Modular Mars Analog Settlements

BEYOND THE LANDER

KENT NEBERGALL

Lander versus Settlement Analog Goals

Lander Analog Goals	Micro-Settlement Analog Goals
• High Fidelity to Space-X MCT form factor (10 M Cylinder)	• Break functions into modules that can be transported and assembled on site.
• Six person crew	• Variable size depending on budget/goals.
• External Greenhouse Available (two zones)	• Much larger greenhouse that can provide food and psychological benefits. Integrated into habitat.
• Multiple out-buildings	• Contiguous but expandable structure.
• Each Crew has a “Discovery Factor” as if they just landed for the first time. • Continuity of Science Recording via the Remote Science Team	• Each crew should expect an existing system and knowledgebase of both the settlement and the surrounding landscape. • Knowledge should be stored on site and mirrored
• Science is simulated, but Engineering (structure) is locked	• Should be able to add and remove experimental habitat systems periodically.

Cost Advantages

Goals	Description
Design in segments that represent modular, lightweight components	• Roughly the scale of a 20 foot shipping container, but broken into parts that can fold flat and be assembled on site with small crew. • Can be built as paid for, so no massive funding wall to be scaled.
Variable Crew Size in Same Design	• Can start with two person construction shack and be scaled up to a subdivision.
Minimal Maintenance Costs	• Able to fully replace any broken or depreciated components without full overhaul of entire structure.
Construction Experimentation	• Can add experimental structures from university architects, etc. and remove when no longer appropriate.
More Sponsorship Opportunities	• Also an off-grid “home” with green energy systems and low-impact construction. Ideal for architectural, university, and vendor sponsorship of these systems.

Science Advantages

Goals	Description
Outdoor Data Management (seek sponsorship: Google/et al)	• Include central, purpose built database of land forms, local geology, and image storage. • Add to data set from drones, rovers, and EVA equipment. • Automatically log weather, etc. • Allow geologists/biologists to expand “wiki” as research expands, and submit reports after missions end.
Indoor Data Management	• “Smart house” features would optimize climate and energy use. • Can keep detailed records on maintenance, parts, etc. • Recording of indoor/outdoor interactions (temperature, etc.) to determine effectiveness of structures for improvement.
Lab Equipment Management	• Labview-type software (home grown, donated, or public domain) with interfaces to current and planned lab gear.

Site Scale Options

Goals	Description	Crew	Full	Arch	Base	Tower
Minimal Cabin Outpost	“399” cabin for early construction experiments.	2	3		2	1?
Generation 1 Outpost	Base model for expansion into full settlement building. 2 module Lab + 2 module greenhouse	2-4	8	2	4	1
Generation 1.5 Outpost	Second story added to base model. Two staterooms, two greenhouse modules.	4	**12**	2	4	1
Full Outpost	More staterooms, living space, full kitchen, second bathroom.	8	**19**	2	6	2
Extended Outpost	Control tower, observatory tower.	8	19	2	6	**8**
Extended Lab	Two story lab with Roof Drone Hangar.	8	**22**	2	6	8

Off-Grid/Analog Features

Goals	Description
Solar/DC power System	• Lighting and basic computer hardware is driven from solar panels and batteries, along with basic fans, etc. • It should be perfectly habitable without AC power. • Some in-line converters for AC plugs where appropriate.
AC Power System	• Used mainly for HVAC, recharging batteries if low, and any hi power situations such as construction.
Gray water Recycling	• Gray water is filtered, sterilized and used to water plants. • If used in desert environment, will also provide humidity to cabin. • Dependent on high grade system being donated – too dangerous to improvise systems.
Composting Toilets/ Separate Urinals	• Integrated into system directly. Simplifies waste disposal (NOT recycled in greenhouse).

