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Budapest, 2013.
6. évfolyam 2. szám**DIMENSION CHANGE IN SPACE LOGISTICS – THE UNIVERSE AHEAD OF US
THE CHALLENGES, THE VISION AND THE FUTURE VALUE OF SPACE LOGISTICS IN THE
21ST CENTURY****AZ ŰRLOGISZTIKA DIMENZIÓVÁLTÁSA - ELŐTTÜNK AZ UNIVERZUM
AZ ŰRLOGISZTIKA KIHÍVÁSAI, JÖVŐKÉPE ÉS JÖVŐÉRTÉKEI A XXI. SZÁZAD-
BAN**

The last century was known as the Space Age, and it is now only past memories. In the 21st century we see further and further in the Solar System surrounding us and even beyond, and we have more and more daring plans. Just before the millennium, rocket scientists, researchers and experts were planning a great mission for the 21st century; the Mission to Mars, meaning landing, subsistence, even settlement and the creation of a self-sustaining society. Parallely, similar issued were raised by the Chinese at the beginning of the 21st century, planning the landing on the Moon and its industrialization. The science and industry of logistics with its knowledge base, appropriate system, resources and means intends to participate in all works either on the Moon on Mars. I believe that the objectives defined above cannot be realized without logistics, because logistics has already been part of space exploration. Also, logistics has participated in every single task of research, although its results were rarely communicated. So without much publicity, it has remained a silent but useful companion in research. Nowadays, logistics as a science has become an integral part of every value generating and service providing activity, so it would be very improbable that it should stay out of the most important ventures of the century, like the logistic support on the Moon or Mars. I also believe that logistics experts will be members of the mission, and I hope that even a trained Hungarian space logistics expert might participate.

A múlt század az űrkorszakkal fémjelezett időszakként vonult át életünkön és a múlt emlékei dimenziójában maradt. A XXI. században egyre távolabbra látunk a minket körülvevő Naprendszerben és azon túlra is, és egyre több nagy ívű terv megvalósítása a kitűzött cél. Az ezredforduló előtt az űrkutatók, tudósok és a tudományok képviselői nagy küldetést terveztek, amelyet a XXI. században valósíthatnak meg. A küldetésben cél a Marsra szállás, az életfenntartás, a letelepedés és önellátó társadalom létrehozása lehet. Ezzel párhuzamosan a kínai elképzelések már a XXI. század elején születtek, ők a Holdra szállás iparosítását tervezték. Úgy a Hold, mint a Mars teljes körű munkájában a logisztikatudomány és logisztikai ipar a tudásbázisával, szükséges rendszereivel, erőivel és eszközeivel részt kíván venni. Úgy gondolom, most már a logisztika nélkül a fentebb említett célkitűzéseket nem lehet megvalósítani. Valószínűsítem mindezeket azért, mivel a logisztika eddig is része volt az űrkutatásnak. Azt is állíthatom, minden egyes kutatási feladatban részt vett, de kevés területen közölték eredményeit. Nem kapott nyilvánosságot, mint a tudományos kutatás csendes társaként végezte dolgát. Viszont napjainkban a logisztika, mint tudomány minden értékteremtő és szolgáltató tevékenységnek részese. Nem valószínű, hogy kimarad a századunk legnagyobb vállalkozásaiból. Azt is vélelmezem, hogy kulcsszerepet kap, úgy a Marson, mint a Holdon a logisztikai támogatásban. Az a gondolat sem áll tőlem távol, hogy logisztikusok tagjai lesznek a nagy küldetésnek. Remélem még azt, hogy magyar felkészített űrlogisztikus is részt vehet az űrfeladatok megoldásában.

“Earth is the cradle of humanity, but one cannot remain in the cradle forever.”

Konstantin Eduardovich Tsiolkovsky

Some might even smile, but it should be remembered that the principles, the methods, the scientific preparedness and the application skills of technology of logistics cover many fields already. The greatest horizontal industry on Earth, with its practical skills can carry out tasks in space environment and circumstances that are today a challenge. It also has to be taken into consideration, that this mission requires long preparation, targeted learning and practice. However, the knowledge base and unfinished new research results are available.

