Living in the space

Alongside everyday projects, our office has been planning for new ways to build on the Moon and on Mars, starting from a base of concrete research and pursuing the aim of developing solutions that can find an actual application in a near future. Considering how bad we are treating the Earth, it is very likely that one day it will be necessary to move on other planets and celestial bodies in order to extract new resources.

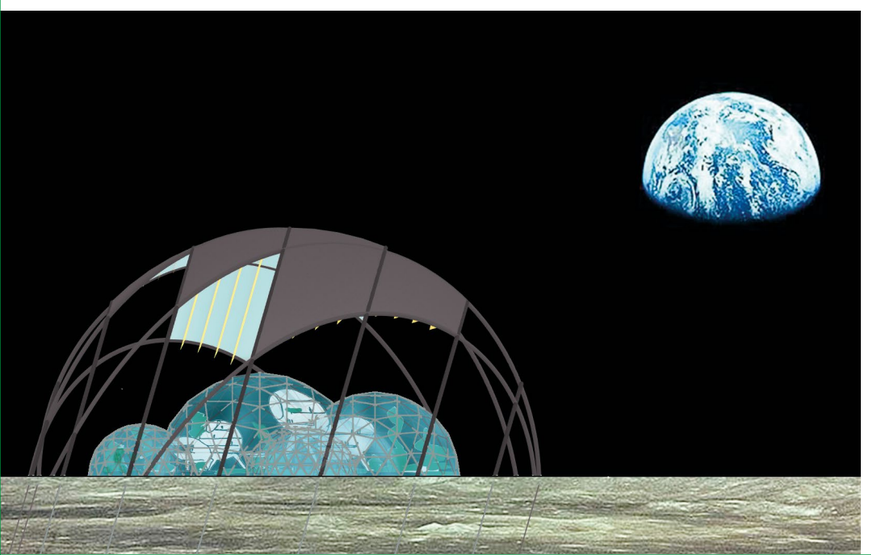
However, living in the space is an extremely difficult challenge: the lack of oxygen, the absolute vacuum, the lack of sound, the enormous temperature leaps and the radiations can make the survival outside the Earth's atmosphere very hard and should also make us reflect even more on the importance of protecting our planet. Thinking about a long stay away from the Earth, we must take into consideration repercussions both at physiological and psychological level: living in a closed environment, in narrow spaces (maybe underground) can indeed lead to depression, psychological and relational distresses.

On this basis, which characteristics should a truly liveable space station have? On this matter, we have imagined a transparent outpost that allows to observe the external view and see the light of the Sun: a comfortable place, rich in vegetation and waterways, that feels exactly like home on the Earth. That would necessarily be an eco-friendly and zero-emission village, given that it is fundamental to safeguard the quality of the air and to preserve the resources in an environment that lacks of atmosphere and that is enclosed inside a casing.

The planning of an extra-terrestrial colony, at first sight, can seem like a purpose that is extremely distant from the engineering practice, but we believe that it represents a super valid occasion to encourage a transverse approach to the planning, as well as a chance to test solutions that can also be used to solve everyday issues (especially the ecological ones).

If the time in which we will be able to live on other planets maybe is still faraway, keeping on dreaming the stars can do nothing but be good for us.

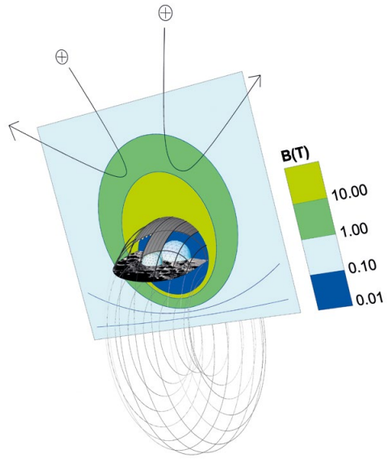
Lunar settlement's rendering under the twist of cables of a vertical toroid (Solenoid Moon Base City).



