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EDIFICE OF ARCHITECTURAL SPACE DEVELOPING IN EXTREME CONDITIONS OF MARS

Abstract.*The article dwells upon the basic principles of the architectural space developing in the stress conditions of Mars. The architectural environment has always played a significant role in social advancement. Nowadays the research study of the environment space forming factors and principles should correspond to the needs of the modern man and public at large. In the meantime, the development of science and technology provides the feasibility of the architectural environment reorganization in light of the necessary requirement to human life and activities. In the development of the architectural space, it is necessary to take into account the reasons determined by natural circumstances. Based on these facts, let us take a closer look at the architectural environment in extreme habitat conditions. The worst conditions for human life and activities of the Mars ecosystem have been chosen for clarity. The architectural space constitution in extreme conditions will allow us to synthesize and analyze information of the morphology, development and function of artificial habitat. The classification model based on typological and hierarchical methods is used. The general principles are presented in the typological method such as: the core principle and all-pervading principles. The article discusses that the core principle is the constant improvement of the architectural space in the extreme habitat conditions. The all-pervading principles include: 1) the principle of consumer orientation; 2) the principle of making fair decisions based on reliable facts; 3) the principle of finalization and monitoring results. The hierarchical way is divided into external and internal factors. External factors in the edifice creation are thought as the influence of various aspects of ecology, economics and technology. Internal factors rely on the interaction of the architectural space with man and society at large. The study of the edifice placemaking in the Mars extreme habitat conditions is based on the strategy of improving architectural spaces not only outside the Earth, but also on its surface. The authors are convinced that such a grotesque example allows to study and develop the topic of extreme conditions and present the best results in the follow-up research.*
Keywords: *architectural environment, society, system, space, planet, Mars, principles, extreme conditions.*

The influence of the architectural environment on the human consciousness formation attracts great public interest, since the interaction between man and artificially created environment becomes close and complex. The studies of all formation factors of the environment space are now in progress. The obtained data provides an insight into the principles the architectural environment should meet for satisfying the needs of the modern man and society. At the same time, the development of science and technology provides practical opportunity for the reorganization of the architectural environment, with regard to the essential requirements for human livelihood.

The topical question is the environment formation in conditions of a natural disaster. V.G. Volovich, the author of "The Man in Extreme Conditions of the Natural Environment", offered reasons for determining the conditions (Volovich, 1983). Among these are temperature and humidity, solar radiation, vegetation, water sources, etc., as well as the survival stressors taking a toll on the body: misery, cold, heat, thirst, hunger, overwork, loneliness, fear (Nicholson, 1968, Joiner, 1978, McLoughlin, 1981). In general, the reasons are called survival factors (Figure 1).

