RESHETNEV
COMPANY

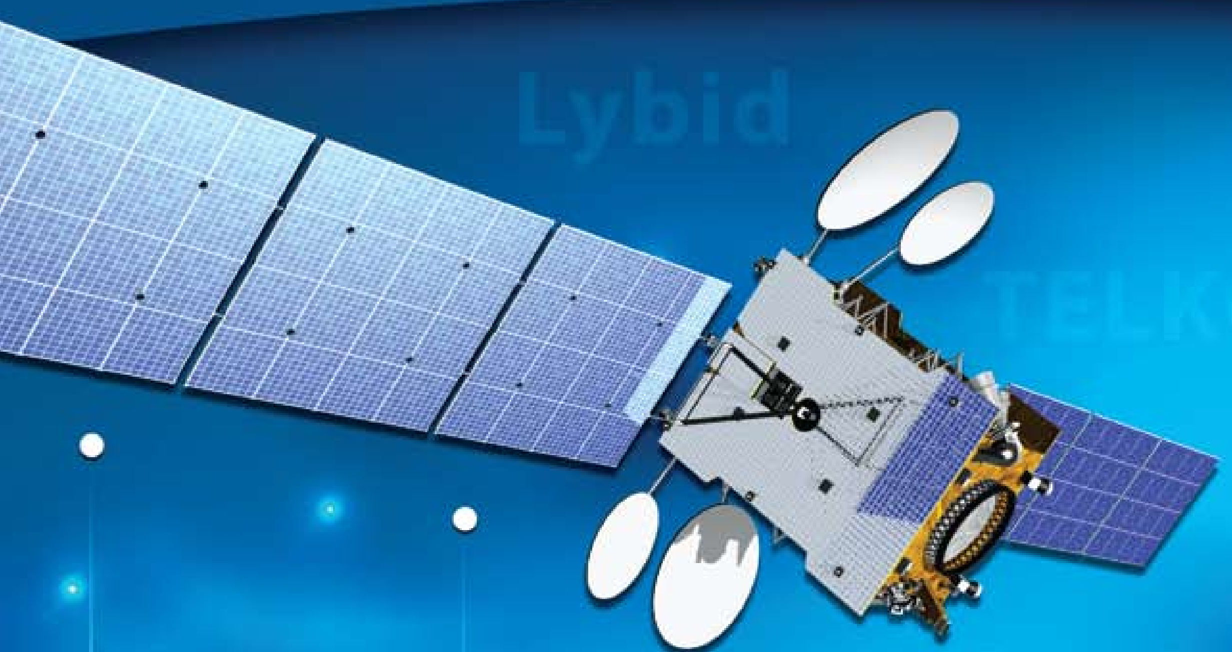
INFORMATION SATELLITE SYSTEMS

№13, 2012

TODAY’S INNOVATIONS – WAY TO SUCCESS

INTERNATIONAL PROJECTS

Telecommunications satellites based on Express-1000H platform



- **AMOS-5** — Israel
- **TELKOM-3** — Indonesia
- **Lybid** — Ukraine
- **KazSat-3** — Kazakhstan

Operational lifetime – 15 years
Inclination and longitude station keeping accuracy – 0.05°
Power supply for the payload – up to 6 kW
Payload power dissipation – up to 3.5 kW
Payload mass – up to 500 kg
Launch mass – 1700-1900 kg

www.iss-reshetnev.com

Dear colleagues,

Space technologies play a pivotal role in our modern information society. Today telecommunications, navigation and geodetic services are essential elements improving the quality of life of millions of people.

Nowadays economic development and new life standards demand alternative approaches to the design and production of advanced space technology as well as the implementation of innovations.

The company's program of innovative development is an integral part of ISS-Reshetnev's strategy aimed at supporting the competitiveness of our space-technology products in the international market.

ISS-Reshetnev's priority activities encompass the modernization of its production and experimental facilities, improvement of the manufacturing processes, standardization and implementation of the most advanced technologies. All these enable the company to manufacture next-generation satellites as well as expand the range of satellite services.

General Designer and Director General
of Academician M.F. Reshetnev
Information Satellite Systems

Nikolay TESTOYEDOV

RESHETNEV
COMPANY

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ACHIEVEMENTS

A NEW LEVEL of strategic partnership

The 49th International Paris Air Show Le Bourget-2011 attracted a lot of leading companies of the aerospace industry. The participants signed a record-breaking number of contracts.

Signing of the KazSat-3 contract

The Paris Air Show is a specialized aerospace exhibition that takes place every 2 years. In 2011 the event brought together over 2000 aerospace companies. Traditionally, the exhibition provides a splendid opportunity for experts and visitors to discover the latest achievements and tendencies in the aviation and space industries. Le Bourget-2011 became an excellent platform for the Siberian satellite manufacturer to demonstrate its recent developments and satellite projects.

The company's delegation was headed by Nikolay Testoyedov, general designer and director general of ISS-Reshetnev. The company's latest achievements and advanced projects in satellite manufacturing were showcased at the Russian Federal Space Agency's integrated exposition and in the company's chalet. ISS-Reshetnev's visitors and guests were able to see models of the AMOS-5 and Express-AM5 telecommunications satellites, the Glonass-M and Glonass-K navigation spacecraft, the Loutch-5A data relay satellite and the Gonets-M personal communications spacecraft.

During the Paris Air Show the ISS-Reshetnev delegation had numerous business meetings with foreign partners and customers. Thus, the Reshetnev Company and the Kazakhstan Republican Center of Space Communication signed a contract for the manufacture and launch of the KazSat-3 telecommunications satellite. It was an important milestone for the development of space cooperation between the two countries. The contract was signed in the presence of Vladimir Popovkin, head of the Federal Space Agency, and Talgat Musabayev, chairman of the National Space Center of Kazakhstan. It is the 4th international project the Siberian satellite manufacturer has won in the last three years.

The subcontract for the supply of the payload and TCR was signed on the same day between ISS-Reshetnev and its long-term partner Thales Alenia Space. As well as that, the Reshetnev Company made a contract with the French company Sodern for the supply of a star tracker for the Lybid satellite being manufactured by the Siberian enterprise for Ukraine. Another remarkable event for ISS-Reshetnev was the signing of an agreement with Jena Optronic (Germany). Now the German star sensor Astro APS will fly aboard a Glonass-M navigation satellite to get its space flight qualification.

All ISS-Reshetnev's business meetings at Le Bourge-2011 proved very productive and allowed the company and its foreign partners to boost their collaborative efforts to a qualitatively new level of international partnership.

According to Nikolai Testoyedov, general designer and director general of ISS-Reshetnev, business contacts established at Le Bourget-2011 will allow the company to build up long-lasting, strategic relationships.

Nikolay Testoyedov and SAFT representatives

STRATEGY

HIGH TECHNOLOGIES – real achievements

Today ISS-Reshetnev's strategy is mainly driven by its innovative development program implemented in accordance with Russia's National System of Innovation. As a leading Russian space enterprise, the Reshetnev Company makes significant contributions to the modernization of the national economy. By the resolution of the Government Commission on high technologies and innovation the company has been included in the list of enterprises whose development programs have strategic importance on the national scale.

Presentation of ISS-Reshetnev's Innovative Development Program to a group of scientists from Tomsk

Competition in space

Space is a highly competitive environment where the world's leading space countries compete for both military and economic dominance. Space technologies that enable communications, navigation, Earth remote sensing and astrophysical research play a pivotal role in the formation of the international information space. In accordance with the key federal space programs the Reshetnev Company manufactures competitive satellites for various applications.

