# The need for a link between astronautics and robotics in the extraction of minerals from space bodies

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***ABSTRACT:*** ***The gravity of different space bodies is different and it varies in very wide limits, from absolutely insignificant values to values that can destroy other space bodies. The approach to the design of extraterrestrial industry on other space bodies outside the Earth has to be specific and tailored within certain limits. There is a conceptual design of a space engine and technology for multiple transportation that can enable us to master outer space within the solar system. mining system Specific aspects of the need to link robotics with cosmonautics are discussed This material heralds the beginning of a new era in which the technical solution to mastering the riches of space is already available. For the created opportunity for man to have the technical ability to realize his dreams of setting foot on other planets and using their natural resources, as well as creating robotic complexes for the extraction of minerals from places harmful to man.***

***Keywords: transport, robotics, astronautics, gravity, mining***

## I. INTRODUCTION

When it comes to mining minerals from space bodies, a number of circumstances must be considered that arise and complicate the mining process compared to that on Earth. Established physico-chemical technologies and methods [7] for extracting minerals on Earth do not differ significantly from technologies for extracting minerals and fuels from space bodies. This is because the physico-chemical laws of the Earth have the same effect on other cosmic bodies.

At the moment, robotics is poorly represented in cosmonautics, with the exception of some automatic systems that include reconfigurable modules. This is due to the fact that outer space is partially mastered only in close orbits around the Earth. In this space, there is no industry, no need (yet) for service robotics, no transfer of bodies of terrestrial origin to bodies of extraterrestrial origin, etc.

When you talk about mining minerals from space bodies, you have to think about organizing a space body industry, and this has a lot to do with the transportation activity, storage economy, energy economy, household sector and many other things.

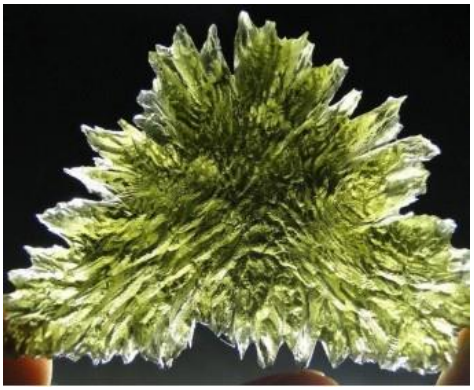

Fig 1. Moldavite, tektites. These crystals are formed on the ground after the impact of an asteroid, at the point of impact, under high pressure and temperature.

Fig. 2. Asteroid gold

Many of the peculiarities of the parameters of extraterrestrial space bodies for the extraction of minerals are related to the huge differences from the terrestrial microclimate to which human existence is adapted, as well as the existing structures of machines on Earth. In this line of thought, some of the existing engineering structures on Earth would undergo modification, others could not be used, and still others would be used without modification.

As for the microclimate determining the existence of man on a cosmic body outside the Earth, space scientists do not point to another body within the Solar System with a microclimate similar to Earth's. This necessitates the application of special protective suits for mining workers where a human is likely to exist.

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Fig. 3 The asteroid Psyche

Psyche is located in the main asteroid belt, located between Mars and Jupiter with an orbit 2.5-3.3 AU from the Sun.

Interest in this asteroid is fueled by the fact that it is metallic and is composed of gold, platinum, nickel, iron, and more. The value of the asteroid's gold is estimated at more than $4 quadrillion, and the iron at more than $100 quadrillion.

So far no spacecraft have been sent to Psyche and excitement is high. The mission has been in the works since 2014. NASA has a contract with SpaceX to launch the Falcon Heavy, the Psyche spacecraft should reach the asteroid's orbit in January 2026, taking advantage of Mars' gravity along the way. The orbiter is expected to study the characteristics of the asteroid for at least 21 months, maintaining various orbits above its surface. It will descend as low as 85 km to collect magnetic field data, photograph the surface and measure gamma rays and neutrons.

There are millions or billions of similar meteorites in space, with different size and different composition of metal content.

Most mining sites off Earth could not have humans, indicating that robots would be working there. They will operate the power machinery. Robots will control the manufacturing process, etc. In this way, there is a natural connection between astronautics and robotics.

There are places for mining minerals and fuels that are not based on a solid surface. This is the extraction of energy from the Sun, (an orbital station for the extraction of energy from the Sun can be created in a close circumsolar orbit). Another type of non-solid surface mining is diamond mining from Saturn. As is known on this planet in the lower atmospheric layers the carbon turns into diamonds and falls as rain on the surface of the planet where it heats up, passes into another state of aggregate and rises up to close its circular cycle. It is enough for a suitably constructed aircraft to fly over one or more such diamond rains and the mining of diamonds is realized.

