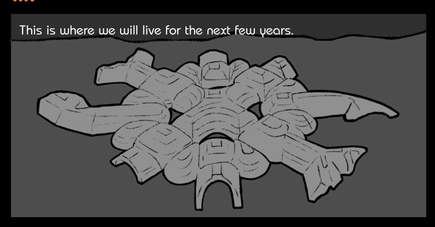

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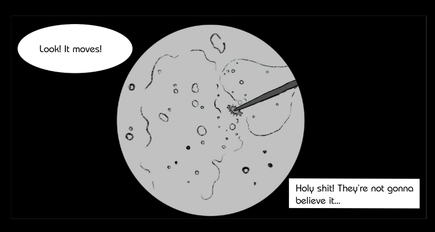

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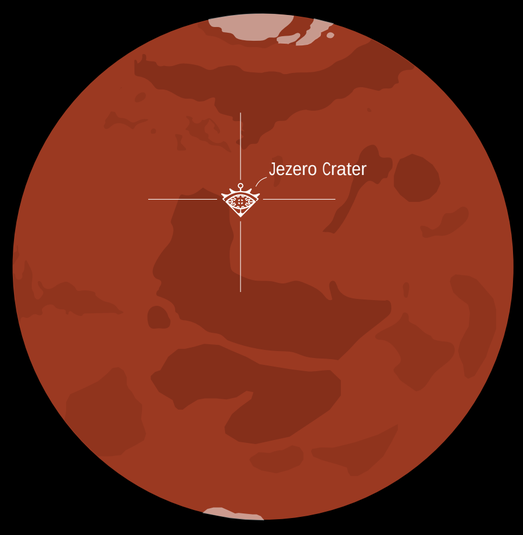
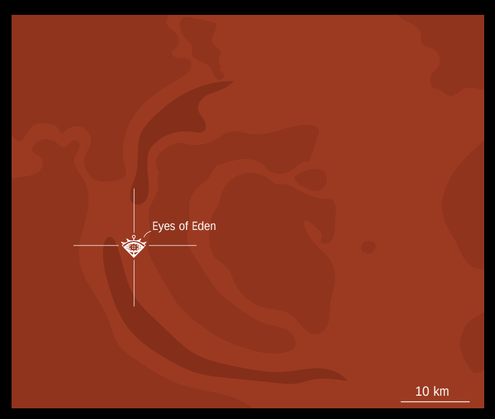
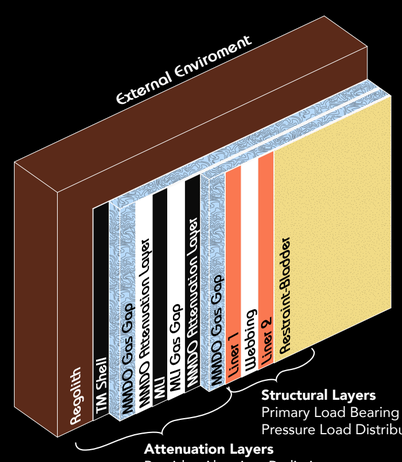




- Used to be a giant lake
- Now the soil is rich in minerals and fossils
- Proven to be safe as a landing site (Perseverance Rover, 2021)



Menu

BREAKFAST

Savory Barley Porridge
Barley, Onion, Parsley, Thyme

Greens & Ginger Scramble
Ginger, Spinach, Swiss Chard, Chives

Sweet Potato & Quinoa Hash
Sweet Potato, Quinoa, Oregano

MAIN FOOD

Legume and Grain Chili
Dry Bean, Pinto Bean, Chickpeas, Barley, Spicy Peppers

Cabbage and Dill Soup
Cabbage, Carrots, Dill, Turnip Greens

Kohlrabi & Snap Bean Sauté
Kohlrabi, Snap Bean, Sage

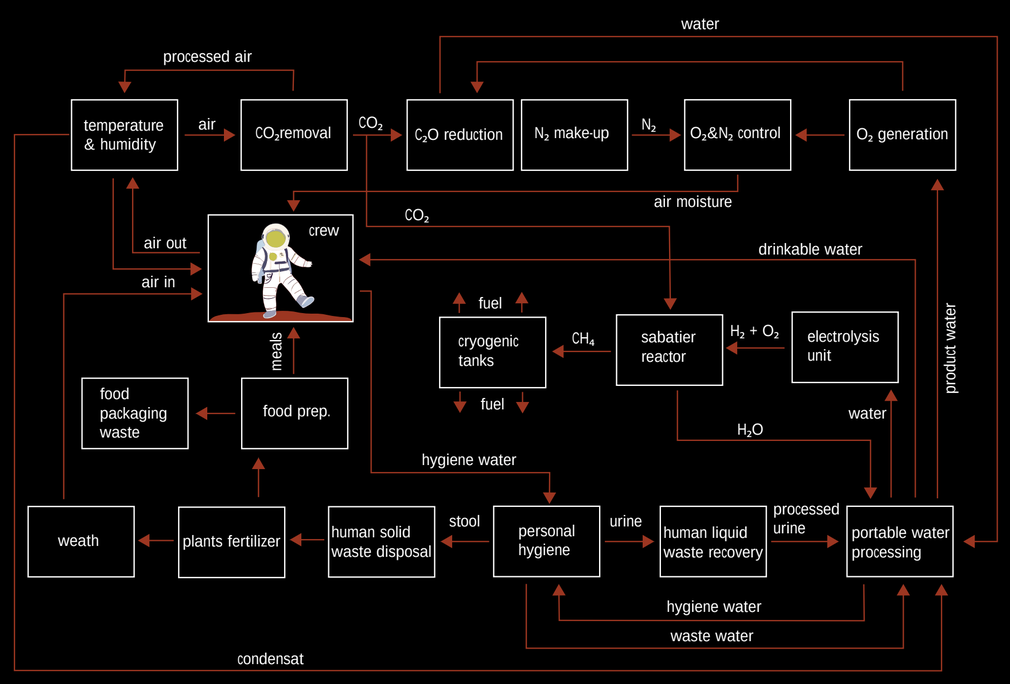
Tomato and Spinach Dal
Spinach, Lentil, Tomato, Thyme