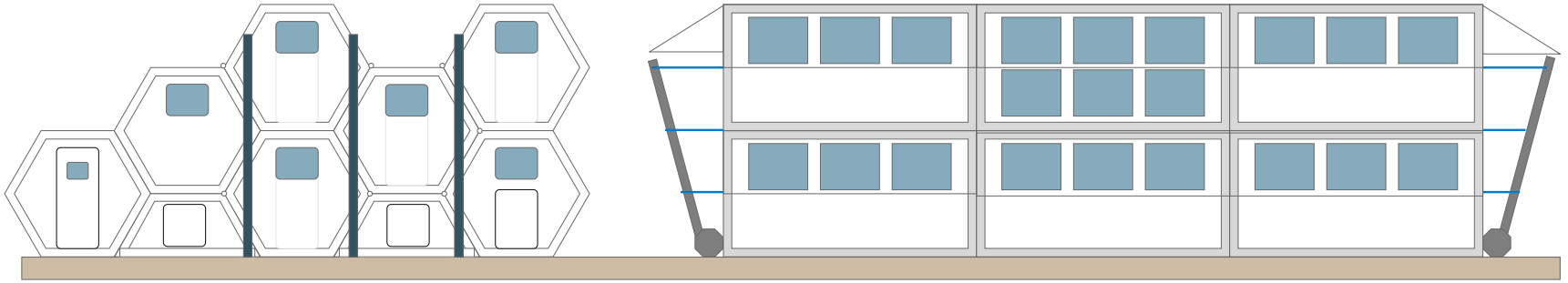
Crew Psychology

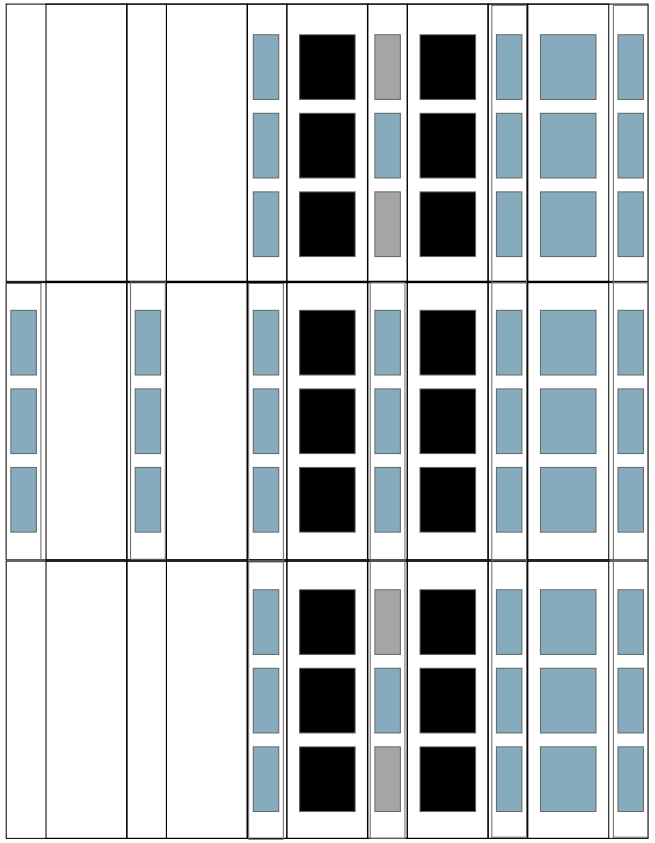
Goals	Description

Avoid the “Tin Can” feel and make a permanent home.	• Very important to Mars settlement psychology
	  • Crew mental health
	  • Public acceptance of settlement concept

Extensive Green Space	• Provides a double digit percentage of food supply. • Gives “outdoor/nature” space even when indoors/desert.
Lighting and Sound Control	• Keep fan/pump/etc noise as close to silence as possible. • Use blue lighting for wake-up, white for work, red for sleep time.
Ultimate goal – “Dream home” feel	• Design Goal: Our biggest problem with crew psychology is that we will have to drag them kicking and screaming out of the airlock when their rotation ends.