## II. SOME SPECIFIC FORMS OF THE CONNECTION OF ROBOTICS WITH COSMONAUTICS

### *A. Transport activity*

When it comes to mining minerals from space bodies, it: First and foremost is the task of reaching this cosmic body. Existing missile designs could reach the pre-targeted body. As already noted in [7], rockets with chemical fuel could not work due to the low efficiency of the fuel. There are developments of atomic engines that would give a much better result than chemical fuel, but the development of these engines is not yet at the necessary height to be able to be used in the means of transport in creating an industry in outer space.

Such a technology has already been created and disclosed to a wide international audience in [ 7 ].

### *B. Landing (capture) of the vehicle to the space object*

In this case, there are several options for action:

a). In the case when the space object has a commensurable mass (inertia) at g~0, that is, the space body has an approximate radius of up to 0.05 km. In this case, due to the low inertia, the capture of the space body can be carried out from the direction of movement of the space body. This maneuver can be realized with the help of robots of the type of industrial robots attached to the transport vehicle in order to grip onto space bodies. As a clarification, the vehicle's engines need to be powerful enough to maneuver the mass of the vehicle along with the mass of the spacecraft.

b). In the case when the space object has a large mass, but low gravity $0<g<2$.

These are relatively large objects reaching the size of our Moon. On such space objects, it is quite reasonable to create industry, the participation of people. This does not exclude the use of robots and robotic complexes.

Similar industrial enterprises from the mining industry can also be created on space objects with higher gravity. At $2<g<15$ the participation of workers is admissible, but at higher levels of $g>15$ human labor is inadmissible.

c). At values of g in the range $15<g<3500$ landing of a transport vehicle with a crew on board on the ground of the space object is unthinkable. Landing can only be done with unmanned aerial vehicles. All loading and unloading activities are performed by robots.

In this range, human involvement is unthinkable because the gravity, in some cases, is so high that it would kill a person in an extremely short time.

This is the most comfortable area of application of the types of basic structures of the technique applied on Earth for the extraction of minerals.

d). At $3500<g<9000$, the gravitational forces are so great that the construction of the so-called EXTREME MACHINES is resorted to for transport activity and extraction of minerals.

At gravity values, the efforts generated by the gravitational forces are extremely large, and for these conditions, wheeled and foot mobile systems with special designs are applied, as an example are the internal barrel gear meshing, eccentric mechanisms, some wedge mechanisms, etc.

e). At speeds of $g>9000$, a SPECIAL TECHNIQUE suitable for the performance of specific tasks is constructed. At these values of gravity, the development of new technologies for landing on a ground, liquid or simply flying at a certain height is required.

It is important to note that this is only a small range of the gravitational forces that exist on cosmic bodies, even if only in the Solar System. Gravitational forces exist in outer

space, which are so great that they change the structure of atoms and their constituent parts.

In the described range of gravitational forces, the materials we have here on Earth to make the necessary equipment and operate it are at the limit range of their capabilities. Materials science, however, is developing and new materials obtained in weightless conditions or in high gravity conditions would be extremely useful in the construction of new, stronger machines.

Thus, the presented classification depending on the gravity load is one-sided and incomplete. A number of additional conditions are also included in the peculiarities of the mining site, such as:

- Radiation background;
- Toxicity of the atmosphere, if any;
- Acidity of the environment;
- Average temperature and temperature range of the environment;
- The forces of aerodynamic and hydrodynamic currents in the region, exerted on the technique, etc.

*C.The locomotion in cosmonautics*

Leg mobility in modern science is considered a part of robotics, although it refers to the activity of transportation.

1. For values of $0<g<2$. These are usually small celestial objects on the order of 0.05 km to 500 km in diameter. There are usually no liquid or gaseous minerals at these sites, only solids. On these space bodies, only means of transport with point contact on the ground are applicable, that is, mobile movement on foot. During foot mobile movement, additional mechanisms can be included to make contact with the ground from the fifth or sixth class of contact, that is, the means of transport, with each step, makes locking contact with the ground, and does not rely on gravity.

In a deep structural analysis, it is noticed that the foot mobile movement is a universal movement for realizing locomotion [2,3,4,7,9,10] on different space bodies with different gravity.

There is also another advantage of foot mobility. The devices with which it is carried out, the so-called manipulators (legs), can also perform other functions, these are:

- Some service functions of the body of the vehicle;
- Stable and reliable attachment to the primer;
- Selection of a point of contact with the primer;
- Softening contact during movement, landing, vibration load damping, etc.

In the presence of manipulators for foot mobile movement [15,16], they can be useful for capturing space objects of small dimensions (diameters smaller than 0.05 km.), which can be brought down directly to the Earth or left in around Earth orbit, as a buffer storage for processing the minerals from them.

## 2. CONCLUSION

3.

Mining is the first step to mastering new worlds. The extraction of minerals and fuels from space bodies is a great leap in the development of mankind. There are already technical solutions for the realization of mining, which would bring inexhaustible riches to people. In fact, the word "wealth" has acquired another meaning. It would open the way to new materials, new fuels and new structures.

