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Architecture on Other Space Bodies

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Abstract— *Since 1989, the author has been lecturing at the postgraduate level, and since 2009 at the doctoral level at the Faculty of Architecture of the University of Sarajevo, on the subject of "Architecture in Context". The author set the goal of this topic as: "Developing and achieving a personal attitude (about architecture) and the ability to explain that attitude, both to oneself and to others". The topic is situated at the very end of the academic study of architecture, and it is aimed at those young people who have decided to deal with architecture in the way of science, in its complex perception. Although postgraduate (and doctoral) students are, as a rule, the most successful students of basic architecture studies, they do not have a systematized image of architecture (as a complex and contradictory discipline), but more or less fragmented knowledge and skills. They base their approach to architectural design, most often, on copying appropriate solutions that they transfer from foreign magazines based on the principle of 'likeability' (and current 'architectural fashion'). Instructed by the experience of his own search for architecture (through his post-graduate and doctoral studies), the Author, just after being selected as an assistant professor at the Faculty of Architecture in Sarajevo (1989), proposed this topic for teaching at the post-graduate studies. The fundamental basis for understanding the complex issues of architecture in context is a good knowledge of the history of architecture, both on a global world level and in individual world regions. At the same time, architecture must be seen in the light (context) of the concrete natural environment, the history of science, technique and technology, all branches of art, as well as in the context of socio-historical events. The fundamental basis for understanding the complex issues of architecture in context is a good knowledge of the individual architectural object, as a physical structure designed and built by man, which, with full designed expediency, should remain stable in a concrete natural environment, for a more or less long period of time. The author also proposed a completely new typology of architecture, derived from his own understanding of architecture as Architecturally Defined Space (ADS). In this way, architecture is completely equated with Man, that is, his generic nature, whose possibilities are endless.*

Keywords— *Architecture, Planet Earth, Other Space Bodies.*

I. INTRODUCTION

For architecture, no matter how paradoxical it sounds, the most complex issue is its self-determination. And while for individual scientific disciplines we have quite decisive definitions that unequivocally and completely determine the range of interests of the discipline in question, it would be very difficult to do so for architecture [1,2]. From some definitions that we will find in textbooks, dictionaries or encyclopedias ('architecture is the art of building', 'architecture is the concretization of existential space', 'architecture consists of an internal space intended for various purposes and an architectural body', for example), but also on based on a superficial reading, we see that architecture is something more than what the definition tells us, or else the definition itself seems quite general to us (so we have to break it down a lot to get to some more specific definitions). In fact, the definiteness of the definition of a term is a direct consequence of the clarity of our idea about that term. What are our ideas about architecture?

Architecture is perceived, experienced, lived in and understood by both the layman and the expert (who deals with one of its many dimensions); for the layman it is 'something beautiful or ugly', 'impressive or boring', often 'unclear' and almost regularly covered with a veil of a kind of fetish that this profession (probably due to its complexity) created during its history. An expert, on the other hand, looks at a specific architectural work (in a similar way as a doctor looks at his patient, a biologist at a plant or animal, for example) critically: to what extent does the work fit into the built and natural environment, to what extent does it follow contemporary trends thoughts, how the materials were used, whether there are any symbols or obvious messages in its appearance...; and furthermore: it judges about the owner of the building (be it an individual, a smaller or larger social community) and, finally, about the personality of the architect himself [1,2,3,4,5,6,7,8,9]. Unlike mathematics, physics or chemistry, for example, where identical answers are expected from all potential solvers for a given problem (task), in solving architectural problems there will be as many different results as there are potential solvers; moreover, each solver individually, at different ages of his life, in different social (economic) circumstances, would give different answers. Of course, this does not mean that all offered answers to architectural problems are 'correct' (that there is one 'correct' or one 'incorrect'), that they are different only because of the architects' conscious desire to be original; it would rather mean that we cannot literally compare architecture with mathematics (and similar exact disciplines). On the other hand, comparisons of architecture with music, literature, fine art...; on the same given theme, every musician will compose a different composition, a poet will sing a different song, an artist will paint a different picture, a graphic, a sculptor will offer a different sculpture... But, while for architecture the existence of a commissioned task (program) is an elementary assumption, for the aforementioned As a rule, this is not the case for art; moreover, their task is not immanent, they are a matter of individual genius, personal artistic determination and inspiration. The value (both artistic and monetary) of the aforementioned works of art (paintings, poems, sculptures, compositions...) is not measured by the amount of used paint, precious stone, format size, nor the time spent for their creation, but by immanent aesthetic standards. Within the framework of a (concrete) architectural program,

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there are certain sections (phases) that are, to the greatest extent, exact: calculation of the constructive system, installation systems, technology and execution organization... In all the mentioned dimensions of architecture, the solutions (to the highest extent) are not conditioned by a personal profile solution proponent, but by the general level of empirical and theoretical knowledge and the level of development of technology. M.P. Vitruvius talks about the complexity of architecture, about the contradictions in which the one who decides on it finds himself. Vitruvius back in the 1st century BC: "So, when this science (architecture) is rich and full of so many different and numerous knowledges, I think that only those who have climbed the stairs of different disciplines from childhood can be rightly recognized as architects, they nourished themselves with knowledge from several sciences and skills while they climbed to the highest temple - to architecture" [10]... "That is why an architect must be literate, skilled in drawing and a good connoisseur of geometry, that he knows history well, that he diligently listened to philosophers and learned about music, that he is not ignorant in medicine either, that he understands legal issues and that he has knowledge of astrology and heavenly laws" [10]. Even though these thoughts are two thousand years old, they do not lose their relevance even today; moreover, they were joined by even stricter and more complex requirements. This is important to emphasize today, since certain scientific disciplines (and technologies) have achieved such a level of knowledge and resources that architecture has acquired in them not only perfect "helpers" in solving its complex problems, but also 'competitors' who have become independent in solving architectural problems[1].