THE UNIVERSE AS THE REPOSITORY OF OPEN POSSIBILITIES

LANDING ON THE MOON AND MARS – THE GREAT CHALLENGE OF MANKIND

Today, many countries claim their demand to exploit Space. The Chinese are building a space station until 2020, then after 2020 a base on Moon for industrial uses and to exploit it according to their interests. The United States is planning the landing on Mars¹, and its exploitation, space tourism, space venture has been passed on to the private, civil sector. The visit of the solar system and even the planets beyond is becoming closer.

The logistic support and efficiency of landing on Mars and the Moon is based on well-constructed and safely operating passenger and cargo ships. This complex task requires specially designed and multi-functional space ships capable of several flight modes and to lift off/land in small areas. The mission to Mars might require ferries, and big cargo vessels.

Rocket scientists and researchers know Mars best, so the idea of its exploitation was formulated already in the past decade as a result of industrial and business interest, well supported by different arguments. According to the formulated ideas, scientists started to realize the ‘Mars Project’, creating space probes and a multigenerational *spacecraft*.

Researchers all think that living conditions can be set up on Mars. Several opinions state that many minerals and chemicals necessary for life are to be found on the planet. Close to the surface there is ice and a significant amount of carbon-dioxide in the air. There are caves inside the mountains, and the surface is covered by red powder rich in iron oxide.

Living conditions and assuring the safety of living - oxygen, air, water, food, accommodation, and protection against radiation, solar wind, extreme temperature, extensive duststorm – are all great challenges in making the planet viable. Using the caves and systems of caves for different logistic purposes can provide shelter for personnel, vehicles, and operating systems. Hangars, stocks, protected bases can be set up there, where equipments can be operated to clean and transform water and air, or other useful premises like heated accommodations and workspaces of constant temperature. Lakes, basins can also be marked out and refilled and to melt snow from the mountains.

¹ Curiously, many stated that after the landing on Moon (1972) *the technology was ready to conquer Mars, with a man aboard*, but this mission was never carried out.

SPACE LOGISTICS – DEFINING MARS LOGISTICS

DELINEATING AREAS OF NEW CONCEPTS²

Space logistics involves every logistic value and service that is realized outside the Earth. According to the researchers of the Calgary University³ space begins at 118 km above the Earth. Astronauts think it is the Karman line⁴ 110 km. According to the NASA, the return altitude is 122 km⁵.

Mars logistics: part of space logistics, every logistic value and service that is realized on the planet Mars, its surface or above its surface. In space logistics, in the years to come probably new scientific results will be applied. A new type of logistic environment will emerge, where space logistics will have a significant strategic role with all of its superstructure, organizations, tasks, technical means, capacities at a space base and other set of conditions. Furthermore there are also possible alternatives of the application of logistic support.

As we get further on the timeline of our century, the tasks of space logistics are becoming known, also in the context of Mars and Moon missions and tasks. Of course, the main area of space logistics services remains the creation of human conditions and activities on Mars or Moon. I do not think that great changes would occur in the functions and principles of logistics. However, the characteristics of space, the technological processes and its systems shift the centroid of logistic vision and thinking.

Space is expanding, development is accelerating; systems and characteristics are adapted to changing circumstances. In this environment, multi-stage support systems, processes and networks function, serving strategic purposes.

The wide application of hybrid logistic support (human and robotic) is a milestone in space logistic support and environment. This projected vision can come true in the decades to come thanks to the results of science and their application.

THE CIRCUMSTANCES AND POSSIBILITIES OF MARS LOGISTICS SUPPORT⁶

It is required of cargo spacecrafts to have a huge cargo bay and to be able to safely transport equipment, material and tools. They also need to be capable of the transport between Earth and Mars repeatedly, mainly in the initial logistic phase.

