RESHETNEV
COMPANY

INFORMATION SATELLITE SYSTEMS

October, 2007

GLONASS
is the national pride of Russia


НПО
ПРИКЛАДНОЙ
МЕХАНИКИ
имени академика
М.Ф.РЕШЕТНЁВА

Dear colleagues,

In 2007 the Russian space community is going to celebrate two significant dates: the 40th anniversary of the navigation satellite "Cosmos-192" launch, and the 25th anniversary of the first satellite "Glonass" launch. Both satellites were created by the specialists of the "Academician M. Reshetnev NPO PM". During 40 years, the considerable amount of work has been done in developing space navigation. In comparison with the first satellites transmitting coordinates only once per two or three hours with accuracy up to 1 km, today state-of-the art satellites of the GLONASS family can determine coordinates with accuracy of up to 1 meter, at any time, with high reliability level and availability under any operating conditions.

On October 26, 2007 we evidenced one of the most significant events in the Russian space development: the next three "Glonass-M" satellites were orbited from the Baikonour launch site. Another three "Glonass–M" satellites are scheduled to launch in December. Thus, the Russian GLONASS system constellation in 2007 will comprise six more satellites. NPO PM plays here a leading role as a head-company in creating the satellite system. Despite the time limits, NPO PM specialists are successfully fulfilling the plan. At the enterprise there is a re-equipment being carried out at a rapid pace, establishment of new operation zones and working places allowing both fulfilling the plan in time and creating a basis for future development. We pay special attention to creating spacecraft of a new generation - "Glonass-K", which is a priority for us.

According to the President of the Russian Federation, Vladimir Putin, "the GLONASS system is the national pride of Russia". Development of the satellite-based navigation became an inevitable condition not only for improving transport business and economical growth but also for ensuring defense capability of Russia.

NPO PM General designer and General director
Nickolay TESTOEDOV

RESHETNEV
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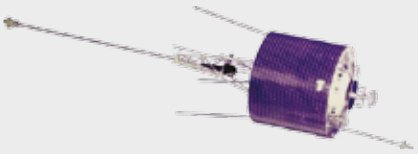
The 25th anniversary of the first "Glonass" satellite launch

On the 12th of October, 1982, the Soviet Union launched the first satellite of the GLObal NAvigation Satellite System GLONASS.

The satellite was designed by NPO PM specialists to determine coordinates of ships and aircraft. The first GLONASS family spacecraft provided better accuracy and continuity of services for the system's users on the Earth surface and that for near-earth objects. In 1993, the President of the Russian Federation signed a decree on the GLONASS system commissioning. Today, special attention is paid to modernization and development of the system. At the same time NPO PM specialists are developing new generation spacecraft – "Glonass-K" and "Glonass-KM".

The 40th anniversary of the Russian space navigation

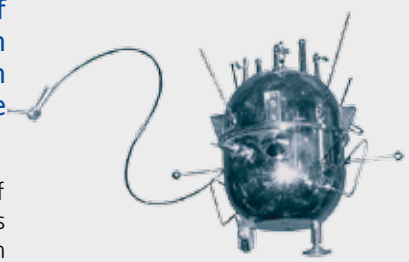


In 2007 the Russian space navigation celebrates its 40th anniversary. The first navigation satellites of the Soviet Union were developed in 1967 (Cosmos-192 and Cosmos-220).

In early 1970 full-scale satellite-based navigation systems comprising 4-6 spacecrafts were already deployed in orbits. A great deal of work has been done in development of space navigation. In comparison with the first satellites that could transmit coordinates only once per 2-3 hours with accuracy up to 1 km, the state-of-the art satellites of GLONASS family can determine coordinates with accuracy up to 1 meter, at any time, with high reliability level and availability under any operating conditions. Development of the satellite-based navigation became an inevitable condition not only for improving transport business and economical growth but also for ensuring defense capability of Russia.

The 40th anniversary of the high space probe satellite's launch

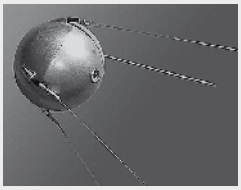
In accordance with the program of the near-earth space research, on the 12th of October, 1967, a high space probe satellite produced by the Reshetnev NPO PM was launched.



The fourth stage put it to the altitude of 4400 km. The Space research institute was a general customer of the satellite. The high space probe satellite was launched in order to further explore the upper atmospheric and ionospheric layers of the Earth and near-earth space. The main experimental task was to collect information about in-altitude distribution of the parameters including: ionosphere characteristics, total space radiation intensity, radiation dose experienced under various protecting shields while passing radiation belts, and neutral hydrogen density. It was for the first time that such scientific researches were carried out at the altitudes mentioned above so they were of great scientific value. The research program was entirely completed.