APPETIZERS

Root Vegetable Fries
White Potato or Carrots

Dandelion & Endive Salad
Dandelion, Endive, Flax Oil

Garlic and Herb Flatbread
Flour, Garlic, Basil/Parsley



Regular Crew:

- x1 Mission Commander
- x2 Doctor
- x2 Engineer
- x1 EVA specialist
- x4 Astrogeologist | Biologist | Chemist | Astrophysicist

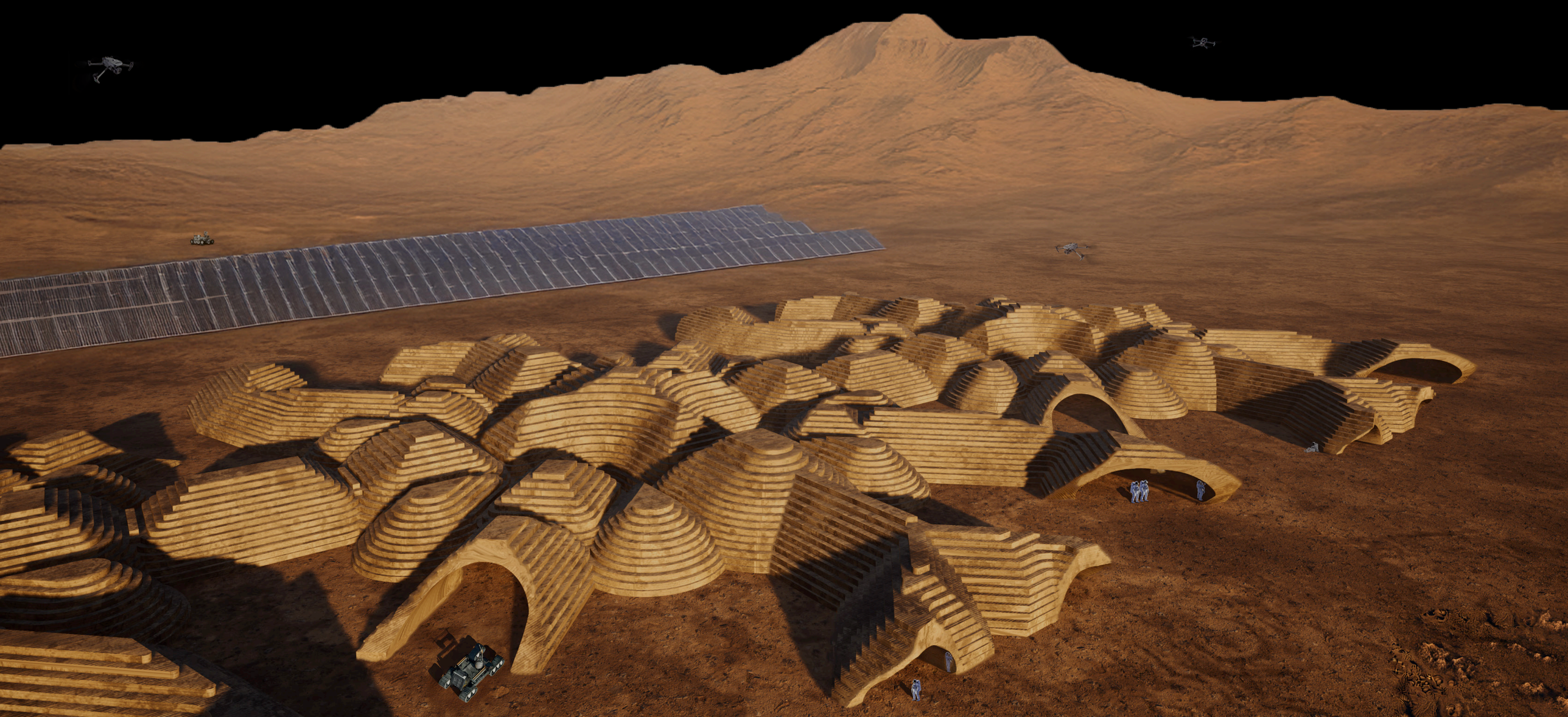
Expanded Crew:

- x3-5 Business guests: space tourists/private space companies

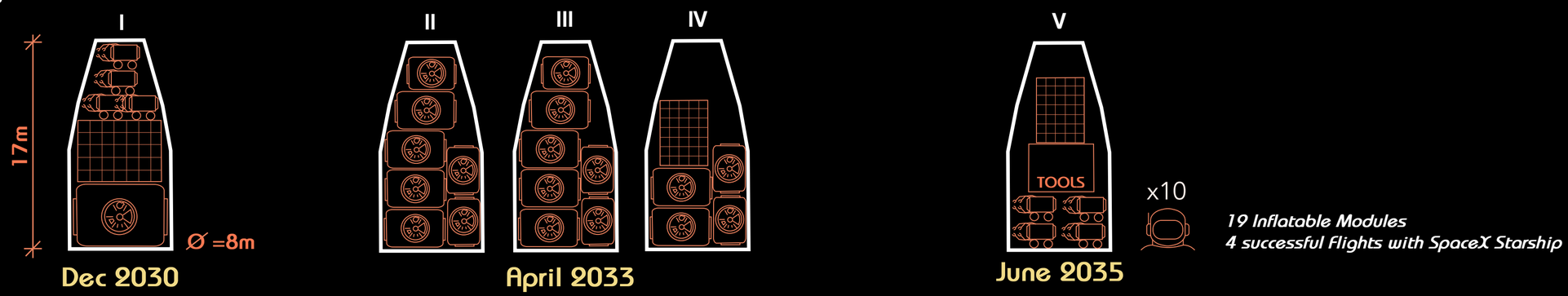
The design of each complex within the Eyes of Eden infrastructure revolves around a core module known as CELSS (Controlled Ecological Life Support System). The general life support system in each structure operates as a hybrid, integrating both chemical and biological processes to sustain the habitat.