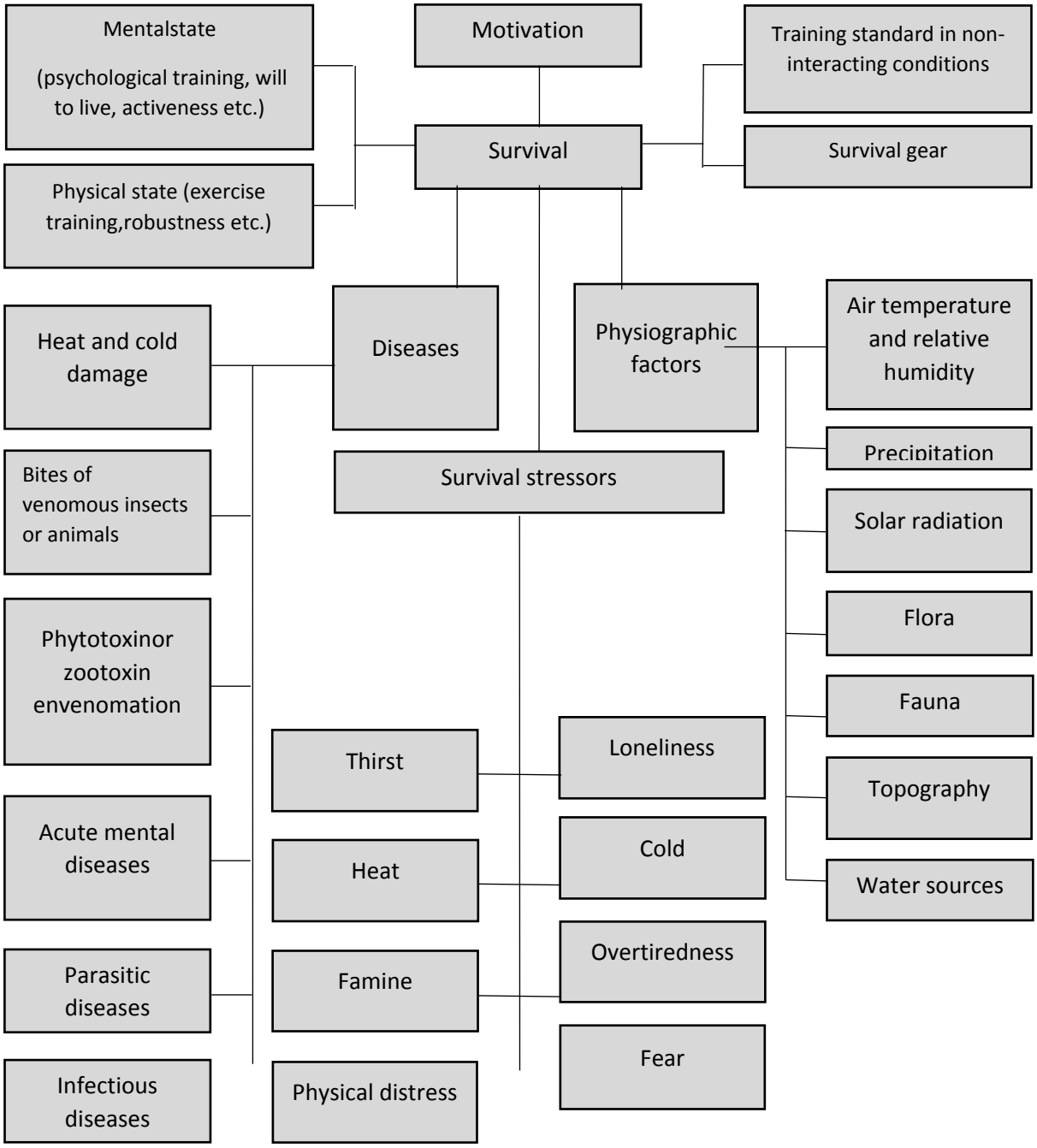

Figure 1. Survival factors

The Mars nature is referred to extreme environment, its colonization inflames lively disputes not only among science fiction writers, but also scientists from different countries. For example, NASA Released Plan Outlining Next Steps in the Journey to Mars on October 9, 2015. The architecture of Mars colonization was presented by Elon Musk, the General Director and Chief Engineer of Space X (Elon Musk, 2016) at the Inspace Forum. The statement "The flight to Mars should become a new round of human events" was published on the blog of cosmonauts of the spacecraft (Yurchikhin, 2010).

There are many opinions and disputes, but the idea of Mars colonization constantly keeps the scientific thought of our planet up. In general, evolutive guidelines of humanizing the architectural environment should be true for the Earth extreme regions when men stay there for a long-term presence. Therefore, the basic principles of the architectural space in the Mars stress

conditions call for special attention. The creation of such system will highlight and combine morphology, law of development and operation of manmade environment in the structure of the Red Planet natural properties. To create and arrange the classification model of the edifice for the environment pattering, let us take a closer look at two methods: typological and hierarchical (Table 1).

Table 1

<table>
<tr><td colspan="10">Classified model of ecodevelopment paradigm of architectural environment in extreme conditions of Mars' nature</td></tr>
<tr><td colspan="2">Typologic Component</td><td colspan="8">Hierarchic Component</td></tr>
<tr><td>Core Principle</td><td>All-pervading principles</td><td colspan="5">External factors</td><td colspan="3">Internal factors</td></tr>
<tr><td rowspan="2">Principle of continual improvement of architectural environment in extreme conditions Marsnaturalsetting</td><td rowspan="2">Principle of consumer orientation
Principle of making objective decisions based on reliable facts
Principle of finalization and results control</td><td>Economics</td><td>Ecology</td><td colspan="4">Technology</td><td colspan="3">Human interaction (society)</td></tr>
<tr><td>Principle ofeconomic expediency</td><td>Principle of ecological compliance</td><td>Principle of trasformativeness</td><td>Principle of mobility</td><td>Principle of modularity</td><td>Principle of integrated system of autonomous house</td><td>Principle of aesthetic and artistic perception</td><td>Principle of functional organization</td><td>Principle of safety and accessibility</td></tr>
</table>