ANNIVERSARIES

The 50th anniversary of the world first artificial earth satellite launch



On the 4th of October, 1957, from the Baikonour launch-site, the R-7 launcher injected into orbit the first artificial earth satellite.

That day was declared a Day of Space Forces of the Russian Federation. The first satellite launch also denoted the beginning of the Space era in the history of the mankind. The event was significant both for science and for politics. Any radio amateur all round the world could receive the signal transmitted by the satellite. This fact enhanced the prestige of the Soviet Union. The first satellite launch was a hard blow to the American propaganda. Just before the Soviet Union launched the satellite, the American government had declared that a modern combat air defense system had been created. Surprisingly for them, every hour and a half a soviet satellite was passing invulnerably over the US territory. Later an article in "The New York Times" said: "90% of talks about artificial earth satellites were led by the USA, but 100% of works were done by Russia..."

The 150th anniversary of Konstantine Tsialkovskij birth date

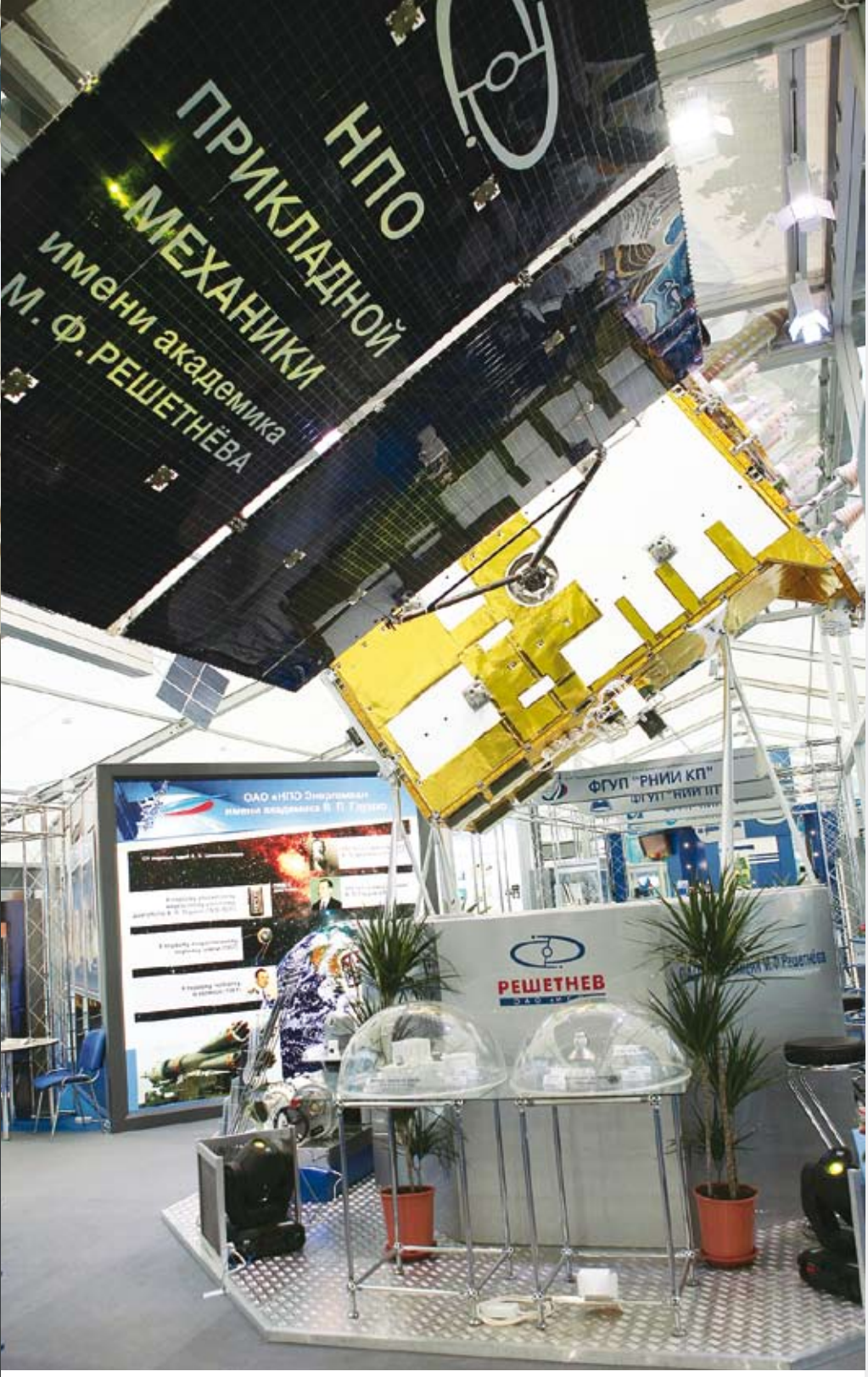
The 17th of September was the 150th birth date anniversary of the theoretical astronautics and rocket dynamics founder – Konstantine Eduardovitch Tsialkovskij.