CELSS comprises multiple plant pod structures (as visible in the section) tailored to meet individual requirements such as lighting spectrum and period, nutrient solution and atmospheric gas composition for each cultivated plant species.

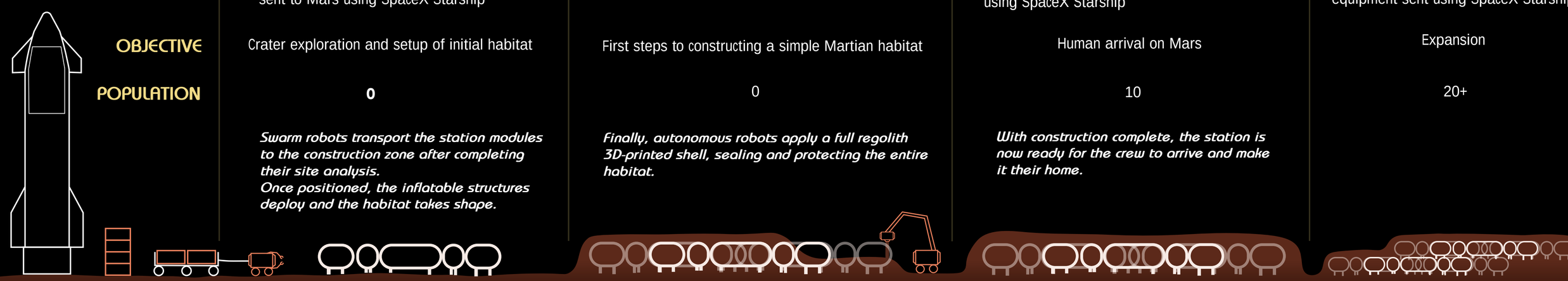
The primary roles of the CELSS module include oxygen production, carbon dioxide reduction, contaminant gas regulation, pressure and humidity regulation, thermal management, waste processing, food production, psychological well-being support, and radiation protection during SPEs (Solar Partile Events). Should any of the aforementioned functions be compromised, they can be supplemented or replaced by the ECLSS (Environmental Control and Life Support System) to maintain overall life support integrity.

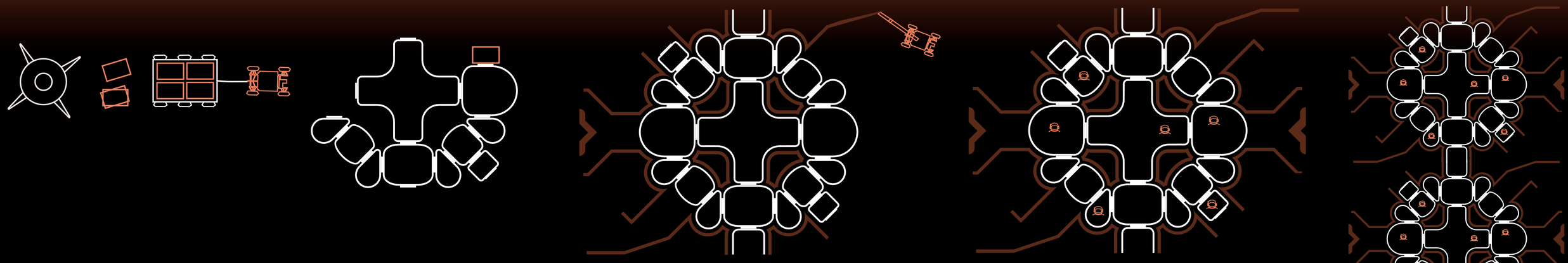


LAUNCH PHASES



	STAGE 1	STAGE 2	STAGE 3	STAGE 4
LOGISTICS	Swarm robotics and initial inflatable module sent to Mars using SpaceX Starship	Additional modules sent using SpaceX Starship	First inhabitants and additional equipment sent using SpaceX Starship	Further inhabitants and additional equipment sent using SpaceX Starship
OBJECTIVE	Crater exploration and setup of initial habitat	First steps to constructing a simple Martian habitat	Human arrival on Mars	Expansion
POPULATION	0	0	10	20+
	Swarm robots transport the station modules to the construction zone after completing their site analysis. Once positioned, the inflatable structures deploy and the habitat takes shape.	*Finally, autonomous robots apply a full regolith 3D-printed shell, sealing and protecting the entire habitat.*	*With construction complete, the station is now ready for the crew to arrive and make it their home.*	





CELSS MODULE

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The CELSS system can be divided into 4 individual plant growth systems, each consisting of 40 plant pods. In order to enable extensive plant research, 4 different, but reliable nutrient delivery systems (NDSs) are chosen for each plant growth system: aeroponics, hydroponics, NFT, and porous tubes.

Each plant pod adapts the growing conditions for the individual plant species to exact preferred values for lighting period, lighting composition, atmospheric composition (CO2 level, N2 level), air temperature, and humidity according to the values given by Ewert et al. (2014).

Each plant pod connects to a base, which is responsible for NDS management, waste management, and Volatile Organic Compound (VOC) management (such as ethylene, plastics, metals (dependent on the primary construction material)).

