RESHETNEV
COMPANY

INFORMATION
SATELLITE
SYSTEMS

№9, 2010

NEW SPACECRAFT – new horizons

SATELLITES OF THE 21ST CENTURY

www.iss-reshetnev.com

Dear colleagues,

Today it is generally accepted to refer to 2009 as the year of the worldwide economic crisis marked by a considerable decline in production. Despite that, for the JSC "Academician M.F. Reshetnev "Information Satellite Systems" it was a period of dynamic growth, new achievements and breakthroughs.

In 2009 the company's volume of work increased considerably, mainly due to the accelerated financing scheme introduced by the government in previous years to support advanced projects in satellite building. Those measures enabled the company to lay the required scientific and technical groundwork, modernize its production and experimental facilities as well as introduce new technologies.

With the backing of Roscosmos, we succeeded in developing principally new products, in particular, medium-class and heavy-class satellites. They are not yet manufactured in Russia; their number is limited in the world.

The further advancement of the JSC "Information Satellite Systems" is closely connected with the implementation, first of all, of long-term federal programs. These are the Federal Space Program, the Federal Target Program, the Global Navigation Satellite System (GLONASS) Program and the Defence Order. Besides, the company aims to increase the number of commercial projects by bidding for satellite manufacturing contracts in the interests of Russian and international customers.

All these factors allow us to feel confident on both Russian and international markets. I am certain that regardless of the economic climate we will always have an opportunity to advance our company and provide the personnel with a solid backlog of orders.

Nikolai TESTOEDOV,
General Designer and Director General
of the JSC "Academician M.F. Reshetnev "Information Satellite Systems"

RESHETNEV
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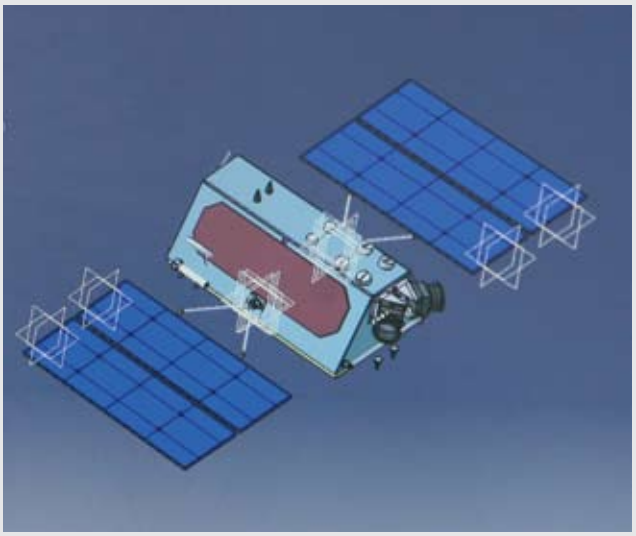
A meeting on the MIC-related issues

Nikolai Testoedov, General Designer and Director General of ISS-Reshetnev, has taken part in the high-level meeting chaired by President Dmitry Medvedev on the questions concerning development of the national military industrial complex.

Nikolai Testoedov was invited to the meeting by President Medvedev as head of a company that implements large government defense contracts for the manufacture of spacecraft. At the meeting President Medvedev brought up the most serious problems of the national military industrial complex. He spoke of the necessity for adopting a federal target program to ensure development of the complex, reduction of production costs and improvement in government contracts legislation. President Medvedev also emphasized that when manufacturing new military hardware priorities must be given to advanced weapons.

Satellites for the agricultural sector



The RF Ministry of Agriculture has awarded a contract to Academician M.F. Reshetnev "Information Satellite Systems" for the manufacture of three Cosmos-CX satellites.

The satellites are intended for remote sensing observations and monitoring of agricultural lands over the whole Russian territory. The spacecraft will allow collection of high-precision satellite data on the condition of agricultural fields as well as crop yield forecasting and assessment. Besides, the new satellites will provide a platform for Earth observations to enable forecasts of droughts, floods and other natural phenomena that might cause damage to the national agricultural complex. With the new technical solutions and capabilities, the Cosmos-CX satellites will provide detailed satellite imagery of the Earth's surface. Payloads (cameras and downlink data transmission equipment) will be supplied by the Space Research Institute of the Russian Academy of Sciences.

Another phase of A&F facility construction over

ISS-Reshetnev has completed the erection and facing of its unique new facility intended for assembling and testing antennas and antenna & feeder systems.

With the heating system installed and the entrance hall made cold proof, the construction of the facility moved into the Interior Work Phase. This will include a concrete floor placement, installation of utility systems and the lining of walls and the dome-shaped roof. Upon completion of the interior work, it is planned to commence reconstruction of an auxiliary building located in the adjacent territory to set up a laboratory and accommodation spaces in there. Construction is scheduled to wrap up in the third quarter of 2010. At present ISS-Reshetnev is testing dedicated support equipment as well as completing the development of the zero-gravity simulation system to enable testing of solar panels and antenna reflectors of different size and mass.

Launch of the Glonass-M clusters

Another six Glonass-M satellites developed and manufactured by the Reshetnev Company were successfully launched in clusters №40 and 41 on December 14, 2009 and March 2, 2010 from the Baikonur Cosmodrome.

Since the successful deployment in orbit, the satellites have been controlled by the Satellite Mission Control Center of the Ministry of Defence located in Krasnoznamensk. The ISS team continues to provide technical assistance as well. The Glonass-M satellites were manufactured within the scope of the GLONASS Federal Target Program for Russia's orbiting fleet of navigation satellites. The 1450-kiligram Glonass-M spacecraft have been designed to orbit for at least 7 years to provide high-precision position and time data for the entire spectrum of users, both military and civilian.

THE LEGISLATIVE FRAMEWORK of the space industry

Activities of ROSCOSMOS enterprises including ISS-Reshetnev are regulated by the Law of the Russian Federation "On space activities". Besides, the space sector is governed by a number of other key normative documents. Nevertheless, these seem insufficient to ensure effective organization of work in the industry. It is obvious that the existing laws and regulations require amendments. For this reason, the State Duma held a round-table session devoted to "Tasks and growth prospects of the space industry: legislative environment". One of the speakers was Nikolai Testoedov, General Designer and Director General of the JSC "Academician M.F. Reshetnev "Information Satellite Systems".

The round-table session called together members of the State Duma and the Federation Council, representatives of Russian space companies and cooperating enterprises, as well as officials from the ministries concerned. As it was stated at the session today's national space industry can be characterized by science-intensive, high-tech manufacturing processes as well as greater innovation capabilities which once realized will fundamentally affect the country's economic development.

Vitaly Davydov, Deputy Head of the Russian Space Agency, took the floor to speak on the agency's strategic objectives. They included

the intensification of use of outer space and enhancement of its effectiveness to enable Russia to solve its current tasks; capacity-building and development; guaranteed access to space; extension of international cooperation and fulfillment of international commitments in the field of space activities. V.A. Davydov also emphasized that the innovative development of the country's economy and the enhancement of national security would be impossible without the use of the space potential. In his report on ROSCOSMOS's activity he went into technical, budgetary, human and structural aspects. 'The condition and prospects of the national space industry are very much dependent on the implementation of the Federal Space Program, GLONASS Federal Program and the Federal Target Development Program of the defence-industry complex. On the whole, the Russian space industry is moving up to the desired level of resource availability to ensure realization of all its development plans as well as succeed in the national strategic objectives in the field of space activities. In the short term, development of the space sector will be largely dependent on a financing resolution on space programs to be taken within the parameters of the federal budgets for 2010 and 2011-2012,' said Vitaly Davydov.

A report on "The legislative framework of the sustainable development of Russian space-industry enterprises" was delivered by Nikolai Testoedov, ISS General Designer and Director General. The speaker outlined the main difficulties of a legislative nature encountered in the process of work on the key federal space programs carried out in the interests of both civil and military customers as well as commercial projects. In his report Nikolai Testoedov stated that one of the major tasks to be solved at the legislative level in the nearest future was the establishment of effective financial support mechanisms to ensure export promotion of Russian space-technology products as well as domestic supplies of satellites. That means that today Russia lacks any long-term crediting mechanisms to support national or foreign satellite buyers. The ISS head referred to the common practice used abroad by the company's major competing firms which act through specialized financial institutions – export credit agencies (ECAs). Their main advantage is that they provide financial support with minimum interest rates, maximum repayment terms (up to 8 years) and maximum amount of financing (up to 85% of the contract value). 'When bidding for Russian and international contracts we have no chance to compete on an equal footing with our foreign rivals, as a buyer, especially during the current economic crisis, has no idle funds. The financial support scheme is very important. Especially in the context of the increasing competition on the Russian satellite telecommunications market caused by the aggressive penetration of large international satellite manufacturers,' stated Nikolai Testoedov. Therefore, it was proposed to work out an action plan to provide for long-term crediting services at competitive terms in the interest of both domestic and foreign buyers of high-tech Russian space-technology products.

The second important issue that the ISS leader put on the "round table" was devoted to the necessity for introducing the zero VAT rate on series-produced military goods. In accordance with the Internal Revenue Code of the Russian Federation the zero VAT rate applies to space-technology products that are subject to obligatory certification, excluding military spacecraft. That is why prime contractors and contracting parties are obliged to pay an 18% VAT out of all advance payments received for military orders from the Ministry of Defence. With a view to establishing equal taxation treatment, Nikolai Testoedov suggested making appropriate amendments to the Internal Revenue Code. So far, some amendments have been already issued.

In his speech the ISS general director also touched on the order of granting budget investments to joint-stock companies that were integrated into a single corporate body. According to Nikolai Testoedov, budgetary funds should be allocated first to parent companies and then distributed among the others. This measure would allow companies to form authorized capital in accordance with the principles established by the Presidential Edict.

Another question concerned the current legislative restrictions hindering full-scale privatization of state-run enterprises located in closed administrative territorial entities (ZATOs). As explained by Nikolai Testoedov, it is the case when the Land Code collides with the Privatization Act. Theoretically, an enterprise must be privatized together with the land it occupies, which is, in fact, impossible in closed cities, since their lands have either been taken out of circulation or have limited transferability. On the whole, it was agreed that the formation of integrated companies in the Russian space industry was not progressing quickly enough, which to some extend was caused by the absence of title documents for the companies' lands. Since the problem was also "legislative" in nature, it was put on the table for careful consideration.

In addition, the sitting members discussed the application of space activity results as well as their integration into the socio-economic and management practices. It was stated that to successfully perform those tasks it was important to introduce a complex of effective modern mechanisms and formalize them legislatively. This task was supposed to be solved within the scope of the principally new federal target program "Application of space activity results in the interests of the socio-economic development of the Russian Federation and its regions". Without a comprehensive solution to the problem, considerable amounts of investments planned into the national space infrastructure for the period until 2015 and further on might not hit the target.

Nevertheless, it was declared that despite all the topical issues raised at the round table the national space industry was attaining the required level of resource availability to realize its development plans and succeed in national objectives in the sphere of space activities.