The Design

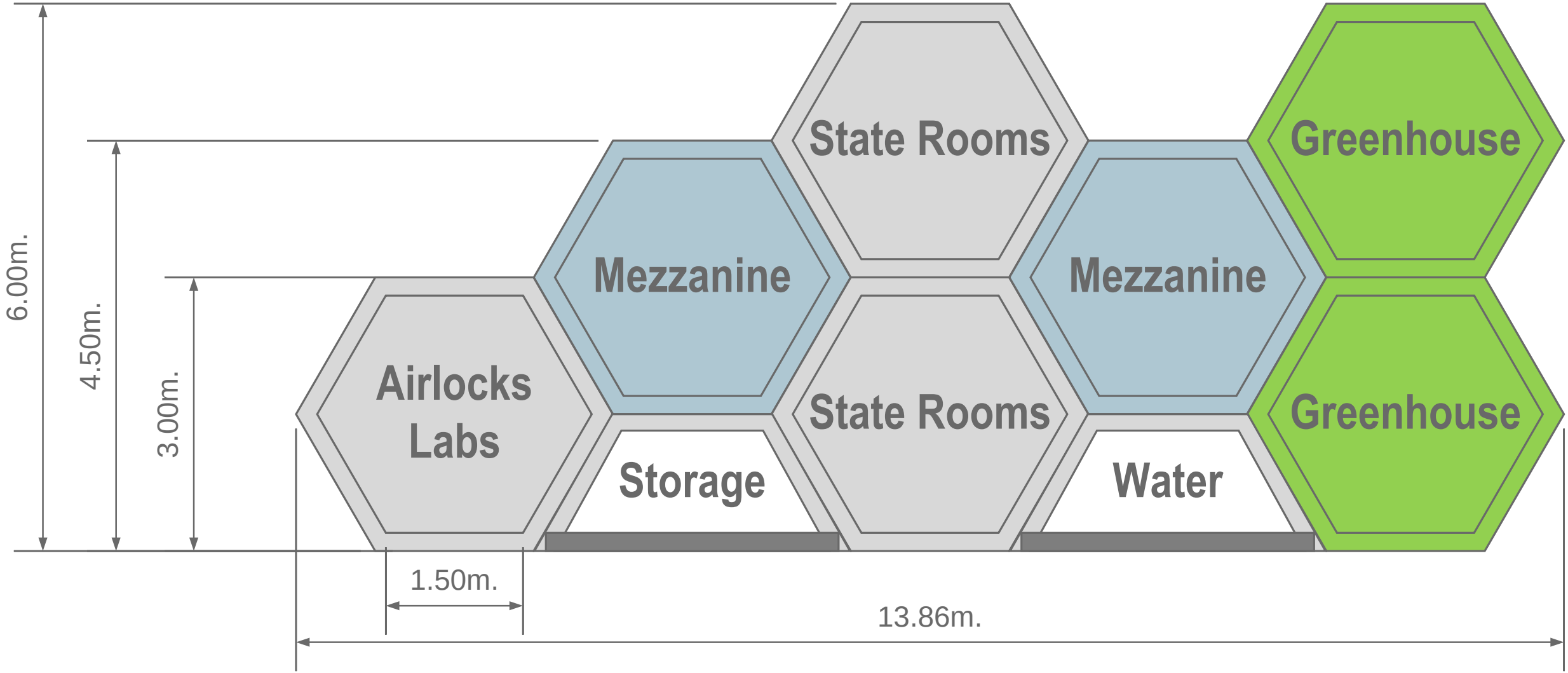