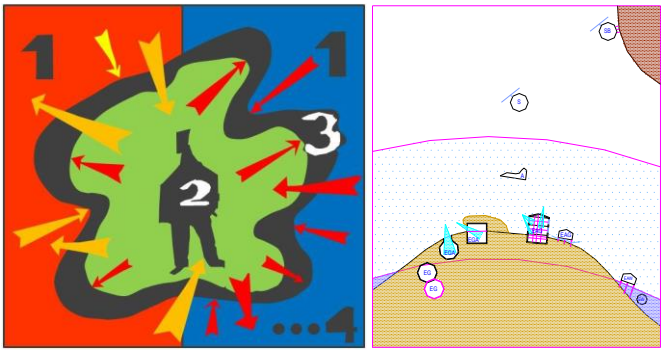

Figure 1. Architecturally Defined Space, ADS (A. Hadrovic, 1987), (left) and Typology of ADS (A. Hadrovic, 2011), (right)

This work was created in the last twenty years; it is a part of the lectures that the author gave since 1989, first at postgraduate studies, and since 2009 at the doctoral studies at the Faculty of Architecture of the University of Sarajevo (Figure 1) [1,2,3,4,5,6,7,8,9] [2].

II. ENVIRONMENT

By 'environment' we mean every possibility in the space in which man can realize his existence [1].

Natural environment

By natural environment, we mean all those features that nature gave, and on which man (mostly) did not exert his influence: geographical location, geomorphology, watercourses and reservoirs, plant and animal life, available soil, climate [1] ...

Figures 2. and 3. show comparative data of some important parameters of the natural environment on Earth and on Mars. Since the mass of the Earth (5.9722×10^{24} kg) is much greater than the mass of Mars (6.4169×10^{23} kg), the gravitational force of the Earth is greater than the gravitational force of Mars [11,12]. In other words, the same man from Earth would be much 'easier' on Mars. The lowest temperature on Mars (-145 ºC) is much lower than the lowest temperature on Earth (-90 ºC). At the same time, the highest temperature on Earth (+60 ºC) is higher than the highest temperature on Mars (+60 ºC). There are great differences in the atmospheric pressure of the Earth of Mars; the atmospheric pressure on Earth (at world sea level) is 1013 hPa, and on Mars 5-11 hPa. This is the result, on the one hand, of the difference in the chemical composition of the atmospheres of Earth and Mars, and on the other hand, the difference in their gravitational forces.

Apparently, a man from Earth would not be able to live in the open space of Mars, but would have to have special suits (spacesuits) in which the necessary composition of air for his breathing would be generated. Likewise, constructions in which humans would live on Mars must be 'autonomous', in which cryptoclimatic conditions would be generated the same as those on Earth [13,14,15,16,17,18].

Parameter		Mars	Earth
Surface gravity		0.38*g*	1.00*g*
Mean surface temperature		−60 °C	+15 °C
Surface temperature range		−145 to +20 °C	−90 to +60 °C
Mean PAR photon flux		8.6×10^{19} photons m^{-2} s^{-1}	2.0×10^{20} photons m^{-2} s^{-1}
UV radiation spectral range		>190 nm	>300 nm
Atmospheric pressure		5–11 hPa	1013 hPa (mean at sea level)
Atmospheric composition (average)	N_2	0.189 hPa, 2.7 %	780 hPa, 78 %
	O_2	0.009 hPa, 0.13 %	210 hPa, 21 %
	CO_2	6.67 hPa, 95.3 %	0.38 hPa, 0.038 %
	Ar	0.112 hPa, 1.6 %	10.13 hPa, 1 %

Figure 2. Environmental parameters on Mars and Earth surfaces
(Adapted from: Eira Kanervo, Kirsi Lehto, Kurt Ståhle, Harry Lehto and Pirkko Mäenpää: Characterization of growth and photosynthesis of Synechocystis sp. PCC 6803 cultures under reduced atmospheric pressures and enhanced CO_2 levels, Published online by Cambridge University Press: 8 September 2005)
Source:https://www.cambridge.org/core/journals/international-journal-of-astrobiology/article/abs/characterization-of-growth-and-photosynthesis-of-synechocystis-sp-pcc-6803-cultures-under-reduced-atmospheric-pressures-

[1] In the last thirty years, in the framework of the great global debate on energy and the environment, for example, technique and technology offer a multitude of solutions on the use of alternative energy sources that directly determine the disposition of the horizontal and vertical plan as the materialization of the boundaries (wall, roof, interfloor structure) of architectural objects .

[2] „Students of architecture, as well as most architects, have the problem of seeing the context in architecture, the problem of having a picture of the development of architecture, both horizontally (geographical space on Earth), vertically (historical continuity) and content (a variety of architectural contents). An even bigger problem is the parallel perception of the ideas of one time through other arts, philosophy, technique and technology. By not having this image, architects often randomly reach for copying certain architectural forms, thus losing sight of one of the basic characteristics of architecture, which is the framework of concrete life and its more or less permanent, materialized image" [4].

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and-enhanced-co2-levels/71BB9A7CD2F86BD32A7FCA2928F90BB0, Accessed: July 14, 2023.

