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INTERNATIONAL DIMENSION OF TECHNOLOGICAL ASPECT OF SPACE ECONOMY

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The article deals with the analysis of the main features of space economy. The main trends and factors of space economy are analyzed. The tendencies of management of technological component of the industry are specified. On example of international projects the trends of international cooperation are shown. The objectives for the further analysis of the economy of space were proposed.

Keywords: *technology transfer, space industry, index, funding, space economy, international cooperation.*

Introduction. Space economy is the full range of activities and use of resources that create and provide value and benefits to human beings in the course of exploring, understanding and utilizing space. Space activities are focused on improving the efficiency of solving problems of an economic nature, to ensure national security and contributes to the development of national science and technology.

The three major sectors of the space industry are: satellite manufacturing, support ground equipment manufacturing, and the launch industry. Also commercialization of space is the use of equipment sent into or through outer space to provide goods or services of commercial value, either by a corporation or state.

Technological innovation drives competitiveness and growth, while innovations are driven by many factors, but the exploration and exploitation of the space frontier is one of them. The focus of space exploration today is in the economic arena. Rising living standards and technological advancement around the world mean greater competition from places that were never competitors before.

Analysis of recent researches and publications. Michael Griffin, NASA Administrator, underlines that "we see the transformative effects of the space economy all around us through numerous technologies and life-saving capabilities… We see the space economy in the lives saved when advanced breast cancer screening catches tumors in time for treatment, or when a heart defibrillator restores the proper rhythm of a patient's heart. We see it when GPS, the Global Positioning System developed by the Air Force for military applications, helps guide a traveler to his or her destination. We see it when weather satellites warn us of coming hurricanes, or when satellites provide information critical to understanding our environment and the effects of climate change. We see it when we use an ATM or pay for gas at the pump with an immediate electronic response via satellite. Technologies developed for exploring space are being used to increase crop yields and to search for good fishing regions at sea" [4].

The Organisation for Economic Co-operation and Development (OECD) launched in 2006 the 'Space Forum' in cooperation with the space community. The Forum, hosted by the International Futures Programme (IFP) as part of its mission to explore emerging sectors, aims to assist governments, space-related agencies and the private sector to better identify the statistical contours of the growing space sector worldwide, while investigating the space infrastructure's economic importance and potential impacts for the larger economy. The Forum builds on the recommendations presented in the OECD publication Space 2030: Tackling Society's Challenges (2005), which benefited from consultation with more than 100 public and private actors in the international space community.

Among analytical report concerning space economy its necessary to mind Space Technologies and Food Security (2011): second OECD publication on the value chains and socio-economic contributions derived from the use of innovative space applications (e.g. monitoring crops from space) and Space Technologies and Climate Change: Prospects and Implications for Water management, Marine Resources and Maritime Transport (2008): OECD publication which provides findings on the socio-economic contributions that may be derived from the use of space applications, with an extensive review of existing assessing methodologies.

Previously unsettled problem constituent. In OECD Handbook on Measuring the Space Economy [6] is noticed that although current economic conditions will probably affect selected countries (which may see their institutional space budgets reduced at least in the short term), two key factors point to further growth in the space economy: the ongoing globalization of space activities (more actors with more budgets), as well as the growing importance of space applications in decision makers' portfolio to meet key societal challenges. Today the analysis of features management of these two areas in the context of international accounting factor is the actual scientific and practical task.

While the benefits of space science and technology and its applications for developing countries are generally recognized, experience has shown that successful implementation and operational use of this technology is subject to the resolution of some major issues, including the continuous development of human resources at all levels, training of end-users, development of appropriate infrastructure and policy regulations, allocation of necessary budgetary resources.

Main purpose of the article is to analyze the basic parameters of space economy and consideration of the main tasks of technology management.

Results and discussions. The space sector has often been considered one of the main frontrunners of technological development, since the beginning of the space age. Benefiting from advances in related domains (e.g. material sciences), the number of space-related patents has almost quadrupled in 50 years.