ISS-Reshetnev is the prime contractor for the space-based segment of the GLONASS global navigation satellite system. The use of GLONASS services is becoming increasingly widespread in the territory of the Russian Federation. GLONASS provides high-precision real-time position determination for the Ministry of the Russian Federation for Civil Defence, Emergencies and Elimination of Consequences of Natural Disasters, the transport and forest industries and many other users. GLONASS applications are generating more and more interest both at home and abroad.

With the aid of ISS-Reshetnev-built satellites the country is implementing its large-scale digital television and radio broadcasting program. The company continues consolidating its hold on the national and international markets by regularly entering into new contracts. At present ISS-Reshetnev is implementing a number of satellite programs for Russia's largest satellite operators RSCC and Gazprom Space Systems as well as carrying out 4 projects for foreign customers – AMOS-5 for Israel, TELKOM-3 for Indonesia, Lybid for Ukraine and KazSat-3 for Kazakhstan.

In addition, ISS-Reshetnev is manufacturing next-generation GEO-IK-2 satellites designed to provide high-precision geodetic measurements. These advanced spacecraft will allow Russian science to upgrade the cartographic model of the Earth and specify more precisely its geophysical parameters.

Today Academician M.F. Reshetnev Information Satellite Systems is a large corporate body formed from 10 Russian enterprises. Together with its Russian and foreign partners and a number of scientific institutions, the company is carrying out missions aimed at:

- increasing the availability of space information services for Russia's citizens regardless of their place of residence within the country;
- broadening the spectrum of space information services (navigation, communications, television broadcasting, Earth remote sensing, hydrometeorology, ecological monitoring, emergency control);
- increasing ISS-Reshetnev's share of high-tech products in the national and global satellite markets.

Tools for development

In compliance with international standards, the Reshetnev Company manufactures satellites with 15-year mission lifetimes. This has become possible due to the use and implementation of cutting-edge Russian and foreign design and production technologies.

When creating a competitive high-technology product it is essential to observe a great number of conditions and requirements for the use of materials and technologies as well as methods of work organization. That is especially important for the space industry. The Reshetnev Company uses a comprehensive range of innovative design techniques to develop advanced satellites, in particular, 3D graphic design programs, strength and thermal analysis programs, etc. The company has evolved a range of satellite platforms which can be tailored to satisfy specific customer needs and requirements. By approaching a satellite platform as a separate module the company receives an effective tool to reduce satellite production time and costs, which is especially important in view of the present-day market demands when a satellite's delivery is expected within 26-32 months after the effective date of a contract.

Loutch-5A being prepared for vibration tests

STRATEGY

Visit of the Authorized Representative of the RF President Viktor Tolokonsky to ISS-Reshetnev

A central isogrid tube as an advanced structural solution in satellite manufacturing

One of ISS-Reshetnev's innovative solutions is the use of modern polymer composites. These lightweight materials increase strength and reduce satellite mass. Besides, they posses a number of other unique properties, such as low thermal expansion, dimensional stability and heat resistance that make them indispensable in the manufacture of satellite components and subassemblies.

Among other things, the company has the latest technology to manufacture honeycomb panels, gold-plated wire meshes, contour-beam antennas and UHF components. Many unique techniques were developed in-house, for instance, the method of gilding 15-micron tungsten wires for the production of gold-plated meshes used in large-sized reflector antennas of ISS-Reshetnev's Loutch satellite series. The first satellite of the multifunctional space data relay system – Loutch-5A – was inserted into orbit at the end of the 2011 year. Loutch satellites are designed to provide communications between the Earth and low-altitude spacecraft as well as manned space vehicles.

The combination of innovative Russian, foreign and in-house technologies allows the Reshetnev Company to manufacture commercially attractive, high-performance space-technology products.

Strategic program

The company's Innovative Development Program developed for the period until 2020 is aimed at establishing a complex innovative system within the Reshetnev Group of companies to ensure ISS-Reshetnev further expansion into the global satellite market.

The program is a complex of time-bound scientific, research, experimental and production activities agreed upon in terms of aims and resources. These activities have been included into the company's strategic plan for the period until 2020. The Innovative Development Program is general for all ISS-Reshetnev's affiliate companies and is aimed at:

- providing effective information support to streamline business processes;
- improving the system of management;
- increasing product quality, energy and labour efficiency;
- personnel development.


Installation of Yamal-300K equipment

The program also calls for improving the “availability” and “user properties” indexes so as to solve two problems – economic and social. The first suggests expanding the spectrum of space services and their cost reduction, which is important for innovation-intensive sectors of the economy whose dynamic development requires quick access to different types of information from various parts of the country. The second task is aimed at providing the country's population with free access to space information services regardless of their place of residence.

As a rule, companies have and implement more than one strategy. ISS-Reshetnev, with more than 50 years' experience in space technology manufacturing, is a recognized authority both in Russia and abroad. With the largest share of the Russian satellite market (in different years it varied from 45% to 95%) the company occupies the leading position in the national satellite industry. This leadership obliges ISS-Reshetnev not only to keep up the pace but also develop products that will be in demand for many years.

Taking into account the current growth in demand for satellite services observed in different spheres, the Reshetnev Company sees great prospects for its technological and intellectual potential.

As for the company's expansion into the international market, ISS-Reshetnev will continue strengthening its position by increasing the volume of sales, consolidating its hold over the existing customers and attracting new ones. Making every effort in this direction, the company aims to position itself as a strong player in the global market.

ISS-Reshetnev has also a growth strategy to continue integrating Russian space companies under its single structure and brand.

Thus, by implementing the Innovative Development Program the Reshetnev Company aims to reinforce its position in the Russian space industry and become a global player in the manufacture of telecommunications, navigation and geodetic satellites by 2020-2025.


TELKOM-3 in the assembly workshop

NEW SOLUTIONS to develop the industry

ISS-Reshetnev's Industrial Center for Large-Sized Foldable Mechanical Structures (IC for short) has been working for 5 years. The Center's mission is to solve fundamental problems in specific areas and develop related technologies. Large-sized foldable mechanical structures are essential satellite parts whose design and development is a focus area of all leading aerospace companies. In fact, the Center was named "Industrial" to emphasize its importance for the whole industry.

Today we talk with Vladimir Khalimanovich, ISS-Reshetnev deputy general designer and IC director, about the Center's contribution to the development of advanced technology.

- The Industrial Center for Large-Sized Foldable Mechanical Structures has been working for 5 years. What results have been achieved?

- We achieve results annually. Looking at our targets we can speak of results in particular areas. For instance, a lot of effort has gone into developing solar arrays and antennas. As a result, we have generated a new concept of solar arrays and their deployment mechanisms. Today we pay a lot of attention to international requirements. But most importantly, in the last 5 years we have conducted a series of studies and tests that allowed us to create an industrial standard of solar arrays. Now we only change the geometry of solar array components and the solar cell carrier; all the rest is rather standard including deployment kinematics, the method of attaching solar arrays to a satellite as well as the method of attaching solar cells. Such standard solutions enable us to make fairly large solar arrays. A solar array 112 square meters in area – the result we have recently achieved – is not the limit for us. Now we are going to make solar arrays of a larger area for a project related to manned cosmonautics.

As for antennas, we have gained considerable expertise in manufacturing foldable reflectors. The ISS-Reshetnev-built Loutch-5A data relay satellite accommodates two 4-meter antennas. It was successfully placed into orbit in December, 2011 and with the launch of the satellite, the new antennas will receive their flight-proven status. Today this standard antenna design solution is widely used in ISS-Reshetnev's projects; the Loutch program was just the beginning.