Source	Elements
Atmosphere[a]	CO_2, N_2
Soil, rocks[a]	P, S, Mg, Fe, Ca, Na, K, and metal micronutrients
Ice caps, subsurface ice, atmosphere, hydrated minerals[a]	H_2O
Solar radiation[a]	Energy for photosynthesis, heat
Human waste	Fixed N, organic material, CO_2, H_2O
Side effects of other artificial processes (fuel combustion, manufacturing…)	CO_2, H_2O
Cyanobacteria (fed with the above)	O_2, fixed N, organic material, metal nutrients

[a]Naturally present, independently of human activity

Figure 3. Main sources of nutrients for cyanobacterium-based biological processes on Mars

Source: Verseux, Cyprien & Paulino Lima, Ivan Glaucio & Baqué, Mickael & Billi, Daniela & Rothschild, Lynn. (2016). Synthetic Biology for Space Exploration: Promises and Societal Implications. 10.1007/978-3-319-21088-9_4.

Of course, before sending a man to Mars, on Earth, in the initiated conditions of the environment on Mars, simulations should be carried out.

Social environment

By Social environment we mean everything that man has created and that separates him from the world of other living being. It includes both physical structures (various material, more or less ordered products of their activity) and the immaterial world that we know with the intellect (science, philosophy, religion, law, morality) through an ordered system of abstract symbols (letters, signs) [1]. Man came to know the Universe long and hard, step by step. These findings are also threatened by a large number of human victims[3].

[3] A brief chronology of the 'conquest' of the Universe:
1. The first artificial Earth satellite „Sputnik-1“ was launched (October 4, 1957),
2. The first living being flew into space (the dog Lajka), (03.11.1957),
3. The first American satellite „Explorer-l“ was launched (January 31, 1958),
4. Launched the first artificial planet of the solar system „Luna-1“ (02.01. 1959),
5. The first work of man („Luna-2“) reached the surface of the Moon („hard“ descent), (September 13, 1959),
6. „Luna-3“ sent the first images of the other side of the Moon (Soviet, October 4, 1959),
7. The first meteorological satellite „Tiros-1“ was launched (April 1, 1960),
8. The first living creatures (dogs Strelka and Belka) returned from space to Earth (August 19/20, 1960),
9. The first cosmonaut in history (Yurij Gagarin) flew into space (April 12, 1961),
10. The first all-day manned flight into space was completed (06/07/08/1961),
11. Launched the first satellite („Oskar“) for amateur radio communications (December 12, 1961),
12. The first American astronaut (John Glenn) took off (February 20, 1962),
13. The first transoceanic television transmission was carried out using the „Telstar-1“ satellite (July 10, 1962),
14. The first joint flight of manned spacecraft „Vastok-3“ and „Vastok-4“ (11/15/08/1962),
15. Launched the first automatic station („Mars-1“) towards the planet Mars (01.11.1962),
16. The first spacecraft with three seats („Vashod-1“) was launched (October 12, 1964),
17. The first exit of a cosmonaut (Aleksej Leonov) into open space (March 18, 1965),
18. Launched the first geostationary telecommunication satellite („Intelsat-l“), (April 6, 1965),
19. For the first time in history, images of the surface of Mars were received from the automatic station „Mariner-4“ (July 14, 1965),
20. The first meeting of piloted spaceships („Gemini-6“ and „Gemini-7“) without connecting on the path (15.12.1965),
21. The first „soft“ landing of an automatic station (USSR with the „Lunjik IX“ probe) on the surface of the Moon (February 3, 1966),
22. The first artificial moon satellite („Luna-10“) was launched (March 31, 1966),
23. The first connection of the manned spacecraft „Gemini-8“ and the automated spacecraft „Agena“ in space (March 16/17, 1966),
24. The Americans achieved the first „soft“ landing of their probe („Surveyor I“) on the surface of the Moon, (June 2, 1966),
25. Astronauts Grissom, White and Chafee, who died in the cabin of the spaceship „Apollo“ on Earth (January 27, 1967),
26. „Surveyor-3“ delivered the first device for digging in the soil to the surface of the Moon (April 17, 1967),
27. Cosmonaut Komarov died (in „Soyuz-1“) while returning to Earth (April 24, 1967),
28. The first „soft“ descent of the automatic station („Venera-4“) to the surface of the planet Venus, (18.10.1967),
29. The first automatic connection of unmanned spacecraft („Kosmos-186“ and „Kosmos-188“) in orbit around the Earth (October 30, 1967),
30. The first flight of the automatic station („Zond-5“) around the Moon with a return to Earth (September 15/22, 1968),
31. The first flight of the manned spaceship „Apollo-7“ around the Earth (October 11, 1968),
32. The first flight of the manned spacecraft „Apollo-8“ around the Moon (21/27/12/1968),
33. The first connection of spaceships with a crew („Soyuz-4“ and „Soyuz-5“) in space (January 14/18, 1969),
34. The first soft landing of a spaceship with a crew („Apollo-11“) and the crew's exit to the surface of the Moon (July 20/21, 1969),
35. The first group flight of manned spaceships („Soyuz-6“, „Soyuz-7“ and „Soyuz-8“), (11/18/10/1969),
36. The first samples of lunar soil delivered to Earth by an automatic spacecraft („Luna -16“), (12/24/09/1970),
37. The first automatic vehicle „Lunohod-1“ delivered to the lunar surface (November 17, 1970),
38. Launched the first manned orbital station („Saljut-11“), (April 15, 1971),
39. „Soyuz-11“ cosmonauts Dobrovoljski, Volkov and Pačaev, who died on their return to Earth (June 30, 1971),
40. The crew of the ship „Apollo-15“ drove the first jeep „Lunar Rover“ on the surface of the moon (6/7/08/1971),
41. The first artificial satellite „Mariner-9“ launched into orbit around Mars (November 14, 1971),
42. The first „soft“ landing of the automatic station „Mars-2“ on the surface of the planet Mars (November 27, 1971),
43. Automatic station „Pioneer-10“ sent the first images of the planet Jupiter (03.03.1972),
44. Launched the first artificial satellite for Earth resources research ERTS-1 (23.07.1972),
45. The first American orbital station „Skylab-l“ was launched (May 14, 1973),
46. The first joint flight of spaceships with a crew („Apollo-Soyuz“) with a connection in space (15/24.07.1975),
47. Launched automatic station „Voyager-l“, which sent images of Saturn's rings (September 5, 1977),
48. The first transport unmanned spacecraft „Progres-1“ was launched to supply the orbital station (January 20, 1978),
49. Launched the first reusable spacecraft (Space Shuttle „Columbia“), (April 12, 1981),
50. During the launch of the Space Shuttle „Challenger“, seven astronauts died (January 28, 1986),
51. The first complex orbital station „Mir“ was launched (February 20, 1986),
52. Launched spacecraft from the Phobos mission, towards Mars (July 7 and 12, 1988),
53. Space apparatus „Galileo“ directed towards Jupiter and its moons (October 18, 1989),
54. „Magellan“ probe launched for Venus research (April 28, 1989),