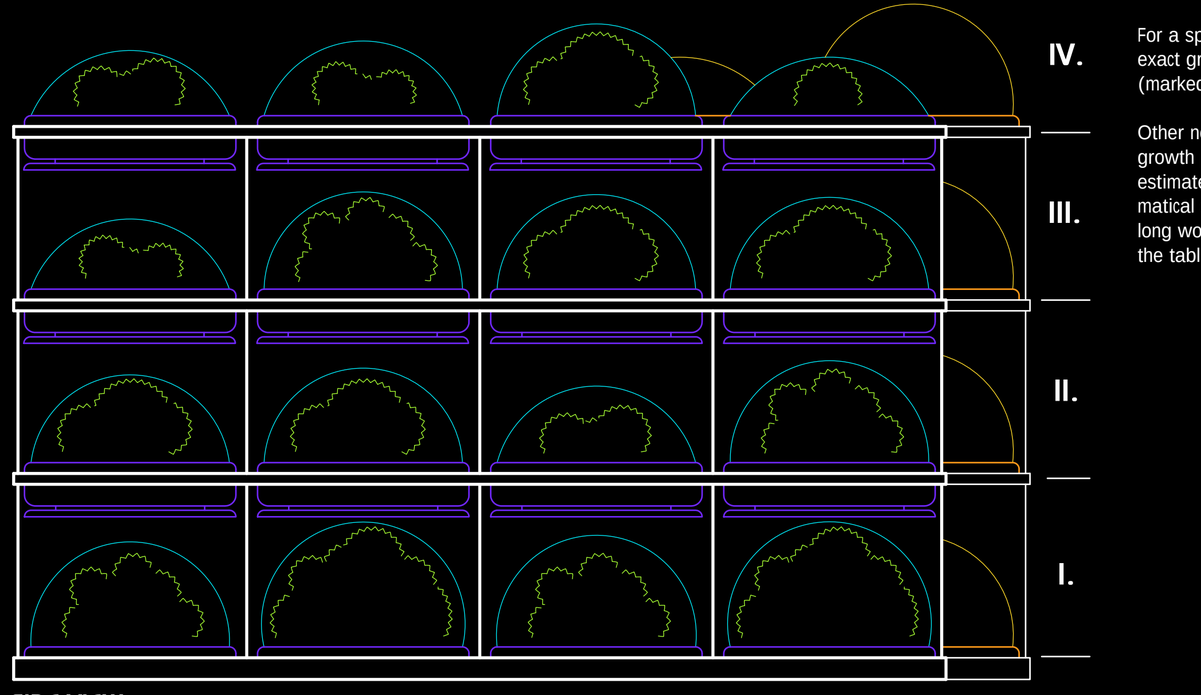
For a specific amount of the given plant species in the created table, exact growth parameters can be gathered from past plant studies (marked in pink).

Other non-marked plant species would require research for their growth parameters. The table offers an overview of mathematically estimated O2 and CO2 rates. The visualised values are purely mathematical estimates based on a formula derived using extensive, month-long work with AI to receive values similar to the plants specified in the table illustrated by Ewert (2022) on page 174.

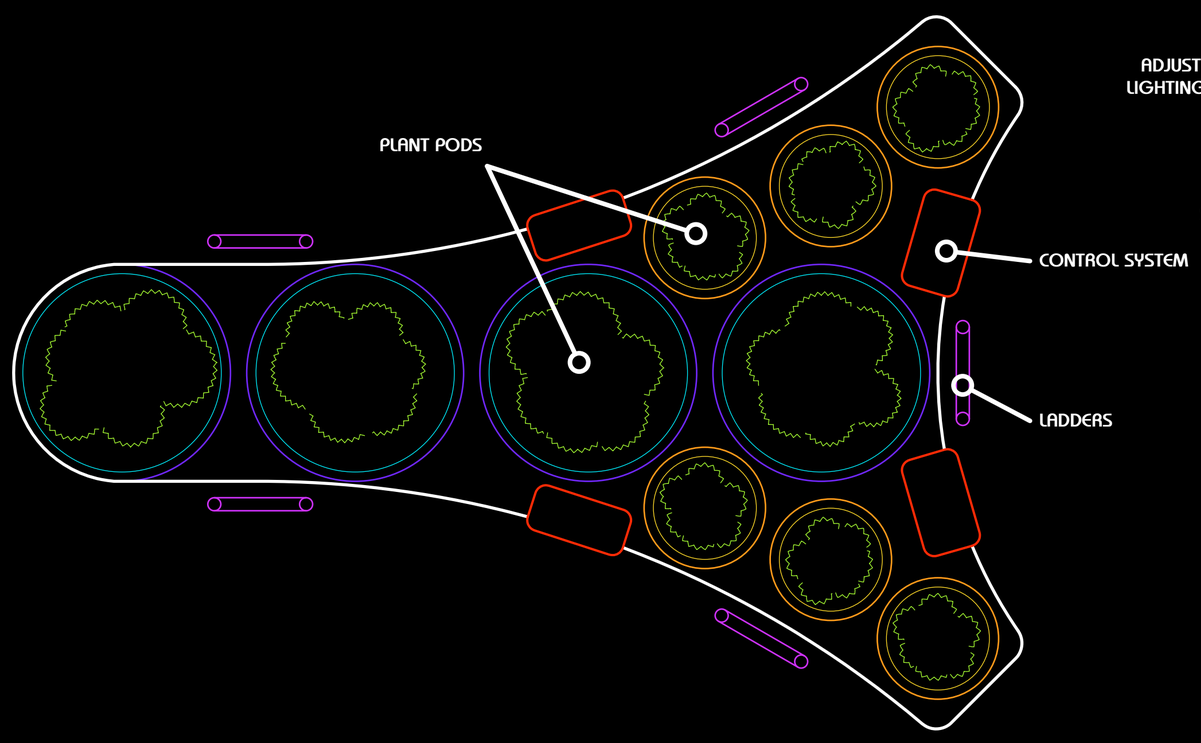
CATEGORY	Name (EN)	Name (LA)	Key nutrients	plant density/m²	CO_2 absorption g/m2d	O_2 production g/m2d	days to maturity	harvest cycle (days)	Spread harvesting	Notes regarding harvest
Leafy greens										
X	Cabbage	*Brassica oleracea*	Vit C, Vit K, Fiber, Folate	4	9,88	7,19	70-100	Single harvest		
X	Chard	*Beta vulgaris cicla*	Vit A, Vit C, Vit K, Mg, K	4	15,79	11,49	70-100	Single harvest		
	Chinese cabbage	*Brassica rapa*	Vit A, Vit C, Ca, Fe	6	14,68	10,67	50-80	10-14	x	
	Collards	*Brassica oleracea var. acephala*	Vit A, Vit C, Vit K, Ca, Fiber	6	6,36	4,62	60-85	7-14	x	
X	Celery	*Apium graveolens*	Vit A, Vit C, Vit K, Fiber	6	16,83	12,24	100-130	Single harvest		
	Dandelion	*Taraxacum officinale*	Vit A, Vit C, Vit K, Ca, Fe	10	3,53	2,57	40-50	10-15	x	
	Endive	*Cichorium endivia*	Vit A, Vit C, Vit K, Fiber	10	8,15	5,93	45-95	10-15	x	
	Kale	*Brassica oleracea Acephala*	Vit A, Vit C, Vit K, Antioxidants	8	7,83	5,69	55-75	7-14	x	
X	Lettuce	*Lactuca*	Vit A, Vit K	10	10,70	7,78	30-50	7-10	x	