In modern conditions a list of new factors has a significant influence on space activities and industrial enterprises and organizations of space industry:

- lack of public funding;
- inflation is a constant;
- radical changes in geopolitical situation
- increased competition in space activities and a significant expansion in recent years, the market of commercial space services;
- increasing of international regulatory requirements to reduce the adverse effects of space activities;
- violation of the pre-existing co-operation of developers, manufacturers rocket and space technology, elements of space infrastructure and utilities;
- rapid commercialization of space activities.

All these factors create a unique economic and management environment in the industry. One of the components is the management of technological portfolio of industry at national and international level.

Beyond the many technological factors that could make space commercialization more widespread, it has been suggested that the lack of private property, difficulty or inability of individuals in establishing property rights in space, has been an impediment to the development of space for both human habitation and commercial development [8].

The global space economy grew to $314.17 billion in commercial revenue and government budgets in 2013, reflecting growth of 4% from the 2012 total of $302.22 billion. Commercial activity — space products and services and commercial infrastructure — drove much of this increase. From 2008 through 2013, the total has grown by 27%. Commercial space products and services revenue increased 7% since 2012, and commercial infrastructure and support industries increased by 4.6%.

Government spending decreased by 1.7% in 2013, although changes varied significantly from country to country. Substantial space budget cuts in the United States outweighed gains in Canada, India, Russia, South Korea and the United Kingdom, all of which increased budgets by 25% or more.

2013 Global Space Report's [1] key findings include:

- global space economy grew to $304.31 billion in commercial revenue and government budgets in 2012, reflecting growth of 6.7 percent from the 2011 total of $285.33 billion. Commercial activity, space products and services and commercial infrastructure, drove much of this increase. From 2007 through 2012, the total has grown by 37 percent.

- commercial space products and services revenue increased 6.5 percent since 2011, and commercial infrastructure and support industries increased by 11 percent.

- government spending increased by 1.3% in 2012, although changes varied significantly from country to country, with India, Russia and Brazil increasing budgets by more than 20 percent, while other nations, including several in Europe, experienced declines of 25 percent or more.

- global space economy grew by nearly 7% in 2012, reaching a new record of $304.31 billion. As in previous years, the vast majority of this growth was in the commercial sector, which now constitutes nearly three-quarters of the space economy, with government spending making up the rest.

- commercial space products and services such as broadcasting, communications, and Earth observation made up the largest portion of the space economy, growing by 6.5% in 2012.

The Space Foundation Infrastructure Index outperformed the S&P 500 and the NASDAQ during 2013 and 2014 (Fig. 1), while the main Space Foundation Index and Space Foundation Services Index did not perform as well as the NASDAQ, but substantially better than the S&P 500. These indexes, which are updated daily on the Space Foundation website, are easy-to-understand mechanisms for gauging the financial performance of space industry companies listed on U.S. stock exchanges.

