Insight Surface Base Design

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Presented to the Mars Society Conference, October, 2021
Slides and speech notes follow.
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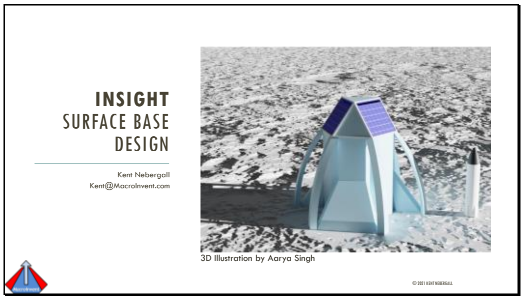
Slide 1



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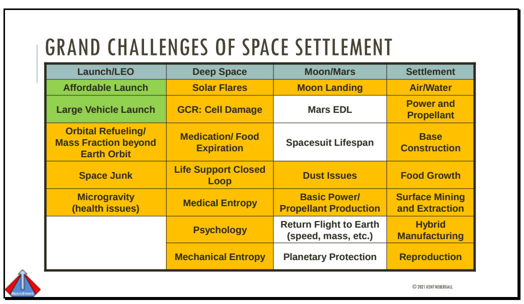

Launch/LEO	Deep Space	Moon/Mars	Settlement
Affordable Launch	Solar Flares	Moon Landing	Air/Water
Large Vehicle Launch	GCR: Cell Damage	Mars EDL	Power and Propellant
Orbital Refueling/ Mass Fraction beyond Earth Orbit	Medication/ Food Expiration	Spacesuit Lifespan	Base Construction
Space Junk	Life Support Closed Loop	Dust Issues	Food Growth
Microgravity (health issues)	Medical Entropy	Basic Power/ Propellant Production	Surface Mining and Extraction
	Psychology	Return Flight to Earth (speed, mass, etc.)	Hybrid Manufacturing
	Mechanical Entropy	Planetary Protection	Reproduction

<Grand Challenges>
Here is my usual table of the grand challenges of space settlement. It starts at the top left, with each column representing the challenges at a given distance from Earth.
SpaceX Starship breaks the top corner.
That enables the path forward.
By using starship as a foundation, we open all the challenges shown in orange. It allows us to solve most of the problems of becoming a multiplanetary species.

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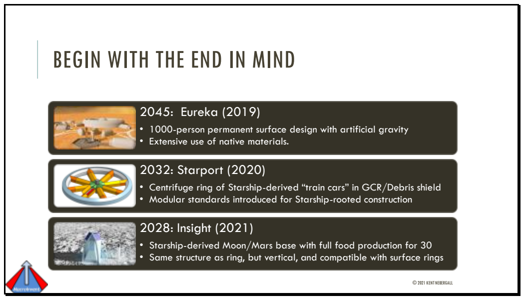

<Design History>
In 2019, I presented the thousand-person settlement on Mars called Eureka.
But since it was a surface city, it did not cover issues like orbital refueling or debris.
So the following year, I presented Starport. While this was designed as a logistics solution, it also lets you put a large space city of up to 1000 people anywhere in the solar system.
However, there is still a major gap between first landings and permanent outposts.
So this year will close that gap with the Insight surface base.

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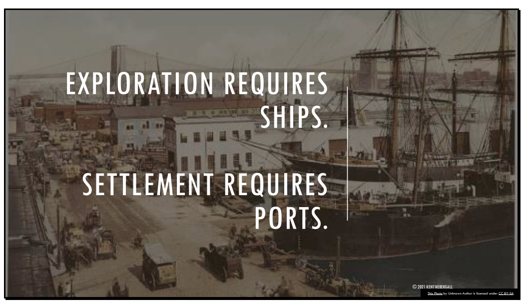

<Ports>
The principle is simple. You must transition from ships to ports to make any permanent gains. Otherwise, you are just visiting.

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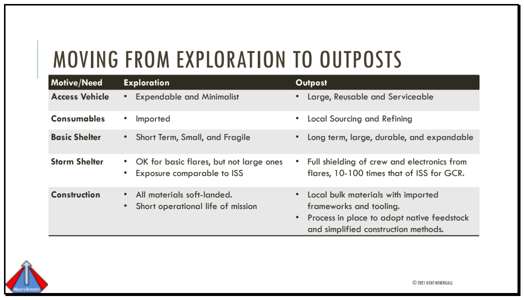

Motive/Need	Exploration	Outpost
Access Vehicle	• Expendable and Minimalist	• Large, Reusable and Serviceable
Consumables	• Imported	• Local Sourcing and Refining
Basic Shelter	• Short Term, Small, and Fragile	• Long term, large, durable, and expandable
Storm Shelter	• OK for basic flares, but not large ones • Exposure comparable to ISS	• Full shielding of crew and electronics from flares, 10-100 times that of ISS for GCR.
Construction	• All materials soft-landed. • Short operational life of mission	• Local bulk materials with imported frameworks and tooling. • Process in place to adopt native feedstock and simplified construction methods.