As for another focus area – automation – we are currently testing the reliability of our new electromechanical devices used for deploying antennas and solar arrays. We are working both on the functionality and mass of drive mechanisms. Today we can make very light drives with masses ranging from 400-600 grams.

- How competitive are your products in comparison with their foreign counterparts?

- Nowadays there is an increasing demand for our products in the national market. For instance, we have designed, manufactured and supplied solar arrays to Lavochkin Association for two of its spacecraft.

One of them, Electro-L, is already performing its mission in orbit; the other was successfully launched on July 18, 2011 and is now undergoing flight tests. In manufacturing solar array rotation mechanisms we use the same methods as the world's leading space technology manufacturers. Today we supply rotation mechanisms to S.P. Korolev Rocket and Space Corporation Energia. We have also concluded contracts for the supply of our mechanisms to the Arsenal Design Bureau, TsSKB-Progress, the Military Industrial Corporation NPO-Mashinostroyenia and some foreign companies. All our new electromechanical solutions satisfy international requirements and the latest trends in this area.

We plan to further improve technical characteristics of our products so as to increase the competitive edge of ISS-Reshetnev's satellites.

- One of the main trends in modern satellite manufacturing is the use of new materials. What progress has been achieved by your Center in this direction?

- A lot has been done to close the gap in this area. Now we are working fast to make up for the time lost in the period of economic hardship in the 1990s. Special focus is given to polymer composite materials. Annually over 30 new materials are developed by our Center. Testing materials is a rather lengthy process which requires certain knowledge and expertise from all our staff members no matter whether they are designers or workers. It is impossible to work with composite materials on the basis of purely theoretical knowledge taken from textbooks, reference books or scientific publications. The most important thing here is our practical experience and technical know-how that we have accumulated in the last 5 years. These advantages allow us to create new high-performance products.

We have invested a lot of efforts to ensure the required rigidity of large-sized structures using high-modulus polymer materials. Our advances in the use of composite materials can be best demonstrated by our achievements in antenna manufacturing. Our rigid reflectors are mostly made of carbon fiber. Based on our solutions, the Reshetnev Company is ready to launch production of contoured-beam antennas, precision antennas and antennas with polarization-selective surfaces. Thus far, we have commissioned a vacuum coating system to improve radioreflective characteristics of our reflectors.

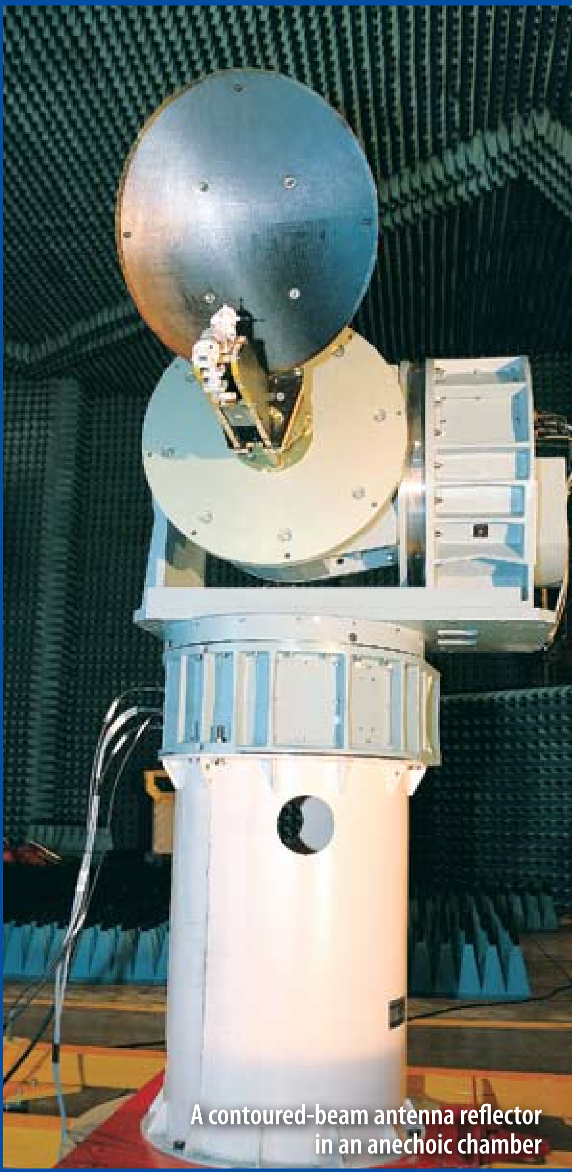
- What caused the recent reforms at the Center?

- We have been restructuring our Center intentionally and on a step-by-step basis. Now we are intensifying antenna production as well as building up the design process chain. A special sector has been opened within the Antenna Systems and Payload Assembly Department (ASPAD) for making products with the use of composite materials. As well as that, we have separated the Large Reflectors laboratory from the ASPAD for our team to better concentrate on the key tasks. Besides, we have taken on new technologists with expertise in antenna manufacturing. Consequently, our technological services are reorganizing themselves to solve new tasks related to antenna production.

- Manufacturing such sophisticated products is a complex task that requires considerable expertise and high qualifications. What measures are taken in your Center to facilitate the employees' professional growth and development?

- It is worth mentioning that we hire a lot of young people. Owing to ISS-Reshetnev's target intake program we have an opportunity to select and train the city's best school leavers. Besides, graduates of the country's leading state universities (Moscow, St. Petersburg, Krasnoyarsk, Tomsk, Novosibirsk, Kazan) come to work for us within the scope of the federal Industry Student Career Intake program.

Now there are numerous discussions going on in Russia about the introduction of the two-level educational system. I must say that together with Siberian State Aerospace University we have been training students using this system for almost 30 years. A student studies at university for 4 years, yet he becomes a real engineer only when he starts working at our company. We take responsibility for ensuring the required level and quality of preparation of such specialists. Then, in cooperation with higher educational establishments, we regularly provide different training courses.



A contoured-beam antenna reflector in an anechoic chamber

Loutch-5A thermal test

INTERVIEW


Express-2000 solar arrays being deployed

- You are head of one of SIBSAU's deparments, aren't you?

- Absolutely right. The department made up of the company's best experts can give students a deep and broad knowledge of satellite production requirements and train future specialists accordingly.

- What difficulties does your Center face with?

- Despite our good progress we should work faster. Developing technology is a lengthy and demanding process. There must be no risk of failure in space. That is why everything is thoroughly checked including flight qualification of separate devices, subcontractors' capabilities and so on. These problems are typical of the whole industry.

- What are the Center's main prospects of development in the nearest future? What projects are being implemented?

- Our today's achievements, in particular, satellites with 15-year lifetimes, are the outcome of years of sustained effort. That is why our basic principle is continuity. New solutions, to a large extent, are based on the company's know-how accumulated during our 50-year history. Having this stable foundation to build on, we can definitely reach new heights. As for the future, we need to continue developing our experimental and manufacturing facilities.

At the moment the Industrial Center is taking part in the Millemetron space observatory program. We are creating a high-precision 12-meter telescope capable of operating at cryogenic temperatures.

Technical modernization – the company's priority

But the most important thing is technical modernization. In the nearest future we expect to receive equipment tailored to our needs to perform deformation measurements under extreme temperatures and in vacuum. This is important for polymer antennas. Now we are developing methods for testing such reflectors. Some tests have been already carried out on test models; yet they were done in open air, not in vacuum. As soon as the new equipment is installed testing of new antennas will be performed in accordance with international standards –first on test models, then on finished products. Thus, we will receive qualified solutions and an answer to the question: what geometric shape will the reflector take under operating conditions?