At the close of the session the present members passed recommendations regarding "Tasks and growth prospects of the space industry: legislative environment". Those included Nikolai Testoedov's proposals as well. According to the ISS General Director, the round-table session enabled all the participants including members of the State Duma and the Federation Council to jointly formulate lines of action for the Russian Government and the State Duma to work on.

Nikolai Testoedov,
"The company increased its output considerably in 2009"

The year 2009 for the JSC "Academician M.F. Reshetnev "Information Satellite Systems" proved a period of dynamic growth marked by significant changes in all aspects of the company's activity. The implementation of the current tasks and the initiation of new projects dictated the high tempo of work. What was the most valuable and essential experience in the intensive flow of events? The last year's results are summarized by Nikolai Testoedov, General Designer and Director General of the ISS-Reshetnev Company.

- Mr. Testoedov, what do you think were the most important events for the Reshetnev Company in 2009?

- First of all, it was an anniversary year for the company. 50 years is a long term and we succeeded in showing its significance as well as making progress in technology, science, human resources, social programs and manufacturing capabilities. It was definitely the main event. Equally important were satellite launches. We launched 8 spacecraft last year: three Glonass-M navigation satellites, the Express-AM44 spacecraft, the most powerful and effective satellite in the Russian orbital constellation deployed to serve the interests of the national economy, and also military spacecraft manufactured under the Defence Order. By comparison with the previous year, in 2009 the company increased its output by 50%, which indicates that ISS-Reshetnev met all its commitments by executing production plans and programs. It is very important to emphasize that it was not a mere increase in the company's annual output. It was an interim result of a number of long-term federal programs, such as the Federal Space Program, the Global Navigation Satellite System (GLONASS) Program and others. Besides, we are now participating in Gasprom Space Systems' programs and a number of international projects. We feel secure to go ahead mainly thanks to our personnel, whose number increased considerably in 2009, and high tempos of the ongoing re-equipment program. In 2009 we entered the final phase of the construction of the new A&F (antenna & feeder systems) facility. We also laid the foundations of the galvanizing plant and kept on modernizing our machinery pool and workplaces.

- What are the company's main tasks for 2010?

- As for the production targets, first of all, we continue implementing the abovementioned federal programs. We expect production to grow by approximately 40-50% in 2010,

depending on the results of the bidding processes we are currently participating in. According to the launch schedule for 2010, we plan to deliver 23 satellites in orbit, including 10 Glonass spacecraft. 9 Glonass-M satellites will be deployed to provide the current fleet of navigation spacecraft with the required number of operational and reserve spacecraft to ensure full global coverage. The 10th navigation spacecraft scheduled for launch in 2010 is the next-generation Glonass-K satellite.

We are also planning to carry on the construction of two production facilities as well as the re-equipment program. The latter suggests our switch to the use of up-to-the-minute tools and machinery as well as information technology.

- Mr. Testoedov, how did the company's financial status change in 2009 in comparison with the previous corresponding periods?

- In 2006 the company's turnover was 4.4 billion roubles; in 2008 and 2009 it increased to 9.6 and 14.1 billion roubles correspondingly. Our forecast for 2010 is 21 billion. It is noteworthy that this considerable increase was mainly caused by the amount of the business done. Besides, today we can benefit from the improvements in the banking system. If previously, we had to spend 100 million roubles out of a 3-billion turnover on loan interests, then in 2009 we paid only 40 million out of 14 billion roubles. It became possible, first of all, due to the anti-recessionary measures undertaken by the Russian Government in 2009 to bind customers to increase advance payments, and secondly, due to the rate cuts provided by the banks.

- You have taken part in a number of high-level government meetings recently (a visiting session of the Government of the Russian Federation, a round-table session at the State Duma, etc.) Do you think meetings of that kind have any positive impact on the industry in general and ISS-Reshetnev in particular?

- When participating in events like these you can see how quickly the government's efforts and macroeconomic policies start producing favorable effects on production results. The high-level meetings in which we took part and especially those held at ISS under the chairmanship of Prime Minister Vladimir Putin as well as meetings with President Dmitry Medvedev have shown that, first of all, these sessions help coordinate customers and the industry, and secondly, define and correct main lines of the industry's development. Then there appear results. For instance, the visiting session of the Russian Government hosted by the Reshetnev Company on October 21, 2008 resulted in Vladimir Putin taking a decision to grant a 15% preference to Russian companies competing for Russian contracts against foreign rivals. The decision has been implemented. Moreover, Russian companies have received priority for space contract awards. These include launch services by Russian rockets and the manufacture of satellites by Russian prime contractors. Taken together, government measures promote activities in the space sector to a great degree.


At the RF Government meeting with space companies

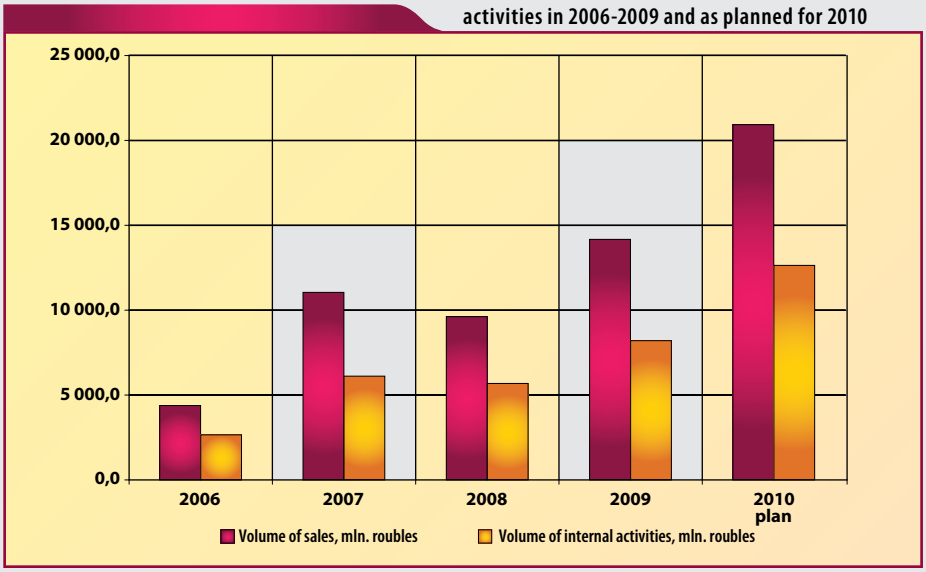
Furthermore, the anti-recessionary measures undertaken by the government last year proved very effective. Thus, when the special commission headed by the Russian Minister of Finance A.G. Siluanov reviewed the list of Russia's strategic enterprises including ISS-Reshetnev, it was resolved to reduce interests on bank credits for these companies, which resulted in improved framework conditions for their further development. A number of enterprises including ISS were allowed to keep dividends to boost production.

Another crucial issue was settled through the agency of the State Duma and the Ministry of Defence. It concerned the application of the zero VAT rate to series-produced military products. Since it was not provided for in the Internal Revenue Code, by Federal Act № 281 of November 25, 2009 the zero VAT rate was introduced for series-produced military goods. We had been discussing this issue with various committees in the State Duma for almost a year and a half before, and finally it worked out.

- Today ISS-Reshetnev bids almost for all international contracts for the manufacture of telecommunications spacecraft. What are the company's prospects?

- The company's chances for success in international competitions were determined 5 years ago when Roscosmos allocated funds to the implementation

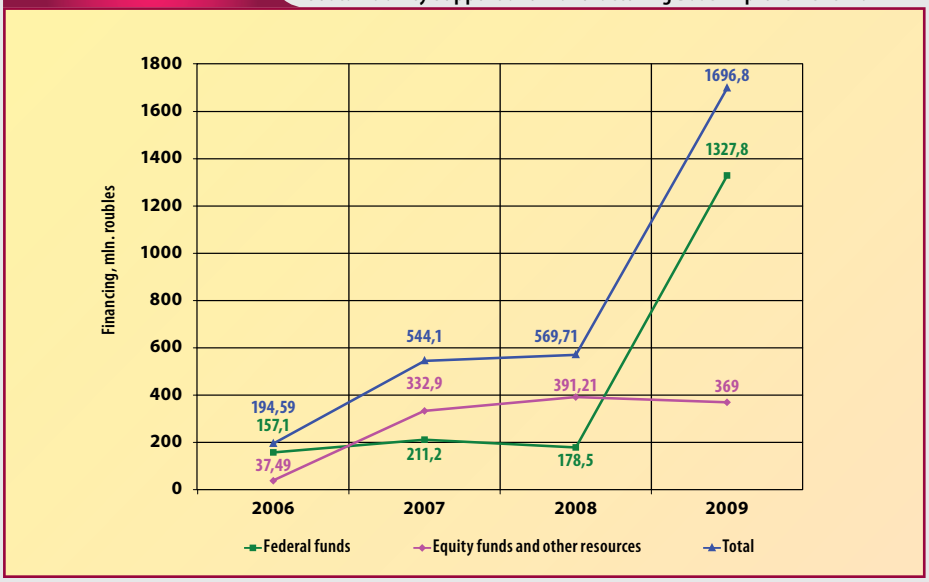
ISS-Reshetnev's volumes of sales and internal activities in 2006-2009 and as planned for 2010




The assembly of the Glonass-M spacecraft

of a forward-looking decision to create unified satellite buses, Express-1000 and Express-2000. Then, by breaking through in our efforts to find most progressive solutions in satellite design, we managed to form the base for our future satellite projects. These are high-powered satellite platforms of unpressurized design with a 15-year service life and high-precision station-keeping capabilities. In fact, we succeeded in creating unique products, i.e. a medium-class satellite platform with 6 kW of power available for the payload and capable of being launched in tandem atop a Proton rocket; and a heavy-class platform intended for the creation of high-powered satellites that have never been launched before. Thus, that timely, forward-looking financing strategy allowed us to avoid lagging behind the world's latest satellite building technology but immediately put us in the vanguard of technological progress. Today our standardized flight-proven platforms and unified avionics enable us to build satellites at lower costs. So, we are ready to manufacture custom-tailored spacecraft at the price of mass-produced items, which allows us to bid confidently for Russian and foreign contracts. As a result, we have made a number of contracts for the manufacture of satellites, in particular, Amos-5 for Israel, Telkom-3 for Indonesia, Yamal-300K for Gazprom Space Systems, and Express-AM5 and Express-AM6 for the Russian Satellite Communications Company. Indeed, we compete practically for all international contracts, especially if there is a possibility of building satellites on the abovementioned platforms.

Funds allocated for the "2006-2009 ISS Technical Sustainability Support and Manufacturing Base Improvement Plan"



- Foreign customers prefer to order satellites with qualified systems and equipment. In the light of such great significance attached to the use of qualified satellite components aboard a spacecraft, how do you meet this challenge at ISS?

