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ICON ENGINEERING CONCEIVES NEW DIMENSIONS THAT WILL ENABLE THE EXPANSION OF HUMAN LIFE ON AND BEYOND EARTH.

OUR MISSION is mainly based on the field of engineering (especially aerospace engineering), but also involves diverse disciplines such as physiology, psychology, and sociology.
Like architecture on Earth, the attempt is to go beyond the component elements and systems and gain a broad understanding of the issues that affect design success.

IN SPACE
Fundamental to space architecture is designing for physical and psychological wellness in space. What often is taken for granted on Earth – air, water, food, trash disposal – must be designed for in fastidious detail.
A starting point for space architecture theory is the search for extreme environments in terrestrial settings where humans have lived, and the formation of analogs between these environments and space.
For example, humans have lived in submarines deep in the ocean, in bunkers beneath the Earth's surface, and on Antarctica, and have safely entered burning buildings, radioactively contaminated zones, and the stratosphere with the help of technology.

ARCHITECTURE on the MOON and MARS
Architecture on Earth plays a critical role in the way we live. On the Moon first and later on Mars, this reaches a higher level of importance since buildings are also machines we depend on to keep us alive and well.
In Space architecture, every design decision is of great consequence to the success of a mission. Structures must be resilient and interior layouts must be tuned to mission demands. And yet, since sustained social and mental health are also mission-critical, Space habitats must be designed to be rich, useful and interesting worlds onto themselves.
Lunar and Martian architecture usually falls into one of two categories: architecture imported from Earth fully assembled and architecture making use of local resources.

On the MOON
lunar structures can be built utilizing indigenous materials.
The locally available materials include lunar regolith, cast regolith, glass and glass composites, metals and concrete. Their mechanical properties are summarized and their suitability for lunar construction is evaluated. The most materials are cast regolith and lunar glass. Several lunar bases concepts utilizing indigenous materials are described and evaluated. Precast modules and large cast in place structures can be fabricated from lunar concrete. Large cylindrical modules, curved and flat panels and arches cast from lunar regolith are also feasible.
The basic ingredients for lunarcrete would be the same as those for terrestrial concrete: aggregate, water, and cement. In the case of lunarcrete, the aggregate would be lunar regolith. The cement would be manufactured by beneficiating lunar rock that had a high calcium content. Water would either be supplied from off the Moon, or by combining oxygen with hydrogen produced from lunar soil.

Several approaches have benn suggested to use **Lunar** or **Martian** aggregate in extraterrestrial construction. These approaches include hot pressing of Lunar soils producing cements and concretes of various types and microwaves irradiation to sintering of Lunar soils. Another alternative is also highly present: that of using sulfur found on the Moon and Mars to produce building materials and Structure elements.

Sulfur, which is widely available **On MARS**, can take the place of water and bind the concrete together.
Sulfur concrete made with Martian soil came out twice as strong as its Earthly counterpart, because the sulfur bonds chemically with the minerals found in Martian soil, whereas on Earth the sulfur only serves as glue for the gravel. Furthermore, since gravity on Mars is one-third what it is on Earth, the strength is effectively tripled.
This material, then, has the strength needed to construct a shelter. But it also solidifies in an hour or less. Even fast-setting concrete takes 24 to 48 hours, and regular concrete needs up to 28 days to set. That makes sulfur concrete much more attractive for 3D printing.

The substance can also be melted down and recast, so it’s reusable. The main drawback, is that it’s not very resistant to high temperatures; if a sulfur concrete building catches fire, the heat could melt the material.

Sulfur concrete is a composite construction material, composed mainly of sulfur and aggregate (generally a coarse aggregate made of gravel or crushed rocks and a fine aggregate such as sand). Cement and water, important compounds in normal concrete, are not part of sulfur concrete. The concrete is heated above the melting point of sulfur ca. 140 °C in a ratio of between 12% and 25% sulfur, the rest being aggregate.
After cooling the concrete reaches a high strength, not needing a curing like normal concrete. Sulfur concrete is resistant to some compounds like acids which attack normal concrete, however unlike ordinary concrete, it cannot withstand high heat, thus it is not fire resistant. Sulfur concrete was developed and promoted as building material to get rid of large amounts of stored sulfur produced by hydrodesulfurization of gas and oil.

In later missions, bricks could be made from Lunar / Martian regolith mixture for shielding or even primary, airtight structural components.
The environment on the Moon and Mars offers different opportunities for space suit design, even something like the skin-tight Bio-Suit.