<Moving to Settlement>
The transition from exploration to commerce is complex, because many of the engineering goals are exact opposites.
Exploration means traveling light for short periods. Exploration systems like Apollo do not translate well to the heavy, permanent structures of long-term habitation.
However, even with Starship, the conversion is complex. Because the two design languages are entirely different.

We need to think more like plumbers and electricians than rocket scientists.

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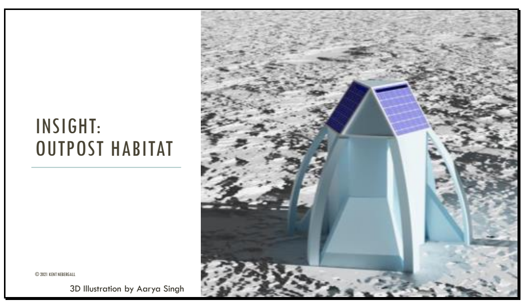

<Insight Hab>
So on to Insight. There are three main building types. This is the outpost habitat.

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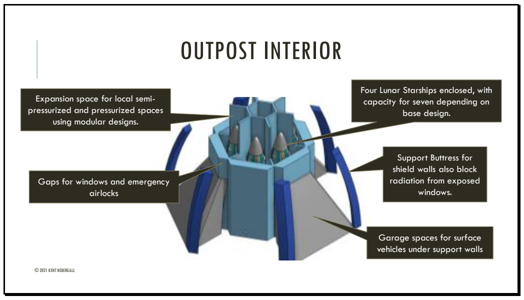

<Outpost Interior>

We park four Lunar Starships next to each other on a foundation. Then we build a walls to block radiation and thermal stress.

The walls are built of frames brought from Earth. These frames are then filled with essentially interlocking sandbags. These bags are filled with moondust and sintered with microwaves once settled in place.

Settlers will use the extended tower workspace like an unfinished basement. They will determine how much atmospheric pressure it can hold and extend living spaces into it.

In the early stages, the fuel tanks of the Starships will be converted to LED greenhouses to sustain the outpost. One starship can feed and house ten settlers in this way. This drastically reduces food imports from Earth. So the tower can hold forty people in this configuration.

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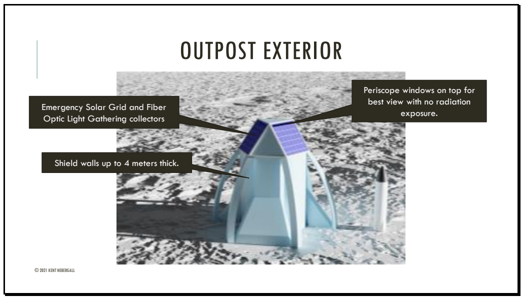

<Exterior>
The exterior of the structure has emergency solar panels, fiber optic light gathering systems for the greenhouses, and periscope windows. Using periscopes like this gives the settlers at any level of the habitat a top-floor view.
Note the lunar starship for scale.

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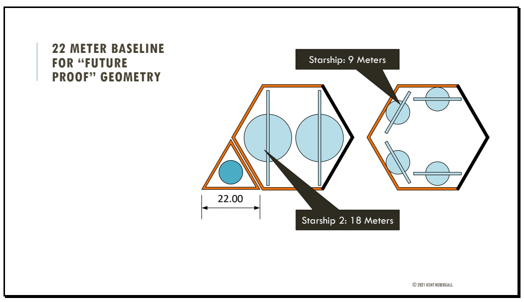

<Geometry>
The hexagon structure has a 22 meter baseline to keep the foundations future proof.
We want these hexagonal structures for space settlement to allow for future Starship designs of 18 meters in diameter or larger.
Settlement designs must have an architecture that can be maintained in living economies over centuries, just like in our homes today. We must used standard sizes for construction, pipes, brickwork, and so on for maintenance.

