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**METHODOLOGY OF COMMERCIALY VALUABLE ON THE
INTERNATIONAL SPACE SERVICES MARKET COMMUNICATION
SPACECRAFT REQUIREMENTS FORMATION**

Master's Programme Spacecraft system design

The abstract of the Master's Thesis

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The thesis work is done at the “Applied physics and space technology” department of Federal State Autonomous Educational Institution of Higher Professional Education «Siberian Federal University».

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GENERAL DESCRIPTION OF WORK

Relevance of the topic. One of the main steps in the design of commercial spacecraft (SC) communication is the formation of technical requirements for SC, promotes production of competitive vehicles.

Currently, domestic enterprises - suppliers of space services has not spent generating mechanism by analyzing the technical requirements of the international market of space services to increase the efficiency of the output products to the requirements of the end user and reduce unreasonable costs for technical line-systems on board the spacecraft. To conduct the necessary research and analysis, domestic companies have been forced to resort to foreign companies such as: Thales Alenia Space, Euroconsult, SATconsult and others. Even today, many domestic space industry, tasked in the formation at its base units responsible for market research and analysis of satellite services.

The aim of the thesis is to develop the concept of a space communication system and remote sensing «TropiSat», forming to her specifications by conducting in-depth analysis of the market situation, (the basic principles of construction have been proposed Ukrainian-Brazilian company «Alcantara Cyclone Space»).

In the course of the dissertation must be solved the following problems:

1. Study and analysis of the current dynamics of the international market of space services (special efforts to market research - Brazil).
2. Identification and qualification system capabilities «TropiSat», market needs analysis systems for monitoring and understanding of the Earth system of privileges offered «TropiSat».
3. Formation of technical requirements based on the needs of end polzovateley space services and the basic principles of construction of proposed Alcantara Cyclone Space.
4. Develop proposals for space system «TropiSat».

Object of study of the thesis is promising satellite communication system and remote sensing «TropiSat», as well as space market in South America, particularly Brazil.

The subject of this study is to increase the competitiveness of advanced spacecraft domestic production, increase performance SC by using modern methods of analysis of the international market of space services and focus on the end user.

Research methods. Work performed under an informational support of companies such as Thales Alenia Space; Alcantara Cyclone Space; JSC "Information Satellite Systems" Academician MF Reshetnev "and" Dneprotechservice. " To solve the problems used in the statistical material provided by SATconsult, the basics of building satellite communication systems and remote sensing provided by O3b, scientific - technical groundwork JSC "ISS" to work on the platform "Express 500" external environment analysis theory, the basics line-up of small communications satellites in general and individual service subsystems.

Scientific novelty of the thesis is the proposed method of forming the technical requirements for spacecraft communications, based on the study of the internal and external markets countries and the overall analysis, allowing to raise the level of competitiveness of products (SC), as well as to optimize costs in the design and manufacture of spacecraft.

Testing results of the work. Basic theoretical and practical results of the thesis discussed and reported at the following conferences:

1. XIII International Youth Scientific Conference "Intelligence and Science", Zheleznogorsk, April 16-18, 2013.

2. IX All-Russian scientific and technical conference of students and young scientists with international participation "Youth and Science", Krasnoyarsk, 15-25 April 2013.

3. XVII International Scientific Conference dedicated to the memory of General Designer of space rocket systems Academician Reshetnev (12-14 November 2013, Krasnoyarsk).

Dissertation research results were used in the performance of scientific research during the international internship at Thales Alenia Space (Toulouse, France).

CONTENTS OF WORK

The first chapter presents the results of studies of the dynamics of the current international market of space services and future trends, as well as methods of analysis of the world market of satellite services (special efforts to market research in Brazil).

The emergence of new satellite systems and promotes the expansion of the market, and competition: the volume of public investment and the use of equity has given a strong impetus; currently at least 15-20 countries are planning to build their first communication infrastructure using satellites during the past five years;

In this environment, the ability to optimize the position in the market and the organization of new partnerships and deals are the key factors that contribute to the development of this business:

- different trends create new growth opportunities for satellite communications, as well as show an increase in diversity and complexity;
- remains higher than the average growth of 3.3%, the growth in the industry in 2012 is fraught with significant differences among the markets and participants;
- spread over 32,000 TV channels;
- as DTH (direct broadcast satellite) and terrestrial networks continue to perform the main growth drivers.

Communication services also continue to evolve, helped by several applications running (eg, relay cellular backhaul, Internet access) and markets with a vertical structure (eg, marine and aviation industries).

In 2012, the revenues of operators FSS (fixed communication services via satellites) reached U.S. \$ 12.1 billion, representing a 4.4% growth when excluding the impact of exchange rate for the lease of capacity from about 7,600 employees at the end of repeater 2012.