Lunar regolith can also be used for the production of methane, for use as rocket propellant. A process for producing hydrogen and oxygen from the lunar regolith; however, the amount of regolith needed to be processed and the energy needed for the processing were quite high. Methane, if it can be produced, has advantages with respect to the use of lunar hydrogen in that it is more easily stored and should be less easily lost from the production process, although it provides lower performance in rocket engines than hydrogen.
As for Mars, Using hydrogen imported from Earth with carbon dioxide from Martian atmosphere, the Sabatier reaction can be used to manufacture methane (for rocket propellant) and water (for drinking and for oxygen production through electrolysis).

HIGH PERFORMANCE ECO MATERIALS
Our buildings are printed with natural and recycled composite materials which are stronger and more durable than concrete. It's a simpler, more sustainable solution for building on and beyond this planet.
Using fibers known to be found on the Moon/Mars and materials that are effective shields for radiation PLA (renewable bioplastic-polylactic acid-processed from plants grown on the Moon and Mars), we achieved our recyclable polymer composite that would outperform concrete in Lunar and Martian environmental conditions.

So, our composite will be:

Super Strong
Basalt fiber is known for its superb tensile strength. It's comparable to carbon fiber and kevlar yet much simpler to produce.
Shields Radiation
Due to their low overall atomic weight, plastics are effective shields for ionizing cosmic radiation.
Mission Renewable
PLA is a strong thermoplastic that is recyclable yet and has the added benefit of in-situ manufacture.
Dimensionally Stable
PLA has lowest coefficient of thermal expansion among plastics – crucial to achieving composite action with chopped basalt fiber, which is also highly stable.
Non-Toxic
Being a bioplastic, emissions from PLA printing are benign, unlike petrochemical plastics which emit high levels of toxic micro-particles such as styrene.
Non-Conductive
PLA is prized for its low conductivity and basalt is among the most effective insulators known. Together, they shield against the extreme exterior environment.

MODULAR ARCHITECTURE results in a layout similar to a tunnel system where passage through several modules is often required to reach any particular destination. It also tends to standardize the internal diameter or width of

pressurized rooms, with machinery and furniture placed along the circumference.
These types of space stations and surface living space are often a major challenge with modular architecture. As a solution, flexible furniture (collapsible tables, curtains on rails, deployable beds) can be used to transform interiors for different functions and change the partitioning between private and group space.

Powering a MOON or a MARTIAN village
There are significant challenges in establishing a self-sufficient outpost on the Lunar and Martian surface. A principal requirement is a reliable source of energy - to keep electronics and human occupants warm in the frigid Martian weather, and the high difference of temperature on the Moon, to enable scientific research, to produce propellant from in situ resources for return flights, and so on. To date, the two energy sources utilized for Lunar and Martian missions have been sunlight and radioactive decay. A manned mission or permanent settlement would likely also have to choose between these two ot to simply combine them together

On the Moon
Solar power plant
A solar power plant at the south pole would have to maintain an array of solar panels facing horizontally, with a rotational capability in order to track the sun through 360à,° over the course of the month. However, such a power station would have to overcome the problem of mutual shadowing, in which some panels would always be shadowed from the horizontal sun by some neighbouring panels, or indeed by any other surface constructions such as the Habitat itself.
Furthermore, the darkness periods demand the inclusion of large energy storage capability.
Based on a 59kW power requirement for the Habitat, a solar system with a battery would require approximately 282m2 of solar panels, while a solar system with regenerative fuel cell storage would require 329m2 of solar panels. The latter, however, is much lighter at a total mass of 14t, whereas the solar battery power station comes in at 68t due to the much greater weight of the lithium-ion batteries.

Nuclear fission plant

The second option of a nuclear fission reactor is a technology that is already under development for space travel and lunar surface applications, particularly within NASA.

As far back as 2018 NASA and the US Department of Energy demonstrated the Kilopower reactor named Krusty (Kilopower Reactor Using Stirling Technology) capable of providing up to 10kW of electrical power for at least 10 years.

The prototype system uses a solid cast uranium-235 reactor core, about the size of a paper towel roll, and passive sodium heat pipes transfer reactor heat to high efficiency Stirling engines, which convert the heat to electricity.

As many Krustys as are required to meet the power requirements could be implemented together.

A nuclear fission reactor would be more compact, for a given power capability, than a solar power farm. However, extensive cooling radiators are required to reject the waste heat at a temperature low enough to suit the power conversion principle involved.

Protection of crew and systems from the ionising radiation emissions of an operating reactor also is a requirement and would be achieved by a combination of distance and shielding by regolith.

The mass of a space fission reactor system depends on various design parameters and assumptions, but a broad estimate indicates a total power station mass of about 5.6t to deliver the Habitat's 59kW requirement.