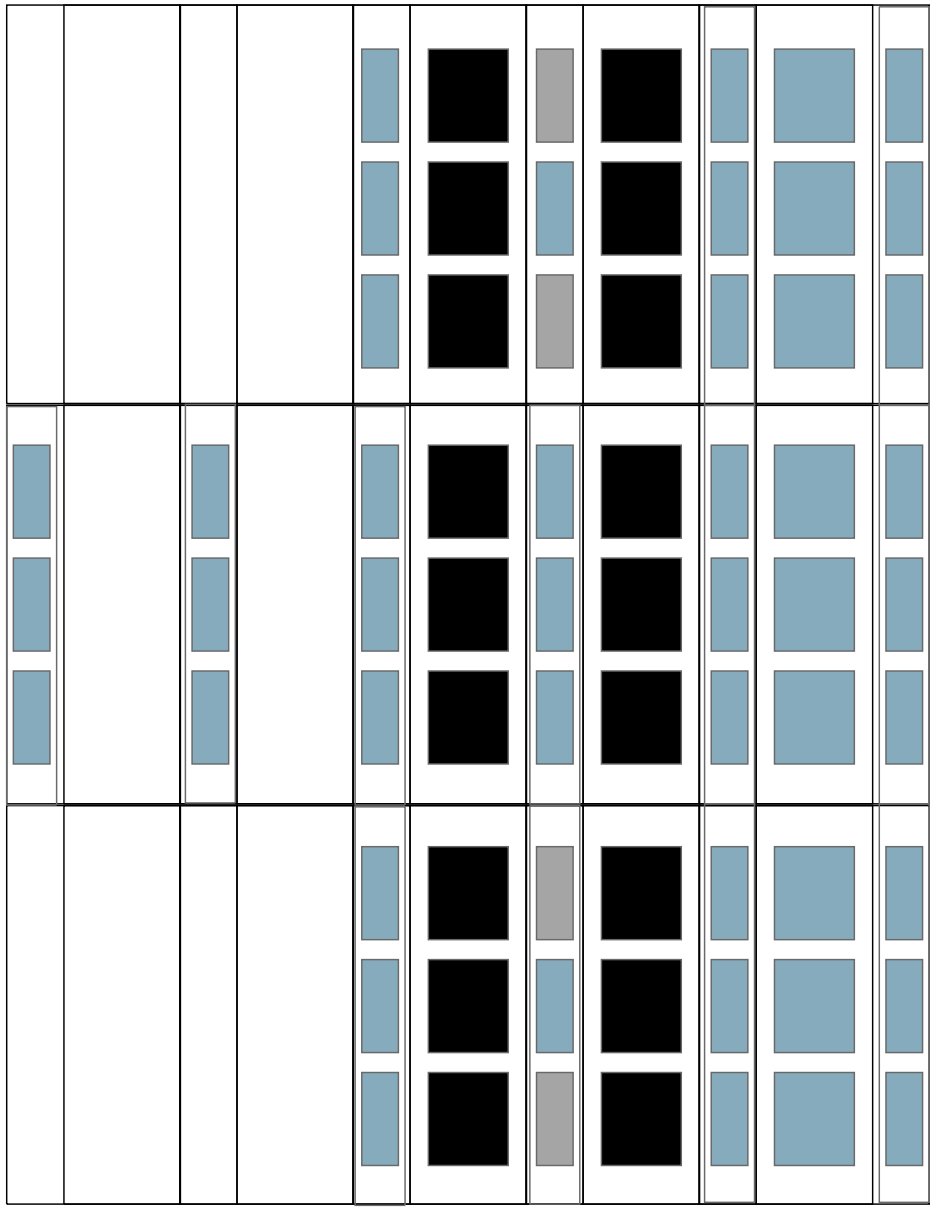


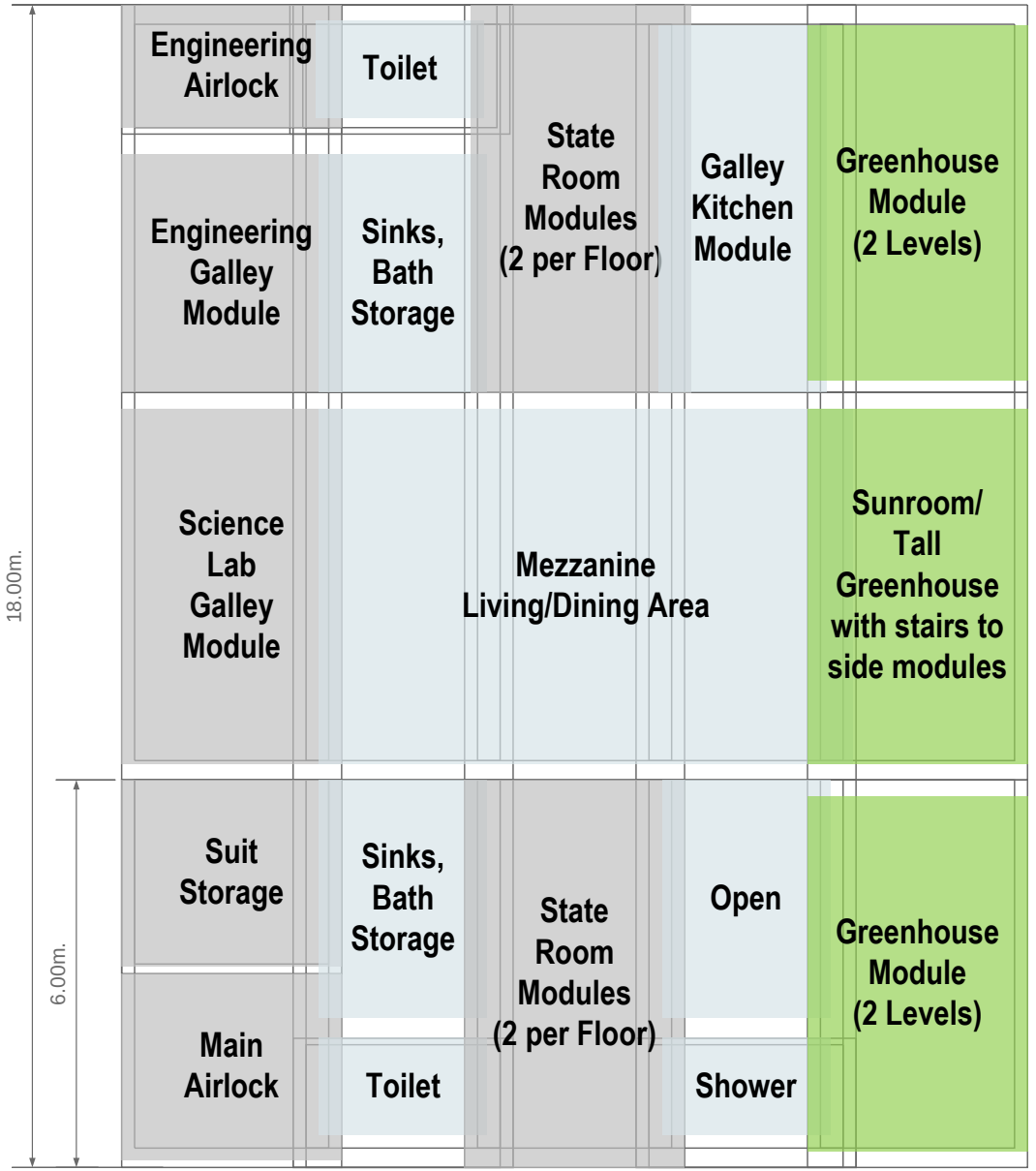