The employment rate was about 77% globally (source: Euroconsult). This figure is the absolute maximum in the history of satellite communication systems. As a clear sign of the inherent satellite communications sector prosperity and stability, as well as high levels of employment are a reliable means of anti-fall conditions.

Based on the high rates of demographic and economic growth:

- 48% of the population of Latin America,
- 41% of the region's economy, the sixth in the world in terms of GDP.

	2006	2007	2008	2009	2010	2011	2012
Population (million)	185,5	187,6	189,6	191,4	193,2	194,9	196,5
GDP (R \$ billion)	2,369	2,661	3,032	3,239	3,770	4,143	4,403
GDP (US \$ billion)	1,089	1,367	1,651	1,626	2,144	2,475	2,253
GDP per capita (R \$)	12,769	14,183	15,992	16,918	19,509	21,252	22,402
PIB per capita (US \$)	5,867	7,283	8,707	8,490	11,094	12,696	11,462
Annual growth rate	3,7%	5,4%	5,1%	(0,2%)	7,5%	2,7%	1,3%

Brazil is a promising and the largest telecommunications market in Latin America, with particularly strong growth dynamics in all directions:

- subscription / connection $\frac{3}{4}$ especially for mobile telephony, Internet access and Pay TV
- density - especially for broadband and pay-TV
- home - especially for telephone and television.

The total revenue of the country telecom industry was valued at 113 billion dollars in 2012 according to market participants expected to reach 120 billion U.S. dollars in 2013.

According to the Central Bank of Brazil, during 2012, the sector has attracted about U.S. \$ 6.6 billion of foreign investment, which is ten times greater than the investment rate in the U.S. \$ 656 million, which came into the country in 2011.

In the second chapter the concept of creating a satellite system TropiSat, qualification of its capabilities, the rationale for the proposed satellite system of privileges, as well as based on data from studies of the international market of space services derived meets the needs of the proposed market positioning tasks.

Justification of the proposed system of privileges is that the integrated system is designed as a hybrid TropiSat satellite remote sensing system and telecommunications intended for use by both public and private companies in Brazil and other tropical countries.

Telecommunications system component Tropisat Cyclone (TropiSat-C), is designed to provide a wide range of services to the subscribers of fixed and mobile communications, such as high-speed internet, and data communications.

Being a part of a more ambitious project Alcantara Cyclone Space (Alcantara Cyclone Space), aimed at launching satellites with the Brazilian Alcantara pad Ukrainian launch vehicle Cyclone-4, which determines the need for the timely preparation of the future of the launch complex.

System Tropisat Cyclone (TropiSat-C) will focus on regional markets (such as Brazil), where the deployment of a large frequency range is limited due to geographic, economic and political obstacles, as well as target markets and the requirements that will help bridge the digital divide between developed and developing regions.

Characteristics of the project:

Number of operational spacecraft	8-10
Height	8 000 км
Inclination of the orbit	2°
The coverage area	0° ± 40°
Number of repeaters SC	10
Number of Rx / Tx antenna of SC	10
Each frequency range satellite transponder	300 МГц
Rx / Tx speed for each satellite transponder	600 Гбит/с

The total frequency range of one SC	6 ГГц
The diameter of a single beam coverage	500 км
Speed data transfer / receipt of ground stations	. 600 Мбит/с . 155 Мбит/с . 5 Мбит/с (канал прямой связи) . 256 Кбит/с(возвратный канал)

According to data obtained by the analysis, the competitive bid system Tropisat Cyclone (TropiSat-C) is interesting because of the following:

- the fundamental features of the Brazilian telecommunications market and a significant long-term potential, which can be obtained from it;
- more favorable business and legal framework, which the Brazilian government used in its National Plan of broadband development.

Bid system Tropisat Cyclone (TropiSat-C) would be a solution of a number of important competitive issues, such as:

- accessibility: fiber-optic cable is often not izspolzuetsya economic reasons - the operators are often not able to invest tens of millions of dollars to cover the rural areas and isolated residence. System Tropisat Cyclone (TropiSat-C) can offer a wide coverage area, high performance and deadlines waiting for a lower price than the fiber optic solutions for a wide coverage in rural areas;
- high throughput: System Tropisat Cyclone (TropiSat-C) can provide direct access to the Internet through the main sites of aggregation of content and further the connection necessary for virtual private networks, with up to 600 Mbps;
- deadlines expectations: System Tropisat Cyclone (TropiSat-C) will have less latency than fiber-optic long-distance relationship with a value of less than 150 milliseconds, and three times greater than any possible alternative satellite system (except, perhaps, O3b).