III. MAN

Space acquires meaning only if it stands in some relation to man. This relationship ranges from the relations of the already known dimensions of space, through those that can be sensed, to those that are currently beyond the reach of human imagination. In other words, man is a being on the way, a being who continuously learns, a being of open possibilities. The term 'man' is a huge question, the essence of which he himself is trying to decipher within his limits, within the limits of the Earth and the limits of the Universe [1].

Figure 4. Zero-Gravity USA
Source: https://www.ieagle.com/flyhigh/zero-gravity-flights-usa/, Accessed: July 14, 2023.
Source: https://incredible-adventures.com/zero-gravity-usa.html, Accessed: July 14, 2023.

As the parameters of the Space environment are significantly different from the parameters of the (natural) EAG environment, man, in order to survive at all, had to design and realize the ADS Limits of extremely sophisticated performance in the Space environment, i.e., within the Limits, achieve the conditions that are him, as a living being, predetermined by the EAG – environment (Figure 4) [4].

IV. BOUNDARIES: ARCHITECTURE AS A FRAMEWORK OF LIFE

Boundaries are those places in the environment where the situations encountered are controlled according to very specific human needs. Conditions are all those discovered and undiscovered phenomena in space that have a stimulating or degrading effect on humans. Borders, therefore, have the task of enabling the selection of influences. In the architectural sense, they enclose, but also include a person in the conditions of a certain environment [1].

Typology. One of the most common approaches to viewing (studying) architecture is the historical approach, in which architecture is followed through the historical epochs of humanity, more or less simultaneously through the monitoring of geopolitics, socio-economic relations, philosophy (general view of the world), the state of science and the state of other branches of art [2]. Most schools of architecture in the world add to the general history (and theory of architecture) the history of the architecture of their country or their people (ethnos). When it comes to learning the methodology and skills of designing in architecture, for a long time (until today) the approach based on the purpose of the buildings was represented in schools of architecture: Residential buildings, Public buildings, Commercial buildings, Memorial architecture, for example. At the same time, each of the mentioned groups of buildings was followed through a more or less wide array of special buildings: Residential buildings (weekend houses, family houses, villas, buildings for collective housing, hotels, student and student dormitories, homes for the elderly, for example), Public buildings (schools and colleges, offices, banks and post offices, museums, theaters, opera houses, health facilities, libraries, for example), Commercial buildings (public garages, factories, department stores, shopping centers, stationary traffic facilities '-stations, farms, grain storage silos, mills, for example). The organization and furnishing of the 'inside' of the architectural object was treated through a special segment of design, through 'internal architecture' or interior. In a similar way, we talk about 'external decoration of buildings'. The perception of individual buildings in the wider context of the built environment was processed through 'urban planning' and 'urban design'. Regardless of the fact that such a partial approach to architecture could always be justified, it often created artificial, basically non-existent differences between individual architectural programs that often led to absurdity. The oeuvre of individual great architects, in a wide variety of architectural programs, is the best confirmation of the existence of an 'approach to architecture', an 'approach to architectural design', which each author invents according to

55. Launched satellite „Hiparhos“ for measuring the position of the stars (August 9, 1989),
56. The GRANAT satellite was launched, which for the first time discovered and confirmed the existence of a black hole in the center of our Galaxy (December 1, 1989).
57. The Hubble space telescope, HST, was launched (April 24, 1990),
58. Shuttle „Discovery“ launched the interplanetary probe "Ulysses" in the first research mission to fly over the solar poles (October 6, 1990),
59. Research vehicle „Sojourner-Pathfinder“ launched on Mars (July 4, 1997),
60. Hundredth launch of the „Arianne“ rocket (September 23, 1997).