Windows

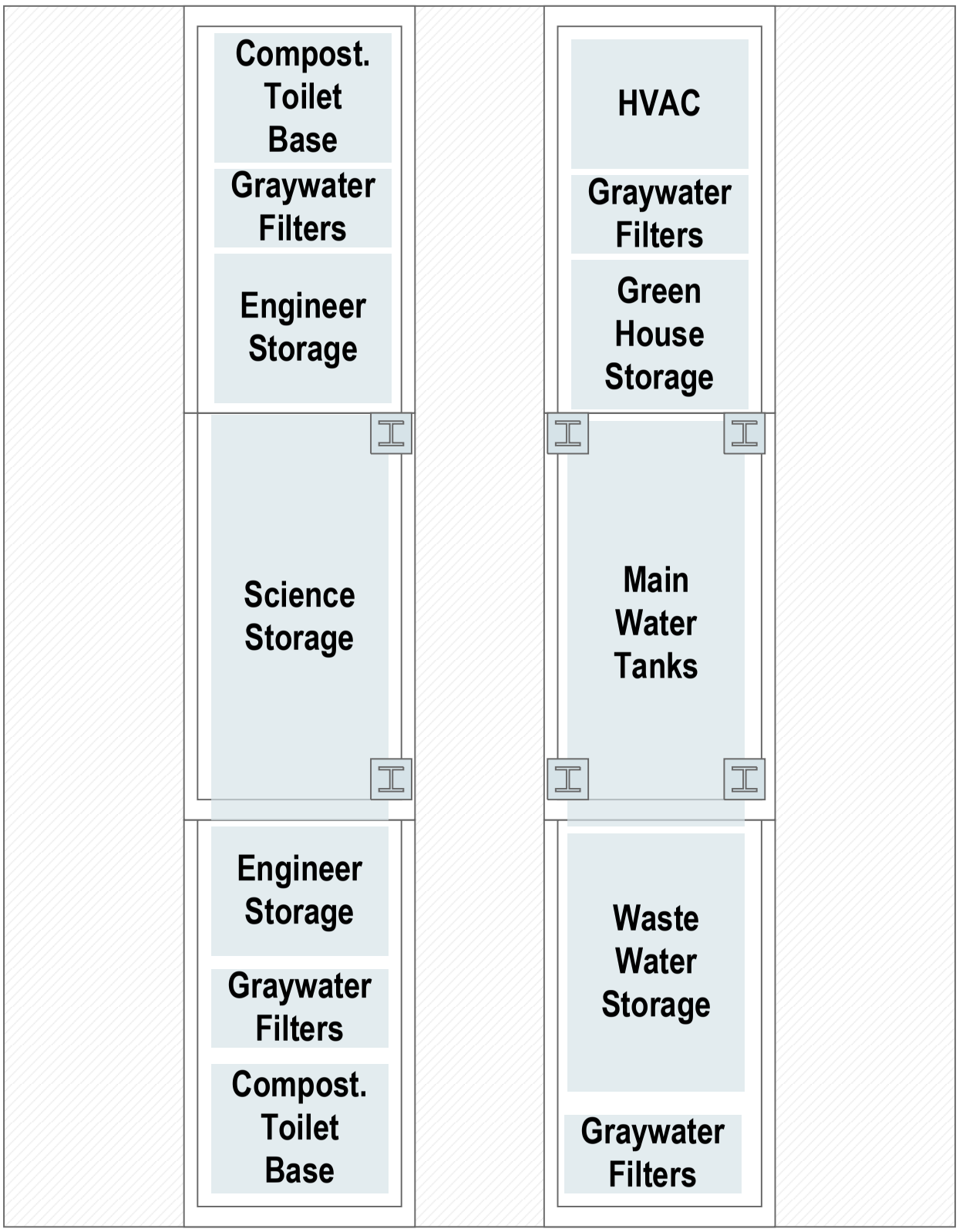
Solar Panels (30.24 m2)