	New Zealand spinach	*Tetragonia tetragonioides*	Vit A, Vit C, Ca, Fe	6	2,65	1,93	55-70	7-10		
	Red mustard	*Brassica juncea*	Vit A, Vit C, Vit K, Antioxidants	15	35,87	26,08	30-50	7-10	x	
X	Spinach	*Spinacia oleracaea*	Vit A, Vit C, Vit K, Fe, Folate	20	10,70	7,78	35-50	7-10*	x	*regrows once or twice*
	Swiss chard	*Beta vulgaris cicla*	Vit A, Vit C, Vit K, Mg, K	40	4,82	3,50	50-65	7-14	x	
	Turnip greens	*Brassica rapa*	Vit A, Vit C, Vit K, Ca	4	4,54	3,30	30-40	7-10	x	
Herbs/spices										
	Chives	*Allium schoenoprasum*	Vit A, Vit C, Antioxidants	25	2,65	1,93	60-90	14-21	x	
	Dill	*Anethum graveolens*	Vit C, Mn	20	1,41	1,03	60-90	7-14	x	
	Fennel	*Foeniculum vulgare*	Vit C, Fiber, K	10	28,27	20,55	60-90	14-21	x	
	Oregano	*Origanum vulgare*	Vit K, Vit E, Antioxidants	8	0,94	0,68	80-100	14-28	x	
	Parsley	*Petroselinum crispum*	Vit A, Vit C, Vit K	20	4,24	3,08	40-60	14	x	
	Saffron	*Safranum*	Vit C, Mn, Antioxidants	100	3,18	2,31	40-60	90	x	
	Sage	*Salvia officinalis*	Vit K, Antioxidants	8	2,65	1,93	75-90	28-42	x	
	Thyme	*Thymus vulgaris*	Vit A, Vit C, Antioxidants	8	5,30	3,85	70-90	21-28	x	
Grains										
	Barley	*Hordeum vulgare*	Vit B, Se, Fiber	250	0,88	0,64	80-100	Single harvest		
	Flax	*Linum usitatissimum*	Omega-3 acids, Fiber, Lignans	2000	0,36	0,26	90-120	Single harvest		
	Millets	*Milium*	Vit B, Mn, P	200	0,28	0,20	60-90	Single harvest		
	Oats	*Avena sativa*	Vit B, Fe, Fiber	250	0,46	0,33	90-120	Single harvest		
	Quinoa	*Chenopodium quinoa*	Mg, Fe, Protein	10	0,15	0,11	90-120	Single harvest		
X	Rice	*Oryza*	Vit B, Fiber	50	36,55	26,57	100-150	Single harvest		
	Sorghum	*Syrucum*	Vit B, Fe, Antioxidants	80	0,76	0,55	100-120	Single harvest		