The core and all-pervading principles are aimed at the sustainable development of the architectural environment in extreme natural conditions. The quality management of the architectural environment is based on the requirements of ISO 9000 (GOST R ISO 9000-2015, Quality Management Systems, 2015). These requirements constitute a series of international standards containing terms and definitions, the basic principles of quality management, the requirements for quality management system of enterprises and organizations, as well as guidance on making major achievements. We should properly quantify all risks, as well as factors and conditions that determine the growth prospects of the projected environment quality. The principle of continual improvement is basic in creating comfortable, efficient and functional architectural space in extreme conditions. Its implementation will allow to improve the environmental quality, improving it in accordance with the varied user requests and characteristics of Mars.

The principle of consumer orientation includes: 1) analysis of the needs and means of users of the architectural environment in extreme conditions of Mars' nature; 2) attraction of people in the discussion and evaluation of space development projects at all levels. Placemaking of buildings, external arrangements of space, beautification features andvehicular & pedestrian structure etc. can fit into the principle; 3) reinforcement in the public mind of the importance and necessity of designing the safe and comfortable environment.

The principle of making objective decisions based on reliable facts prioritizes to upgrade the operation and quality of the architectural space in extreme conditions following on from the

results of the case study. However, following these principles, we should not reduce a piece of architecture to assembled equations, otherwise there is a risk of losing not only the individuality of the environment, but also the transcendental component determining the piece of architecture.

The principle of finalization and results control allows to monitor the efficiency of implemented arrangements, the rationality of the allocation of supplies and timing budget, the adequacy and finality of taken decisions and design projects.

The hierarchic component of the principles of the architectural environment formation in the extreme conditions is represented by the complex structure created under the influence of external and internal factors. Externally influencing factors are: economic, ecological and technological components. The listed components do not depend on human interaction. Internal factors, on the contrary, reveal the direct interaction between the architectural space, man and society.

Let us consider the components of external factors.

The economic component is based on the principle of economic expediency. Formation of the Mars environment requires the compilation of estimates and use of economically viable technologies and materials. For example, we can consider the launch-to-orbit cost of two carriers into the Earth's orbit: Proton-M (Russia) - 69-70 million dollars (cost of launching the satellites "Proton-M", 2015) and "Falcon 9" (USA) - 61 million dollars. Falcon 9 with the reusable first stage successfully launched the satellite SES-10, 2017. The space shuttle is a state-of-the-art development, with the advantage of a stage return, this innovation allows to reduce the cost of launches. Pascal Lee, the director of the Mars Institute has calculated how much the space launch to Mars will cost. He is confident that manned flight to the "Red Planet" will cost the mankind from 400 billion to 1 trillion dollars, the most budget will be spent on creating new technologies to save the astronauts' lives in the hostile environment of Mars. By comparison, Pascal recalls that in 1960 the entire program of moon landing cost $ 24 billion (The cost of the Mars flight is called Mars, 2017).

The Ecological Compliance is the important principle of the ecological component; the human safe living conditions are determined by the action of the environment substances. The Mars atmosphere is not suitable for human life. Its main characteristics can be distinguished as follows: 1) pressure - from 4 to 8.7 mb. according to the season; 2) diurnal range of operating temperature from -89 C^0 to -31 C^0; 3) wind velocity 2-10 m/s and 17-30 m/s during dust storms; 4) the basic atmospheric composition is carbon dioxide - 95.32%; nitrogen - 2.7%; argon - 1.6%; the oxygen content is 0.13%; carbon monoxide - 0.08% (Mars Fact Sheet, 2016). A separate issue is the background radiation of Mars. "Per day, the human body or other living beings will accumulate about 0.21 millisieverts of ionizing radiation, it is ten times greater than similar values for the Earth. As the authors note, this value is 2 times less than the level of radiation in open space measured during the Curiosity flight from Earth to Mars." (The scientists published the first estimates of the radiation level on the Mars surface, 2013).