01

Solenoid Moon Base City / Version with vertical toroid, 2017

Building a lunar base with a transparent casing is a complicated task: the external walls must be multi-layered and sturdy enough to resist the internal pressure and to guarantee thermal insulation, but at the same time it is also necessary to create a barrier against cosmic radiations.
Our solution consists in creating an artificial magnetic field powerful enough to repel the damaging ionised particles, but it must also be harmless in proximity of the inhabited area.
In a first study of 2017, we designed a space base collocated inside a big vertical toroid made by superconducting electrical high-voltage cables, which are mostly buried under the lunar surface.
The necessary electric current that we have estimated is elevated because the power has to be inversely proportional to the resistance provided by the cables during the passage of the electricity. The cables will be put inside curvilinear tubes in VECTRAN, inflated with high-pressure, and a dome composed of metal sheet panels (as a protection from micro-meteorites) will lean on them. The construction of the roof frame (around 200 metres high) and the panels is made possible thanks to low gravity and absence of meteoric actions. The technology that is necessary to build this base is already available: the spaces will be enclosed in pressurised domes composed of cushions made up of several layers of EFTE and supported by a twist of wires in traction.
Our research has been presented at the AIAA Space Forum 2017 in Orlando (Florida) and mentioned in the video *Can We Protect Astronauts From Radiation?* on the YouTube channel *Universe Today*.
In 2018, our project appeared also on the astronomy/ astronautics magazine *Nuovo Orione* (in June) and on the italian national daily newspaper *La Stampa* (in November).



Visualisation of the magnetic field's intensity generated by the toroid of cables.

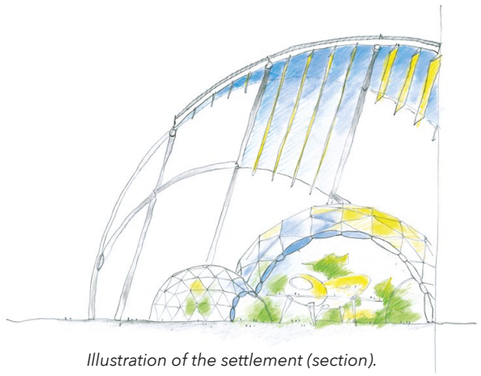
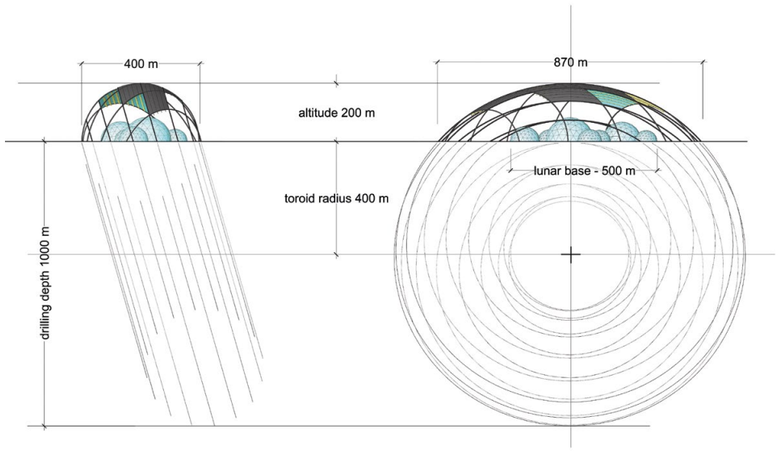


Illustration of the settlement (section).

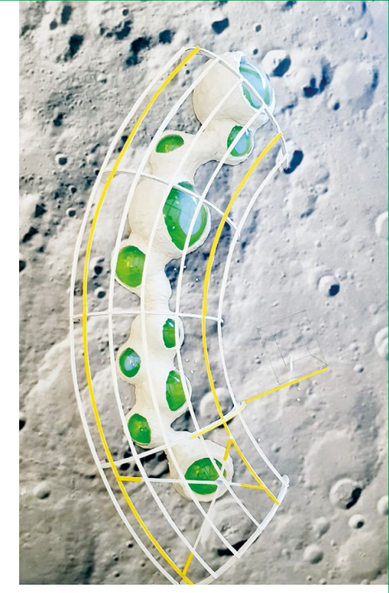
Perspective drawings of the lunar base. The majority of the cables are buried under the lunar surface.