As for advanced development, our Center plans to conduct research into the types of reflector arrays. These antennas can be used as an alternative to parabolic antennas due to their flat reflectarrays which give an advantage in terms of weight and size. At the moment we are also focused on the development of solar concentrator arrays.

- In 2010 the RF Government Commission on High Technologies and Innovation adopted a resolution to set up technology platforms in Russia. The Reshetnev Company developed and presented its own technology platform, with the Industrial Center for Large Foldable Mechanical Structures as one of its active participants. What role will the platform play in the innovative development of the company and industry?

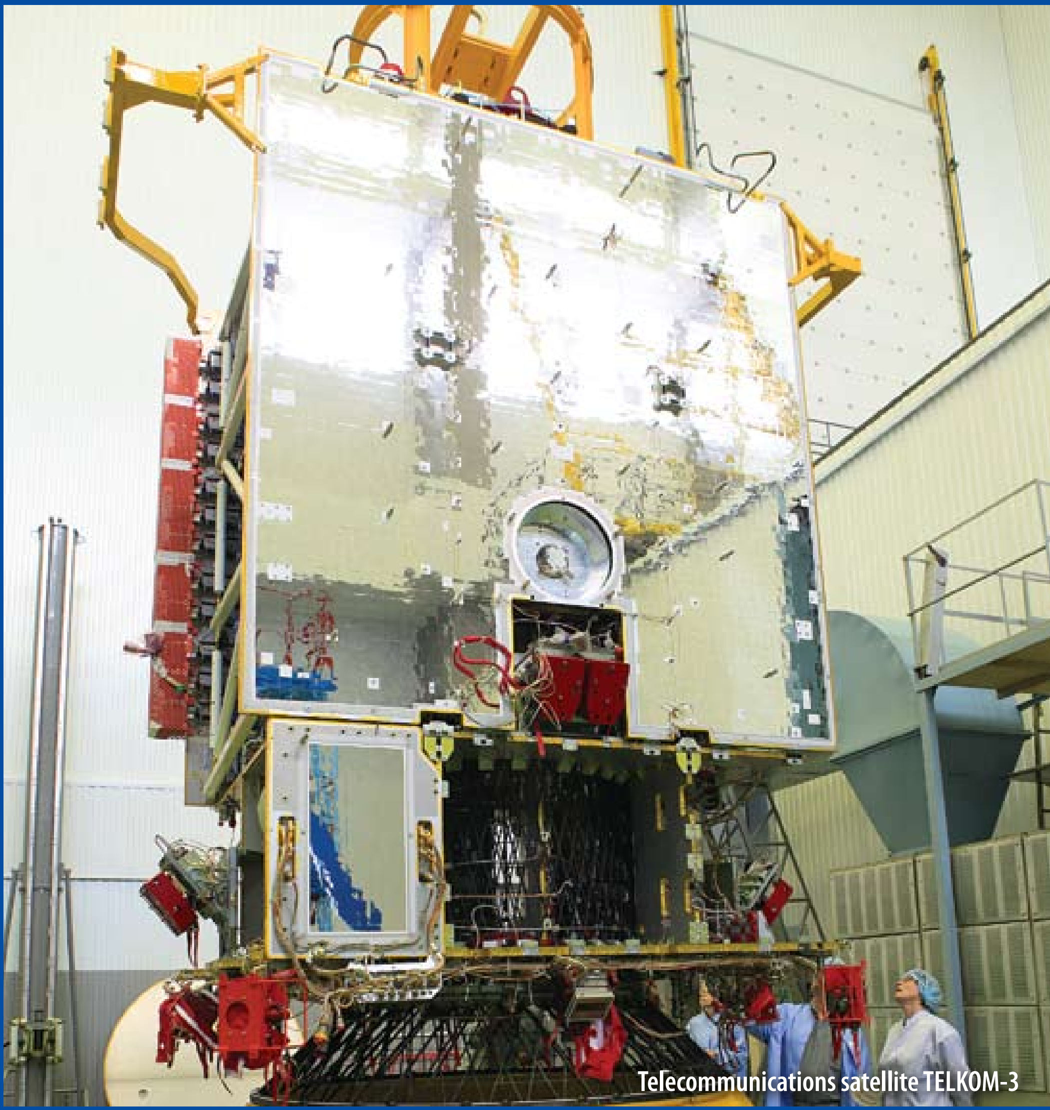
- Indeed, the Commission on High Technologies and Innovation chaired by Prime Minister Vladimir Putin approved the list of platforms on April 1, 2011. I must say that there are two technology platforms in Siberia: one is in the sphere of medicine, whereas the other – ours – is focused on space. The program is called "National information satellite system" and, in fact, is a communications platform for introducing the latest technologies into satellite manufacturing and space services.

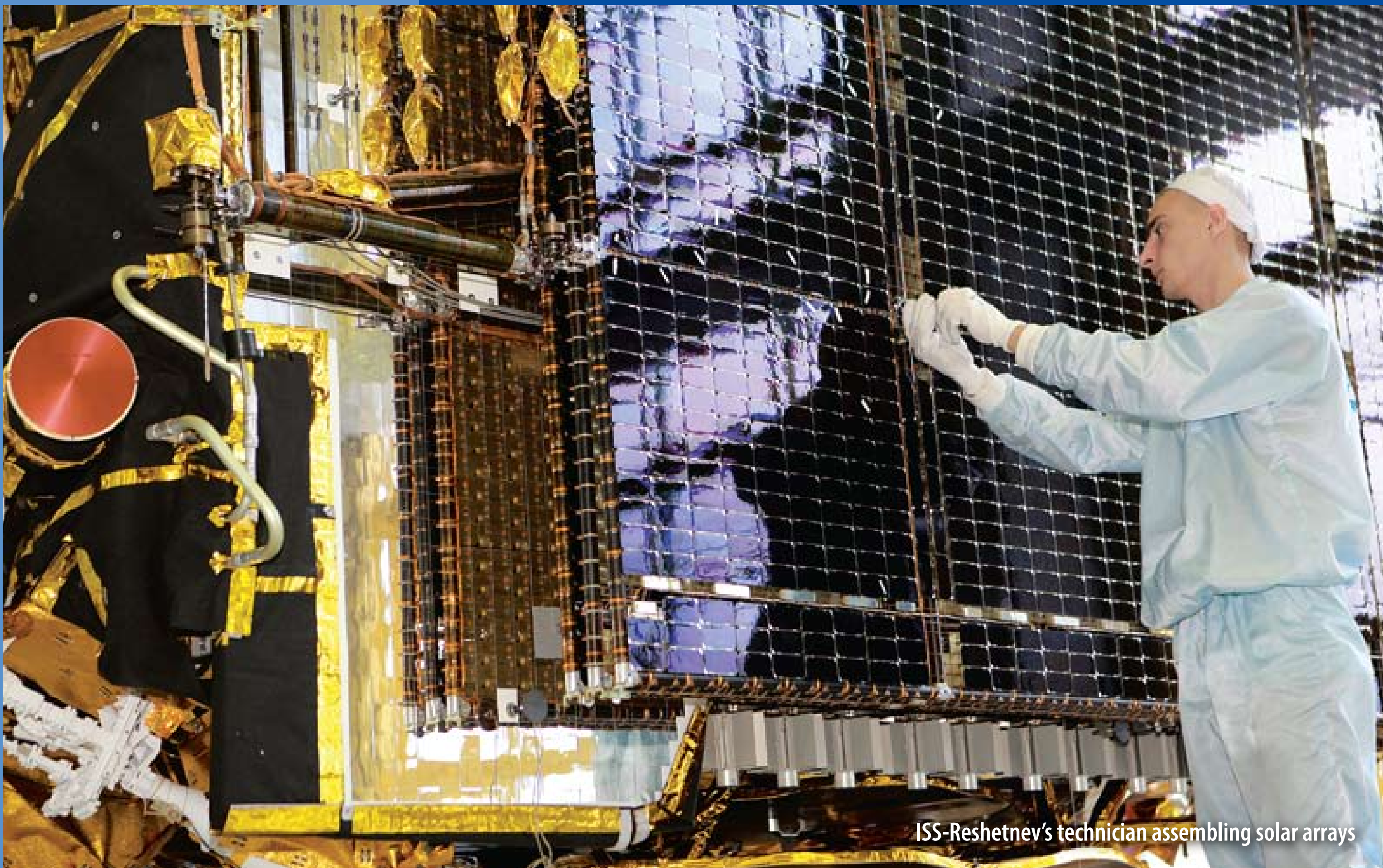
I must mention another space technology platform developed under the auspices of TSNIIMASH and the Moscow Aviation Institute. I think that we will cooperate closely and exchange ideas as we go along.