It follows that the Ecological Compliance Principle is the key one in creating the viable architectural space in the Mars extreme conditions. At the moment, it is possible to note the most successful artificial ecosystems' experiments that are able to provide security and indispensable living needs: Bios-3 (USSR) developed back in 1972 – 1980, which set a record of being in seclusive artificial environment for 15 months, and "Yuegun-1" (PRC) ("Moon Palace", 2013), the complex which reproduced the conditions of the lunar base, the experiment lasted 105 days (Tkachenko Y., Morozov S.D, 2017). Another example is the construction and operation of the International Space Station. The experiments are the most striking instance of the creating an autonomous and self-sufficient habitat for humans, but all of them were conducted in close proximity to the Earth. In the Mars conditions, the creation of self-made environment will require a particularly detailed study. For example, the earth magnetic field protects the ecosystem from radiation, and it also concerns the ISS on-orbit. Moreover, the Martian soil could protect people from ionizing radiation (Regolith from Mars can be used to protect against radiation, 2014). The

ecological state of the planet itself also applies to the principle of ecological safety. It is important to observe appropriate precautions so as not do damage the Martian ecology. It should be taken into account in the study of the "Red Planet" as it is not yet determined if there is a lack of life on Mars. Contamination of the planet can greatly complicate the search.

The next part of the external factors affecting the design of the Mars architectural environment is the technological component. It is afforded by the principles of the integrated system of an autonomous building: transformability, mobility and modularity.

Let us examine the principle of the integrated system of an autonomous house: there is no infrastructure on Mars, autonomous systems are needed that can function independently in external conditions. Innovative systems of autonomous provision can create effective functioning for human life. Such systems put into operation on Mars in the future can encourage founding settlements on other planets of the solar system. During the above described experiments the scientists achieved some results in the artificial ecosystems creation in particular regarding human provision, oxygen and food supply (Tkachenko Yu., Morozov SD, 2017). In practice, you can see the effective use of alternative energy sources based on the electromagnetic solar radiation and motional wind energy. The advantage of these systems is ecological cleanness, low cost of operation, and the most important possibility of stand-alone use.

Further, we will consider such principles of the technological component as mobility, modularity and transformability. The Process Technology and Innovation promotes the efficient use of the principles and has an impact on economic feasibility. For example, the creation mobility, modularity and transformability will allow to construct a building to the limit, move it to another place, and quickly addthe blocks to expand the available space. In the context of a long distance from the Earth the principles will have a positive impact on the development of the architectural environment, especially at the first stage of its formation.

There is another side of the process affecting the creation of the Mars architectural environment. Its origin comes from internal action and is defined by the interaction between man and environment. The aesthetic perception, functional organization, security and accessibility are the main principles.

The principle of aesthetic and artistic perception shows the necessity of adopting the paradigm of humans' aesthetic preferences to different types of architectural environment. Aesthetic valuation unites all man requirements to the environment, showing their need for ego-consciousness and environmental integrity. The man and environment synthesis corresponds to the modern concept of humanization of the architectural environment in the extreme conditions of the Mars natural settings. Due to the lack of human culture on Mars, this parameter is more relevant than in the life conditions on Earth and requires in-depth study.

The principle of functional organization is particularly important, since the architectural environment has the property of varying with time, and man is the key factor of its development. That is why, it is necessary to give the subject the extensive outfit for interaction with the environment at the level of the planning pattern and functional relations. Thus, a person occupies a special niche in the design process. This approach is necessary in Martian conditions, because of the long distance from the Earth, and specific conditions of habitat. When involving the subject in the design process, one cannot ignore the principle of safety and accessibility not only for an individual but also for society as a whole.

The creation of social infrastructure in the extreme natural settings of Mars should comply with safety regulations in such areas as: economy, ecology, information, fire and military laws. The principle of safety and accessibility is responsible for it. Under ecosystem enclosure, the compliance with safety measures is needed, because of the affection of corpus separatum to the security of the whole society. The social order observance is the key point to the successful safety rules implementation in various areas. It is also worth mentioning the observance of accessibility standards for the low-mobility groups of population. The harsh conditions of Mars do not mean

that such social group will not exist there, therefore we should appreciate *the Martian architectural environment* in design.

The placemaking paradigm in the extreme conditions of the Mars natural setting form the basis of the strategy for improving architectural spaces and enhancing their quality outside the Earth. The system integration has a positive effect on the architectural space development and public consciousness in the extreme conditions. Dedicated principles encourage the human material needs in comfort, safety and aesthetic appeal and they also exert influence on the development of science and technology.

The creation of architectural environment in *extreme conditionsof the Mars natural setting on the basis of the stated paradigm will give an opportunity to a deeper perception of the Universe monism, declared by K.E Tsiolkovsky, and it will provide further insight that everything in the Universe is woven into a global infinite ecosystem.*

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