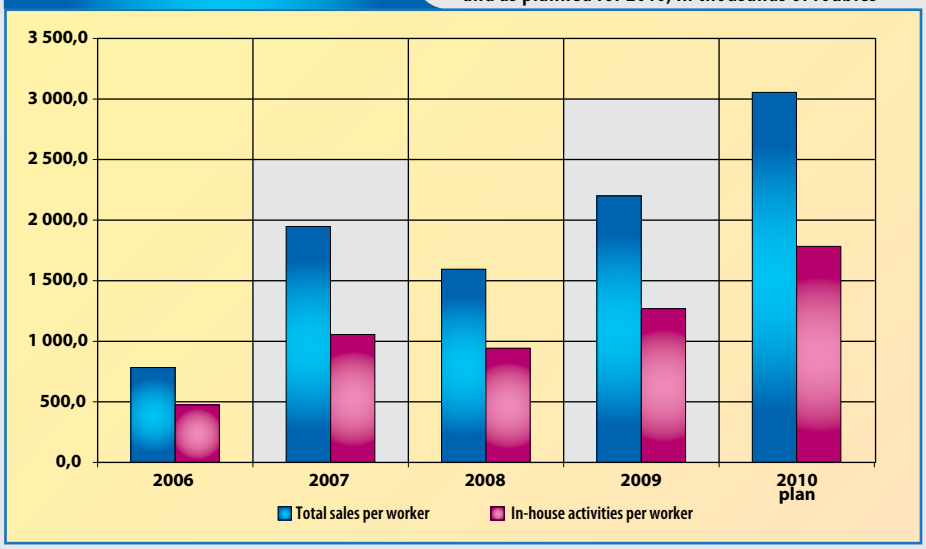
- When creating a series of satellites with masses ranging from 800kg to 3.5 tons by using the same platform equipment we have an opportunity to test and prove these devices in space aboard the first spacecraft launched. This serves as a ground for including space-proven devices into the next project without additional testing, which saves time and money. It is important to distinguish the terms "flight-qualified" and "flight-proven". Generally speaking, flight qualification is received when the first satellite in a series, that was supposed to run, let's say, for 15 years, in fact has completed its mission as guaranteed. When a satellite has been in orbit for half a year and its equipment is functioning well we can confirm that it is flight-proven and able to work in space. Since we can not wait for 15 years for the first satellite to complete its mission, we have worked out a strategy to test separate devices, assemblies, coatings and subsystems onboard our various satellites manufactured and launched annually in large quantities to perform missions different from those that the equipment-to-test must perform. For instance, we install communications equipment to be tested into vacant spaces onboard 6 navigation satellites that are launched annually within the scope of the GLONASS Federal Target Program. Thus, the communications equipment receives its "flight-proven" status and quality assurance 2-3 years prior to the launch of the first communications satellite. We follow this pattern with regard to almost all devices that are manufactured at ISS or purchased from our business partners. It is our most important proof of efficiency of our devices, assemblies and avionics together with ISS-made platforms, onboard which they pass their tests.

- It is no secret that the shortage of reliable Russian-made components poses a serious problem for the Russian space industry. Today ISS-Reshetnev has the largest order book in the industry for the manufacture of military, civilian and commercial satellites. What measures are being taken to improve the reliability of the component base?

- You formulated the main problem of Russian satellite manufacturing

correctly, i.e. the insufficiently reliable component base with a number of crucial characteristics missing. The problem exists, yet it is being solved by means of some federal target programs. However, as satellite manufacturers, we can not wait until essential satellite elements are created, and so we are also trying to find solutions. First of all, we place special orders for batches of components preliminarily agreed upon with the manufacturers in terms of volumes, materials, inspection points, order of acceptance, etc. Secondly, apart from go/no go tests, we conduct additional performance tests of 100% of Russian-made radio equipment. These include electrical, thermal and thermal-vacuum tests to check the parameters of the procured radio equipment. "Potentially unreliable" items are rejected as well, together with a small number of components which fail to meet requirements. If during additional testing we notice a slight drift of parameters towards the boundary points, we reject the item, as we understand that at some point of a satellite's lifetime, projected, let's say, for 15 years, these parameters might slip beyond the given range. As far as foreign radio components are concerned, I would like to point out that they are used on Russian satellites in strict compliance with the existing regulatory system. Besides, a list of foreign components accepted for use on a spacecraft is always submitted to the customer for approval. As regards quality, it is our understanding that there are three standards in Western component manufacturing. The first is INDUSTRY or, simply put, household standard. The second is MILITARY and, as it is clear from the word, it includes improved quality components used in ground conditions, which means they can be replaced or repaired. Finally, the SPACE quality standard, i.e. the highest quality components produced specially for long-term operation in space conditions. At our enterprise we issued a directive several years ago to use exclusively MILITARY and SPACE quality elements. In cases when these are not available in terms of parameters, we have to use INDUSTRY, but every time this happens, we sign a program for additional testing and launch the same procedures as we have with Russian-made electronic components. That makes us confident that the components to be used meet all quality and parameter requirements as regards specifications, performance in space and radiation resistance.

Output per worker in 2006-2009 and as planned for 2010, in thousands of roubles



- In 2009 ISS-Reshetnev completed business integration. What principles do you follow in running such a large company? How real is it to centralize the process of handling numerous questions that arise at various units and concern production, social sphere, human resources, etc.?

- In late December we fulfilled the RF Presidential Edict of June 2006 establishing an integrated structure on the ISS-Reshetnev base. The question that had to be answered was what to do next. To clone our system of management at the other business units? Or to let them go on their own? The answer was very simple - to borrow the best of every enterprise, every single system. If at a certain enterprise there exists a better system of financial accounting, we will consider it, compare with ours and introduce, as it is, for the whole integrated structure. If there exists a better accounting system, we will do the same. At the same time the process of dealing with all crucial questions regarding production facilities, capacity, technology, information security, local data processing networks, social programs, property, etc. will be standardized. It is important to stress that we plan neither resubordination nor affiliation. All the enterprises integrated into ISS-Reshetnev will still remain separate legal entities and will pay taxes at the place of registration and residence in order to avoid disagreement with local authorities and the new conditions. I think this model is optimal, as it leads to no conflict between interested parties and most fully reflects Roscosmos's conception of developing large integrated companies.

Thermoelectric tests of the Gonets spacecraft at ISS-Reshetnev

CREATING STATE-OF-THE-ART Express-AM5 and AM6

The contract for the manufacture of the Express-AM5 and Express-AM6 telecommunications satellites was awarded to ISS-Reshetnev in 2009 by RSCC, Russia's state satellite operator. The history of cooperation between the two companies spans more than one decade. In fact, ISS-Reshetnev has designed and manufactured a variety of satellite series for the Russian Satellite Communications Company, such as Gorizont, Ekran-M, Express, Express-A and Express-AM, all intended for domestic service. In 2009 ISS and RSCC made another contract for the supply of the Express-AM5 and Express-AM6 satellites, which was definitely an important milestone in the history of ISS-RSCC relations.

According to the contract signed in August 2009, ISS will design, develop, manufacture, test, conduct pre-launch preparations and in-orbit commissioning of two heavy-class telecommunications spacecraft. The satellites will be manufactured within the scope of the on-going Federal Space Program set for a period up to 2015 to meet domestic needs of the increasing satellite communications and digital broadcasting market.

Express-AM5 and Express-AM6 will provide the country with the necessary telecommunications infrastructure and accessible multichannel digital TV and radio broadcasting services. The new spacecraft are also intended to provide mobile presidential and governmental communication, multimedia services (telephony, videoconferencing, data relaying, the Internet) and VSAT networks.

The contract entered into force on October 27, 2010. According to the terms of the contract, the first satellite is scheduled to be manufactured within 29 months; the second one is due 4 months later.

The satellites will employ the versatile Express-2000 platform developed by the Reshetnev Company. At present the engineering model of the platform structure has been manufactured and tested. Designed as heavy as 3400kg, the satellites are expected to orbit for 15 years.

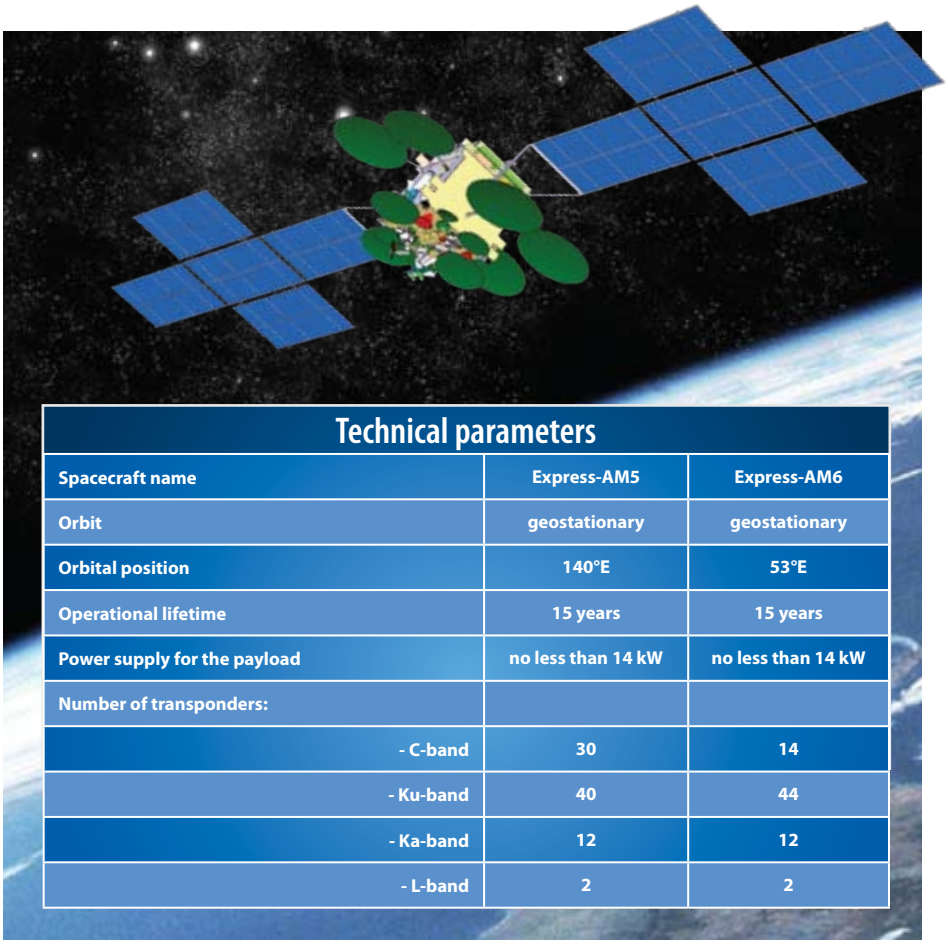
The satellites' electrical power subsystem will generate no less than 14kW of power. According to Nikolai Testoedov, General Designer and Director General of Information Satellite Systems, the Express-AM5 and Express-AM6 satellites will become the most powerful Russian-built satellites. They will accommodate a large number of transponders in the C-, Ku-, Ka- and L-bands, which will allow Russia to more efficiently use its orbit frequency resources.