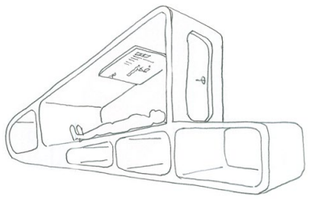
02

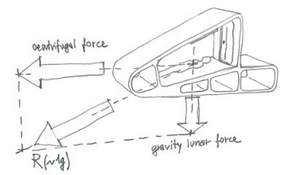
Solenoid Moon Base City / Version with horizontal toroid, 2018

In occasion of the IAC Congress of Brema 2018, we presented a new version of the lunar base developed together with Professor Giancarlo Genta from the Polytechnic University of Turin.
This time, the toroid of cables is placed in horizontal position: the upper part is supported by arches that are organised in the shape of a circle along the perimeter of the torus, while the lower part evolves in underground tunnels under the lunar surface.
The residential domes will be "printed" in situ using the lunar regolith and taking advantage of the structure itself of the cables' frame as component of the printer: an overhead travelling crane will move along the tracks that coincide with some of the cables, and it will allow the amplification of the settlement in the future.
The domes will be partially covered at the top in order to protect them from micro-meteorites and they will result transparent only in correspondence with the glass windows, which are built using triangular modules in geodetic configuration and made up of multi-layered and thick windowpanes. By doing this, it won't be necessary to establish another protective shield, like we did in the 2017 project.
Considering that the low gravity of the Moon can affect the human body over long periods, we have designed a "gravitational centrifuge" in order to contrast its effect on the settlers.
It consists of a series of rooms displaced in a circle that revolve around a central axis, in order to generate a new centrifugal force: the settlers will spend 2-3 hours here every day, in a lying position, and they will be stimulated by an artificial weight force towards the feet that is equal to the terrestrial one.



Model of the lunar base's horizontal toroid.





On the top right: sketches of the rooms that make up the gravitational centrifuge.
On the side: sketch of the centrifuge as a whole.

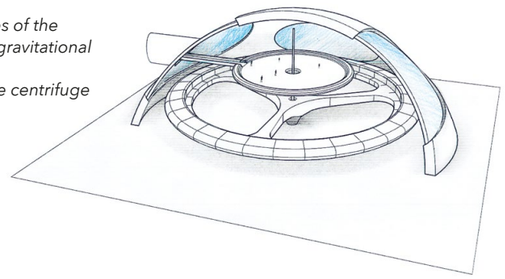
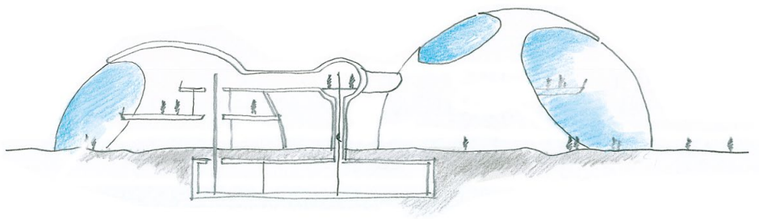


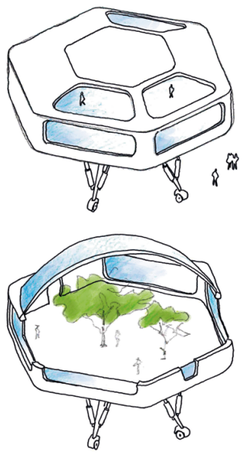
Illustration of the section of some settlement's domes.