Our platform has gained support from over 40 Russian space companies and three regions' authorities. We continue to receive proposals for adding new participants including foreign ones to the program. Thus, we may have an opportunity for cooperation with some European platforms.

Learning to use new technologies requires consolidation of intellectual resources. It is not surprising that in satellite manufacturing this process will be implemented with the use of innovative solutions of Russia's leading satellite manufacturing company.

The National Information Satellite System platform is a way to define priorities in government spending for the benefits of the industry and its innovative development. In this case money will not be scattered on one and the same task solved by different organizations. Consequently, science, industry and business can concentrate their efforts on the modernization of the Russian economy. As a result, we expect to see an increased satellite availability index, improved user properties and a broadened range of cost-effective space services. Besides, the National Information Satellite System platform will enable us to determine priority investment areas.


Telecommunications satellite TELKOM-3


ISS-Reshetnev's technician assembling solar arrays

COOPERATION

ISS-RESHETNEV AND JENA OPTRONIK: prospective partnership

Satellite reliability greatly depends on the quality of tools used in the manufacturing process. All satellite producers are interested in increasing the number of suppliers of high-quality spacecraft components. Satellite equipment manufacturers, in their turn, strive to promote their products to new markets.

Mutual interest between Academician M.F. Reshetnev Information Satellite Systems and the German firm Jena Optronik has paved the way for their cooperation in advanced satellite projects. Jena Optronik is a well-known supplier of optoelectronic instruments for satellites.

The companies' representatives first met at the International Aviation and Space Salon MAKS-2009 in Moscow. The German company offered to test one of its instruments at the ISS-Reshetnev's advanced testing facilities.

The reason why Jena Optronik had chosen the Reshetnev Company was quite obvious: ISS-Reshetnev is a leading satellite manufacturing enterprise whose satellites are the key assets in Russia's telecommunications satellite fleet and have a good reputation for their faultless in-orbit performance. It was highly crucial for the German company to win the recognition of the largest satellite producer in Russia, one of the world's leading space countries. Pursuing its own goals, ISS-Reshetnev got interested in an instrument supplier that provided opportunities for testing new technology and assessing its quality and effectiveness.

Today Jena Optronik is going to provide ISS-Reshetnev with the Astro APS star sensor intended for spacecraft attitude control. Astro APS is expected to be fight-tested as a hosted payload aboard a Glonass-M satellite scheduled for launch in 2013.

At the same time ISS-Reshetnev also sets long-range objectives. Russia's satellite navigation constellation is to be replenished with next-generation Glonass-K satellites. As part of the GLONASS modernization program the Block II Glonass-K satellite is to be launched in order to boost the accuracy of GLONASS navigation data. ISS-Reshetnev aims to provide its spacecraft with optoelectronic instruments. It goes without saying that reliable high-quality equipment is essential for the design, development and manufacture of competitive satellites. Integration of both Russian-made sun- and earth sensors and the German-produced Astro APS star sensor into the same satellite will enable the Reshetnev Company to uncover the new features and benefits of star sensors as well as the expediency of their utilization aboard next-generation navigation satellites. In case Astro APS demonstrates flawless flight performance it may be accepted for ISS-Reshetnev's subsequent satellite projects.

The agreement between Academician M.F. Reshetnev Information Satellite Systems and Jena Optronik was signed at the 49th International Paris Air Show Le Bourget-2011. Under the terms of the contract, the German company is responsible for providing the star sensor as well as the associated testing equipment, and ISS-Reshetnev is to augment necessary improvements to the instrument before satellite assembly commences. The star sensor will be integrated into the spacecraft and as soon as it completes flight tests the manufacturer will receive an ample performance feedback.

Eugene Yakimov,
General designer-head
of the AOCS design and testing
department

GROUND CONTROL SEGMENTS for foreign customers

Academician M.F. Reshetnev Information Satellite Systems is involved in a number of international projects. In particular, the company has recently manufactured the AMOS-5 spacecraft for the Israeli operator Space-Communication Ltd., and is currently completing the TELKOM-3 satellite for the Indonesian operator PT Telekomunikasi Indonesia Tbk. Under the terms of the contracts ISS-Reshetnev will also provide ground control segments.

The ground control segments are being built on the customers' territories. The Reshetnev Company is responsible for the assembly and installation of the TCR items and other types of equipment in the mission control centers as well as for the development of the dedicated software and software simulators. Once handed over to the customer, this equipment will enable support and control over the satellites throughout their missions.

Within the scope of the programs ISS-Reshetnev has subcontracted antenna systems and TCR items to the German company Vertex Antennentechnik. One of ISS-Reshetnev's affiliates, NPO PM-Razvitiye, has supplied a 7.2-meter antenna for testing the payload module in the C-band. Due to close cooperation with Vertex Antennentechnik, ISS-Reshetnev has gained valuable experience in manufacturing world-class TCR items.

Upon completion of the ground control segments in Israel and Indonesia ISS-Reshetnev will provide training to the customers' personnel. In order to fulfill its commitments the Reshetnev Company will supply dynamic software simulators designed and produced in-house.

A satellite software simulator is a sophisticated system of satellite software models which enables a customer to receive knowledge and skills in satellite control and get ready for a possible malfunction. Modern satellites can be characterized as very complicated systems and customers, being aware of this fact, are apt to purchase satellite software simulators. In response to the increasing demand ISS-Reshetnev successfully develops software products in-house and provides its customers with leading edge solutions.

In accordance with the terms of the contract, the AMOS-5 satellite at first will be controlled from ISS-Reshetnev's Information Computation Center. As soon as the satellite completes flight tests it will be handed over to the customer to be controlled from Israel. As for the TELKOM-3 satellite, from the very beginning it will be tracked and controlled by the Indonesian mission control center with the assistance of the Reshetnev Company's specialists.

For the first time in its history, the Reshetnev Company is building ground control segments on the customers' territories – in Israel and Indonesia. By expanding its activities the Reshetnev Company gains additional advantages and increases its competitiveness in the satellite market. The high quality of the company's product line and its authority on the global market make it very attractive for foreign companies to place orders with ISS-Reshetnev for the manufacture and installation of ground control segments.