Within the framework of the project, ISS-Reshetnev is subcontracting the repeater and antenna systems to the Canadian company MDA. NII Radio, a Russian Scientific Research Institute, will carry out the integration of the onboard repeater equipment as well as design and manufacture the payload

modules. The unique feature of the Express-AM5 and AM6 satellites consists in the fact that these are going to be the first heavy-class unpressurized satellites with a large number of transponders and sophisticated antenna systems. It is important to mention that ISS-Reshetnev will also take part in the manufacture of spacecraft antenna systems. In the nearest future the company is planning to launch production of shaped reflector antennas. To that end, ISS is procuring equipment and developing the manufacturing and measurement technology. It is also worth mentioning that some years ago the company's management set the task of moving on to the manufacture of PLM elements and their integration instead of purchasing ready-assembled ones. Today the company is following that course successfully.

The contract for the supply of the Express-AM5 and Express-AM6 satellites is of great significance for both – the manufacturer, ISS, and the customer, RSCC. According to Yuri Prokhorov, acting general director of RSCC, 'The step-by-step implementation of the Satellite Constellation Replenishment Program will allow RSCC to provide high-quality telecommunications services to the population of Russia as well as commercial and government users nationwide. The creation of the new Express-AM5 and Express-AM6 spacecraft will open new pages in the history of the Russian orbital constellation'.

Based on the RSCC materials



Technical parameters

Spacecraft name	Express-AM5	Express-AM6
Orbit	geostationary	geostationary
Orbital position	140°E	53°E
Operational lifetime	15 years	15 years
Power supply for the payload	no less than 14 kW	no less than 14 kW
Number of transponders:		
- C-band	30	14
- Ku-band	40	44
- Ka-band	12	12
- L-band	2	2

A satellite model based on the Express-2000 platform

About RSCC

The Russian Satellite Communications Company is Russia's national satellite operator whose satellites provide full global coverage. The company was founded in 1967. Today RSCC is listed among the world's top ten largest satellite communications service providers. The company operates Russia's largest fleet of spacecraft spaced between 14° W and 140° E, thus covering the entire Russian territory, the CIS, Europe, the Middle East, Africa, the Asia-Pacific Region, North and South America, and Australia.

The company has 5 space communications centers: Dubna, Bear Lakes, Skolkovo, Zheleznogorsk, Khabarovsk and the Shabolovka Technical Center in Moscow as well as its own high-speed optical-fiber digital network.

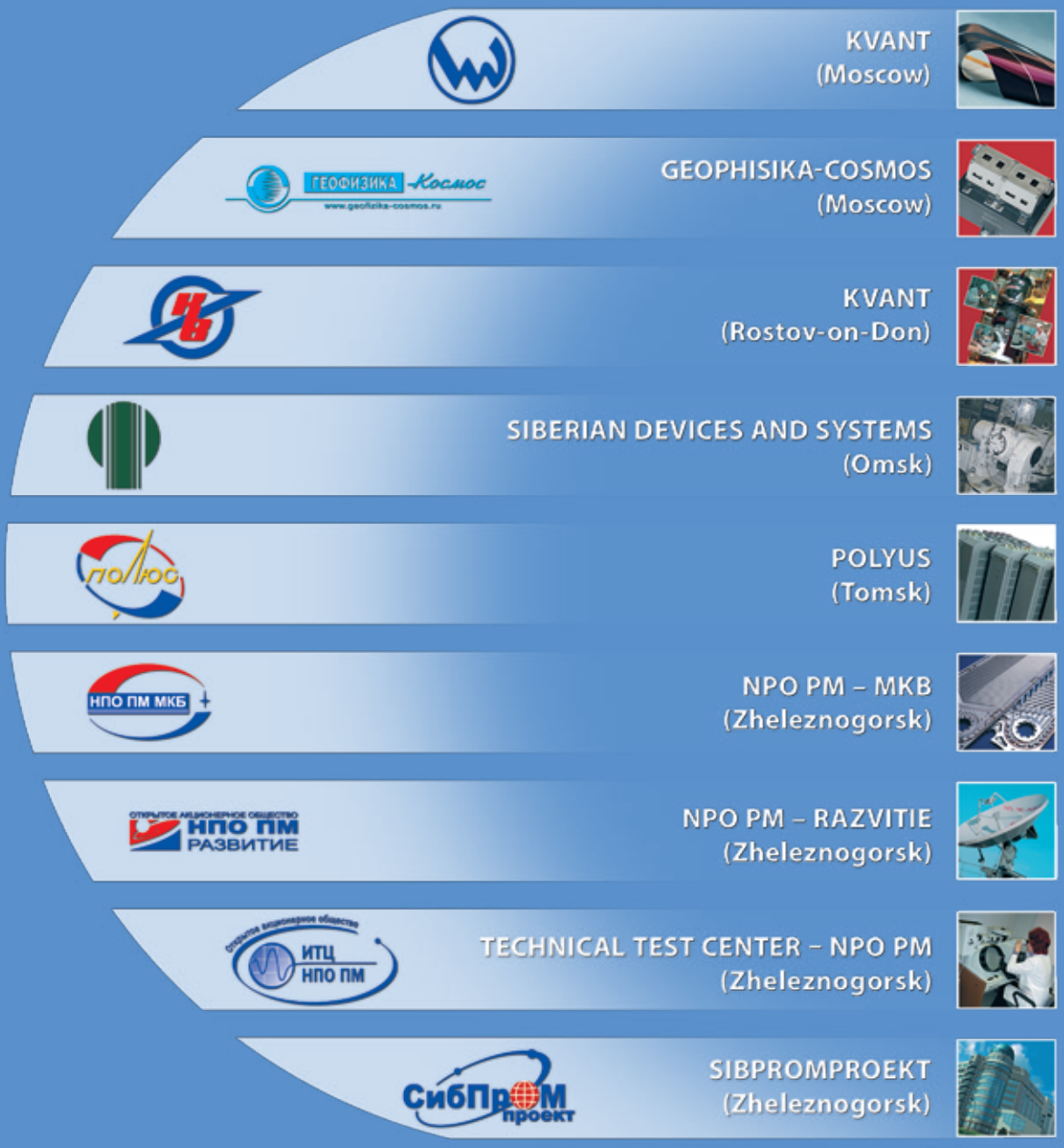
BUSINESS INTEGRATION

In December 2009 the JSC "Academician M.F. Reshetnev "Information Satellite Systems" completed business integration to form a large integrated company. The ambitious integration process was launched 8 years ago in the context of the ongoing restructuring of the national military-industrial complex and has been carried out with a view to optimizing the production management system in the industry.

The Presidential Edict of June 9, 2006 on the formation of the integrated company "Academician M.F. Reshetnev "Information Satellite Systems" defined priority lines of activity for the new corporate body as the design, development, modernization, manufacture and maintenance of space-based information and coordinate-measuring systems, complexes and spacecraft for various applications. Thus, the main field of the company's activity was defined as space.

Today the formation of integrated structures is strictly controlled by the Government of the Russian Federation. At one of the meetings devoted to the restructuring of the Russian space industry held in August 2009, Prime Minister Vladimir Putin stated that the strategic objectives of the industrial structural reforms were a competitive growth of space-related enterprises and an effective use of their potential for the country to succeed in domestic socio-economic objectives as well as penetrate hi-tech international markets. The meeting produced deadlines for the integration process and the number of integrated structures to be formed; thus, the figures for 2009 and 2010 were 4 and 5 correspondingly. The first in the list to carry business integration through was the joint-stock company "Academician M.F. Reshetnev "Information Satellite Systems".

The first meeting of the Board of Directors of the enlarged Information Satellite Systems was chaired by



Anatoly Perminov, head of the Russian Space Agency, on October 20, 2009. The members of the Board adopted a number of resolutions aimed at facilitating the business integration process. At present ISS-Reshetnev is a large corporate body formed from nine Russian enterprises specializing in spacecraft manufacturing. In December 2009 the authorized capital stock of the Reshetnev Company was enlarged through share capital injections from 5 enterprises: the JSC "Scientific and Production Enterprise "Kvant" (Moscow), the JSC "Research & Production Enterprise "Geophisika-Cosmos" (Moscow), the JSC "Scientific and Production Center "Polyus" (Tomsk), the JSC "Siberian Devices and Systems" (Omsk) and the JSC "Scientific and Research Enterprise of Space Instrumentation Industry "Kvant" (Rostov-on-Don). The same procedure had been previously launched to integrate four companies from Zheleznogorsk: the JSC "NPO PM – Razvitie", the JSC "NPO PM – MKB", the JSC "Technical Test Center – NPO PM" and the JSC "Sibpromproekt". Thus, the formation of the new integrated company was successfully completed in 2009.

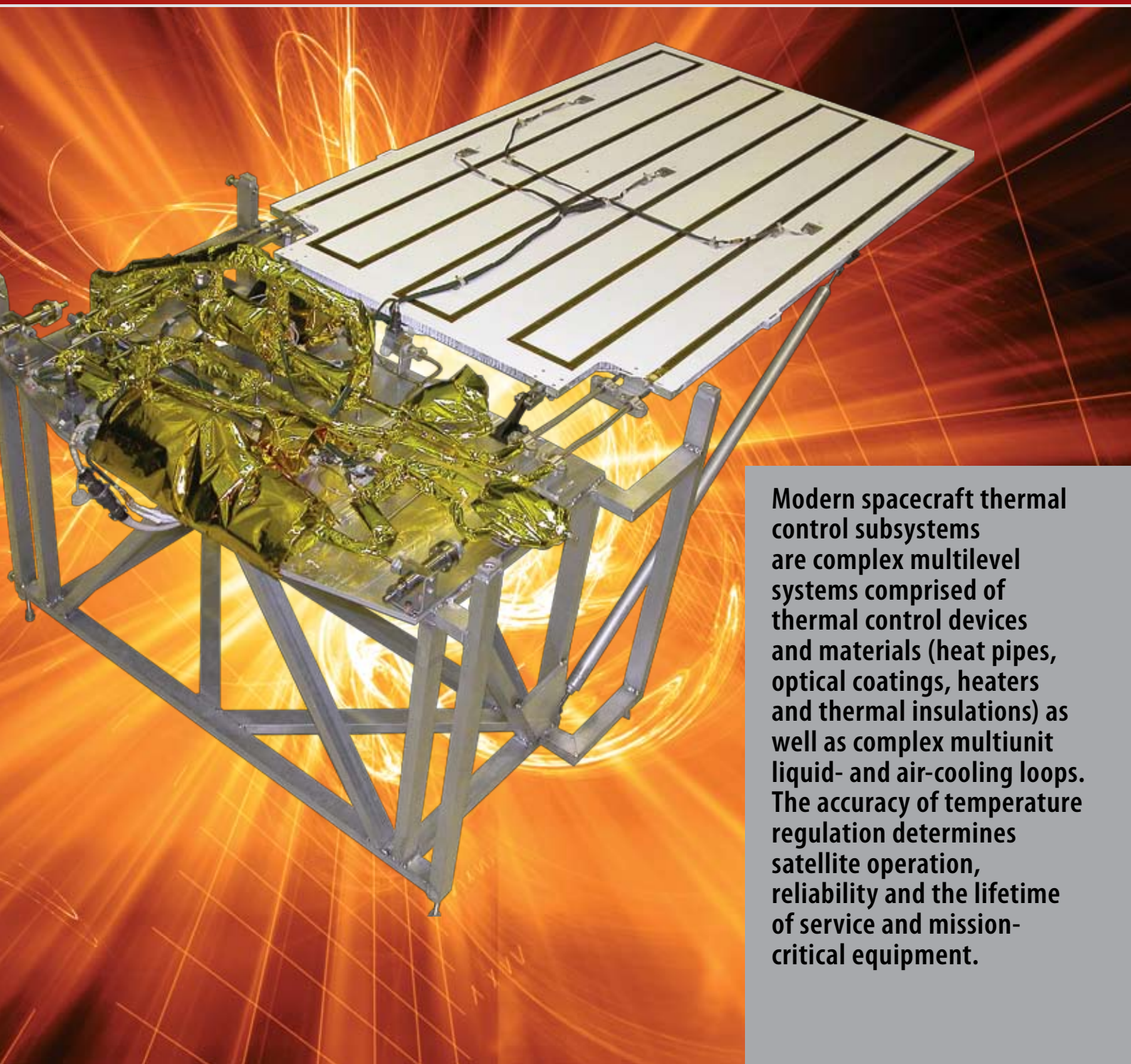
Currently, ISS-Reshetnev, as a shareholder with almost 100% stake, is forming teams to manage the 9 companies. These will also include representatives of the Reshetnev Company, which will allow the headquarters to introduce its well-proven management system to facilitate the realization of the national space programs and plans. It is important to emphasize that apart from their main activities, all the companies will be diversifying into profit-making businesses. ISS-Reshetnev, as the majority shareholder, will support and encourage attractive long-term projects and development plans.

