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PLANETARY ENGINEERING: THE HUMANITY'S POTENTIAL TO LIVE ON OTHER PLANETS

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Annotation. This article examines how rapid advances in space exploration and technological development may influence the future of humanity. It explores missions aimed at space colonization and considers the potential expansion of human activity within the Solar system and beyond. Particular attention is given to the roles of leading space agencies and private aerospace companies, such as NASA and SpaceX, which are currently developing large-scale initiatives in this field.

Keywords. Space engineering, terraforming, Lagrange points, celestial body, ecopoiesis, ISRU

Introduction. For many centuries humanity has been looking at the stars with curiosity, but today this interest has evolved into a pragmatic necessity. The main reasons for space expansion are limits of the Earth itself: global climate change, lack of natural resources and uncontrollable population growth. We are approaching the point, where a single planet might just not be enough for species survival [1]. With that being said, the attention focus drifts from simple space exploration to planetary engineering. If we were only spectators in the past, now we discuss the possibility to directly change environmental conditions on other celestial bodies to make them suitable for living. The goal of this article is to analyse the technological competence, required basis and ethical dilemmas of turning humanity into a multiplanetary species.

Main part. The concept of planetary engineering requires careful examination. Planetary engineering is a complex of theoretical concepts and methods, aimed for intentional full-scale changes of physical, chemical and biological traits and parameters of planets, satellites and other celestial bodies. The main tool of this concept is terraforming – intentional change of atmosphere, temperature and ecology of a planet to fit Earth's standards. For example, for Mars it implies the creation of greenhouse effect for surface heating. However creating atmosphere is just half of the work. It is required to provide special magnetic protection. Without strong magnetic field the solar wind will simply eradicate any created atmosphere, created by humanity. Scientists offer ambitious projects about creating artificial magnetic shields in Lagrange points [2]. The concept of terraforming is demonstrated on Figure 1.

Figure 1 – The concept of terraforming Mars

Such stage is already tedious, as it requires a lot of funds, time, energy and resources to change at least a fraction of an atmosphere. This especially scales with the surface area of a planet: the bigger the planet, the more atmosphere area needs to be changed. But once it is done, a new stage is about to be executed afterwards. Such stage is ecopoiesis – a process of inhabiting plantes with the most primitive living organisms. Cyanobacteria and lichens should be the first colonisers, who will begin to recycle carbon dioxide into oxygen, preparing soil for more complex life forms.

As mentioned above, carrying all the necessary resources and technological basis is not possible: it's too expensive and inefficient. So the key concept becomes In-Situ Resource Utilisation (ISRU) – usage of local resources, instead of dragging them from our home planet. The humanity should learn how to extract water from Mars's polar waters or Moon and print living modules on 3D-printers, using local regolith – space dust and stones. In order to maintain such activity a colossal infrastructure is necessary: orbital factories, automatised, mines on asteroids for gathering rare metals and, possibly, space elevators, radically reducing the cost of delivering cargo into orbit.

Space exploration is already an interesting topic to discuss and to imagine how everything would turn out in the future. But planetary engineering puts the toughest ethical and moral questions before humanity. Do humans have the right to adjust worlds for our interests? Is humanity ready for such radical change of living space and creating new ones? It begets the conflict of planetary defense: if at least one life collapses on Mars, our intervention might just bring to its total destruction [2]. Supervision is as important question as the previous. Who will become the owner of new territories? Private corporations, such as BlackRock? State coalitions, such as Russia and China? Space monopolies, such as SpaceX? The risk of forming new forms of colonialism or revival of neo-colonialism and neo-nationalist and neo-capitalist ideas, the risk of the emergence of new geopolitical conflicts just for space resources is a threat that needs to be resolved even before the first landing. Moreover, ethical dilemma also can't be ignored: is it worth spending trillions of dollars into Mars colonisation, if we can't handle the problems on our home planet Earth?

Despite such questions that are yet to be answered in the near or far future, we stand on an active preparation stage today. Artemis program from NASA makes the return into Moon and creation of a permanent Moon base, where it will become a training field, a primary goal before jumping straight to Mars [3]. Private initiatives, such as Elon Musk's Starship project, are directed to a reduction in launch cost through increased flight frequency. In long-term perspective a vision of interplanetary civilisation means that a death of a planet won't be an extinction of the entire humanity. It's like building an emergency exit for our culture and knowledge.

Conclusion. Planetary engineering is a project designed for centuries, if not millennia. It appears technologically feasible in the foreseeable future, but ethical and legal difficulties of the process remain as brakes for such opportunity to happen. The main challenges will be not only radiation and absence of oxygen, but also ability to make deals about rules and restrictions in the new world full of technology and exploration.

Dominant space companies, such as SpaceX, Blue Origin, Rocket Lab, United Launch Alliance (ULA) and Arianespace, also tend to fund special mission for space exploration, and the competitions between such companies keep the operations going, analysing further details of space expansion and planet inhabitation. At present, Mars is considered the most viable candidate for large-scale planetary engineering, since other planets like Mercury, Venus and gas giants are either too hot, or do not contain any solid surface, and their satellites are too far away, making transportation costs off the scale.

Humanity has long questioned whether travel beyond Earth is possible. Today, we possess the technological resources to pursue such ambitions; however, significant ethical and moral questions remain unanswered. Nevertheless, leaving the orbit of our home planet Earth is, perhaps, the only way to maintain long-term survival of the mankind and its further development as an interplanetary species.

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