Constantine Shmik,
Head of Design Department for computer-aided management and control over satellite constellations

Assembly of ground antennas in Indonesia

TEST EQUIPMENT for modern satellites

Academician M.F. Reshetnev Information Satellite Systems has recently purchased new thermal balance test equipment within the framework of its modernization program, thus, making new significant steps towards innovative development.

The new horizontal vacuum chamber (GVU-600) with a capacity of 600 m^3 considerably surpasses the equipment currently available at ISS-Reshetnev in terms of volume. GVU-600 also features high cleanliness and vacuum levels ($P = 5x10^{-6}$ mm Hg) which enable the company to carry out tests under conditions close to those of outer space.

Many hi-tech solutions are embodied in the GVU-600 vacuum chamber. For instance, the structure of its sliding door ensures higher levels of airtightness. The new equipment is intended for thermal vacuum tests on unpressurised satellites whose thermal control subsystems are based on the heat pipe technology, i.e. next-generation Glonass-K satellites and spacecraft of the Yamal, Express-AM and Express-AT series. GVU-600 is also suitable for conducting thermal vacuum tests on satellite's large-size structures – antennas and solar arrays.

The new horizontal vacuum chamber consists of a number of basic subsystems – cryogenic, vacuum pumping, leakage and depressurization control, vacuum contamination and cleanliness control subsystems. In addition to cryogenic shields it also includes a solar and a heat flow simulators based on the infrared radiation technology. GVU-600 surpasses other ISS-Reshetnev's vacuum chambers in terms of capacity. Moreover, it has two additional subsystems - temperature control and weightlessness simulation.

The GVU-600 vacuum chamber was developed specially for ISS-Reshetnev in the Beijing Institute of Environmental Test Engineering. The equipment meets all requirements for satellite testing.

During his working visit to the ISS-Reshetnev site Xu Xiaoquan, representative of the Fifth Academy, said, "A vacuum exhaust system of this chamber is a very complicated structure. That is why we have developed a new solution to streamline the installation process. We have cooperated with some Chinese companies that specialize in vacuum systems. Moreover, after signing the contract with ISS-Reshetnev, a number of European spacecraft manufacturers

GVU-600 cryopumps

got interested in our products and decided to cooperate with us".

The chamber was assembled within a year and a half by Chinese and Russian specialists. Over this period the two parties managed to successfully overcome all difficulties concerning the equipment design, customs clearance and delivery.

Considerable contributions to problem-solving were made by Glavkosmos and China Great Wall Industrial Corporation. The companies signed a contract which covers the design, manufacture and assembly of the Chinese equipment and its delivery to ISS-Reshetnev's site. Vladimir Tolshmyakov, Glavkosmos deputy director, who was present at the acceptance procedure, underlined, "We accept this chamber as the customer of China Great Wall Industrial Corporation, and ISS-Reshetnev, in its turn, accepts it as the customer of our company. It has been a complicated joint multitask project which finally yielded positive results. Our Chinese partners delivered their high-quality product in the shortest possible time. We hope that we will further cooperate fruitfully with China Great Wall Industrial Corporation and ISS-Reshetnev".

It should be mentioned that it is the first time spacecraft testing equipment has been exported from China to Russia, and therefore the governments of both countries paid greater attention to the project.

Acceptance tests verified GVU-600's compliance with ISS-Reshetnev's requirements specification. Valery Khristich, a leading specialist at the department of pneumatic-and-vacuum tests, highlighted the chamber's uniqueness, "GVU-600 is a good example of implementation of leading-edge technologies in satellite production. Some of the chamber's components were imported, but some were produced in our country and purchased by ISS-Reshetnev within the GLONASS R&D framework".

Having purchased the thermal vacuum chamber, the Reshetnev Company made a new step in the direction of reequipment and innovative development. GVU-600 is expected to provide ISS-Reshetnev with new testing opportunities. As a company with a solid backlog of orders, ISS-Reshetnev aims at modernizing its manufacturing and testing facilities to maintain sustainable development.


GVU-600 assembly


Horizontal vacuum chamber GVU-600

«TEXTILES» in service to space

Gold-plated mesh is one of ISS-Reshetnev's unique developments applied in the manufacture of large-sized foldable antennas. Thus, metallic textile materials are being used to create high-precision foldable satellite antennas for the Loutch data relay satellite series.

High-precision parabolic antennas intended for the satellites of the multifunctional space-based data relay system Loutch have to meet rigorous structural requirements, such as large size, compact stowage and high specific strength and stiffness after repeatable packing and deployment cycles. These antennas can be also characterized by means of the transformation coefficient, i.e. the ratio of the antenna diameter in a folded position to the dish size in a deployed position.

Thus, deployable antenna structures determine the need for light, flexible surfaces with high reflection coefficients (up to 99%), minimal increase of the surface distortion, and highly stable physical, mechanical and electrophysical characteristics. These requirements are best satisfied by means of metal wire meshes (up to 50 micrometers in diameter) that have a number of unique properties: they are lightweight, strong, crease-resistant and quick at restoring their original shape after mechanical effect, thus, ensuring reflectors dimensional stability. Such physical and mechanical characteristics of metal meshes are enabled by their loopy structure and thread properties. It is essential that metal threads have a minimum coefficient of thermal expansion, sufficient strength and low electrical resistance.

The Reshetnev Company first used the mesh technology on its first-generation Loutch satellites in the mid 1980s. At that time wires were mostly made of nickel-plated steel or tungsten. While developing the technology the company managed to make nickel coatings long-lasting and, thus, very reliable. The mesh wire developed in-house had a number of advantages. However, with the course of time satellite requirements got much tougher, especially those concerning characteristics of radioreflective surfaces.

In 2000 the company returned to the use of tungsten and molybdenum wires and decided in favour of gold plating for better radioreflective properties. The gold plating technology was developed in-house in partnership with Kosygin Moscow Textile University. As a

Gold-plated mesh samples comparison

result, the new material demonstrated much better characteristics than the previous one developed in the 1980s. Good progress was achieved in terms of mass – a gold plated mesh was 4 times lighter than a nickel-plated one. Yet, the rapid development of space technology required that the company should not rest on its laurels. In particular, the manufacture of new satellites intended for the Loutch multifunctional data relay system requires the development of large-sized foldable antennas with improved radio-physical characteristics.

Today the Reshetnev Company applies a new method of making meshes. Now it is 15-micron wires that are gold-plated, but not a finished mesh. Plating wires allows making larger meshes – 2 meters in width and 12 meters in length. It means that now it is possible to manufacture large-sized antennas with fewer joint elements, more accurate configuration and maximum interference immunity.

For operations with wide meshes the Reshetnev Company plans to create new workplaces as well as expand its mesh-cutting and mesh-lacing facility.

Important contributions to the development of the new technology were made by Promelectronika (Saratov) and Triinvest (Moscow).

The main advantage of the gold-plated mesh made with the new technology is its high radio-reflective properties – 99,8%. Other benefits include:

- Flexibility and elasticity necessary for folding and unfolding antennas with minimal impact on the load-bearing structure;
- Absence of folds and creases when folding and unfolding the antenna structure;
- Strength to withstand repeatable packing and deployment cycles;
- Fault localization and the detection of reflector surface imperfections;
- Minimum weight;
- Environmental resistance.