[4] In free Space, for example, there is no Earth's gravity (in certain relations, neither the gravity of any other celestial body). In such a ('weightless state') one of the most important parameters of the natural EAG – environment, which determines the complete concept of ADP, is missing. Also, the parameters that man (according to EAG – environment) determines his relationship to space are missing here: down-up, east-west-north-south. As it is a space without an atmosphere (as man knows and according to which he is destined to live on Earth, in the EAG environment) we have a situation where one physical body (man, parts of his technical equipment...) is simultaneously exposed to extremely different temperatures: on the side exposed to the Sun the temperature is over + 150 °C, and on the side in the 'shadow' -140 °C. Space travel exposes humans to much higher accelerations than our body is used to. Physiological (and pathological effects) depend on the length and magnitude of acceleration, its direction and immediate effect. Accelerations lasting less than a second have the greatest potential for tissue injury. Long-term accelerations cause physiological changes in the body (according to Newton's third law of action and reaction). The speed that the spacecraft must develop in order to leave the Earth's gravitational field (about 42,000 km/h) is quite high, but the force that acts on the man (astronaut) at that moment is smaller if it acts on his anteroposterior axis, and this is achieved by directing seats the astronaut in the direction of the trajectory during the acceleration period. The engines that propel the spacecraft cause vibrations that act on the human body causing oscillations of body parts and fatigue of the muscles that try to stabilize the body in the new change. Low-frequency vibrations can cause shortness of breath, motion sickness, chest and abdominal pain... People on Earth (in the EAG environment) are protected from space radiation every moment by the Earth's atmosphere and magnetic field. Cosmic radiation is that whose energy originates from the Sun itself (solar radiation) but also from outside the Solar System (galactic radiation. A. A. Penzias and R. W. Wilson jointly received the Nobel Prize in Physics in 1978, because they were the first to discover cosmic radiation, although in fact initially they didn't know what they discovered). In space, people (astronauts) are protected from radiation by specially designed spacecraft walls and spacesuits.

his personality profile, and which he (or an observer from the side) defines as his own. artistic credo'; sometimes an artistic credo is extremely individual, sometimes appropriate to a larger or smaller group of architects, sometimes appropriate to an entire epoch (when we talk about a 'movement': in architecture, in art, in philosophy, for example).

In accordance with the author's understanding of architecture as an Architecturally Defined Space with its four basic elements - Environment, Man, Boundaries and Perspectives - here we will propose a typology of architecture according to the way its boundaries (envelope) are defined, and according to specifics global natural environments in which man can realize his existence: on Earth (type E) in open space (type S) and on other celestial bodies (type SB). For this approach to establishing a typology in architecture, the author had in mind, on the one hand, the title of this book, and on the other hand, the achievements of architecture in environments that are today understood as 'unusual', 'extreme', 'sensationalist'... Everything that what has been said and written about architecture to date is based on man's experience of life on Earth; as man has long since stepped into Space, first with spacecraft without a human crew, and later with personal presence, new spaces have been opened for his existence, and accordingly, completely new experiences in creating the boundaries of Architecturally Defined Space. These new experiences will also be transferred to the already known experiences of his life on Earth, where one can expect, until now, an unimaginable approach to defining the boundaries of the Architecturally Defined Space.

Arhitektura Tip Space Body (SB)

Architecture Type Space Body (SB) implies that ADS that is (that is, will be) established on other celestial bodies (Figures 5,6,7,8,9,10) [2]. Since its inception, man has tried to understand and determine his place and role, both on Earth and in the Universe: from the myths of ancient civilizations about the 'ordering' of the Universe (Ancient India, the Sumerians, Ancient Egypt...), the naive realism of the Miletus philosophical schools of Ancient Greece (with Thales, Anaximander, Anaximen, 5th century BC), Pythagoreans, atomists, Aristotle, Ptolemy, ... Copernicus, Tycho Brae, Kepler, Galileo, Newton, I. Kant, J.H. Lambert, W. and J. Herschel, E. Hubble (1924), Einstein (1932), F. Hoyle, H. Bondi, T. Goldom (1948), Arno A. Penzias and Robert W. Wilson (1965). Over time, a special science (astronomy) was established that studies the Universe in its overall complexity; it is mainly based on physics and mathematics (thus, on exact measurements and calculations), and, quite often, on assumptions at the level of philosophy.

Parallel to the scientific approach to understanding the Universe, part of humanity is inclined to believe (according to the holy books) that the Universe is the work of the Great Creator and as such is definitely unfathomable for man [3].

Figure 5. Image of the Boomerang Nebula (obtained using instruments located on the Hubble Space Telescope)
Source: https://esahubble.org/images/heic0301a/, Accessed: July 14, 2023.

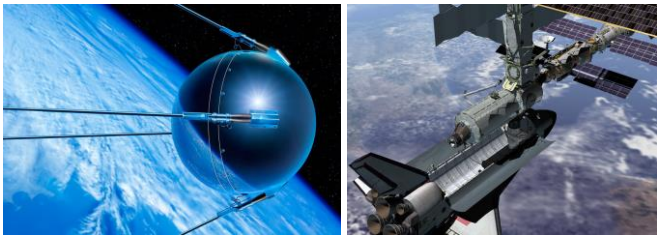

Figure 6. Left: “Sputnik 1” (Earth's first artificial satellite). Right: Space Architecture
Source: https://cosmosmagazine.com/space/how-sputnik-1-launched-the-space-age/, Accessed: July 14, 2023.
Source: https://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/International_Space_Station/ISS_puts_on_weight
Accessed: July 14, 2023.