Today, to ensure development of the integrated company, ISS is considering possible courses of action, including growth prospects and further expansion of its shareholder base. Under the new circumstances, the Reshetnev Company will definitely take advantage of the new acquisitions, for all the companies are involved in the same space-oriented business.

Finally, all these steps are being undertaken to consolidate scientific, manufacturing and financial resources of the space industry enterprises in order to succeed in the strategic objectives set by the President of the Russian Federation.

TECHNOLOGY

SPACECRAFT THERMAL CONTROL SUBSYSTEMS DEVELOPED AT ISS



Modern spacecraft thermal control subsystems are complex multilevel systems comprised of thermal control devices and materials (heat pipes, optical coatings, heaters and thermal insulations) as well as complex multiunit liquid- and air-cooling loops. The accuracy of temperature regulation determines satellite operation, reliability and the lifetime of service and mission-critical equipment.

The purpose of the thermal control subsystem is to reject heat dissipated by the equipment and maintain onboard temperatures within the desired temperature range through the life of the mission regardless of light conditions and satellite modes.

Thermal control is crucial not only for individual devices and components but also for large-sized instrument panels. In some cases temperatures must be maintained within a critical range. For instance, the reference frequency oscillator of a navigation satellite requires that the temperature is maintained within ±0.1°C.

Current trends in Russian and Western satellite manufacturing are indicative of the continuing growth in satellite size and power. Thus, the Express-AM5 spacecraft has been designed to have a 15-kW power consumption. With the present-day global market making greater demands on satellite lifetime, satellites are expected to operate for no less than 15 years. In this regard, the development of highly precise and reliable thermal control systems for large-sized instrument-bearing structures is a truly challenging endeavor.

The unique feature of the thermal control subsystem is that it determines satellite configuration which to a large extent depends on the way heat is removed. This knowledge is a guiding principle in satellite design.

At present the Reshetnev Company has introduced a number of methods for cooling satellite equipment:

- gas cooling applied in a pressurized container (Glonass-M);
- liquid cooling performed with the aid of a pipeline going under the mounting place or directly through ducts inside the equipment item;
- heat transfer by means of heat pipes (Gonets, Yubileiny, Glonass-K);
- heat rejection by radiating panels to which equipment is mounted from the inside.

The last method, in the presence of concentrated powerful heat sources, requires heat pipes to spread heat along the radiating panel, and heaters to avoid overcooling in a stand-by mode.

There are also combined methods of thermal control:

- by transferring heat to a fluid;
- by using both gas and liquid, the two loops being thermally coupled via a heat exchanger.

The gas-liquid thermal subsystem has been used on a number of medium- and high-powered satellites, such as SESAT, Express-A and Express-AM.

Thermal subsystems with liquid and gas loops ensure the best control capabilities, as they allow keeping satellite equipment temperature fluctuations within the range of 10°C through the life of the mission. For reference, heat pipe subsystems allow temperature fluctuations more than 30°C. In this case satellite equipment is subjected to temperature cycling, which reduces a satellite's lifetime. Liquid loops when embedded into honeycomb panels provide greater flexibility and appear to be very convenient for the payload and the platform.

Satellites of the Express-AM series provide an illustrative example of the successful application of the gas-liquid thermal subsystem in spacecraft design. Combined with the technology of embedding liquid loops into honeycomb panels (developed by ISS), the gas-liquid subsystem has considerably simplified the manufacturing and testing of payload modules in Thales Alenia Space as well as their follow-up integration. The new method ensured a tight arrangement of parts, which also proved convenient for the antenna subsystem due to the so-called "honeycomb tower" shape. Such a result could have been hardly achieved if the equipment had been placed on the radiation panels containing heat pipes as it was supposed in accordance with the common Western practice. Despite the advantages, liquid-gas subsystems have some shortcomings, such as impossibility or great difficulty in providing a redundant loop, as well as an increase in satellite mass owing to the use of a pressurized container and loop units.

One of the recent developments of the ISS-Reshetnev Company – the advanced non-pressurized satellite bus Express-1000H – combines the advantageous attributes of both liquid and heat-pipe systems. The liquid loop cools down the service module equipment and then comes out on the internal surface of the radiating panels containing built-in heat pipes, thus, providing a thermal coupling between the opposite radiating panels. This principle is particularly beneficial to a geostationary spacecraft, as during a year either one side of a satellite or the other faces the Sun, and as a result, one of the panels may get considerably heated whereas the other gets considerably cooled. A thermal coupling allows temperature equalization and at the same time increases efficiency of the panels. This approach to thermal control has been accepted for ISS's new satellites, in particular, Amos-5, Telkom-3, Yamal-300K, Express-AM5 and Express-AM6.

The ESA's predictive analysis regarding thermal control trends for 2010-2020 shows that the advancement of modern technologies puts forward a challenging task of developing new heat-transfer devices and systems to be based on the capillary-pumped heat pipe technology in order to enable operation within particular temperature ranges.

Thus, the hybrid scheme based on the combination of heat pipes and the liquid loop is going to be widely used in satellite thermal control in the nearest future. In the distant future, vapor-liquid (or two-phase) systems, whose major advantage resides in high heat transfer coefficients, will take

Honeycomb panels with embedded heat pipes


Visional inspection of heat pipes

Loop heat pipes as qualitatively new developments from the axial and artery heat pipes are an upcoming trend in the thermal control technology. By undertaking R&D activities on the design of LHPs, ISS-Reshetnev is, in fact, laying the foundations of developing new, high-performance elements for the thermal control subsystem.

pride of place. Within the framework of the Federal Space Program set for 2006-2015, the Reshetnev Company is responsible for R&D activities on the two-phase thermal control technology as well as for the creation of basic elements for the new system.

The simplest example of the two-phase thermal control system is a heat pipe, along which vapor and liquid flow in opposite directions, thus transporting up to 100W of waste heat at a distance of 2 m and with a very minor temperature difference. Theoretically, the two-phase loop system must have greater capabilities for transferring considerable amounts of heat over large distances.

In the short-term, loop heat pipes (LHP) will take priority over regular heat pipes due to a number of advantages. The heart of a loop heat pipe is a capillary evaporator (CE) that has a high-porous sintered metal structure with a two-micron pore diameter. When ammonia is used, the capillary head of up to 0.4 bar is generated by the surface tension inside the CE, thus enabling vapour and liquid circulation over tens of meters along very small-sized transport lines (a few millimeters!). Besides, due to the high capillary head inside the CE there are no restrictions on the position of the heat pipe relative to the horizon during ground tests. Another important advantage of LHPs is that they provide an opportunity to remove heat to deployable double-sided radiating panels by utilizing flexible lines and a deployment mechanism. This is crucial for high-powered satellites, as they need extra radiation surface areas outside the satellite body.

ISS-Reshetnev initiated efforts to develop the technology in the late 1980s. Quite soon, in 1989-1991, a number of experimental modules with 120W of power were installed on three Gorizont spacecraft (№30, 31, 32). It was the first flight experiment with this type of systems in the world. Later, in 2007-2008 ISS specialists created a pilot two-phase deployable radiator system. It consisted of two loop heat pipes with condensers embedded into a deployable honeycomb radiator panel. Heat was transferred from the heater to one of the LHP's evaporators, the heat rejection capacity being 700 W. The second evaporator had a body with a flow-type heat exchanger and the heat rejection capacity was almost 1000W. Tests proved a success.

Thus far, ISS has issued design documentation for capillary evaporators. At present the company is developing the technology of manufacturing sintered powder wicks and capillary evaporators. An experimental 3-kW thermal control system based on capillary evaporators is scheduled to be manufactured this year for ground testing. To conduct flight tests, ISS specialists have installed a miniature loop heat pipe instead of one of the two variable conductance heat pipes on the Yubileiny-2 spacecraft.

Academician M.F. Reshetnev "Information Satellite Systems" has considerable expertise in the application of all the existing types of thermal control. The latest developments in this field that are currently being implemented within the Amos-5 and Telkom-3 projects, will allow the company to manufacture a really unique system. Besides, with the additional use of loop heat pipes, which is expected in the future, there will appear more opportunities for the creation of hybrid-type systems for high-powered spacecraft.

Gennady DMITRIEV,
Principal Thermal Design
Engineer of the Thermal Control
and Analysis Department.