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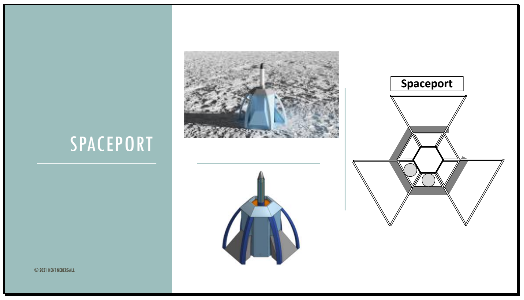

<Spaceport section>
Now onto the spaceport.

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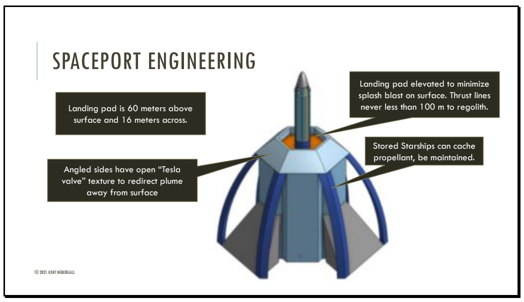

<Spaceport exterior>
The goal of the spaceport is to get the exhaust plumes of arriving spacecraft as far from the surface rock as possible. In this configuration, a visiting starship's exhaust plume is never closer than 100 meters from the surrounding surface.
The angled panels have an open-faced pattern of tesla valves to redirect the plume back on itself. This would help protect the panels from blast damage.
Yes, the central elevator was inspired by the ones in 2001 and Space:1999.

The area within vicinity of any landing site would also be scrubbed of dust during construction.
A tower with vehicle catch arms could be added. This would also allow easier crew access.
As with the Habitat, up to seven starships could be housed inside. Some would be converted to fuel storage for oxygen made locally on the moon, or both propellants on Mars.

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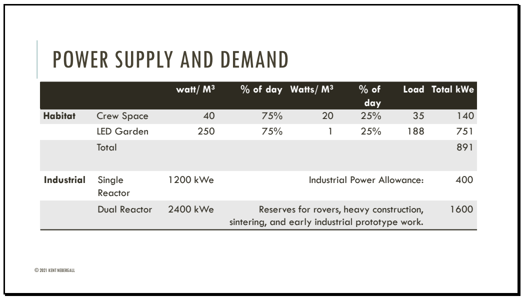

<Power Supply/Demand>
These greenhouses will consume most of the electrical power. We also need to allow for industrial capacity.

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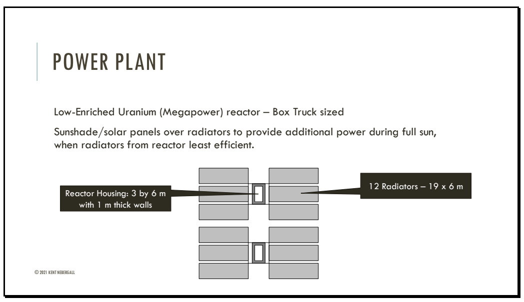

<Power Plant>
So, the power plant is meant to be cheap, long lasting, and low maintenance. Low enriched uranium is much easier to work with and lasts longer, even though it doesn't make quite as much heat as conventional reactors. It can still meet all the base needs for LED greenhouses with one reactor.

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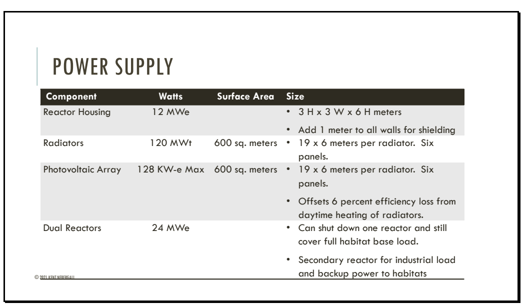

<Power Supply>
So here is the power supply. Dual reactors provide industrial capacity when both are working, and backup power during maintenance.
Each fits in a small shipping container. We can shade the radiators with solar panels so that if they get too warm in daylight, the solar panels make up the difference. At night, the solar panels are useless, but the radiators work at peak efficiency. This configuration works on both the moon and Mars.

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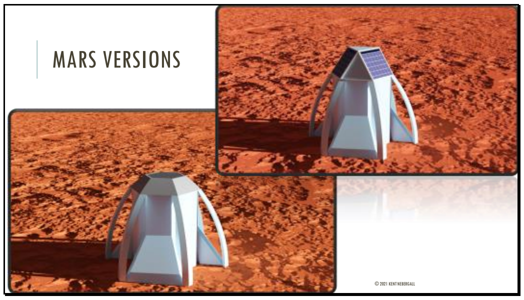

<Mars Versions>
So here is the Mars version. Yes, the terrain is tinted from the moon picture.
But the wall construction methods are different as well.