The third chapter of the proposals on the creation of space communication systems and remote sensing, based on low-orbit constellation, to provide communication services and remote sensing of various departments and services of the ekvatorialnogo belt, as well as on the basis of the above methods of research and analysis formed the basic technical requirements with system design principles satellite system TropiSat.

According to the results to develop proposals for a satellite communication system TropiSat can draw the following conclusions:

1. Communication system is constructed based on 8 spacecraft into a circular orbit at an altitude of 8000 km with an inclination of 0° ;
2. Advantageous service region is the territory of Brazil;
3. Spacecraft built on a platform of "Express-500";
4. Payload 10 includes a transponder 10 of transceiver antennas, each transponder bandwidth of 300 MHz, the velocity of transmission / reception at each transponder 600 Mbit / s, the total band is one SC 6 GHz;
5. Primary purpose of the system is to provide a backbone satellite links for the transmission of high-speed data, a further object is to provide a communication (the Internet at speeds up to 5 Mbit / s) subscribers;
6. For the system proposes a set of earth stations comprising:
 - AP for reception / transmission at speeds of 600 Mbit / s;
 - AP for reception / transmission at 155 Mbit / s;
 - subscriber terminal with a mirror steerable antenna for transmitting / receiving data at a speed of 5 Mbit / s (direct channel) 256 kbit / s (reverse link);
 - AFAR subscriber terminal for transmitting / receiving data at a speed of 5 Mbit / s (direct channel) 256 kbit / s (reverse link).
7. To communicate in the system is proposed to use multiple access frequency division multiplexing (FDMA) and DAMA (DAMA).

Following the results of the development of proposals to establish a system of remote sensing TropiSat can draw the following conclusions:

1. Remote sensing system is constructed on the basis of 3 SC (two optical range, one radar range) on a circular orbit of 630 km with an inclination of $97,5^\circ$;
2. Region service area is the entire globe in the latitude belt $\pm 45-50^\circ$;
3. ERS satellites in the optical range are based on the platform "Express 500" for spacecraft radar signature required modernization platform "Express 500" in order to increase its mass-energy characteristics;
4. Payload for ERS satellites optical range may include one of the options in cameras:
 - OEA - company "Peleng", Belarus;
 - RALCAM - of MDA, Canada;
 - VHRI - company SSTL, UK.

Payload for ERS satellite radar range may include one of the options radars:

- type NovaSAR-S - company SSTL, UK;
- type Radar - of MDA, Canada.

They all output characteristics meet the requirements of the customer.

Involving industry in Brazil and personnel will open up new opportunities for the state in the establishment and operation of satellite systems.

CONCLUSION

Thus we can conclude that the satellite system TropiSat-C may play a role in the future of telecommunications services, especially considering:

- significant growth dynamics, a high priority for the system target market (Brazil), which has a significant need to build capacity in the near future and for a long period of time;
- the current state of competition - both intermodal and intramodal;
- particularly favorable political environment is a high priority for the system target market.

This is all the more appropriate because:

- there is an obvious dynamics with respect to both new and innovative to the satellite systems around the world, especially among the large emerging economies of the BRICS group of influential (participant is and Brazil);
- in many countries around the world, including in Brazil, there is no infrastructure, appropriate to the needs of the 21st century.

Execution results of the thesis should be regarded as the scientific and technical, marketing and economic advance in the field of demand generation to create a communications spacecraft, as well as satellite systems. Further development of the dissertation topic should be carried out in the direction of unification of the methods that will help to create a universal methodology of forming requirements for space systems.

CONTRIBUTION INTERSHIPS

During the program, the company Thales Alenia Space has studied the experience of the leading European organization that develops spacecraft wide range of applications. Visiting shops manufacturing departments spacecraft design, as well as departments of research and analysis of promising projects, enabled a scientific discussion with French colleagues on the dissertation topic. During the job training was formed on a technical proposal for spacecraft Telcom-3S.

The main content of the dissertation was published in the papers:

1. Ptukha PS Development of methodology for analyzing market mezhdunarpodnogo commercial communications spacecraft / Intelligence and science: proceedings XIII Intern. young. scientific. conf. / Min. Ed. AV Hnykin; Zheleznogor. SFU branch. - Zheleznogorsk, 2013. - P. 42-43.

2. Ptukha, P.S. Development of methodology of market analysis of an international commercial communication satellite // Special engineering education - training of modern engineering personnel: abstracts [first] regional scientific conference undergraduates November 19, 2013 / Sib. a fed. Univ; Num. for MY. EA Shipilova. - 2013. - P. 43-44.

3. Ptukha PS Identification of promising directions in the design of spacecraft communications through research and development of methodology for analyzing the international market of space services // XVII International

Scientific Conference dedicated to the memory of General Designer of space rocket systems Academician MF Reshetnev (November 12-14 - 2013, Krasnoyarsk) - № 2. - S. 223-225.