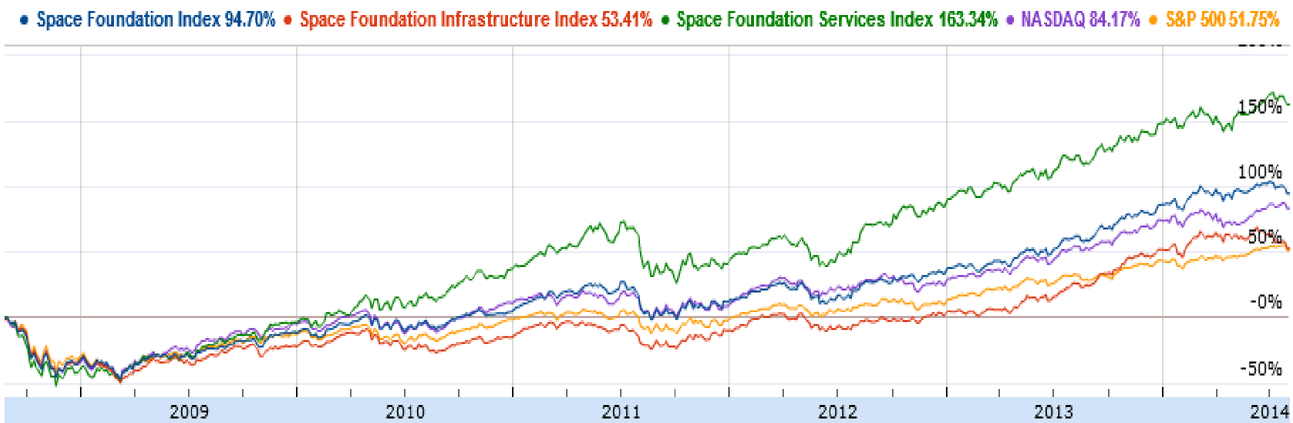

Figure 1 Space Indexes and other market indexes [9]

The main item of expenditure will be programs related to Earth observation - for these purposes will be spent 22.3% of the budget or € 915,9 million. Next in importance are the cost of the navigation system and the construction and development of launch vehicles – 15,4% (€ 630,2 million) and 15,1% (€ 617,4 million). Finally, the fourth key item of expenditure will be manned missions - this budget allocated 9% or € 370,9 million.

Another aspect of the analysis is the inequality in the development and use of space technology. According to the countries' share in space-related patents over the 2000-08 period shows the United States and Europe leading, followed by Korea and Japan (Fig. 2). Finally, in terms of revealed technological advantage, eight countries demonstrate a level of specialization in space technologies patenting. The Russian Federation, France, Israel and the United States show a large amount of patenting in space activities, compared to other economic sectors (Fig. 3).

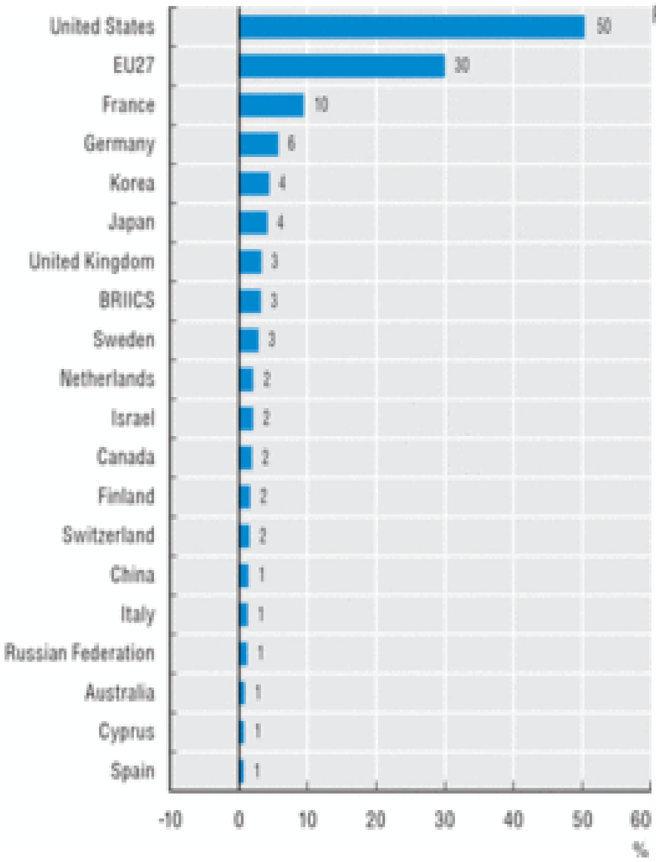

Figure 2. Country share in space-related patents (2000-08) [11]