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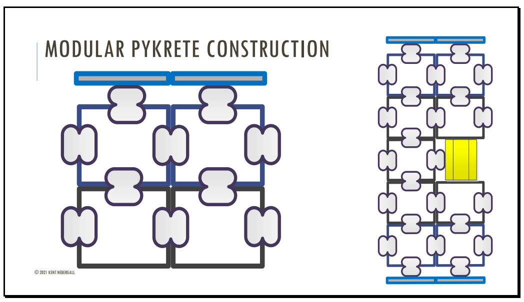

<Pykrete Construction>
Naturally, on Mars we use a different construction material. The frames and bags are similar to those on the lunar version. Except on Mars, we can fill the outside bags with reenforced water ice that is harder than traditional concrete. The bags use expansion seals between bricks to retain an atmosphere. Interior bricks near the warm living spaces would be more like clay brickwork.

Note the seals shown here are larger than in real life so you can see them better. This same ice construction methods can be used in low earth orbit for debris shielding, or deep space for cosmic ray shielding.

Insight Surface Base Design
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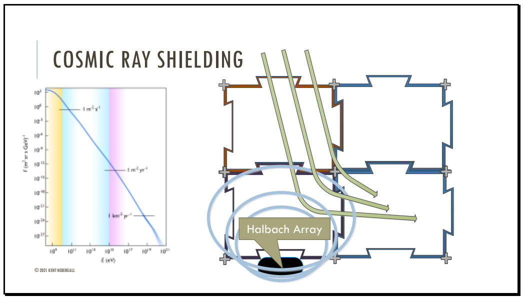

<Cosmic Ray Shielding>
We can make the walls thinner by adding Holbach array magnets to the inside wall. This would force cosmic rays to take a longer path through the ice or dust shielding material before reaching the interior. Low energy cosmic rays are much more plentiful than high energy ones. And the magnets would deflect lower energy particles more than high energy ones.

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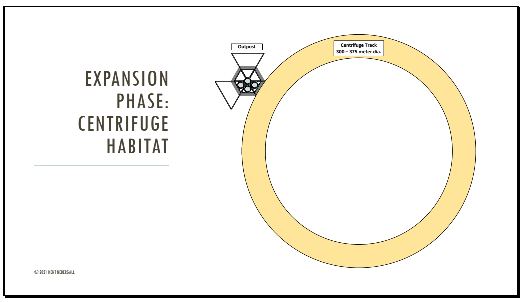

<Ring Layout>
In the long term, we can use the outpost as a construction shack and access point for a centrifuge habitat.

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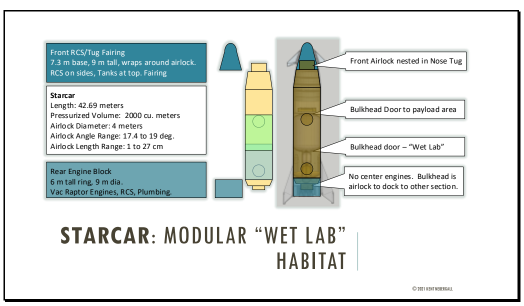

<WetLab Habitat>
This is the "Starcar" design. It is the rail car to go inside the centrifuge track. The car is basically a starship that can be converted into a habitat with airlocks on both ends.

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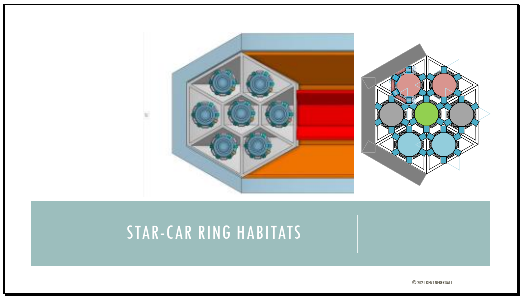

<Ring Habitats>
This is the original orbital design for a seven-track ring of star-cars. At ten people per starcar, this is a population of 1200 people.

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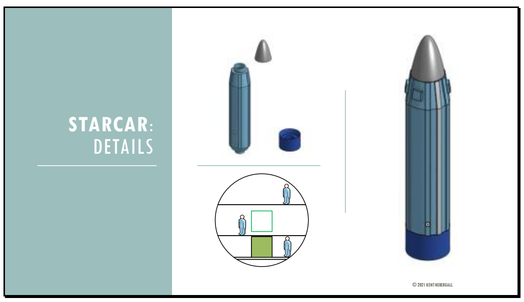

<Starcar Details>
Removing the rear center engines opens a 2-meter central walkway all the way through the vehicle.
Would also have side hatches to get in and out from adjoining systems.
The gray rail shown here would be for a fiber optic light input from a mirror complex outside the ring. It would feed the greenhouses inside.