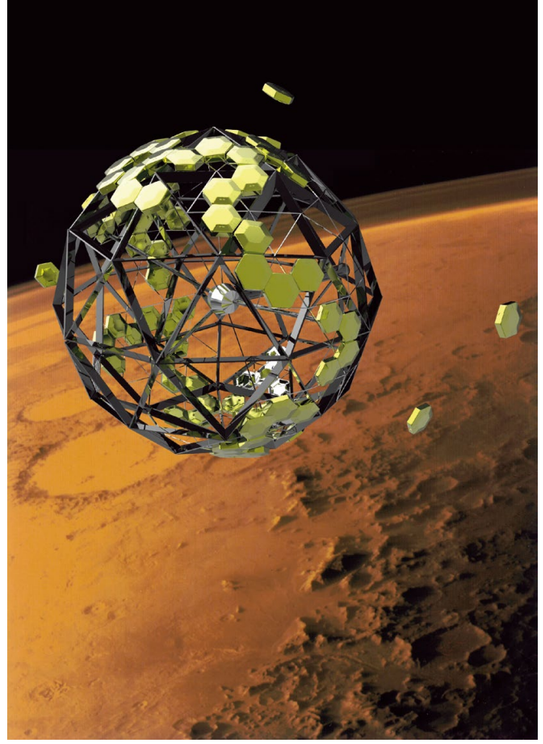
03

Spaceship project and settlement on Mars / 2018

Even if it has its own atmosphere (100 times less thick than the one of the Earth), Mars is not easy to colonise because of the cosmic radiations.
At the moment, the red planet is achievable by a 8-month long trip, so our project aims to protect both the outpost and the spaceship with an artificial magnetic field. The residential modules of the future base will be moved on the spaceship, and will be positioned in the shape of a cylinder (or geodetic sphere): the rotation of the structure will produce the gravitational force that is necessary to protect astronauts during the trip.
Once close to Mars, the modules (equipped with descent motors and independent parachutes) will detach from the ship and land on the surface; once on the ground, they will hook one to another, thus putting together the village.
The settlers have the task of installing the electric wires of the toroid to protect the settlement: the structure will be horizontal here as well, so that there won't be the need to dig too deep.
This project was presented at the AIAA Space Forum Congress 2018 in Orlando (Florida) and was published on the eminent American Journal of Aerospace Engineering in November 2018. It was also mentioned by the US space journalist Leonard David on his blog, in the article *Mars, Moon Dwellings: Artificial Magnetic Fields Protect Settlers* (26 October 2018).



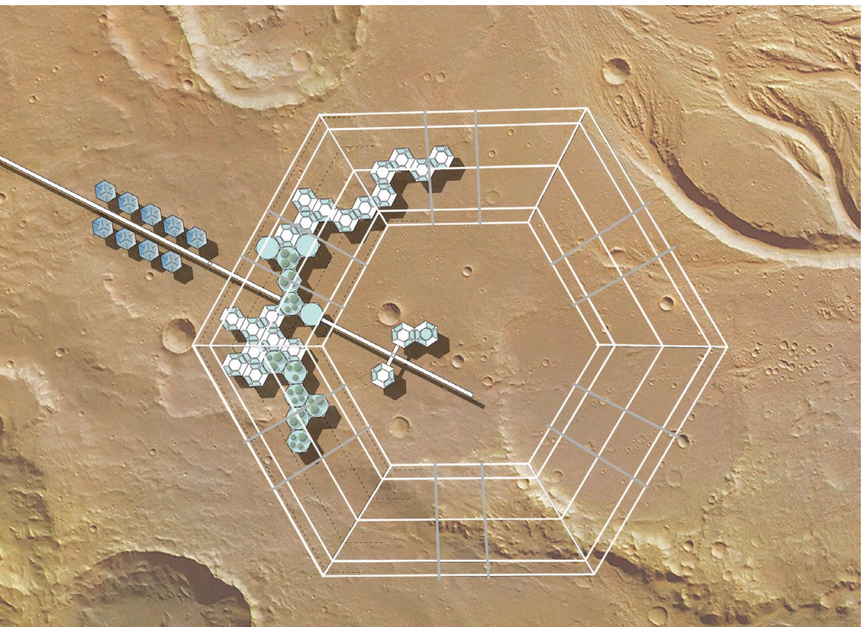
Sketches of a residential module: the outside and the internal section have a greenhouse for intensive hydroponics plantations.

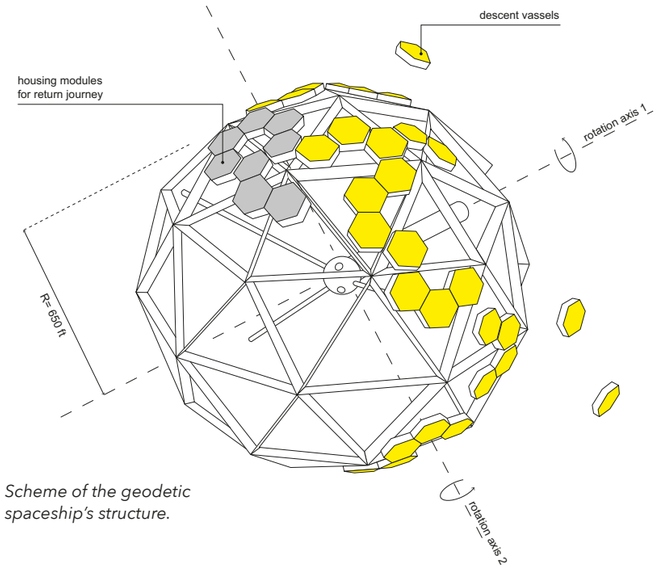


Rendering of a second version of the spaceship for the transport of the residential modules and the settlers on Mars.

Scale model of a first version of the spaceship for the transport of the residential modules and the settlers.

Simulation of the settlement's planimetry on the surface of Mars.





Scheme of the geodetic spaceship's structure.

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Living in space

We give structure to ideas