CATEGORY	Name (EN)	Name (LA)	Key nutrients	plant density/m²	CO_2 absorption g/m2d	O_2 production g/m2d	days to maturity	harvest cycle (days)	Spread harvesting	notes
Tubers & roots										
X	Beet	*Beta vulgaris*	Mn, Nitrates, Folate	25	9,77	7,10	50-70	Single harvest		
X	Carrot	*Daucus carota subsp. sativus*	Beta-Carotene	40	22,50	16,36	60-80	Single harvest		
	Garlic	*Allium sativum*	Vit C, Vit B6, Allicin	25	0,28	0,20	240-270	Single harvest		
	Ginger	*Zingiber officinale*	Gingerol, Anti-inflammatory properties	10	2,01	1,46	240-300	Single harvest		
X	Green onion	*Allium fistulosum*	Vit B, Vit C, Quercetin	20	14,47	10,67	60-75	Single harvest		
	Horseradish	*Armoracia rusticana*	Vit C, Glucosinolates	10	0,99	0,72	140-180	Single harvest		
	Kohlrabi	*Brassica oleracea var. gongylodes*	Vit C, K, Fiber	10	1,27	0,92	45-60	Single harvest		
	Nut sedge	*Cyperus rotundus*	Fiber, Starch	40	0,91	0,66	90-120	Single harvest		
X	Onion	*Allium cepa*	Vit C, Vit B6, Quercetin	25	16,50	12,00	90-120	Single harvest		
X	Radish	*Raphanus sativus*	Vit C, Antioxidants	50	16,31	11,86	25-40	Single harvest		
X	Sweet potato	*Ipomoea batatas*	Beta-Carotene, K, Fiber	6	56,54	41,12	90-150	Single harvest		
	Taro	*Colocasia esculenta*	Vit E, Fiber, Starch	4	2,12	1,54	150-200	Single harvest		
	Turnip	*Brassica rapa subsp. rapa*	Vit C, Fiber	25	1,33	0,97	40-60	7-10		
X	White potato	*Solanum tuberosum*	Vit B6, Vit C, K	6	45,23	32,23	90-120	Single harvest		
	Young potato	*Solanum tuberosum*	Vit B6, Vit C, K	8	2,73	1,98	60-80	Single harvest		
Fruiting crops										
	Butternut squash	*Cucurbita moschata*	Vit A, Vit C, K, Mg, Fiber, Antioxidants	2	10,60	7,71	90-110	Single harvest		
	Cucumber	*Cucumis sativus*	Vit C, Vit K, K, Antioxidants	6	53,00	38,53	50-70	3-5	x	
	Gac	*Momordica cochinchinensis*	Vit A, Vit C, K, Fe, Fiber, Antioxidants	2	5,62	4,09	180-210	7-14		
X	Pepper	*Capsicum annuum*	Vit C, Capsaicin	6	33,98	24,71	60-90	Single harvest	x	*2-3 weeks of continous harvest*
	Pumpkin	*Cucurbita pepo*	Vit C, Vit K, Fe, Mn, Fiber, Folate, Protein	1	7,95	5,78	85-125	Single harvest		
Ultra dwarf fruit trees										
	Banana	*Musa × paradisiaca*	Vit B6, Vit C, K	2	8,83	6,42	270-450	Single harvest		
	Grape	*Vitis vinifera*	Vit K, Antioxidants	1	0,29	0,21	730-1095	90		
	Melon	*Cucumis melo*	Vit C	1	1,74	2,72	70-100	Single harvest		
	Papaya	*Carica papaya*	Vit A, Vit C, Digestive enzymes	1	3,79	2,76	275-425	7-14		
	Spicy peppers	*Capsicum annuum*	Vit C, Capsaicin	4	6,63	4,82	60-150	7-10*		*for 4-8 weeks*
X	Strawberry	*Fragaria × ananassa*	Vit C, Antioxidants	20	34,82	25,32	90-120	3-5*	x	*for 2-6 weeks*
	Tomatillo	*Physalis philadelphica*	Vit C, Niacin	2	3,18	2,31	70-100	5-7*	x	*for 2-4 weeks*
X	Tomato	*Solanum lycopersicum*	Vit C, K, Lycopene	2	26,36	26,36	60-85	5-7*	x	*for 4-8 weeks*
Legumes										
	Chickpea	*Cicer arietinum*	Fe, Folate, Fiber, Protein	30	0,16	0,12	90-110	Single harvest		
	Cowpea	*Vigna unguiculata*	Fe, Folate, Protein	85	0,26	0,19	60-100	7-10		
X	Dry Bean	*Phaseolus vulgaris*	Fe, Folate, Fiber, Protein	15	42,17	30,67	60-90	Single harvest		
	Garden pea	*Pisum sativum*	Vit A, Vit C, Vit K, Fiber, Protein	75	0,40	0,29	55-75	3-5*	x	*for 2-3 weeks*
	Green bean	*Phaseolus vulgaris*		25	0,24	0,17	50-70	2-4*	x	*for 2-4 weeks*
	Lentil	*Lens culinaris*	Fe, Folate, Fiber, Protein	150	1,15	0,84	80-110	Single harvest		
X	Pea	*Pisum sativum*	Vit A, Vit C, Vit K, Fiber, Protein	10	45,26	32,92	60-90	Single harvest		
	Pinto bean	*Phaseolus vulgaris*	Fe, Folate, Fiber, Protein	25	1,01	0,73	90-120	Single harvest		
X	Snap bean	*Phaseolus vulgaris*	Fe, Folate, Fiber, Protein	15	50,09	36,43	50-70	Single harvest		
	Snow pea	*Pisum sativum var. saccharatum*	Vit C, Fiber	15	0,46	0,34	60-70	3-5*	x	*for 2-3 weeks*
X	Soybean	*Glycine max*	Fe, Ca, Protein	20	19,13	13,91	80-120	Single harvest		
	Winged bean	*Psophocarpus tetragonolobus*	Vit A, Vit C, Protein	4	0,18	0,13	80-100	3-7	x	
Oil-storing crops										
	Canola	*Brassica napus*	Omega-3 acids	80	0,40	0,29	90-120	Single harvest		
	Flax (oil)	*Linum usitatissimum*	Omega-3 acids, Lignans	30	0,10	0,07	90-120	Single harvest		
X	Peanut	*Arachis hypogaea*	Folate, Niacin, Protein, Healthy fats	15	49,28	35,84	100-140	Single harvest		
	Sunflower	*Helianthus annuus*	Vit E, Healthy fats	6	0,61	0,44	90-120	Single harvest		
X	Wheat	*Triticum*	Vit B, proteins	300	77,00	56,00	100-150	Single harvest		
Special crops										
	Green tea extract	*Camellia sinensis*	Catechins, Antioxidants	10000	2,65	1,93	300	7-14		
	Duckweed	*Lemna*	Protein, Antioxidants, Amino acids	whole gu	145,75	105,96	7-14	3-5		