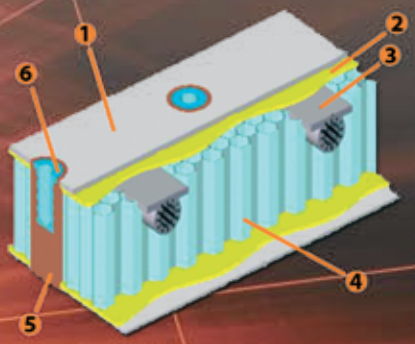

Heat pipes

RESHETNEV
COMPANY

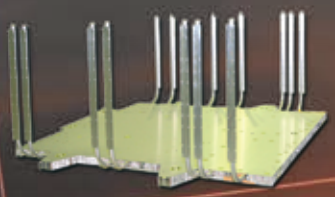
JOINT - STOCK COMPANY

"ACADEMICIAN M.F. RESHETNEV" INFORMATION SATELLITE SYSTEMS"

HONEYCOMB PANELS

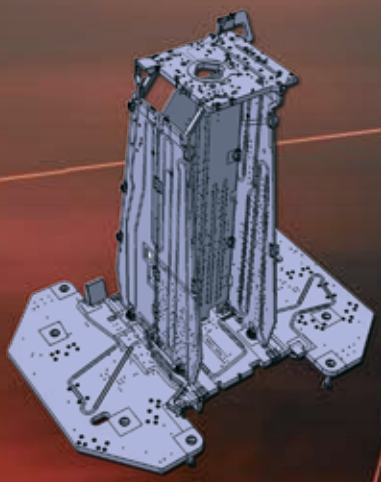


1. PANEL SKIN (ALUMINUM OR CARBON)
2. FILM GLUE
3. EMBEDDED HEAT PIPES (OR FLUID LOOP)
4. HONEYCOMB
5. FOAM GLUE
6. BOBBIN-TYPE INSERTS



HONEYCOMB PANEL WITH EMBEDDED HEAT PIPES

INSERTS



EAM33/44 PLM STRUCTURE WITH EMBEDDED FLUID LOOP

HEAT PIPES

GAS REGULATED HEAT PIPE

HEAT PIPE WITH FLOW HEAT EXCHANGER

AXIALLY GROOVED HEAT PIPES

HP type	Diameter, mm	Number of grooves	Heat Transfer Capacity, W•m	Specific mass (mass), kg/m	Controlled Power, W	Lifetime
Gas Regulated HP	14,6	36	-	mass = 0,8 kg	2,2 to 20	10
	12,0 (stainless steel)	wick	-	mass = 0,9 kg	1,5 to 20	10
AGHP	15,0	36	160	0,32		10
	14,6	36	130	0,28		15,25
	11,1	24	110	0,25		15,25
	10,6	22	105	0,26		10

TWO-PHASE SYSTEMS WITH CAPILLARY EVAPORATORS

MOCK-UP OF TWO-PHASE SYSTEM WITH DEPLOYABLE RADIATOR

FLIGHT MODULE OF CAPILLARY PUMPED LOOP, LAUNCHED IN 1989 ON-BOARD "GORIZONT" SATELLITE

EVAPORATORS (PROVIDED BY INSTITUTE OF THERMAL PHYSICS, URAL BRANCH OF THE RUSSIAN ACADEMY OF SCIENCES)

EDUCATION, SCIENCE AND MANUFACTURE: 50 YEARS' PARTNERSHIP

Russia's higher education has a good reputation, long traditions and remarkable achievements made by generations of outstanding scientists and educators. Among the numerous branches of the Russian educational system, aerospace education is reckoned an elite university program that has proved its effectiveness and made tremendous contributions to Russian aviation and cosmonautics.

The cradle of cooperation

Academician M.F. Reshetnev Siberian State Aerospace University (SIBSAU) is the only aerospace establishment in Siberia and the Russian Far East. It was founded by the Government Resolution of December 30, 1959 as an educational plant facility with the aim of preparing specialists for the aerospace industry, in particular the Krasmash machine-building plant. One of the orders of the USSR Defence Technology Committee stated, "The Krasnoyarsk educational plant facility shall be of great significance to Krasnoyarsk's cluster of defence enterprises in terms of education and preparation of highly-qualified staff". Therefore, the history of Siberian Aerospace University is closely connected with the establishment of a large rocket-and-space complex dedicated to defence and space missions.

The first 200 freshmen began their studies on September 1, 1960 having three major academic disciplines to choose from, i.e. rocket building, rocket engines and flying vehicle control systems. From the very first days the new educational establishment acted in close cooperation with the subsidiary of Design Bureau-1 (now Information Satellite Systems). With the backing of their head, Mikhail Reshetnev, the young university was able to provide onsite specialized training for teachers as well as tool up university laboratories. As part of the educational process, students and lecturers were allowed to attend the enterprise to gain detailed insight into the manufacturing process.

In 1966 the university granted its first degrees. 149 graduates got diplomas in rocket engineering. It was

an important milestone suggesting that in the future Krasnoyarsk Aerospace University would be able to meet the growing demand of regional enterprises for homegrown aerospace specialists. Mikhail Reshetnev, who was presiding at the State Examination Board for rocket building, appreciated the level of students' preparation. Some graduates of the inaugural class were offered placement in the Reshetnev Company, in which they worked with great dedication till retirement.

Academician M.F. Reshetnev placed great emphasis on the thorough preparation of specialists. He was in charge of the Krasnoyarsk branch of the All-Union Aerospace Association "Union" and one of the founders of the Regional Cosmonautics School for gifted children. M. Reshetnev's opinion of issues related to aerospace education was of particular importance to all concerned in this field. He was always given a warm reception by federal educational authorities and aerospace institutions; his competent judgments founded on the in-depth analysis, scientific evidence and personal responsibility were always treated with due deference. Starting from 1992 and till his untimely death on January 26, 1996, M. Reshetnev headed the Spacecraft Department as well as the Dissertation Council in the university.

The JSC "Information Satellite Systems" and SIBSAU attach great significance to perpetuating M. Reshetnev's memory as well as his scientific heritage. Since 1996 the Reshetnev Company and Aerospace University have been organizing the All-Russian Scientific Conference "Reshetnev Readings". Owing to its high quality, topical issues and the participation of famous scientists and industry experts the conference has become a noticeable event for the scientific community. The conference prestige continues to grow as more and more participants including guests from abroad express willingness to partake in Reshetnev Readings.

Preparation of elite specialists

In 2006-2009 Siberian Aerospace University and the JSC "Information Satellite Systems" moved to a new level of cooperation. Today the university is the company's basic source of manpower. In return, ISS executives and leading specialists give lectures, seminars and lab practicals as well as supervise term and diploma projects. A number of ISS gurus hold chairs in the university. These are V. Khalimanivich, E. Golovenkin, A. Kozlov, V.Raevsky and A. Shatrov. In 2008 Professor N. Testoedov, the General Designer and Director General of the Reshetnev Company headed the department of Space-based Information Systems.

The collaborative effort of the two teams is chiefly directed towards improvement in the quality of student preparation so as to enable them to create spacecraft of tomorrow. The preparation of elite specialists is carried out on the basis of an innovative teaching philosophy and methods, thus resulting in graduates' thorough knowledge, broad scientific erudition and specialized competences.

To encourage students' progress and scientific research, the Reshetnev Company has established the Academician M.F. Reshetnev Encouragement Scholarship Award that is granted to the best university students as well as those being trained within the scope of the Government Program for the Preparation of Specialists.

In total, over 20 000 specialists have graduated from Siberian Aerospace University to work in the aerospace industry as well as other high-tech fields. Over 60% of the ISS and Krasmash staff are former students of this renowned university.

The university's mission is to promote the national space and defence industries by providing qualified human resources and innovative scientific solutions to enable the creation of new-day space-technology products.

The university offers 42 graduate programs, 17 undergraduate programs and 32 postgraduate professional programs. At present Siberian Aerospace University is among those Russian universities that prepare specialists and scientific workers under the State Defence Order. The order figures for 2009 were: 204 graduates, 48 undergraduates and 42 postgraduates. Besides, the university prepares reserve officers and professional soldiers for service in the strategic rocket forces.

Today the university offers 46 Master's Degree Programs in 11 fields of study. The last intake of students for master degrees exceeded 300 people, 20 % of whom are graduates of other educational establishments.

At present over 300 postgraduate level students are doing their research at SIBSAU. Besides, the university hosts 7 Doctorate Dissertation Councils, 5 of which are dedicated to the space industry. Currently, 22 PhD students are doing their studies in 5 majors.

Siberian Aerospace University issues its own periodical, SIBGAU's Herald, approved by the Supreme Attestation Commission of the Russian Federation.

New educational technologies

To ensure dynamic development and continuous quality improvement, the university keeps on enhancing its

The installation of a laser reflector into the Yubileiny-2's instrumentation unit panel


SIBSAU students working with professional equipment. Siberian Aerospace University

educational process by introducing state-of-the-art technology as well as promoting fundamental and goal-oriented research activities with a view to further improvements in this crucial field. By the order of the RF Ministry of Education and Science, Siberian Aerospace University is listed among higher educational establishments actively implementing innovation, in particular, the introduction of the credit-based modular system. Thus, through competent approaches to education and training, innovative methods, student-tailored plans and a full range of developmental opportunities, the university motivates students to study and learn more, and so improves the quality of student preparation.

One of the advantages of SIBSAU's aerospace education is its complex character achieved through the combination of either theory and field experience or theory and scientific work. The university cooperates with a number of leading aerospace enterprises in offering its graduates industrial placement opportunities that often lead to permanent employment.

One of the university's key ingredients of success in student preparation is its policy of cooperation with the Russian Academy of Sciences. The strategic partnership agreement signed between SIBSAU and the Krasnoyarsk Scientific Center of the Siberian Branch of the Russian Academy of Sciences boosted the collaborative efforts to a qualitatively new level, thus enabling the university to take advantage of the academic potential of a number of Siberian universities, on whose bases SIBSAU has recently opened its departments.


SIBSAU students assembling the Yubileiny-2 spacecraft at ISS-Reshetnev

From theory to practice

With the backing of the Reshetnev Company, Krasnoyarsk Scientific Center, the Institute of Biophysics and the Design Bureau "Science", the university has recently established three educational centers: (1) the Institute of Space Research and High Technology; (2) Space-based Systems and Technologies and (3) Outer Space Closed Systems. The new centers have been set up in the interests of the aerospace industry upon the agreement with the Russian Space Agency and the Academy of Sciences.

The centers have been successfully integrated into the university's educational activity. Thus, at "Space-based Systems and Technologies" a team of university students, postgraduates and PhDs together with ISS specialists are currently working on the creation of a series of scientific and educational small-sized spacecraft. They also carry out numerous experiments in outer space. The center consists of a student design bureau and a number of laboratories equipped with state-of-the-art high-precision manufacturing, measuring and testing equipment. The existing base provides capabilities for small-sized spacecraft integration and mechanical testing; the center also tests spacecraft electronics.

SIBSAU conducts research with focus on aerospace problem areas as well as performs tasks set by the university's research programs and the Federal Space Program.

The university has defined the following areas of priority research in the next 10 years:

- Space-based information systems;
- Space closed human factor systems;
- Space technology manufacturing.

"Space-based information systems" is the area in which SIBSAU has taken the lead on a national scale in preparing specialists and scientific workers. The university conducts applied research, and besides, designs and develops advanced satellite buses and control systems.

In 2007 SIBSAU established a student mission control center. It employs a transmit/receive software


The granting of the ISS-Reshetnev Encouragement Scholarship Award to SIBSAU's best students

and hardware complex that enables satellite control in real time. Students doing aerospace subjects at SIBSAU have a unique opportunity to control Russian and foreign spacecraft as well as receive and process telemetry data. At the MCC students also attend simulation classes, which allow them through simulation experiments on the advanced Express-AM telecommunications spacecraft to get a detailed understanding of how satellite service systems function. The student mission control center fulfils a function of a ground control segment for the orbital constellation of scientific and educational small-sized satellites being created jointly with the university partners, including the Reshetnev Company.