Man's interest directed towards other heavenly bodies and the Universe in general is based on his immanent nature, in the need to learn. This need (after the mastery of certain knowledge) has, regularly in history, been superimposed on other (also immanently human) needs, first of all, the mastery of new resources, which confirmed the superiority of individuals and their groups over other people.

Figure 7. Left: Space Shuttle “Columbia” (1986). Right: Illustration of NOAA's GOES-17 satellite, which was launched on March 1, 2018 and is currently operational as GOES West, providing coverage of the western US, Alaska, Hawaii and the Pacific Ocean
Source: https://todayinhistory.blog/2021/01/28/january-28-1986-space-truck/, Accessed: July 14, 2023.
Source: https://oceanexplorer.noaa.gov/technology/satellites/satellites.html, Accessed: July 14, 2023.

As much as the human aspiration to penetrate into the unknown is worthy of universal admiration, its results (through application) at the level of social relations deepened

the gap between people, and in a certain way turned against the shell of the essence[5].

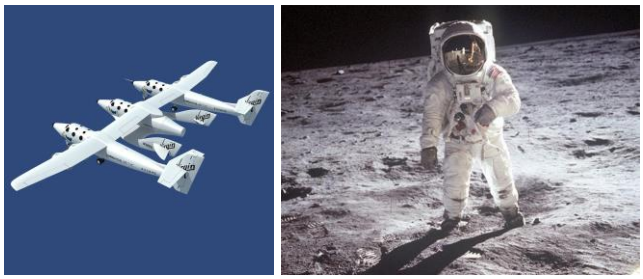

Figure 8. Left: WhiteKnightTwo (2009). Right: American cosmonaut Neil Armstrong on the moon (July 20/21, 1969)
Source: https://dpictures.homes/white-knight-ii-plane, Accessed: July 14, 2023.
Source:https://www.forbes.com/sites/adriennegibbs/2019/07/17/man-on-the-moon-music-the-apollo-11-moon-landing-mixtape-and-spotifys-top-streamed-lunar-tunes/?sh=13df8c6d16ed, Accessed: July 14, 2023.

Figure 9. Apollo Lunar Module LM-2 (on display at the National Air and Space Museum, Washington, DC)
Source: https://airandspace.si.edu/collection-objects/lunar-module-2-apollo/nasm_A19711598000, Accessed: July 14, 2023.

In the design of ADS of the Space (S) and Space-Body (SB) type, a number of physical-scientific and technical issues had to be solved first, how to get into Space and land on other celestial bodies [2]. The answers to these questions had to always have in mind the Man and the Limits of ADS, which will ensure his safety (not yet the comfort that he provides in the EAG environment). This regularly led to the search for materials[6] with unprecedented performance, for their assemblies (Boundaries) that will respond to flows of matter and energy for which there is no experience on Earth[7].

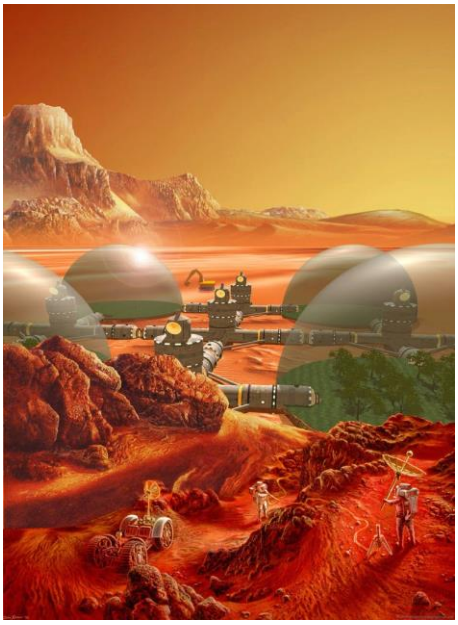

Figure 10. Astronaut camp on Mars (project)
Source: https://sciencecampsamerica.com/space-camp/, Accessed: July 14, 2023.

Figure 11. A mock-up of a space shuttle leading edge made with an RCC-panel taken from Discovery. Simulation of known and possible conditions of the foam impact on Columbia's final launch showed brittle failure of RCC
Source:https://www.semanticscholar.org/paper/A-Summary-of-the-Space-Shuttle-Columbia-Tragedy-and-Melis-Carney/00b3e71009903e51302b8b4fbb719bbc667c8214, Accessed: July 14, 2023.

The visions of the city of the future (Figure 12) by architect Antonio Sant'Elia (1914) are greatly surpassed today (Figures 12,13,14,15,16,18). There is no doubt that today's visions of cities on Earth and those in the Space will be reached[8].

[5] For example: one of the most brilliant human realizations about the unity of matter and energy, the unity of the world ($E = mc^2$, A. Einstein, 1905) resulted in its application through an atomic bomb of incalculable destructive power.
[6] Such materials have been named 'supermaterials'. Their mechanical strengths and resistance to high temperatures, for example, exceed all the extreme values of materials that man works with on Earth.
[7] Precisely because of ignorance of the numerous inputs that determine the Space (S) and Space Body (SB) ADS Limits, even the slightest carelessness in materializing the ADS Limits can end tragically. This is also confirmed by the disaster experienced by the American Space Shuttle „Columbia“ (February 1, 2003) on its return from space to Earth, where the ship caught fire upon entering the Earth's atmosphere. Seven astronauts died on that occasion. A later investigation showed that the cause of the accident occurred during the launch of the Space Shuttle „Columbia“ from the Earth into space, when a solid object damaged the wall (boundary) of the Space Shuttle, which was enough to cause in that place (at a temperature of 1600 °C), develops a fire and destroys the aircraft (Figure 11).
[8] Apart from architecture and science (we would say 'by definition') as well as other arts (film, literature, painting, music...) are looking into the future of Man. The famous novel 2001: A Space Odyssey (1968) by Arthur C. Clarke. The same author published a novel on a similar theme, 2010: Odyssey Two (1982), which was adapted into a film of the same name (1984), and the novel 2061: Odyssey Three (1987).

