Extremophilic and biomimetic architectures for space

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Abstract. Extremophilic organisms, living beings with amazing capacities of adaptation to the most hostile and deadly environments to all other living beings, they demonstrate natural adaptation solutions, captivating for the implantation of the life on other planets as much as for the brutal changes of ours. Since the dawn of time, man has used nature as a source of inspiration to innovate and design with a key word, adaptation. This is biomimicry, because nature is the best technology in the world: millions of years of feedback and no copyright...

1.1 Extremophilic architecture

We are passionate about it and decided to devote our energy to it by founding the Real Dream agency. Since 2017, we have designed several spatial concepts and created partnerships with the main actors of the sector in France.

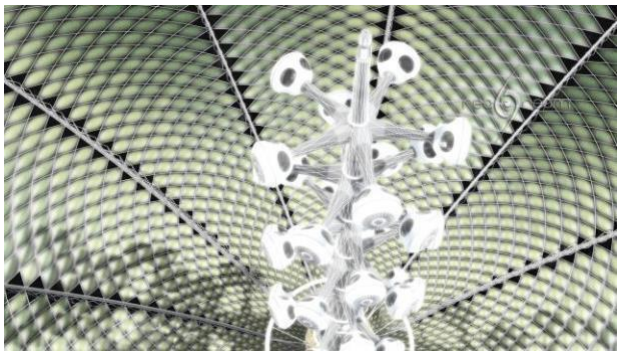

Fig. 1. Solar spore Concept of an algae space station

The cosmos is an unparalleled field of experimentation and design, with strong constraints remaining for us the best way to innovate. Let us introduce you to our philosophy. Inventing is an immutable process.

A new idea is created from an older one. Architecture is no exception to this rule, and architects sometimes improvise themselves as researchers, scientists, or archaeologists. Thus, Pierre-Paul Riquet exploited the genius of aqueducts and ancient canals to build the Canal du Midi. This canal inspired Baron Haussmann to clean up the streets of Paris. Another example; the rediscovery of antiquity, leading to the emergence of mathematical rules that are still in use today, and which were themselves originally a clever collage of Arab, Greek, Indian and Chinese cultures.

New concepts always find their origins in the existing. This is our starting point.

1.2 Biomimicry

Biomimicry is a very old practice, the Egyptians already used it but its best ambassador was Leonardo da Vinci. He transmitted to us a method based on observation and translation into the architecture and mechanisms of the language of plants and organisms.

It is an infinite library, source of our imagination since the dawn of time. Copying it for aesthetic purposes only would be a real waste, because the benefits would be lost. Far from greenwashing, the bio-morphological design is only interesting if it is imitated in a literal way.

Nothing forbids it! Thus, when Airbus sought, in many ways, to reduce the drag of its aircraft wings, only the faithful reproduction of the curved edge of those of the eagles proved effective.

There is no pastiche in biomimicry, unless, of course, one removes the direct effects to take only the "beautiful". Nature has no copyright and its feedback is millions of years old. If the biosphere, does it, then so can we.

1.3 Architectural design

In architectural design, we treat a project as if it were a living organism.

How does it breathe? Where are its vital organs located and how are they connected? Flora and fauna know how to metamorphose, depending on their environment even the most constraining. Nature is a champion at this game. At the speed at which our planetary ecosystem is evolving, adaptability is a quality that we will need more and more. Our architectural structures are mostly prototypes, and each building is adapted to a particular site.

This is how we begin each project at Real Dream. We discover a plot of land, a geographical site with its urban fabric, and our first question is always the same: "Which organism would be the most appropriate? One that digs and buries itself in the earth? Or one that stands on stilts? And the shape? Skeleton or shell? And why not weave a web? To answer this question, we simply need to observe and study our ecosystem, bearing in mind that any organism always ends up by making its own environment.

These reflections are essential when applied to an extreme context. Concordia, the Franco-Italian polar base, is an example. It consists of two large polygonal domes connected by a tube, it is organised in a similar way to the vital organs (heart, lungs, etc.). The station also rests on pillars fitted with jacks that raise and lower it according to the amount of ice accumulated on the ground

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1.4 Global warming

With its attendant natural and health disasters, this thinking is being applied to other buildings. Rising sea levels, repeated droughts, devastating cyclones, we need to reinvent building methods to adapt to these unprecedented conditions.

This will be undoubtedly accompanied by an upheaval in the architectural styles and forms we are used to.

1.5 Extreme stress environments

These are conducive to creation and innovation and allow the solutions of the future to be tested and realised. This field, at the crossroads of avant-garde human techniques and nature's multi-millennial knowledge, is looking for a way to extend life to places were, on the face of it, it would be impossible.

This ability of living beings to triumph over the most delicate and dangerous situations, often with audacity, commands respect.

Adaptation and resilience! A very current vocabulary that shows the gulf that separates us from a not-so-distant era that always asked more of us. For centuries we have sought to domesticate our ecosystem, proud of our technical progress and convinced of a certain superiority over nature. The failure that we see at the beginning of the 21st century is all the more crushing.

We have now entered an era of humility in which we must do better, with less, and advance little by little. But we will never stop dreaming and being innovative! By considering nature as a partner, it is perhaps nature that will teach us how to get out of this mess, if we know how to listen to it.

1.6 Space

Space is the most inhospitable place we know, and to have human beings living there seems an aberrant idea. However, space habitats do exist and avant-garde solutions applicable to our planet are emerging from these enclosed places, where people are able to live totally self-sufficiently.In this sense, the ISS has, for the past twenty years, been an essential discovery tool.

The solutions related to waste recycling and CO^2 control, that are essential there, are already finding everyday terrestrial applications. There are many inventions that come from space, but it can sometimes take several decades to find an equivalent on Earth.

Solar panels, for example, were developed specifically for the Vangard-1 satellite, launched in 1958, and were soon used for other launches, but did not appear on the roofs of buildings until the 1970s. Then, it was not until the early 2000s that a dedicated industry was born. On the moon it is the preferred form of energy for habitats, as without an atmosphere the performance is identical to that in space.

The lunar cycle of 12 days and 12 nights requires storage. Except for the poles, where it is possible to have permanent lighting bytaking advantage of the terrain.

Fig. 2. Lunar power plant

Many other constraints go far beyond those encountered on Earth. For example, long-term settlement on the moon or Mars requires solving most of the problems found on a space station floating in a vacuum: recreating a breathable atmosphere, protection from meteorites and cosmic radiation, drinking and feeding largely from local production.

Fig. 3. Mars Service Vehicle

On these planets, the use of vehicles, a highly adherent and abrasive dust requires particular solutions for resistance and sealing. In both cases, the very weak gravity, 1/6 and 1/3 of that of the earth, also requires medical monitoring of the body's adaptation and permanent training to preserve muscle mass and organ function.

Thus, the construction and organisation of permanent habitats will always be the result of an individualized adaptation, considering these various requirements. The architect will often call upon the analogy with nature for situations such as deserts or the deep sea.

1.7 Conclusion

Extremophilic architecture combined with biomimicry applied to life in space and on other planets is proving to be a mine of solutions to anticipate and adapt to the bioclimatic changes of our earth.