The new gold-plated mesh will be used not only in the new data relay satellite for the Loutch system, but also in next-generation communications satellite projects, in particular, in advanced large foldable antennas (3 and more meters in diameter). Modern metal mesh solutions can be used for antennas operating at frequencies up to 40 GHz, which will allow accelerating the conquest of the attractive Ka-band. Besides, the company is interested in supplying meshes as well as meshed antennas to foreign customers.

It must be mentioned that mesh materials developed by the Reshetnev Company in partnership with Kosygin Moscow Textile University for the reflective surface of antennas are highly competitive in the international market, especially two-ply threads (each 15 micrometers in diameter) that allow reducing the mass of a dish and at the same time increase its size.

Today Academician M.F. Reshetnev Information Satellite Systems is the only space company in Russia that has the technology to manufacture gold-plated wire meshes. The theoretical study and experimental research conducted by the company open up opportunities for further improvement of the materials as well as new developments.

Sergey Podshivalov,
head of sector of the Materials Engineering Department

Gold-plated mesh lay out

COMPOSITES – materials of the future

The development of the modern satellite manufacturing industry is impossible without the use of polymer composite materials which ensure improved satellite characteristics and increase satellite reliability and longevity.

Composite materials have a broad range of benefits, the most important of which are strength and stiffness, low density, high corrosion resistance, weather resistance, special geometry and excellent resistance to static and dynamic loads. Composites ensure weight reduction and increase product reliability and durability in space conditions.

The most advanced structural composites are based on quartz, carbon and organic fibers. The Reshetnev Company uses almost the whole spectrum of modern polymer composites to manufacture various items and satellite subassemblies including both structural elements (fittings, pipes, solar panel structures, antenna booms, honeycomb panel sheets, antenna spokes) and elements of antenna-feeder devices (reflectors, horns, emitters). At present ISS-Reshetnev has two production units responsible for the manufacture of satellite parts from composite materials. A new facility has been recently phased in for the same purposes, thus, illustrating the increasing amount of operations being done in-house with the use of composites.

Today the Reshetnev Company has taken the lead among the Russian aerospace enterprises in the application of polymer composites. Annually 37 new composite materials are developed and tested here. Besides, the company takes advantage of different molding methods (vacuum, autoclave, compression and thermocompression).

Molding parts out of composite materials is impossible without proper


Honeycomb panel sheets stretching


Antenna spokes made of polymer composite materials

molding equipment. In order to get a dimensionally stable product which is manufactured under high temperatures (up to 190°C) it is important that molding equipment be also made from dimensionally stable materials. For instance, invar and graphite have the lowest coefficient of thermal expansion which enables the product to have tailor-made properties.

The company's intensive use of composite materials allows its specialists to feel confident in this field of activity. Due to the accumulated practical experience ISS-Reshetnev is capable of manufacturing high-quality satellite parts and subassemblies using composite materials which, unlike metals, have their own 'character' and require different processing conditions. Thus, for every single product a different composite is developed to satisfy particular technical requirements.

The use of composite materials has enabled the Reshetnev Company to expand the antenna product line, in particular, the antenna type with rigid reflectors (precision, contour-beam and with polarization selective surfaces).

Elements of foldable antennas are also made from composite materials to ensure the required strength, stiffness and dimensional stability of their deployable structures. Besides, low-density composites allow reducing the dead weight of a satellite as well as increasing its payload mass, thus, leading to improvements in a product's competitive edge.

Nowadays automated spacecraft have 60% of parts and subassemblies made from composite materials. Thus, technological progress in satellite manufacturing is moving towards replacing traditional materials (titanium, aluminum, etc.) with polymer composites.


Assessment of pre-preg

OUTLOOK for the two-phase loop

Satellite thermal control is an important subsystem that ensures normal operation and functionality of a satellite payload under the predetermined temperature conditions during both spacecraft ground test and in-orbit operation. With the increasing number of transponders onboard modern spacecraft satellite mass and amounts of heat generated by satellite electronics also increase, which makes greater demands on the satellite thermal control subsystem as related to increasing its efficiency, heat-rejection capability and topological compatibility with the rest of the satellite equipment.

Improvement of the satellite thermal control subsystem presents a real challenge to the space industry. ISS-Reshetnev is one of the few companies that have considerable expertise and intellectual potential to develop the thermal control technology based on two-phase loops that ensure effective thermal conditions for satellite equipment and, at that, reduce satellite mass and power consumption.

During ground testing, at launch and in orbit a satellite's equipment, structures and deployable elements must be maintained within the desired temperature range regardless of extreme external conditions the satellite is exposed to through the life of its mission.

At present on Russian-made satellites, with heat rejection levels being more than 2kW, heat is transferred from heat sources to radiating surfaces (radiators) by means of liquid loops in which a working fluid (heat transfer fluid) is "forced" to circulate using heating and cooling mechanisms. With medium heat loads (up to 4kW) such closed loop systems demonstrate high reliability and efficiency due to mechanical pumps ensuring fluid circulation and radiators rejecting waste heat into space.

However, the increasing amounts of heat rejection on modern satellites along with increases in satellite mass have raised the need for developing two-phase thermal control systems.

Heat pipes

The simplest of them are heat pipes that are widely used on modern Russian satellites in combination with liquid loops.

In a two-phase loop system heat is accumulated as latent heat via evaporation of a fluid at the heat source with its subsequent condensation at the heat rejection location, which allows transferring larger amounts of heat (8-10 times larger than in a single-phase heat transfer system).The advantage of a two-phase loop system is that a heat transfer liquid boils at a constant temperature which remains almost unchanged during condensation, thus, enabling very precise temperature control of the satellite equipment.

The Reshetnev Company has accumulated considerable experience in the study of both passive and active two-phase systems. In 2006 the company won a tender competition within the scope of the federal space program for the R&D project "Creation of basic elements of new integrated thermal control subsystems for advanced spacecraft and stations". In 2011 the company signed a new contract for the second phase of the project which will run for 4 years and result in the creation of experimental prototypes of two-phase thermal control elements to ensure an overall reduction in satellite mass, size and power consumption as well as improve satellite equipment quality and reliability. The project is also aimed at launching production of two-phase thermal control elements at ISS-Reshetnev for the benefits of the whole industry.

The R&D activities under the project will be focused on two main areas – development of active and passive thermal control systems. Passive thermal control is used in automated spacecraft with heat rejection levels from 8 to 15 kW. The passive two-phase system employs loop heat pipes that use capillary action to remove heat from a source via vaporization and passively move it to the condenser region (radiators), from where the condensed liquid is returned to the capillary pump. The advantage of the passive two-phase system is that it has no moving parts and power consumption, which increases the overall system reliability.


A heat pipe array

Active two-phase thermal control is advantageous for larger vehicles with heat rejection levels higher than 30 kW, for example, space stations. Active two-phase systems employ mechanical pumps which transfer a liquid to a heat source where heat is absorbed. Waste heat is rejected as a result of vapour condensation in pipes with radiating surfaces.


Instrumentation panel of the two-phase control subsystem prototype

Efficient phase-change heat transfer allows reducing the weight of a thermal control system, which is an important advantage over single-phase systems achieved by:

- Smaller mass / volume flow rates;
- Partial loop filling;
- Smaller pipeline diameter;
- Low power consumption / or no power consumption in some systems;
- Possibility of self-regulation.

Nevertheless, some problems are encountered when designing two-phase loops (TPLs). These occur during both the design of TPL elements for the condition of weightlessness (heat exchangers, evaporators, condensers, flow limiters, flow regulators, pipelines) and the integration of a whole system (two-phase flow analysis, filling, regulation, steady-flow operation regardless of configuration and heat rejection levels in zero gravity, TPL ground testing). These important problems are being addressed by ISS-Reshetnev and its associate contractors within the scope of the experimental development of a two-phase thermal control system.