Figure 12. Left: Futurist Manifesto of Architecture, 1914 (Architect: Antonio Sant'Elia). Center and right: Some visions of the city of the future on Earth (Image at right: Frank R. Paul)
Source: https://www.wired.com/images_blogs/photos/uncategorized/2008/11/11/santelia.jpg, Accessed: July 14, 2023.
Source: https://article.murata.com/en-sg/article/vision-and-technology-for-the-future-of-smart-cities, Accessed: July 14, 2023.
Source: https://i.redd.it/ntjqxazvo8m91.jpg, Accessed: July 14, 2023.

In the future, architecture will certainly be studied according to individual celestial bodies (Moon, Mars, Venus...), in a similar way as today we talk about the architecture of Ancient Egypt, Gothic architecture or modern architecture, for example.

Figure 13. Artist rendering of The Toroidal Colony by Rick Guidice
Source: https://www.artsy.net/article/artsy-editorial-nasa-art-shape-vision-future Accessed: July 14, 2023.

In the last ten years, many architects have given their proposals for 'habitats on Mars'.

Seed Of Life (Architects: Zaki Warith and Amir Amzar, Malaysia). Architects propose bamboo as the basic building material, which could be grown on Mars. Robots would then weave it into a balloon-shaped envelope around the ETFE membrane under pressure. For added protection from the elements of the natural environment on Mars, the bamboo structure could be filled with ice and the habitats could be grouped together to create a greenhouse space in between (Figure 14).

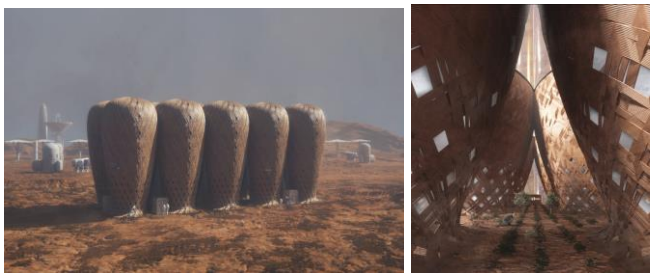

Figure 14. Seed Of Life (Architects: Zaki Warith and Amir Amzar, Malaysia)
Source: https://www.archdaily.com/924023/designers-imagine-bamboo-colony-on-mars, Accessed: July 14, 2023.

Mars Science City, Dubai. The government of the United Arab Emirates is funding this 57,000m^2 experiment in 'Martian vernacular architecture': a group of intersecting transparent domes in Dubai's Mushrif desert (Figure 15). On Mars, it will feature 3D printed, semi-subterranean structures, protected from at least some of the Martian elements; in Dubai will house exhibition, research and educational spaces - something like an interplanetary one, similar to the Eden Project (Cornwall, England, 1996-2000) by architect Nicholas Grimshaw.

Figure 15. Mars Science City, Dubai (Architects: Bjarke Ingels Group: BIG)
Source: https://www.dezeen.com/2017/09/28/bjarke-ingels-mars-science-city-space-exploration-dubai-united-arab-emirates/
Accessed: July 14, 2023.

MARSHA by AI Spacefactory. NASA plans a manned mission to Mars by the mid-2030s; Elon Musk's Space X aims to get there in 2024. But it's not just about the journey. Given the demanding time frames of travel (Earth and Mars align once every two years; a one-way trip takes six to nine months), any visitor to Mars will stay there for a while (Figure 16). The conditions are not very hospitable either. Mars' gravity is 38 percent of Earth's, there is practically no atmosphere, so the air pressure is negligible, the levels of solar radiation are dangerously high, and the daily temperature fluctuation can reach 150 ºC. Meteor strikes are also frequent. These radically different parameters generate radically new types of architecture and design. Building on Mars is a construction challenge. Transporting building materials over a distance of 56 million km is out of the question. Therefore, an acceptable solution would be to build 'in situ', on Mars, from material available there: Martian rock, known as 'regolith'. The current thinking is to send autonomous robots in advance to process this regolith into material suitable for 3D printing, then build habitats remotely, ready for the first human arrivals.

Figure 16. MARSHA (Design: AI Spacefactory)
Source: https://designwanted.com/marsha-ai-spacefactory/, Accessed: July 14, 2023.

V. Conclusion (Perspectives)

By the term 'Perspectives' (in the framework of the theory of Architecturally Defined Space) we mean „that dynamic relationship that connects now-future, existing-possible, realized-desired“ [1]. According to the author's typology of architecture [2], for the perspective of architecture in general, the following types are particularly interesting: S-type (architecture in the free space of the Universe), SB-type (architecture on other celestial bodies) and EW-type (underwater architecture). Exactly ten years after the publication of this typology, humanity experienced the first stay in space in a private arrangement, the flights of businessman Richard Branson (July 12, 2021) and Jeff Bezos (July 20, 2021), (Figure 17).