Other challenge is the elaboration, experimentation of new technical means for transport and support on Mars, such as ion drives, solar sails, magnetic sails, nuclear drives and in surface transport, the movement, transport, building in of huge masses of building materials acquired from Mars. Also, for the sake of flight safety and technical reliability, after the arrival on Mars a service and assistance spacecraft will need to be placed in rescue standby; this would ensure the safety of vessels arriving later, providing discharge, service check and handling even unexpected disorders.

The landing on Mars can be carried out in several phases. First, the preparatory spacecrafts land in 2 or 3 units. Based a project, they make refinements on the site (refining the system of tasks that need to be carried out according to Earth protocol). Local refinement, assessment, and analysis of the situation can be carried out by Mars modules and also the arrival of the first and second phase is prepared.

² The own interpretation and elaboration of the concept of the author

³ <http://www.stop.hu/tudomany/megallapitottak-a-vilagur-hatarat/477885>

⁴ Traditional airplanes cannot be used above this line in lack up upward force; it was named after Theodore von Kármán, who defined it for the first time.

⁵ Astronauts switch off helm and start entering into the atmosphere.

⁶ The own interpretation and elaboration of the concept of the author

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The Mars base is in constant contact with the equipment outside the spacecrafts, the service vessels, every workgroups and accommodations. Of course, also with the space station, the service station, the control and command center of the Earth base, the logistic center and base on Earth and Mars. The base can also be used to emit and forward e-mails and messages.

LIFE SUPPORT LOGISTICS⁷, A CRITICAL ELEMENT IN THE MISSION TO MARS

Life support logistics creates a new logistics culture on Mars and even other planets. Mars logistics (or of any other planet) is primarily *life support logistics*, thus determining emerging logistics, and the logistics of the planet itself would only follow.

Totally new environment everywhere, and very alien I may say to humans, because only indirect information is available about it for the scientist and Earthlings (who will once turn into Martians). The establishment of logistics needs to be *started from scratch*, right from cognition. From the point of view of the planet, there is an *alien* present (a human), who is already familiar with a logistic culture on Earth, and can only start to create Mars logistics and the establishment and maintenance of *supply chains of Mars* from that point of view and vision. Research, exploration, possibilities, setting up living conditions, are determined and develop parallelly with Earth logistics.

A major task of Mars logistics besides the setting up and the maintenance of life support systems is the *establishment on the planet*, that is the creation and long-term sustenance of an *individual settlement* inhabited by humans. This great venture has many milestones and requires the fulfillment of several conditions, such as the decrease of time to get to Mars, the possibility to grow and process aliments, and the presence of a value generating person in every logistic phase.

I believe that besides humans, the *use of robots* is indispensable everywhere possible and *energy (resources)*, *construction materials* need to be excavated and transformed. This is only possible with a sufficient capacity of *transport systems* optimized to Mars environment. Considering all this, it is the question of creating an individual, self-sufficient society on Mars.

The logistic challenge of settlement on Mars consist of the excavation, transport and delivery of resources and energy sources. The mountains, stony ground of the surface of Mars may serve as construction material. For the construction of settlements, there is plenty of always present solar energy, from which electricity can be produced, as well as heat of a thousand degrees. From the point of view of logistics, the establishment of the converting, heat and electricity dispenser systems will mean a great leap for rendering the settlement or all sorts of human environments bearable. This requires the launch of huge power plants, converting solar energy into electricity. Mars may provide a favorable environment for the production of nuclear energy. This also requires cooling systems (it is well known that the temperature ranges from +20 to -140 grades Celsius. After solving this problem, large quantities of nuclear energy may contribute to the establishment of Martian life for humans.

ESTABLISHMENT OF LOGISTICS AND A SUPPLY CHAIN ON MARS AND OTHER PLANETS

The supply chain is the keystone of a new Martian logistic culture. A new logistic environment emerges on all other planets, where the circumstances of Earth-like life are missing. Life based on other unknown components might exist in the solar system and beyond. Space logistics and Mars logistics start from different bases from Earth logistics, which we know and developed already.