The prototypes of two-phase systems manufactured within the program have already demonstrated high efficiency which is 5-8 times higher than that of liquid systems. Another advantage is that heat is transferred over much longer distances and with minimum power consumption.

All the preliminary results received during ground verification will be flight-tested before the completion of the R&D project activities.

Oleg Shylkin, head of section of Thermal Control Systems & Thermal Analysis Department

SATELLITE CONTROL

IN ORBIT

ISS-Reshetnev is one of the few space companies able not only to carry out the full satellite production cycle but also provide satellite in-orbit control and maintenance. Even if handed over to the customer, the satellite remains under the "lifelong tutelage" of the Reshetnev Company and its experienced specialists who know the spacecraft to the last detail.

Technical capabilities

The Reshetnev Company has been providing satellite control since the 1990s. The Gals direct television broadcasting satellite was the first spacecraft controlled by ISS-Reshetnev via its mission control center located on the company's premises. The company developed its satellite in-orbit control technology step by step. Established in 1994 ISS-Reshetnev's mission control center comprised:

- a telemetry data receiving station;
- a command and measuring station;
- control rooms for data processing and mapping, equipped with high-powered workstations and special-purpose software packages;
- 2 space communications centers and various landline facilities.

It was this mission control center that provided control over Gals, Express, Express-A, Sesat and a number of other satellites manufactured by ISS-Reshetnev for civil needs.

As soon as the Russian Satellite Communications Company (RSCC) commissioned its Space Communications Center in Zheleznogorsk to operate civilian geostationary satellites with the support of the Reshetnev Company, the company's mission control center was transformed into the Information Computation Center (ICC). A direct communications link was established between ICC and the Space Communications Center to monitor satellites of the Express and Express-AM series.

Later the Information Computation Center was equipped with a system for real-time information reception and processing to handle almost all ISS-Reshetnev-made commercial and military satellites.

Today it is possible to transmit control information from ICC to the mission control centers operating ISS-Reshetnev-built satellites, which enables the company's specialists to efficiently cooperate with Russia's military and civil ground control segments as well as national and foreign satellite control points.

Since 2005 a new mission control center has been operating within ICC to provide control over the multifunctional communication satellite system Gonets-D1M.

At all stages of flight

With modern software and hardware packages installed at the Information Computation Center ISS-Reshetnev's specialists can make the best use of their intellectual potential in controlling satellites at all flight stages, from launch through commissioning to final in-orbit operations.

Satellite in-orbit control operations encompass:

- satellite control during orbit insertion;
- satellite in-orbit preparation for commissioning;
- in-orbit maneuvers (attitude control and stationkeeping, deorbiting);
- simultaneous support and control over a number of multi-satellite constellations in all types of orbits;
- correction of system failures;
- preventive measures to minimize satellite malfunction effects.

Satellite telemetry data is received and analyzed by the Information Computation Center. In case of abnormal situation early actions are taken to avoid or correct a malfunction. In terms of satellite control, satellites are not identical and require different approaches. Comprehensive knowledge of a satellite's technical capabilities is critical in unscheduled situations, for it enables operators to make the only right decision in the shortest possible time.

Today ISS-Reshetnev is capable of providing satellite control in different types of orbits. Every orbit is peculiar in its own way. For instance, a geostationary satellite can be controlled in two modes – continuously and during communication sessions, whereas a highly elliptical satellite sends data and receives commands only during communication sessions.

It is not a secret that the quality of satellite control greatly depends on the accuracy of satellite health status assessment. Different methods are used to determine the status of satellite onboard subsystems. One of them is "satellite diagnostics and monitoring" implemented with the use of on-ground software. The Reshetnev Company is currently developing such software for ground-based segments.

In cases when a satellite is to be controlled by the customer, ISS-Reshetnev provides training programs for the customer's personnel using satellite simulation software.

Glonass-M №38 launch

Reception of telemetry data

SATELLITE CONTROL

Glonass-K communication session

Satellite control methods and their improvement

Modern satellites are highly sophisticated machines composed of software and hardware systems able to operate both in static and dynamic modes. Dynamic processes in satellite onboard subsystems take place at intervals varying from 1 second to several hours. In real situations it is crucially important to quickly detect the cause of a malfunction and make an appropriate decision. Consequently, there is a need to develop and introduce a dedicated diagnostic software and hardware complex into the analysis process so as to automate the failure identification and decision-making processes.

The satellite diagnostics method is based on the knowledge of a device under assessment and the experience received during its testing and operation. This method is used to determine a satellite's condition by analyzing models on three different levels: a model of a complete satellite (satellite level); subsystems' models and modes (subsystem level); sub-subsystems' models and modes (sub-subsystem level). By a sub-subsystem we understand a number of functionally interconnected systems that compose a satellite subsystem.

There are two ways to determine a set of telemetry parameters that characterize a sub-subsytem's model (mode) and its possible diagnostic conditions. The first is a priori knowledge of a behavior of a sub-subsytem; the second is a posteriori knowledge of its operation, anomaly situations, etc.

Real diagnostic conditions of models along with equipment health parameters determine the matrix of the satellite health status and facilitate decision-making for effective satellite in-orbit control. The satellite health status matrix (SHSM) includes data on the consumption of satellite expendable resources, time-space parameters and other data that influence satellite in-orbit performance directly or indirectly.

The increasing complexity of modern satellite equipment and highly demanding satellite performance and lifetime requirements determine the necessity for improving the existing control methods.

At present the Reshetnev Company is implementing adaptive control techniques. This type of control suggests the use of the onboard computer capable of performing control functions and allows changes in the control of separate dynamic processes running on a satellite in case of an unrecoverable subsystem failure. If such occurs, special equipment joins in to keep the dynamic processes going without any damage to the core process.

As well as that, ISS-Reshetnev is developing and introducing methods of satellite control in the "satellite – mission control center" mode. The increasing operational reliability of onboard and ground equipment used in space systems predetermined the transfer of some satellite equipment control operations to the ground control segment which, in comparison with onboard computers, has more powerful resources. Besides, according to the latest trends, continuous monitoring and control over the satellite equipment status is organized with the use of ground control means. In this case, telemetry data is transmitted non-stop to the ground control segment and then is retransmitted to the mission control center. In addition, considerable progress has been achieved owing to the use of transmitters with solid state power amplifiers.

The main concept of control in the "satellite – mission control center" mode" is that any deviation in the operation of the satellite onboard equipment from the norm is registered as a change of status or a change in the value of a telemetry parameter which is sent to the mission control center. Either change is identified as "abnormal" by ICC's ground diagnostic complex and transmitted to the status control complex which, by analyzing the abnormal parameter, determines a command to correct the deviation. After that the command is automatically sent to the satellite. As soon as it is executed the deviation is eliminated. The parameter under control gets back to its normal state. The "satellite –mission control center" algorithm is complete.

It is important to note that satellite in-orbit performance results contain necessary information which indicates whether the company's design and engineering solutions are successful or not. Thus, satellite in-orbit control and support are not only customer-oriented services, but also a source of valuable experience and know-how for the Reshetnev team.

ISS-RESHETNEV-DESIGNED SATELLITE ANTENNAS

- Large-size foldable antennas
- Contour-beam antennas
- Mirror antennas
- Horn antennas
- Helical antennas
- Antenna array

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