This is at least an order of magnitude lighter than a solar power plant. A nuclear fission reactor approach also has the advantage that its development would be applicable to non-polar lunar applications, providing wider mission flexibility.

NASA says the Kilopower project team is developing mission concepts and performing additional risk reduction activities to prepare for a possible future flight demonstration.

On Mars

Solar power plant

Though a number of robotic probes sent to explore the Martian surface have successfully utilized solar arrays for their power needs, such an approach would have trouble scaling to support human habitation. The principal concern with using solar power to support a mission is intermittency: solar panels only provide power when there is sunlight. This is a familiar problem on Earth, and a major obstacle to wider integration of renewables into the grid. The intermittency problem on Mars is more pernicious: enormous global dust storms envelop the planet typically once a year from 35 to 70 or more Martian days. These dust storms tend to have an opacity, or optical depth, of at least one meaning that the solar flux at the top of the atmosphere is attenuated to less than e-1 = 0.37 (37%) of its original value when it reaches the surface. In addition, because Mars is farther from the Sun than Earth is, it already only receives roughly half the average solar irradiance. This intermittency introduced by multi-month dust storms, combined with the usual diurnal oscillation in solar flux, would necessitate a considerable amount of energy storage.

Nuclear power reactor

Like on the Moon, Nuclear power is an attractive alternative to solar for several reasons. Its power output is constant in time, meaning less risk of prolonged power shortages that could prove hazardous to a human crew. It also weights less per nameplate capacity than does solar when considering a Mars operating environment - a 2016 NASA study found that about 18,000 kg of solar power generation equipment would be needed to match the output of a 9000 kg fission system. This was considering a relatively small system meant to provide 21 kW peak electric power for a handful of astronauts, which translates to roughly 1.2 watts per kilogram for the solar power system and 2.3 watts per kilogram for the nuclear system.

The nighttime temperature on Mars as measured by the Opportunity rover reach as low as -98°C with diurnal temperature variations of up to 100°C, so even a temporary power loss in such an environment could quickly become life-threatening as the heating systems fail. This presents another advantage of nuclear power: even in the event of an electrical fault, the passive heat from the reactor or radioisotopes could be used to warm the habitat.

A nuclear power system on Mars would look quite different from a fission nuclear plant on Earth. It would be small, modular, and self-contained, and rather than using a large steam turbine it would likely use a thermoelectric generator to convert heat from non-fissile radioisotopes, most commonly Pu-238, directly into electricity. Radioisotope thermoelectric generators (RTGs) have already been proven effective in multiple space missions, including the Pioneer and Voyager spacecraft as well as the more recent Mars Science Laboratory (Curiosity) rover. However, NASA is also currently evaluating the performance of its prototype "Kilopower" system, which would use a fissile uranium core instead of plutonium, and a Stirling engine instead of an RTG, to provide 1-10 kW of power per reactor. Though still unproven, this design would be more scalable because of the greater availability of uranium fuel, and would enable higher-powered systems than previously available with RTGs. However, because fissile radioisotopes have the inherent danger of a meltdown, the RTG design may yet win out due to safety considerations.

Oxygen on the Moon and Mars

Different Studies and technics are used to produce Oxygen on the Moon and Mars:

Electrochemistry

Electrolysis, using a soil-fed reactor. It melts the lunar soil at 1600 degrees Celsius and then, through electrolysis, creates oxygen that is stored for use.

Ecopoiesis

Cyanobacteria have long been targeted as candidates to drive biological life support on space missions, as all species produce oxygen through photosynthesis while some can fix atmospheric nitrogen into nutrients. A difficulty is that they cannot grow directly in the Martian atmosphere, where the total pressure is less than 1% of Earth's - 6 to 11 hPa, too low for the presence of liquid water - while the partial pressure of nitrogen gas - 0.2 to 0.3 hPa - is too low for their metabolism

Archaeoglobus fulgidus, today this microbe lives in extreme environments, such as extremely hot hydrothermal vents. It's a member of the Archaea, one of the three domains of life. Archaeans are some of the oldest life forms on Earth, thought to have appeared at least 2.7 billion years ago – and they are possibly much older than that. They often live in environments that don't have oxygen or are otherwise inhospitable to many other living things.

A group of Dutch researchers found that *A. fulgidus* metabolizes perchlorate, a chlorine atom connected to four oxygen atoms.

The use of perchlorate by early ancestral microbes might thus have been one of the first entries of highly oxidative compounds in the microbial metabolism, probably even before photosynthesis evolved.