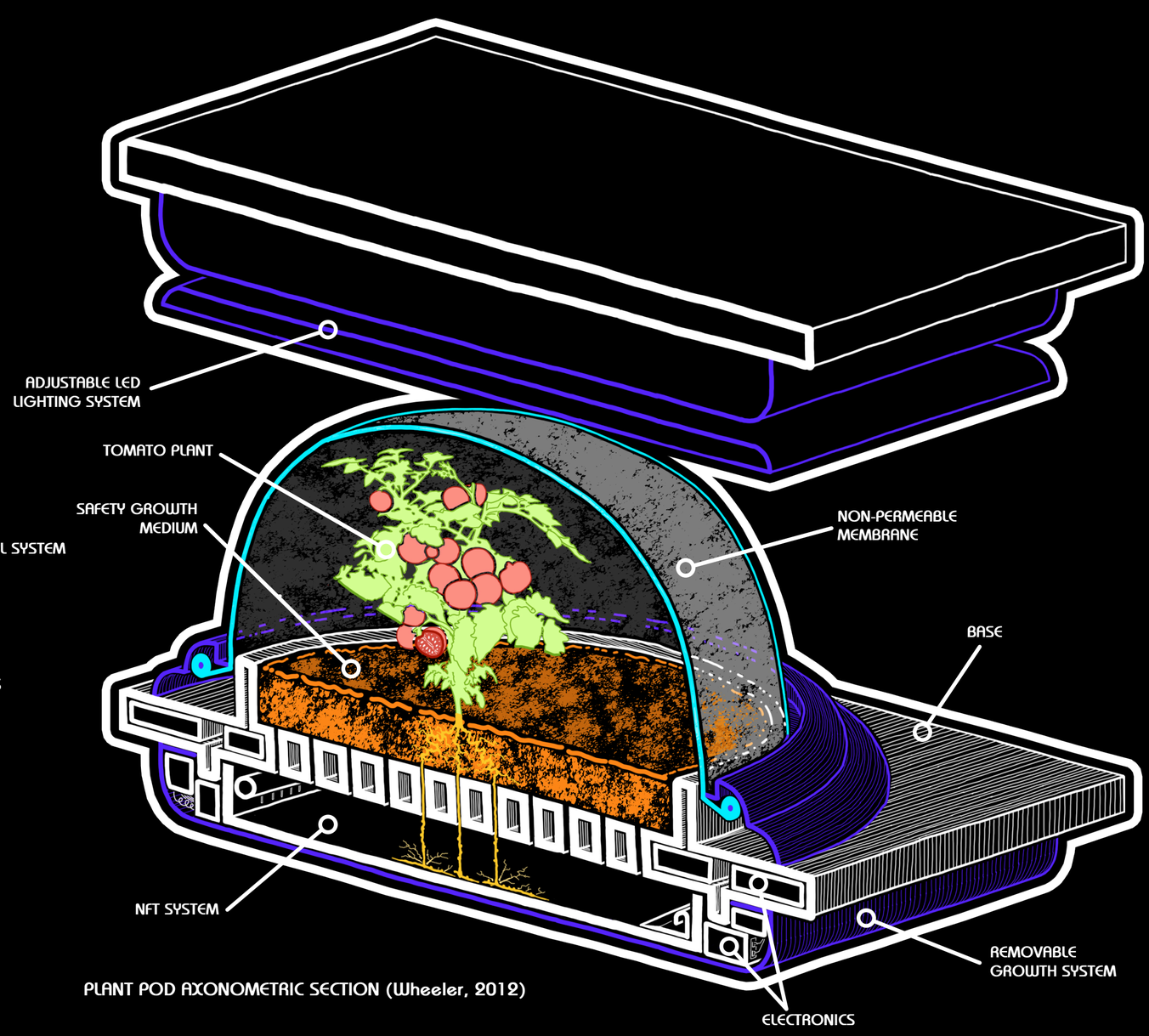
CALCULATED CROP CHART TABLE



SIDE VIEW SCALE 1:50



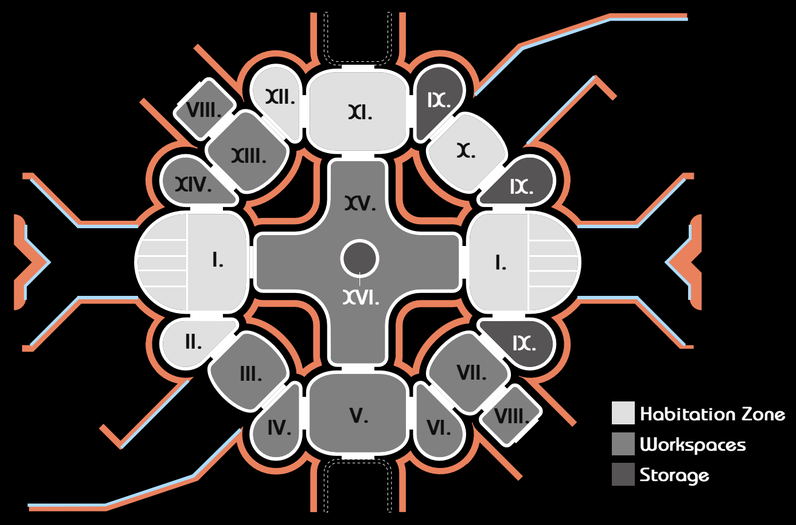
TOP VIEW SCALE 1:50

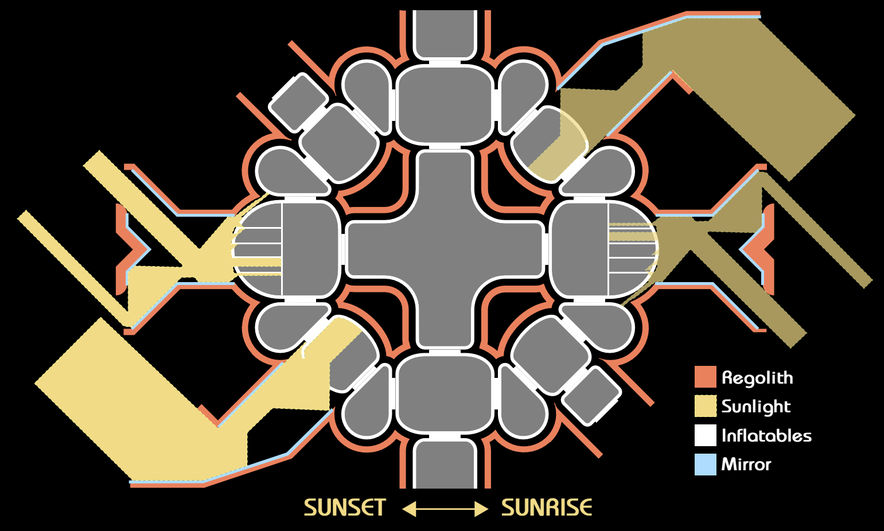


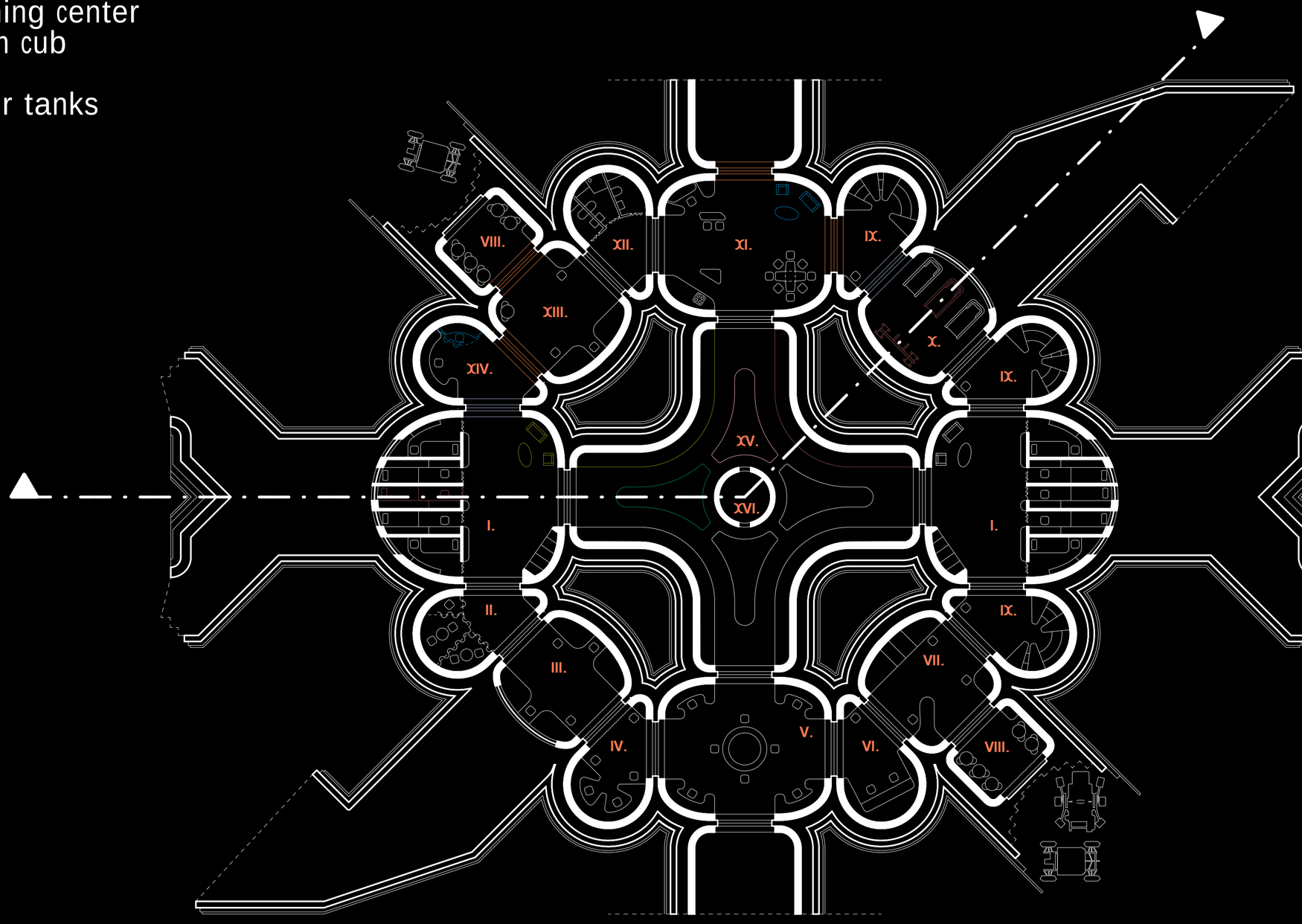
PLANT POD AXONOMETRIC SECTION (Wheeler, 2012)

FUNCTIONS

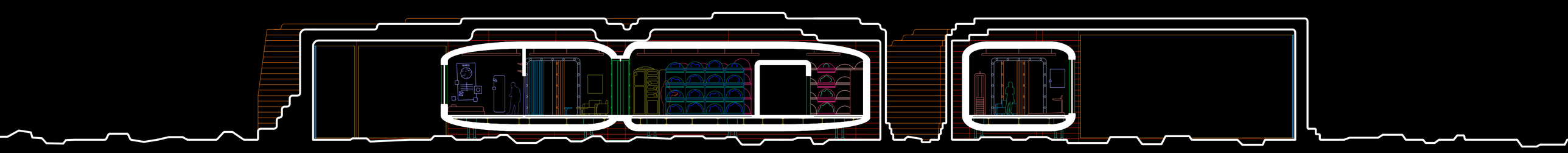
I. sleeping chambers