Figure 17. Left: Richard Branson (July 12, 2021) and Jeff Bezos (July 20, 2021) are the first visitors to space in a private arrangement. Right: Jeff Bezos' flight into space (July 20, 2021)
Source: https://www.aljazeera.com/news/2021/7/20/jeff-bezos-flight-to-edge-of-spacekey-questions-answered, Accessed: July 9, 2023

Richard Branson became the first person to fly into space on a rocket he financed. The supersonic space plane, developed by his company Virgin Galactic, took off early Sunday (July 12, 2021) into the skies above New Mexico, carrying Branson and three crew members. Branson-along with Virgin Galactic employees Beth Moses, Colin Bennett, and Sirisha Bandla, and pilots Dave Mackay and Michael Masucci-boarded SpaceShipTwo, the winged, single-rocket engine the company has been developing for nearly two decades. Attached beneath a massive twin-hulled mother ship, named WhiteKnightTwo, the vehicle took to the skies at 8:30 a.m. MT and climbed about 15 km into the air. Jeff Bezos, the richest man in the world, aboard his company Blue Origin's New Shepard, made (July 20, 2021) a suborbital flight as part of a history-making crew-another milestone in the new era of private space travel. The American billionaire and founder of Amazon took off from a desert site in West Texas on a trip nine days after British rival Richard Branson took off on the successful maiden suborbital flight of his rival Virgin Galactic from New Mexico. In addition to all that has been practically realized so far in terms of underwater architecture, we should remember the 'visions of the underwater world' that have long been presented by artists - writers of science fiction novels and creators (and screenwriters) of science fiction films. It was the works of this type that 'paved the way' for concrete architectural realizations. The Deep South, directed by Bret Haaland, written by Joseph Stewart Burns, is the 12th episode in the second season of the American animated television series Futurama. It originally aired on the Fox network in the US on April 16, 2000.

The design firm Foster & Partners also made a proposal for construction on Mars, “Mars Habitat” (2015). “Continuing this practice's earlier design research for building in extreme environments and extraterrestrial habitats with the Lunar Habitation project, Foster + Partners worked on a NASA-backed competition for a 3D printed modular habitat on Mars. The Mars Habitat design outlines plans for a settlement built by a series of pre-programmed, semi-autonomous robots before the eventual arrival of astronauts. The habitat – created in collaboration with industry and academic partners – envisages a robust 3D-printed dwelling for up to four astronauts built using regolith – loose soil and rock found on the surface of Mars. The proposal considers multiple aspects of the project from delivery and installation to construction and operation. The habitat will be delivered in two phases before the arrival of the astronauts. First, semi-autonomous robots select a site and dig a 1.5-meter-deep crater, followed by a second delivery of inflatable modules that sit inside the crater and form the core of the settlement. Given the great distance from Earth and the resulting communication delays, deployment and construction are designed to take place with minimal human input, relying on rules and goals rather than precisely defined instructions. This makes the system more adaptable to changes and unexpected challenges - a great opportunity for a mission of this scale” (Figure 18) [19].

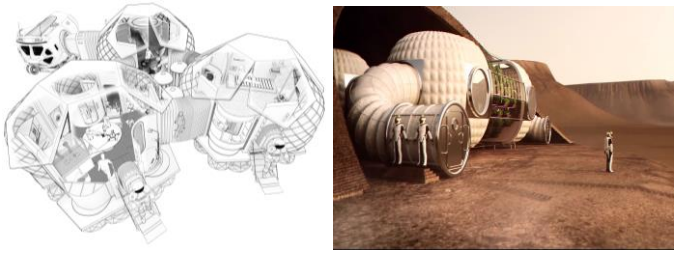

Figure 18. Mars Habitat (2015). Left: Habitat configuration. Right: 3D Printed (Architects: Foster & Partners)
Source: https://www.fosterandpartners.com/projects/mars-habitat, Accessed: July 14, 2023

On August 7, 1996, at NASA headquarters in Washington, D.C. a meteorite from Mars is presented. Scientists have announced that they have found signs of life inside a meteorite. NASA Administrator Daniel Goldin said it was an 'amazing' day [20].

Mars University is an international academic and research organization that enables the first academic programs dedicated to the creation of life on multiple planets. Online courses on 'Mars Settlement and Exploration' have been organized for the summer of 2023. The certificate program is

delivered with small class sizes so that course participants can continue to work and be placed in their home community with the goal of developing the knowledge and skills for exploring and living on Mars.

The search for life on Mars has become more urgent in part thanks to the probes of two rovers (Figure 19) [21] now roaming the surface of Mars and another spacecraft orbiting the planet.

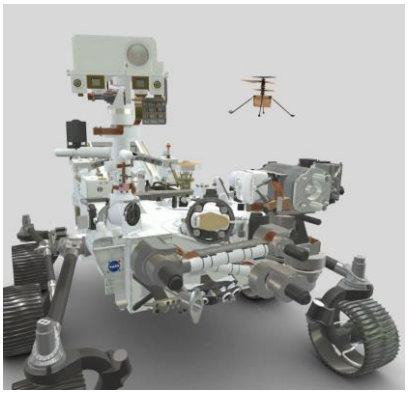

Figure 19. NASA-Perseverance Rover on Mars (2021-present)
Source: https://mars.nasa.gov/mars2020/, Accessed: July 14, 2023

Interest in the Space and other celestial bodies is growing day by day. Man on earth (especially economically strong countries) sees there his new existential space where, potentially, they could develop new technologies and ensure well-being, both on a planet (such as Mars) and on Earth, especially after facing the permanent threats of nuclear war (especially today), which would endanger the entire human population on Earth, as well as itself as a space structure.

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