In accordance with the Strategic Partnership Agreement on the creation of a series of small-sized satellites signed between SIBSAU, Information Satellite Systems, Krasmash and Krasnoyarsk Scientific Center in 2007, the university has adopted a program for the annual creation and launch of 1-2 satellites (technological, scientific and educational) in 2008-2013. The program provides for space flight testing and qualification of new satellite components and systems developed at university. Today the program is beginning to show its first results. Thus, in 2008 the first small-class satellite Yubileiny created by SIBSAU students, teachers and ISS specialists was placed in orbit. For this spacecraft SIBSAU's team had developed the RADEC apparatus with nanocoatings to protect satellite electronic components. Today the university and the Reshetnev Company are developing Yubileiny-2.

In 2008 Siberian Aerospace University established the Outer Space Research Center. It has a unique automated wide-angle telescope to observe space objects. The Center organizes classes for technical and scientific students.

In 2009 SIBSAU was acknowledged as a leader in the preparation of specialists for the aerospace industry with focus on space-based systems. In recognition of the university's competitive advantage, the Ministry of Education and Science and the Russian Federal Space Agency adopted a resolution to establish at SIBSAU a public resource center to be named "Spacecraft and space-based systems". The creation of the new industrial resource center will ensure the university sustainable development and progress.

Continuing the mission

In his last speech at SIBSAU, Mikhail Reshetnev expressed his belief that despite all the hardships Russian cosmonautics would have a great future. For us it was his last will, which we feel obliged to fulfill.

The fruitful, long-term cooperation between SIBSAU and aerospace industry enterprises provides a base for goal-oriented preparation of elite aerospace specialists. We are convinced that in the 21st century they will proudly continue Mikhail Reshetnev's mission to which he dedicated all his life.

Professor V. NAZAROV,
First Vice-Chancellor of
Academician M.F. Reshetnev
Siberian Aerospace University


Quality assessment

RESHETNEV READINGS-2009

Every year since 1997 Siberian State Aerospace University, under the auspices of ISS-Reshetnev, has been organizing the International Research-to-Practice Conference "Reshetnev Readings" in memory of the outstanding Russian scientist, academician and space system designer M.F. Reshetnev. The conference brings together Russian and foreign specialists to exchange new ideas and find collaborative solutions to a number of challenging problems in satellite building. Traditionally, ISS-Reshetnev hosts one of the conference sessions devoted to "Large-sized foldable structures".

The organizers of the Reshetnev Readings Conference have made considerable progress in the advancement of the event in the last 13 years. Initially it was held for students, postgraduates, teachers and specialists of the local enterprises, including ISS-Reshetnev. Gradually the conference broadened the scope and the geography of its participants, and as a result, became an attractive event for scientists and representatives of the largest Russian companies and organizations. Thus, various leading scientific schools started taking an active part in the Siberian conference. Since 2004 scientists, specialists, students and postgraduates from Russia's neighboring countries as well as far abroad have been regularly invited to participate in the event. In 2005 the conference was granted international status. Since the inception, the conference program has been expanded considerably to include a variety of subjects, such as satellite design, control systems, satellite navigation and communications, advanced materials and technologies in satellite manufacturing, mathematical modeling techniques, informational technology, technical maintenance and testing of aerospace technology, large-sized foldable satellite structures, managerial and economic problems of the aerospace complexes as well as preparation of industry-ready graduates.

Anniversary conference

The 13th edition of the Reshetnev Conference held in November 2009 coincided with three remarkable dates, i.e. the 85th anniversary of the birth of Academician M.F. Reshetnev, the 50th anniversary of the Reshetnev Company and the 50th anniversary of Siberian Aerospace University. At the plenary session of the conference Nikolai Testoedov, General Designer and Director General of Information Satellite Systems, made a report on the stages of development of the enterprise. He spoke about the time when OKB-1 (Design Bureau -1) opened a subsidiary in Siberia that in 50 years has evolved into the largest satellite manufacturer and the headquarters of a big integrated company. All the participants paid tribute to M. F. Reshetnev for his invaluable contribution to applied cosmonautics.

In his opening speech, the rector of Siberian Aerospace University mentioned that with every new edition,


At the "Large Foldable Satellite Structures" session

the conference attracted more and more participants. In 2009 the Organizing Committee received almost 500 applications from different parts of Russia as well as Ukraine, Germany, Belgium, Kyrgyzstan and Belorussia.

The conference received high praise from the regional authorities. Olga Kirilova, Deputy Governor of the Krasnoyarsk Territory, underlined the great significance of the Reshetnev Conference for the entire Siberian region.

ISS-hosted scientific sessions

The first scientific session dedicated to "Large-sized foldable satellite structures" was held in 2001. The establishment of the Industrial Center of Large Foldable Mechanical Systems on the ISS base in 2006 gave fresh impetus to these sessions. The new center's basic activities encompass scientific and research work (on onboard antennas, spacecraft, solar arrays, various mechanical devices, materials, and thermal control systems) as well as development verification of mechanical satellite systems. Thus, a wide range of issues is discussed at ISS-hosted sessions. The center's main objective is to concentrate scientific, manufacturing and financial resources for the development of space solutions. There is no doubt that "Large-sized foldable satellite structures" sessions (LFS sessions) held within the framework of the Research-to-Practice Reshetnev Readings Conference help towards the attainment of the center's objectives.

In prospect, the center will be engaged in the development of a new 13-meter antenna for the Loutch data relay spacecraft. Besides, in 2010 it aims to develop large-sized solar arrays for the Express-AM5 and Express-AM6 spacecraft. It is worth mentioning that these satellites will be assembled and tested at the new A&F (antenna & feeder systems) facility being built at ISS-Reshetnev. Today solar arrays with solar reflectors reinforced by sophisticated deployment and folding mechanisms are counted among the latest developments in the solar cell array technology. Much was reported about the new trends, new materials, thermal control tendencies, various mechanical devices used in large-sized foldable structures, etc. during the session. Among the participants there were representatives of Russia's largest universities and aerospace enterprises including ISS-Reshetnev.

The competitiveness of the demonstrated projects continues to grow from conference to conference. So does the demand for the best solutions. The most interesting reports are published in SIBSAU's Herald. It is also important to emphasize that the number of participants taking part


An engineering model of a large foldable antenna


Solar arrays

in the session continues to increase. Thus, last year 31 reports and 17 poster presentations were made at the LFS session. Besides, the scientific and technical level of the event has also risen considerably. The last session was unanimously rated as a top-level event, the best in the history of the Reshetnev Conference.

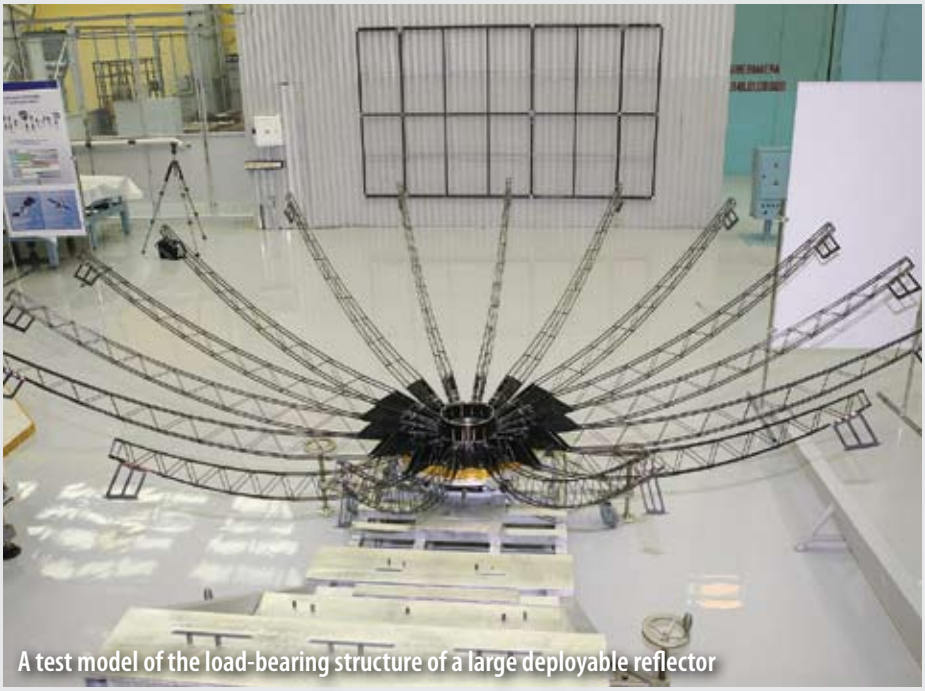
A few reports were devoted to the advanced space observatory Millimetron. With a 12-meter reflector and an operating temperature of 4K the required accuracy of geometrical characteristics is calculated in microns.

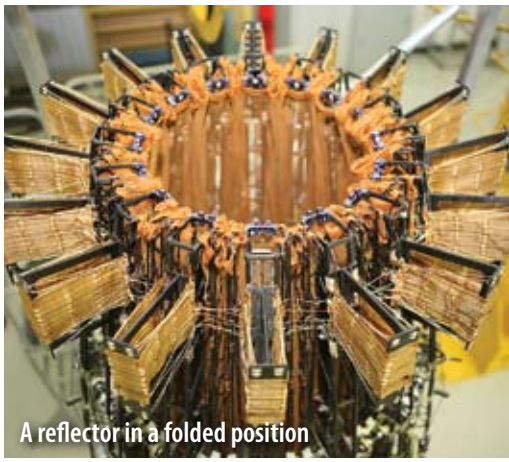
A lot of new solutions were presented by participants from Moscow, St. Petersburg, Tomsk and Novosibirsk. Thus, Yuri Chugui, Director of the Technological Design Institute of Scientific Instrument Engineering shared information on the achievements in optical measuring systems and laser technology. Vladimir Zimin and Andrey Smerdov, representatives of Moscow State Technical University, presented a report of great scientific and practical value on the implementation features of a deployable onboard multi-beam antenna and the possibilities of damping composite elements. Maksim Skorodubov from St. Petesburg (Design Bureau "Arsenal") shared his interesting vision of dynamic simulation of a deployable reflector. In 9 years LFS sessions have earned a good reputation and regular participants. Thus, a group of scientists from the Scientific & Research Institute of Applied Mathematics and Mechanics (Tomsk) come regularly to make informative reports on their developments and solutions dedicated to reflectors and the stress state analysis of components including composite structure elements. Another regular, Alexander Usov from OKB MEI (Moscow), has been delivering reports on LFSs for several years.