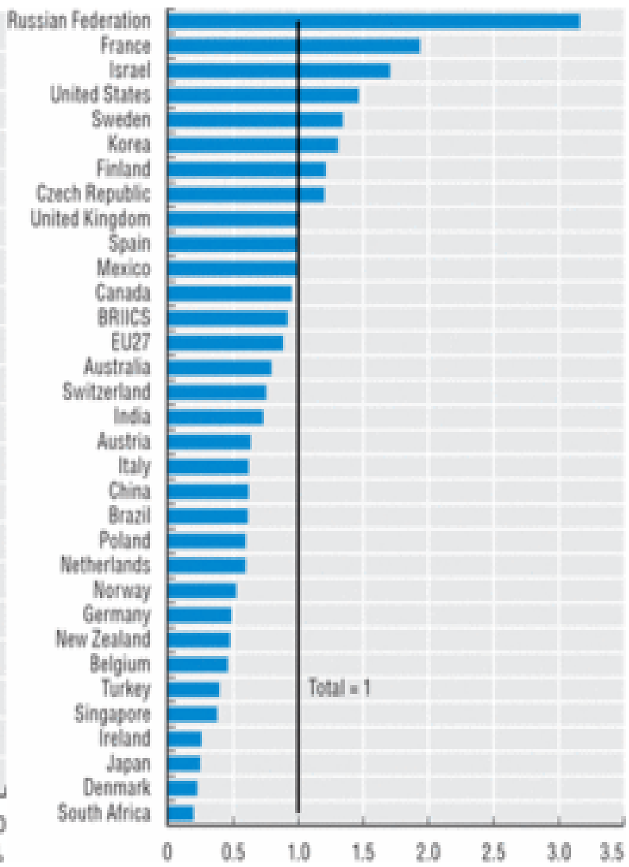

Figure 3. Revealed technological advantage in space technologies [11]

In comparison with 2008, when the global financial crisis started, deductions of countries–participants of the ESA in the overall budget for 2013-2014 increased by € 700 million. This demonstrates high priority of government's investment in the space industry which involves innovation.

A 2011 survey [3] showed 34% respondents (of the 250 tech transfer successes) over the past five years revealed that commercialized NASA technologies have created over 8000 jobs, generated over $1B in revenue, created more than $6B in cost avoidance, saved more than 250,000 lives and significantly improved quality of life for more than 100 million people .

Analysis of the development of the industry should include the factor of international cooperation. Here first of all should be mentioned.

Table 1 shows international cooperation in Curiosity Mars rover creation.

Table 1. Instruments of Curiosity for collection of Mars data from the surface in the context of the participating countries

Component	Country	Organization
ChemCam	France	CESR laboratory
	USA	Los Alamos National Laboratory
Alpha Particle X-ray Spectrometer (APXS)	Canada	Canadian Space Agency
Sample Analysis at Mars (SAM)	USA	NASA Goddard Space Flight Center Honeybee Robotics
	France	Laboratoire Inter-Universitaire des Systèmes Atmosphériques (LISA) (jointly operated by France's CNRS and Parisian universities)
	-	many additional external partners
Radiation assessment detector (RAD)	USA	Southwest Research Institute (SwRI)
	Germany	Christian-Albrechts-Universität zu Kiel
Dynamic Albedo of Neutrons (DAN)	Russian Federation	Russian Federal Space Agency
Rover environmental monitoring station (REMS)	Spain	Spanish Ministry of Education and Science Javier Gómez-Elvira of the Center for Astrobiology
	Finland	Finnish Meteorological Institute

International Space Station (ISS) Program’s greatest accomplishment is as much a human achievement as it is a technological one—how best to plan, coordinate, and monitor the varied activities of the Program’s many organizations.

An international partnership of space agencies provides and operates the elements of the ISS. The ISS has been the most politically complex space exploration program ever undertaken. The International Space Station Program brings together international flight crews, multiple launch vehicles, globally distributed launch, operations, training, engineering, and development facilities; communications networks, and the international scientific research community. Elements launched from different countries and continents are not mated together until they reach orbit, and some elements that have been launched later in the assembly sequence were not yet built when the first elements were placed in orbit.

Fig. 4 and Fig. 5 show what countries contributed which parts to the ISS and international cooperation in ISS operation and management.