Mirrors



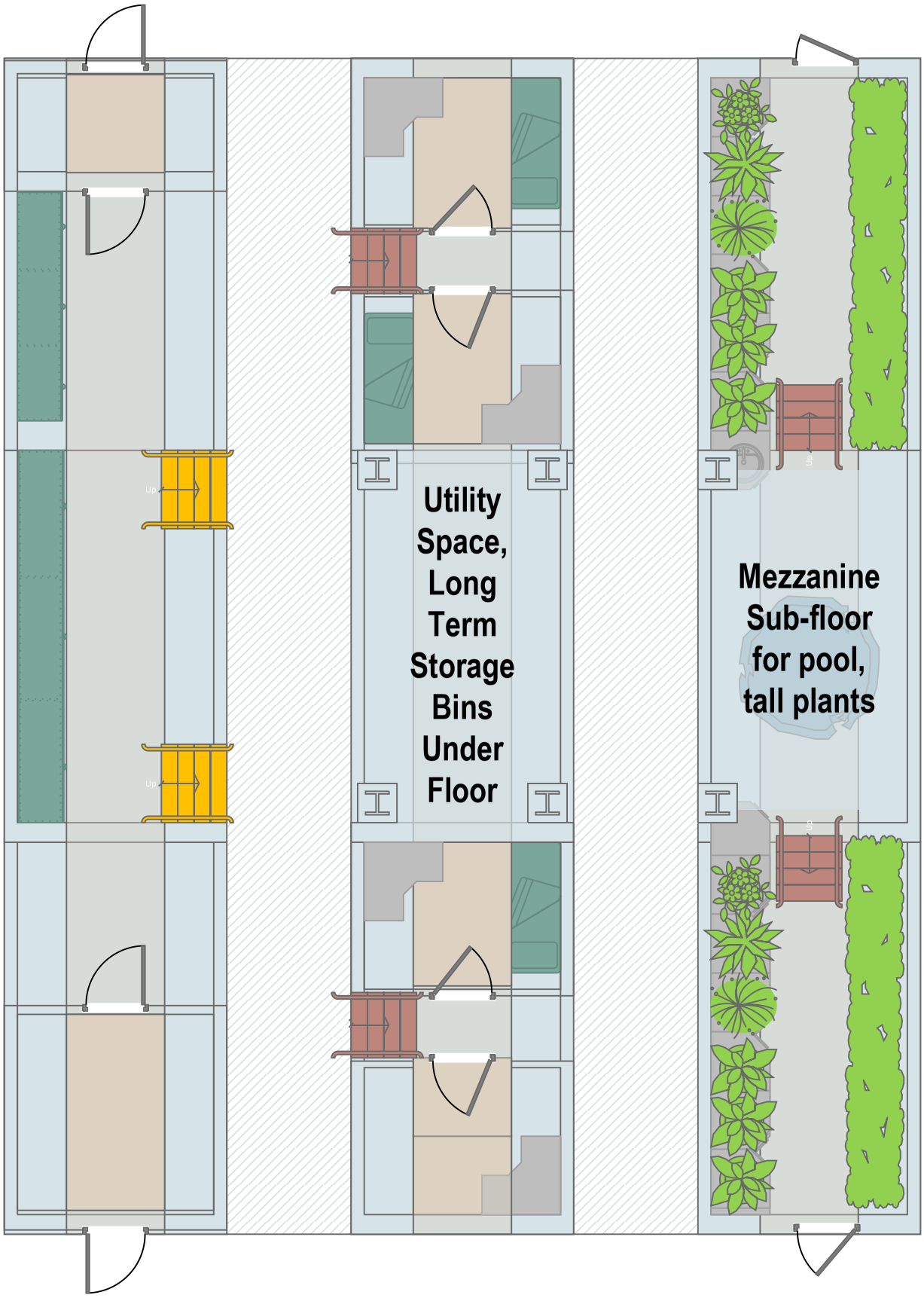


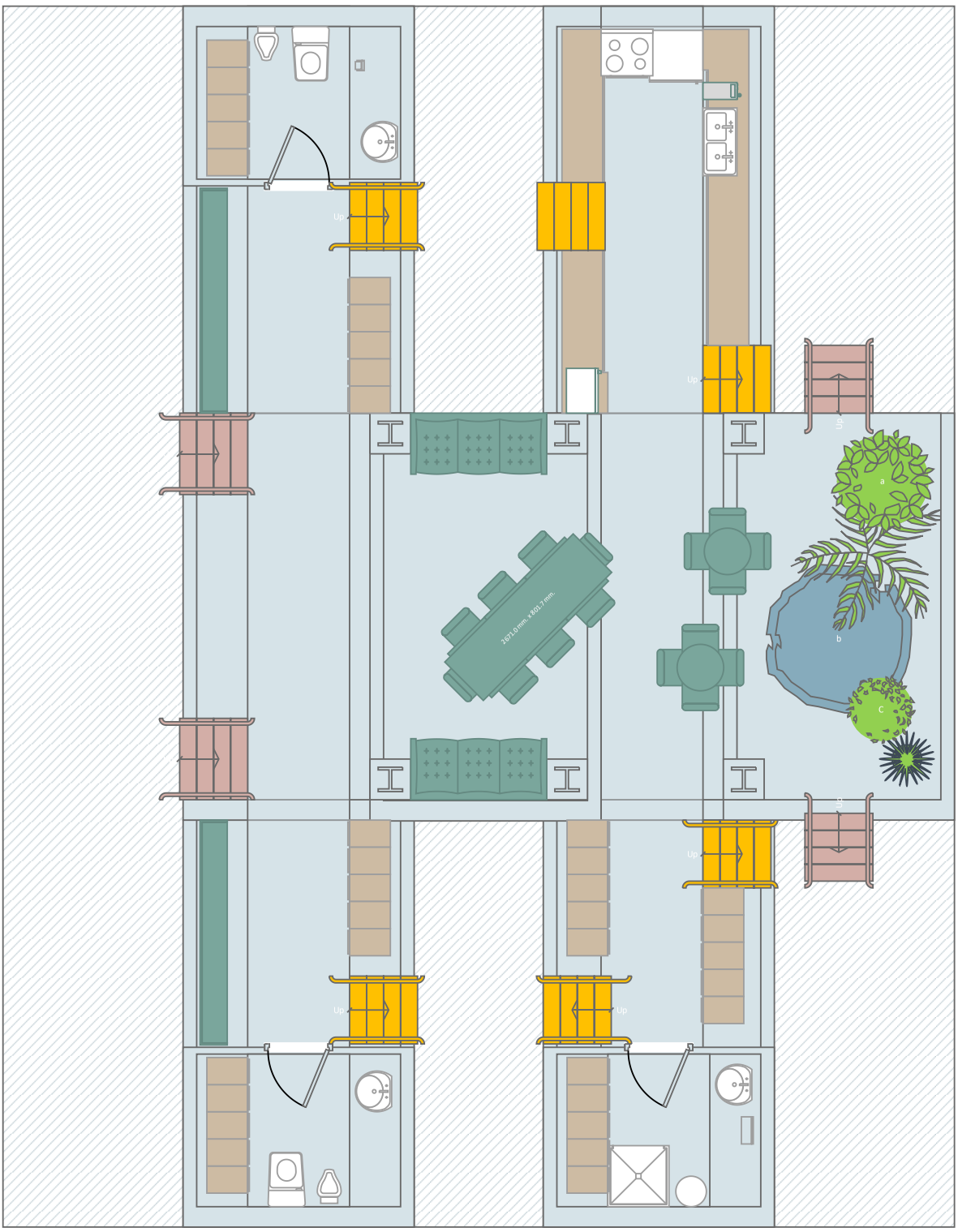


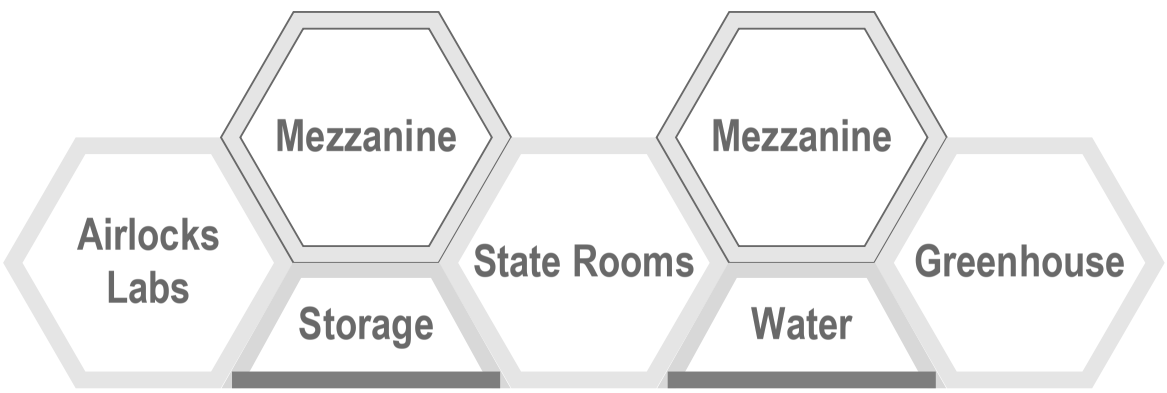


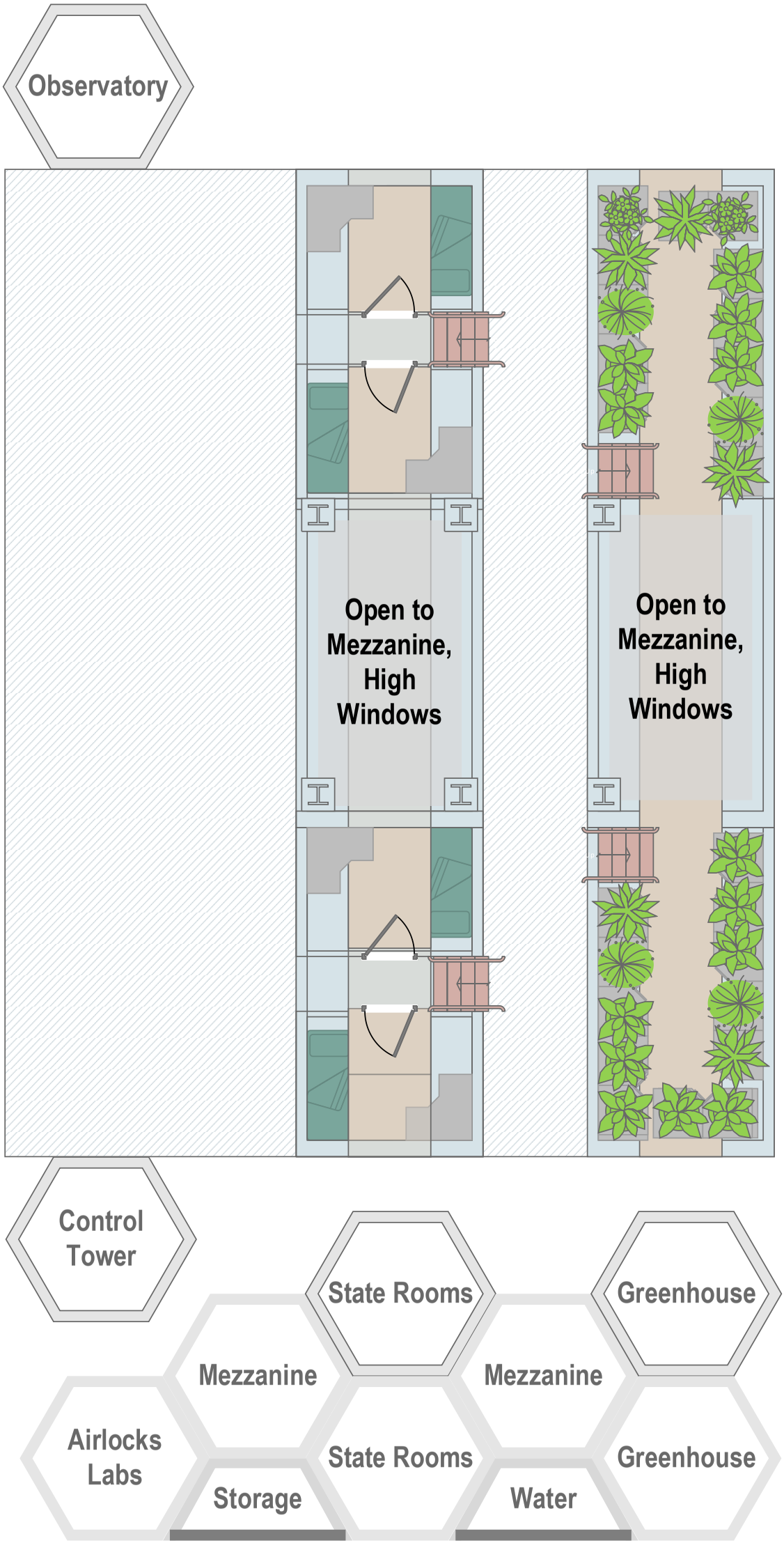
Storage

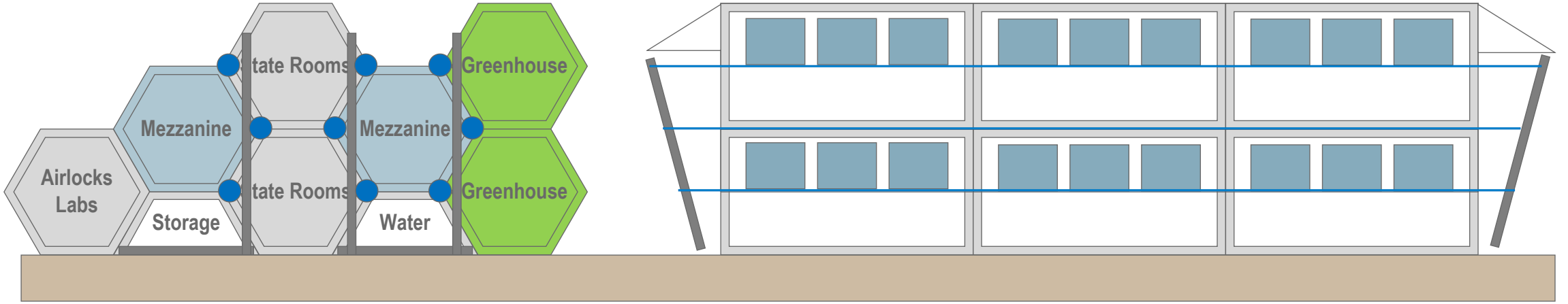
Water











Expansion Options

Goals	Description
Hexagonal Tower “Tunnels”	• Can connect both similar and dissimilar structures to the main building.
Geodesic Dome Workshop	• High greenhouse for trees, integrated aquaponics with fish, etc. • Large structures could have garden, small pool, etc.
Quonset or Hex-Hangar Workshop	• Vehicle storage and repair • Exercise equipment • Common theater/etc. space
Second Settlement	• Additional buildings like the settlement can be added. • Should be done with “bypass” walkways to avoid cutting through other team’s labs or kitchens to get from one place to another.

Application to Mars Surface

Goals	Description
Air Pressure and Hexagons	• Hexagons are braced against each other, so most modules have no pressure differential. • Outer spaces for plants do not need full atmospheric pressure. • Can have internal airlocks and semi-pressure suits with breathing equipment for greenhouse work.
Cosmic Ray shielding	• Add one layer of modules above the habitat and fill with reinforced ice for cosmic ray, meteor, and thermal change protection. • Also caps atmospheric pressure inside.
Towers	• Would connect structures in base to other structures and to the surface airlocks.
Food Growth	• Stored food looses nutritional value if exposed to radiation • Settlers would grow and dehydrate food for crews returning to Earth.

Questions?

Kent Nebergall

kent@macroinvent.com

MacroInvent.com