It has become common practice to invite specialists whose reports are relevant to ISS-Reshetnev's sphere of activity. Thus, at the last session a team from Dnepropetrovsk delivered a report on "Energy-efficient technology of manufacturing polymer composite products with improved mechanical characteristics". Some techniques have already been adopted by ISS-Reshetnev. It is also noteworthy, that the Ukrainian delegation has been often represented at the conference by Vladimir Slivinsky, D.Sc. in Engineering and Chief Research Scientist of the Scientific & Research Institute of Mechanical Engineering Technology.

The importance of LFS sessions is in the collaborative effort of a great many specialists engaged in the same area of activity. The exchange of ideas between the companies specializing in the manufacture of large-sized foldable structures helps their scientific and technical potential expand as well as contribute to the industry development. All reports presented at LFS sessions are of practical value as they offer solutions to be applied in satellite design.

Prof. Vladimir
KHALIMANOVICH,
ISS Deputy General Designer,
Director of the Industrial Center
of Large-sized Foldable
Spacecraft Structures.


A test model of the load-bearing structure of a large deployable reflector


A reflector in a folded position

RESHETNEV'S HERITAGE

On November 10, 2009 was the 85th anniversary of the birth of Mikhail Reshetnev, the founder and the first general director of the Siberian satellite manufacturing company. Owing to his great perseverance and aspirations to reach new heights, a small subsidiary of Design Bureau -1 (OKB-1) located on the banks of the Yenisei River became one of the largest manufacturers of communications, navigation and geodetic satellites in the country. His wisdom and talent as well as his ability to support others' initiatives helped to foster more than one generation of gifted scientists, satellite designers and engineers. Today, following in the footsteps of Mikhail Reshetnev, they keep the ball rolling. Having established a unique enterprise in Siberia that is now globally known as the Reshetnev Company, Academician Reshetnev left behind a heritage of 'star' achievements that we are certainly proud of.

By developing rapidly in 1950-1960, the Soviet rocket and space industry soon became the pillar of the national security and might. Meanwhile the USSR was living through the second revolution, this time scientific. It was the time when plenty of young people were dreaming of space; the time full of optimism, great daring and spirit. It was then that Mikhail Reshetnev started his career of a satellite designer.

After graduating from the Moscow Aeronautical Institute with first class honours in 1950, Mikhail Reshetnev got a job in Design Bureau №1 (OKB-1) headed by Sergey Korolev. In 1958 Reshetnev was appointed Korolev's deputy. Sergey Korolev had a genius for picking out gifted people. Every single engineer designated on his recommendation played an important role in the development of national space technology. Mikhail Reshetnev was not an exception.

In 1959 OKB-1 opened a subsidiary in Krasnoyarsk-26 (now Zheleznogorsk), a closed Siberian town, on which Soviet rocket engineers were pinning a lot of hopes. The 35-year-old Reshetnev was appointed head and general designer of the newly-established organization. Immediately after the appointment Mikhail Reshetnev started building a team of talented young people. The country's best graduates arrived at the enterprise to do their pre-graduation practice and graduation projects or simply to settle down. Many of those graduates still remember their first meeting with Mikhail Reshetnev, at which he sparked their desire to work in satellite manufacturing and create space technology.

The team of managers and engineers led by M. Reshetnev was able to solve unprecedentedly complicated scientific and technical problems, and make headway regardless of conditions. Under Mikhail Reshetnev those talented

engineers ushered in the era of Soviet satellite navigation. Their unique navigational and communications spacecraft Tsyclon, originally built for the navy, was later used as a prototype for a number of navigational, geodetic and communications spacecraft intended for circular subpolar orbits. The Reshetnev Company was the first in the Soviet Union to build data relay satellites, and the first in the world to launch a HEO communications and TV broadcasting satellite system.

In 1974 the launch of the Molnia-1C satellite developed and manufactured by the Reshetnev Company marked a new era, the era of conquering the geostationary orbit. A year later, in 1975, the enterprise built Raduga, Russia's first dedicated geostationary communications satellite. The company's next spacecraft, Ekran, formed the core of the world's first continuous direct broadcasting satellite system that also included associated ground equipment.

Everything that Mikhail Reshetnev had accomplished on the Siberian land has served the interests of the Russian Federation for years. Today, at the beginning of the 21st century, the Russians can fully appreciate his heritage which allows the country to realize its ongoing, large-scale informatization programs.

Today one of the top priorities in the space industry development program is the replenishment and modernization of the GLONASS system, whose history goes back to 1982.

Thanks to the know-how accumulated during those years, the enterprise today is the prime contractor for the design, development and manufacture of Glonass-M satellites. In accordance with the Federal Target Program ISS-Reshetnev has manufactured 25 new Glonass-M satellites since 2003. It became possible mainly due to the company's experimental base, which was established at the suggestion of M.Reshetnev. Today it is the largest satellite test facility in Siberia that offers the entire spectrum of mechanical and electrical testing capabilities.

Nowadays Information Satellite Systems is pursuing a policy of international cooperation initiated in the 1990s by the company's first director, Academician M. F. Reshetnev. The successful execution of such projects as SESAT, Express-A and Express-AM allowed the Reshetnev Company to demonstrate its competitive advantages, capabilities and technologies, and thus, to become an authority on the international market as well as its active participant.

Owing to the Siberian innovations, many of which count as benchmarks today, Russia managed to increase its TV channel capacity. The fact that ISS has started making satellites with a guaranteed 15-year service life speaks for itself as well as for the world-class standards of the company's products.

On November 10, 2009 was the 85th anniversary of the birth of Academician Reshetnev, the Hero of Socialist Labour. In memory of Academician M.F. Reshetnev, the company in which he worked as a general designer for almost 36 years bears his honored name, as well as Siberian Aerospace University and a number of places in Zheleznogorsk (a school, a street, and one of the central squares). By the resolution of the Russian Federation of Cosmonautics Academician M.F.Reshetnev Medal was introduced to honor achievements in the sphere of space technology. The international scientific conference Reshetnev Readings is held annually in Krasnoyarsk and Zheleznogorsk for aerospace scientists, specialists, lecturers and students of higher educational establishments. Mikhail Reshetnev's space achievements are highly appreciated by the international community. Thus, one of the minor planets was named RESHETNEV in memory of the Earth's great scientist.

The man who in his lifetime used to surprise others by his unflagging energy and creativity had left us his priceless heritage. Today we, inhabitants of the Earth, can listen to the radio, watch TV, use the Internet, fly or sail round the globe, and make phone calls to any place in the world.

Looking back to the company's glorious past inseparably associated with the name of Mikhail Reshetnev, the ISS team continues to keep his pot boiling, and the wealth of invaluable experience gained in his administration will always guarantee the company success.

Reshetnev Square in front of the ISS headquarters

HISTORY

THE CONQUEST OF THE GEOSTATIONARY ORBIT

Russia's first geostationary satellite was launched 35 years ago atop a Proton-K launch vehicle. It was Molnia-1C, an experimental spacecraft created by the Reshetnev Company. Its launch marked a new epoch in the history of the enterprise and Russian cosmonautics.

Molnia-1C

The successful launch of the Molnia-1C satellite conducted on June 29, 1974 meant for the USSR a great deal more than just the beginning of the geostationary orbit exploration. It was a significant, national security-building measure; a timely step towards the consolidation of the country's position in space.

The Molnia-1C spacecraft used the basic and well-proven HEO Monia-1 design. It served a platform for testing the latest satellite communications technology in the geostationary orbit. The launch of Molnia-1C also allowed Russia to try out and develop techniques for injecting and stabilizing geostationary satellites. The results were later used when launching

The geostationary orbit is determined with simple mathematics: angular velocity of a satellite must be equal to angular earth velocity. This simple mathematical principle is true only for a single trajectory which is almost 36000 km high above the equator. In the geostationary orbit a satellite appears stationary with respect to a fixed point on the rotating Earth. As a result, an antenna pointed at a GEO satellite is also fixed, thus maintaining a link with a satellite. This is a major advantage of the geostationary orbit.

Just as there is nothing ideal in the world, so there is no ideal geostationary orbit. The higher the latitude of a given place, the worse is the geostationary satellite capability for providing services to local users. Thus, subpolar areas are in fact silent zones.

During the conquest of the geostationary orbit, satellite launching, positioning and attitude control systems were able to guarantee an angular accuracy of no more than 1°. Therefore, the world's resource of satellite locations could not exceed 300 slots. Today the resource has almost doubled; nevertheless, the number of slots available has hardly changed.

At the end of the day there are 425 points of satellite locations available in the geostationary orbit. Angular distances between them vary within 0.1 - 7° range. Every slot can house several spacecraft (more than ten). Harmful interference is excluded due to the frequency separation and different service areas.

HISTORY

spacecraft of the Raduga, Gorizont and Ekran series. The operation of the Molnia-1C spacecraft proved highly effective. As a result, GEO spacecraft manufacturing became a priority activity of the Reshetnev Company.

For the last 35 years ISS-Reshetnev has developed several generations of geostationary spacecraft and systems, which enabled the company to become the largest Russian designer and manufacturer of telecommunications satellites. With the launch of the Raduga spacecraft, the USSR started fixing its orbital slot allocations in GEO. The Raduga satellite embodied a number of the best Soviet solutions. It had a sophisticated antenna complex and a 6-channel C-band repeater. The satellite was supposed to serve the interests of all potential users. The transmission and reception of signals were performed via the Orbita ground station network which had been deployed in the USSR for Molnia-1 satellites and then adapted for the new satellite repeater. Some of the Raduga's channels were used for telephone communications; one – for television broadcasting; all the rest provided communications capabilities for different governmental departments and agencies.

The creation of the Raduga spacecraft was a major step in the advancement of the national space technology. Positive results achieved in the process of work on the Raduga project stimulated greater efforts on the development of other geostationary spacecraft. Thus, the Integrated Satellite Communications System was created on the basis of the Molnia-3 and Raduga design. The system provided trunk communications for large towns and cities via the Orbita ground network, as well as television broadcasting services.

A total of 32 Raduga spacecraft were launched into the geostationary orbit in 1975 -1996. Those were very successful and highly effective missions. Though the satellites were designed to operate for 3 years, in fact, they orbited for 5.9 years; one of them even kept running for 12 years and a half.

In 1964 the USA started exploiting a number of simple, yet effective civil and military geostationary satellites. They were basically used for communications; some were intended for IBM launches detection.

America's first three-axis-stabilized communications satellite was launched into the geostationary orbit in 1975. There was also parallel work going on the development of more advanced satellites.

In 1974-1975 the USA first launched geostationary weather spacecraft. Among its communications satellite projects, one was particularly interesting. It was the unique experimental ATS-6 satellite, which accommodated a 9-meter antenna and could operate in a wide range of bands, from P to Ku.

In 1972 Canada deployed its simple geostationary spacecraft. Four years later, in 1976, together with the USA, Canada launched CTS, a sophisticated new-type experimental satellite, which demonstrated modern characteristics and capabilities in spite of having low mass and two transponders.

By the mid 1970s England had also deployed simple military communications spacecraft in the geostationary orbit.

In late 1974 and the second half of 1975 France and Germany launched two experimental geostationary communications satellites called Symphony.

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