⁷ The own interpretation and elaboration of the concept of the author

The establishment of the supply chain on Mars starts with a new vision and thinking, since we have to face new conditions, like weather, atmosphere, different materials in different environment and state. Transformation is necessary, for the use suitable for human life and adapted to our logistic culture. The logistic environment of Mars requires new technological culture, means and the application of new methods.

Material flow gains a new meaning in the supply chain. The first phase is the collection, transport or stocking of materials, and then the transportation to the area where it will be processed (setting up a stock if necessary) and only then the transformation into useful material can begin. This logistic process is not that simple on Mars, because of the circumstances such as cold temperature, solar wind, radiation, duststorm and great distances.

Thus, in the development, perfection of the supply chain, the involvement of a high number of robots becomes significant, since humans are very few in number and very vulnerable (hard conditions threaten life). For transport tasks, special technical equipment is required, such as a cargo spacecraft and a transport vessel capable of travelling long distances. Also, a Martian transport module is necessary (flight or ground) operating with solar or magnetic energy, of the capacity of 3-5 tons.

If Mars logistics can be developed and perfected through the application of robots, and ground production technologies and machines can be used, Mars logistics will undergo a qualitative change. When resources and transport are given for production, production plants are established, the necessary robotics and automatization are provided, as well as human supervision and management, and other requirements are all met, industrial areas can start to be established on Mars – that is the *industrialization of Mars* begins.

Human can stay on Mars for an extended time and to settle there, if they will be capable of creating an environment similar to what the biosphere provides here on Earth. These results can be achieved first on a lower scale, then increasing it gradually. On Mars, only automatized life support systems can provide such an environment. In order to settle there, the *system of life support and the supply chain* have to be constant and all their elements have to be built out consistently and accurately in Mars environment and made available to everyone anytime.

Survival requires the constellation of several circumstances, like oxygen in the air, water, food, tolerable temperature for humans, gravitation and pressure, reproduction of aliments, climate, so a habitable and viable system of circumstances. It would be wise to use individual equipments for the transformation of carbon-dioxide into oxygen, while a central medical and health preserving system needs to be created too, since the the maintenance of the physical and mental condition and health of the inhabitants of the space colony is vital. Other issues of life support logistics are protection against cosmic radiation, solar wind and magnetic storms.

Values can be generated from the transformation of the acquired material and its use for humans and their environment. An example could be excavating, the snow and ice from the glaciers and the snow caps of mountains to be transformed, cleaned and made into potable water or used for irrigation when growing crops. Water could also be stored in caves or artificial reservoirs. The use of solar energy is also crucial; transformed into solar energy it can be used to heat accommodations, or used to grow crops.

It also important to distribute the energy (heat, water, electricity) by a network. Some think that electricity may eventually become the main export article of space colonies, by using wireless energy transfer, that is, through microwave beams transmitting energy to the Earth or the Moon. This method is free of harmful emissions.⁸

Communication and flow of information is worth operating in two big systems of networks, one in Martian environment, and one at an Earth logistic base and the elements of basic supply chain between. In this chain the most important

⁸ <http://hu.wikipedia.org/wiki/%C5%B0rkoloniz%C3%A1ci%C3%B3#Energia>

issue is not the satisfaction of demands, but possibilities and human capabilities, and the performance of present technology and robotics.

SUMMARY, VISION

Landing on Mars and ensuring living conditions there is a great challenge, a heroic mission of the 21st century, that might be realized by the logistic industry and systems guided by science. *A new era may begin with the creation of space logistics, life support logistics and Mars logistics*, opening up new principles and applications. By the end of the 21st century any planet of the solar system can be reached and *logistic science will gain new knowledge and perfected space logistics*. Space is thus expanding and the researchers, scientists, inhabitants of Earth can have an outlook on planets beyond the solar system and their environment.

Kulcsszavak: űrlogisztika, űrlogisztikus. Hold-logisztika, a Hold iparosítása, Marsra szállás, Mars-logisztika, Mars-bázis, létlogisztika

Keywords: Space logistics, space logistics expert, Moon logistics, industrialization of the Moon, landing on Mars, Mars logistics, Mars base, life support logistics

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