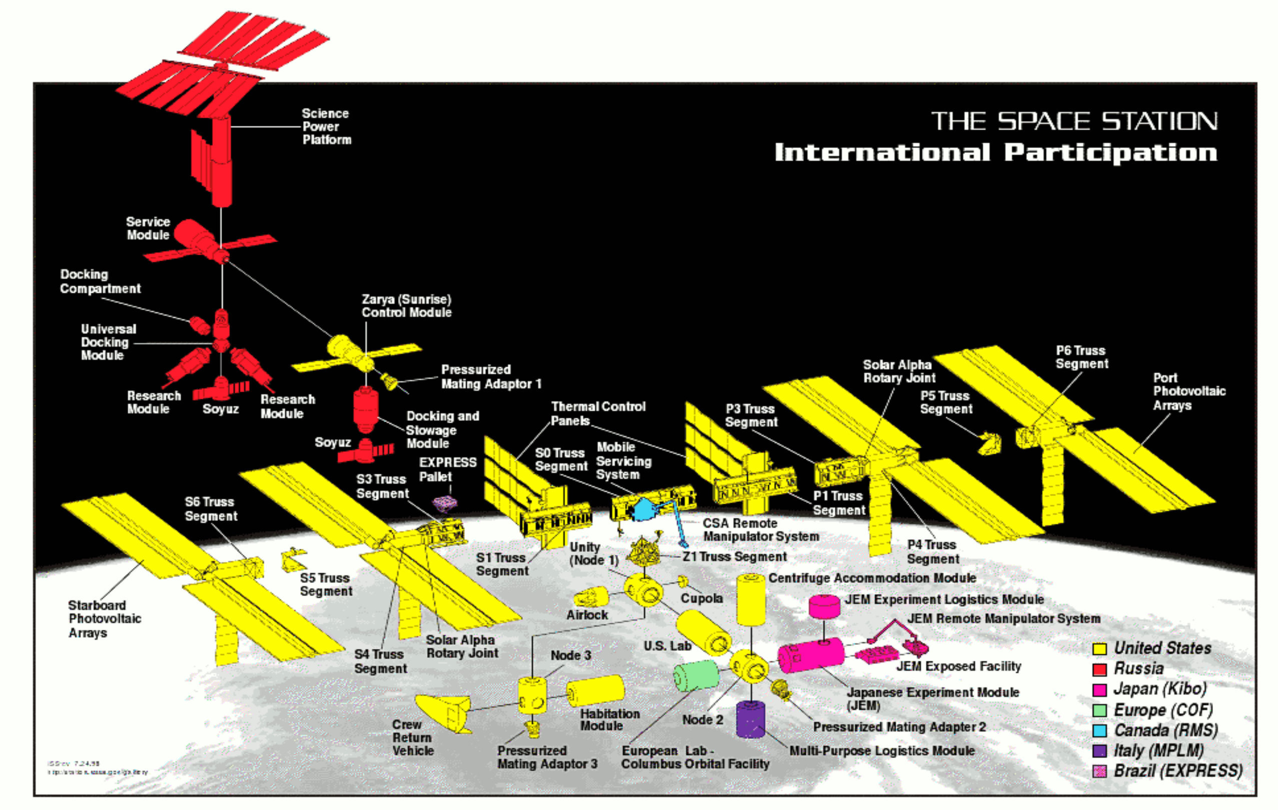

Fig. 4. Countries contributed which parts to the International Space Station

Figure 5. Operation and management of the International Space Station [2]

Generally the main tasks of space economy are:

- applications of space-related technologies, services and information that provide cost-effective solutions and essential input for planning and implementation of programs or projects addressing social and economic development in the above thematic areas;
- needs of end users engaged in the above-referenced activities in developing countries;
- international initiatives, programs and cooperation;
- capacity building in developing countries, including discussions on human, financial and technical resources required for successful use of space technologies, information and services;
- presentations on practical experiences and case studies by participants from various regions.

Number of initiatives are directed to achieve these goals.

One of them is The Human Space Technology Initiative (HSTI), launched in 2010 by the Office under the framework of the United Nations Program on Space Applications, is aimed at involving more countries in activities related to human space flight and space exploration and at increasing the benefit from the outcome of such activities through international cooperation, to make space exploration a truly international effort. The role of the Initiative in these efforts consists of providing a platform to exchange information, to foster collaboration between partners from spacefaring and non-spacefaring countries and to encourage emerging and developing countries to take part in space research and to benefit from space applications.