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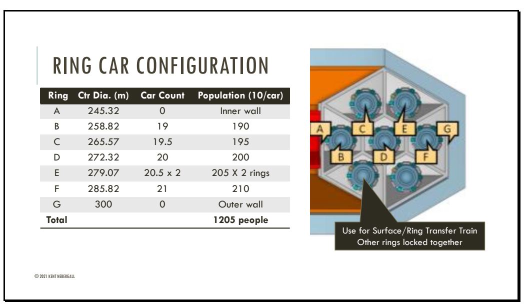

Ring	Ctr Dia. (m)	Car Count	Population (10/car)
A	245.32	0	Inner wall
B	258.82	19	190
C	265.57	19.5	195
D	272.32	20	200
E	279.07	20.5 x 2	205 X 2 rings
F	285.82	21	210
G	300	0	Outer wall
Total			**1205 people**

<Ring Car Configuration>
Since last year, I worked out the perfect length for the cars and the rings. In this design, one additional car will expand the ring exactly the right diameter to surround a smaller interior ring. There would also be half-length cars for the top and bottom tracks.
My original estimate for starcar length was 43 meters. The perfect design, it turns out, is a car 42.69 meters long, or only 31 centimeters off from the original estimate. I was just happy the perfect diameter even existed. My

original design included custom docking adaptors for each ring size. The coupler angles between cars will vary by roughly 4 degrees between rings, and the lengths vary by 3.5 centimeters. So a single coupler design with bushings should work for rings with 17 to 21 cars, with larger rings possible if the train couplers have broader angle ranges.

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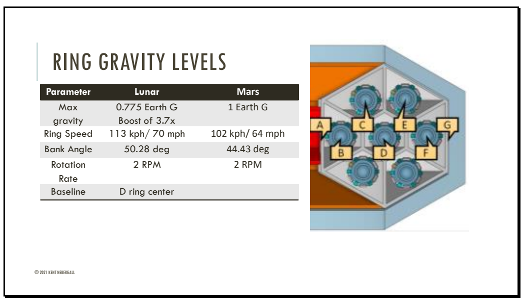

<Ring Gravity Levels>
A basic ring can boost lunar gravity from 12 to 78 percent of Earth gravity. It can also be anything in between, if needed for biology or industrial experiments. A Mars version can reach Earth gravity.
One ring track is purely for getting people and cargo to and from the surface, so it slows to a stop and accelerates to match the other cars as needed. Keeping the cars separate allows one track to be stopped and maintained while others continue to rotate. They would have magnetic lateral docking ports to get from cars in one ring to another.

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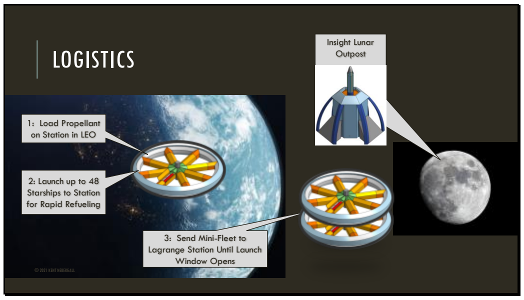

<Logistics>
So this adds to combined Earth-Moon-Mars logistics system. This allows us to send large, fully fueled fleets to Mars every 26 months from L5. These settlers can spend month in deep space getting used to the conditions before committing to the journey. The Insight outpost extends this to the Lunar surface. Similar outposts would be on Mars and Phobos.

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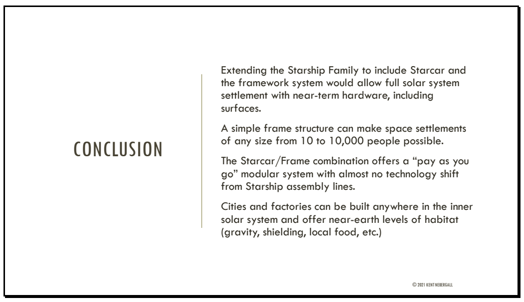

<Conclusion>
So what we have is a clear path forward with the simplest construction methods using minimal changes to Starship. It takes full advantage of local materials and bridges the gap to build full ports. And it can be scaled from ten to 1200 people per ring, and clusters of rings can hold entire cities. It cracks the entire learning and finance curve for space settlement in a single, simple basic design.

Slide 26

<Thanks!>
Here is my contact information.
Thanks! Any questions?

Slide 27

<Thanks!>