All this is possible thanks to the discovery of this new technology for overcoming the huge space distances and the combination of astronautics, engine building and robotics.

*This material heralds the beginning of a new era in which the technical solution to mastering the riches of space is already available. About the need for a connection between cosmonautics and robotics, which will give us the opportunity to penetrate dangerous places for humans, but where the new materials needed by humanity are born.*

## REFERENCES


[1]. Александер Р. – “Биомеханика” – “Мир”, 1970, Москва;

[2]. Артоболевский И. И. – “ Механизмы в современой технике” – Наука, Москва, 1970г.

[3]. Гълъбов, В.Б. – “Синтез на механизми в робототехниката” – ТУ-София, 1992г.

[4]. Вукобратович М. – “Шагающие роботы и антропоморфные механизмы” – “Мир”, 1976; Москва.

[5]. Павлов В.И. “Проектиране на промишлени роботи”, 1993, София

[6]. Саркисян Ю. Л. – “Аппроксимационный синтез механизмов” – “Наука”, 1982, Москва.

[7]. Синилков П. _ „ Някои възможности на транспортните средства при добива на полезни изкопаеми от космически тела“ - 66–та Международна конференция на МГУ – София, 2023 г.

[8]. Синилков П. – “ Скелетна структура на мобилен самопрограмируем роботехнически комплекс (МСРК/КОБОТ)”, Механика на машините 51, кн.2, 2004г.

[9]. Синилков П., ‘’Аналитични предпоставки за синтез на 2D локомоционни механизми’’, Научни известия на научно-техническите съюзи по машиностроене – година XX, Двадесета международна конференция Роботика и Мехатроника 2010 г. ISSN1310-3946, гр. Варна 06 – 09, октомври 2010г.

[10]. Синилков П., ‘’Зависими и независими движения на крачещи мобилни установки’’, Научни известия на научно-техническите съюзи по машиностроене – година XVII, бр. 4114, Деветнадесета международна конференция Роботика и Мехатроника 2009 г., ISSN1310-3946, стр. 18-22, октомври 2009 г.

[11]. Синилков П., ‘’Аналитичен синтиз на механизми за крайници на крачещи мобилни роботи’’, Научни известия на научно-техническия съвет по машиностроене XXI Международна Конференция Роботика и Мехатроника, 2011г., ISSN 1310-3946, гр.Варна 19 – 21 Септември, 2011г.

[12]. Kato I. et al., -“ Modelling and Control of the Biped Gait”, Waseda Univ., Tokyo, 1970.

[13]. Mario W. Gomes, and ect. –“A five-link 2D brachioting ape model with life-like motions and no energy cost”, Theoretical and Applied Mechanics, Cornell University, Ithaca, USA, 2004.

[14]. Muybridge E. -“Human Figure in Motion, Dover Publ., New York, 1955.

[15]. McGee R. B., Frank A. A. – " On the Stability Properties of Quadroped Creeping Gaits " – Matem. Biosei.,3, № 3 – 4, Oct. (1968).
[16]. Натансон И.Н."Увод в теорията на реалните функции"1971,Наука и изкуство.
[17]. Ran Y. – " An efficient and robust human/vechicle classification algorithm using finite frequencies probing" university of Maryland, http;//www.cfar.umd.edu/~rany/research.htm.
[18]. Steven M. S., Charles R. D. – " View-Invariant Analysis of Cyclic Motion " – Intl Journal of Comp. Vis. 25 Pages: 1-23, 1997.
[19]. Tomovic R., McGhee R. B. – " A Finite State Approach to the Synthesis of Bioengineering Control Systems" , IEEE Trans. on Human Factors in Electronics, 7 № 2, June (1966).
[2]. Henry M. F. – " State Detection Paraplegie Gait as Part of a Finite State Based Controller " – IEEE, Biomedical Technological Institute, University of Twente, The Netherlands 2008.
[21].https://bg.wikipedia.org/wiki/%D0%A0%D0%B0%D0%BA%D0%B5%D1%82%D0%B5%D0%BD_%D0%B4%D0%B2%D0%B8%D0%B3%D0%B0%D1%82%D0%B5%D0%BB
[22].https://megavselena.bg/idvat-li-kosmicheski-korabi-s-yadreni-dvigateli/
[23].https://bg.puntomarinero.com/what-are-nuclear-engines/
[24].https://bg.wikipedia.org/wiki/%D0%A0%D0%BE%D0%B1%D0%BE%D1%82%D0%B8%D0%BA%D0%B0
[25].https://bg.wikipedia.org/wiki/%D0%94%D0%B2%D0%B8%D0%B3%D0%B0%D1%82%D0%B5%D0%BB
[26].https://yescrystals.bg/meteoriti/
[27].https://zarata.info/tag/%D0%BC%D0%B5%D1%82%D0%B5%D0%BE%D1%80%D0%B8%D1%82%D0%B