The activities of the Initiative are based upon three pillars:

1. International Cooperation: to promote international cooperation in human spaceflight and activities related to space exploration. The Initiative bridges and connects different partners from the international space community and other United Nations entities, as well as Member States. In close cooperation with ISS partners, information on the management structure of the ISS and on research facilities is provided. Furthermore, the Initiative provides information about opportunities to cooperate with space agencies, as well as educational material on space science and technology.

2. Outreach: to promote increased awareness among Member States of the benefits of utilizing human space technology and its applications. The Initiative organizes expert meetings and workshops annually to raise awareness of the current status of space exploration activities, as well as the benefits of utilizing human space technology and its applications. Experts from around the world meet together and exchange information and discuss possible future projects with regard to human space exploration and its related activities. The Initiative also provides publications and distributes informative materials on those subjects.

3. Capacity-building: to build capacity in microgravity science education and research. The Initiative is conducting the Zero-Gravity Instrument Project (ZGIP), in which microgravity simulation instruments, called clinostats, are distributed worldwide for education and research. In addition to the Project, the Initiative is also seeking to establish programs and fellowships that help researchers from non-spacefaring countries gain access to these facilities. Within such programs, the Initiative provides information on the facilities and on opportunities to utilize them.

http://www.oosa.unvienna.org/oosa/en/SAP/hsti/index.html

Conclusions and directions of feather researches. Space-based systems deliver information and services that protect lives and the environment, enhance security and stimulate industrial and economic development. Advances in satellite remote sensing, global navigation satellite systems and geographic information systems now make it easier to integrate ecological, environmental and other information for developing predictive models that can be used in Space-based systems deliver information and services that protect lives and the environment, enhance security and stimulate industrial and economic development. Advances in satellite remote sensing, global navigation satellite systems and geographic information systems now make it easier to integrate ecological, environmental and other information for developing predictive models that can be used in different industries of human activity.

Among the future issues of research of space technologies, applications, information and services that contribute into sustainable economic and social development programs, primarily in developing countries, are following main objectives:

- to increase awareness among decision makers and representatives of research and academic community of space technology applications for addressing social and economic development, primarily in developing countries;
- to examine low-cost space-related technologies and information resources available for addressing socio-economic development needs in developing countries;
- to promote educational and public awareness initiatives, as well as to contribute into capacity building process in this area; and
- to strengthen international and regional cooperation in the subjects.

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МІЖНАРОДНИЙ ВИМІР ТЕХНОЛОГІЧНОЇ СКЛАДОВОЇ ЕКОНОМІКИ КОСМІЧНОЇ ДІЯЛЬНОСТІ

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Стаття присвячена аналізу основних особливостей економіки космічної діяльності. Проаналізовано основні тенденції й факторів розвитку космічної економіки. Визначено тенденції керування технологічної складової галузі. На прикладі міжнародних проектів показані тенденції міжнародного співробітництва. Запропоновано завдання для подальшого аналізу економіки космосу.

Ключові слова: *трансфер технологій, космічна галузь, індекс, фінансування, економіка космічної галузі, міжнародне співробітництво.*

МЕЖДУНАРОДНОЕ ИЗМЕРЕНИЕ ТЕХНОЛОГИЧЕСКОЙ СОСТАВЛЯЮЩЕЙ ЭКОНОМИКИ КОСМИЧЕСКОЙ ДЕЯТЕЛЬНОСТИ

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Статья посвящена анализу основных особенностей экономики космической деятельности. Проанализированы основные тенденции и факторы развития космической экономики. Определены тенденции управления технологической составляющей отрасли. На примере международных проектов показаны тенденции международного сотрудничества. Предложены задачи для дальнейшего анализа экономики космоса.

Ключевые слова: *трансфер технологий, космическая отрасль, индекс, финансирование, экономика космической деятельности, международное сотрудничество.*