II. wellbeing
III. workshop
IV. sample processing
V. research lab
VI. ECLSS
VII. manufacturing
VIII. EVA
IX. storage
X. fitness
XI. kitchen
XII. hygiene
XIII. learning center
XIV. comm cub
XV. cells
XVI. water tanks



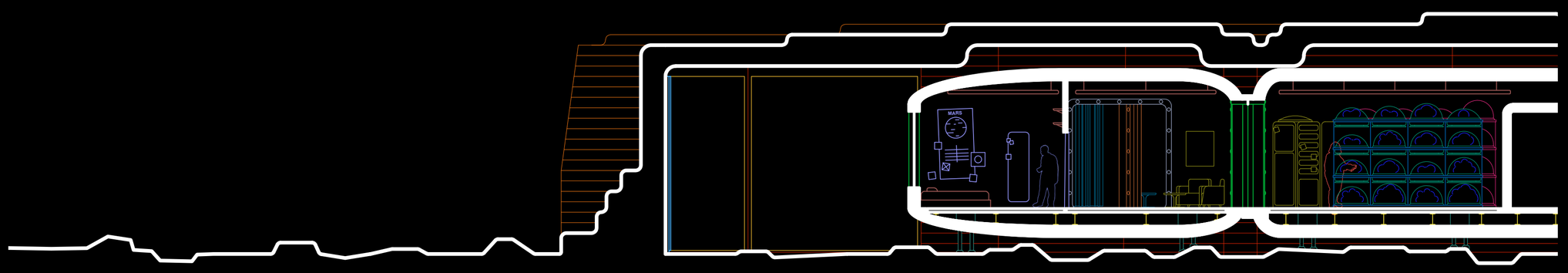




FLOOR PLAN SCALE 1:150



SECTION SCALE 1:150



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