Ecopoesis take too much Energy and Space and Aechaeoglobus Fulgidus only lives in high temperature between 65C and 90C and keeping that type of organism alive at such a high temperature will also cost a lot of Energy . Considering all of those setbacks, Water electrolysis may, untill today, the best technique to use.

OPTIMIZED CREW HEALTH

Since sustained social and mental health are also mission critical, green landscap, Indirect natural light, multi recreational levels and many other factors play an important role in increasing the crew health, while still keeping the crew safe from harmful solar and cosmic radiation. Circadian lighting, designed to recreate Earthly light, is employed to maximize crew health.

A SUSTAINABLE AGRICULTURE ECOSYSTEM for the MOON and MARS

If humans are going to stay (semi) permanently on the Moon and Mars, they will have to grow their own food. The most important ingredients for agriculture are present on both celestial bodies; sand and water (in the form of ice).

On the moon and on Mars, nothing can be allowed to get lost, not the non-eaten plant parts, but also no human faeces.

For a sustainable crop production we will have to build a sustainable agricultural ecosystem.

Due to the circumstances on Mars and the moon, almost no or no air, often very low temperatures way below zero and the cosmic radiation, the crop production will have to be done indoors and below ground with a meter of protective soil on top.

Up till now we have identified four groups that will be necessary:

pollinators, **earthworms**, **bacteria** and **fungi**.

Together they could be able to form a simple sustainable agricultural ecosystem.

Pollinators

Pollination is needed for the plants to set seed. It is something we did earlier by hand in our experiments, but for real crop production it is too laborious.

The most suitable pollinators, also in widespread use in greenhouses on earth, are probably bumble bees. Viable seeds are needed to achieve multiple generations of crops but bringing them by rocket is a waste of valuable space. Even for self-pollinators fruiting and seed setting is better when pollinators are involved. The bumble bees can easily travel to the Moon or Mars in hibernation. Even with pollination, many generations of seeds from a relatively small gene pool may lead to inbreeding problems so, now and then, bringing new genes into the pool will be required.

Earthworms

Earthworms are needed to break down organic matter and to fertilise the soil. They do this by pulling the organic matter into the soil, eating it together with soil particles, and then excreting the mixture; in this way they break down the organico matter so that it is more easily available for growing plants and the soil fertility increases. Worms also dig an extensive system of burrows in the soil. This gives a better aeration of the soil and lets water enter the soil more easily. This all enhances plant growth. The first experiments with worms earlier this year turned out to be very promising. The worms are able to live in the soil simulants we use; after six months they are still alive and kicking.

Bacteria

Bacteria have two main tasks. The first one is to further break down the organic matter that has been chewed by the worms. The bacteria will then release the nutrients from the organic matter, which can then be used by the plants for growth. The second task is to help the plants to fix nitrogen from the air. Some bacteria live in symbiosis with plant roots; they use the non-reactive nitrogen (N2), which cannot be used by plants, and turn it into reactive nitrate (NO3). The plants use the nitrate for growth. This is particularly important on Mars and the Moon, since the soils over there contain many nutrients, but are poor in nitrate. By growing clovers or crops like pea or green bean, which can live in symbiosis with these bacteria, the soil can become more fertile. On Mars and on the Moon there are no bacteria, which gives us the opportunity to bring only the bacteria we want; bacteria that cause diseases can be left on Earth. However, the process of selecting only the bacteria that are needed or wanted will be a major task which still has to be explored

Fungi

Fungi could also fulfil two or even three tasks. Fungi have mycelia which are fine white filaments that the fungus can use to absorb nutrients from its environment. Mycelia allow some fungi to live in symbiosis with plant roots, effectively expanding the plant root system. The mycelium can then help the plant to take up the nutrients from the soil in return for carbon hydrates from the plant. This enhances plant growth, especially in nutrient poor circumstances. Fungi can also help with the break down of organic matter and some of them may even be eaten, such as the common mushroom.

MADE FOR SPACE, EVOLVED FOR EARTH

Icon Engineering began a project to validate our space-technologies on Earth. An eco-friendly 3D printed dwelling made entirely with sustainable renewable and recyclable materials, proves that revolutions in technology, artificial intelligence, and robotics can reduce landfill waste and our collective carbon footprint through Space-driven construction. Its materials minimize environmental impact without compromising comfort and performance. It offers a simpler, more sustainable solution for building on this planet, while advancing the technologies for living on another.

This material has the potential to be leaps and bounds more sustainable than traditional concrete and steel, leading to a future in which we can eliminate the building industry’s massive waste of unrecyclable materials. It could transform the way we build on Earth – and save our planet.

This project is a literal demonstration of how Space technology can reshape how we build and live on planet Earth.