He was an investigator paving new scientific ways, an inventor whose technical works devoted to aerostation, aviation and rocket techniques, enhanced the priority of Russia. Unfortunately some of them as well as his ideas were never to come true – he suffered the same fate as many other scientists of that period.

But it is of no doubt that his ideas were upstripping for the 19th century. His works devoted to rocket techniques are the most original and remarkable inventions of his century.

MAKSIMUM WORK

On the 21st of August, 2007 the International Aerospace show MAKS that is held in Zhukovsksy every 2 years, was opened to the specialists and guests for the 8th time. This year NPO PM participated the exhibition as a head-company of the "ISS" corporation which is being created. The ISS delegation was headed by General designer and General director Nickolay Testoedov.



"Glonass-K" is in the center of the FSA united exposition

It was for the first time that the Reshetnev NPO PM exhibited a full-scale model of the "Glonass-K" satellite, during the International Aerospace show MAKS-2007. The model was located in the central part of the FSA (Federal Space Agency) exposition, it couldn't but draw everyone's attention.

While developing this satellite NPO PM solves tasks of the national priority: namely, modernization of the Global Navigation Satellite System GLONASS foreseen by the Federal purpose-oriented program. Lately this issue has being thoroughly discussed at the state level. Mass media also pays much attention to this question. That is why it was decided to make a full-scale model of the satellite and to let the specialists and the guests of the exhibition see how a satellite could really look in orbit. The results were beyond all expectations: the satellite became a focus of attention.

The President of the Russian Federation, Vladimir Putin:

"MAKS has become not only one of the praiseworthy aerospace shows but also one of the leading shows of the world. MAKS-2007 presents a new philosophy of a show arrangements and the most important is a program of the aerospace show, its scientific conferences, and meetings and seminars. Active involvement of scientists, designers, engineers; discussions on the ways of aviation development and space exploration - is one of the new tendencies of the Russian exhibition".

The head of the Federal Space Agency, Anatolij Perminov:

"Comparing MAKS-2007 with the previous aerospace shows I should say this year Roscosmos has considerably enlarged its exposition. We have presented about 25 companies. The key moment of the exposition was demonstration of the development of the Global Navigation Satellite System. It was for the first time that we demonstrated the prospective spacecraft "Glonass–K" set to launch in 2010 and which will become the basis of the orbital constellation. Its characteristics are equal to those of GPS, even better. Why was the spacecraft presented? Because we wanted other countries to know that this spacecraft already exists".

General designer and General director of NPO PM, Nickolay Testoedov:

"During the exhibition the "ISS" Corporation was entirely presented. The united exposition maintained by Roscosmos, NPO PM and the companies-members of the JSC "ISS", demonstrated our common production available at the domestic and international markets. In the terms of the Global Navigation Satellite system development we presented perspective spacecraft. A full-scale model of the "Glonass-K" satellite became a center of attention both for the exposition of NPO PM and for the whole Russian exposition. Besides that we presented models of the perspective satellite systems".

In addition to this satellite NPO PM also represented 4 models of satellites among which there were:

- Express-AM 33 (1:10) - a project of the national significance. The satellite will provide telecommunications all over the Russian territory. It is being created in accordance with the "Federal space program of Russia for 2006-2015";
- Express-AT (1:10) – a new telecommunication satellite, which is being developed on the basis of "Express-2000" high-powered platform. It'll be applied to in the sphere of interactive TV-broadcasting, radio broadcasting with on-board TV programs multiplexing and packaging capabilities;
- Loutch-5A (1:10) - a prospective geo–stationary relay satellite to be integrated into the multi-purpose data relay space system LOUTCH and work with LEO satellites, manned space complexes and other space and rocket objects.
- Gonets-M (1:5) - a spacecraft designed to modernize the multi-purpose personal satellite communications system Gonets-D1M, which is to provide e-mail services, digital data transmission, provide user's with information concerning their terminal's position with the help of GPS and GLONASS systems.

Besides, the Reshetnev NPO PM participated the exposition of the Russian Space Forces and demonstrated there the models of the "Glonass-M" (1:5) and "Glonass-K" (1:10) satellites.

The Common Cause

The companies-members of the "ISS" company also participated the "ISS" exposition. They exhibited newly developed designs of space equipment; in particular, the devices to be installed on a prospective satellite "Glonass-K".

General designer and General director commented on this way of show arrangments which he considers to be more effective: "a device itself might not draw anyone's attention, only being a part of the whole exposition that comprises a spacecraft model where the device to be installed - it will show different approaches to its technical and conceptual usage - THIS can impress".

JSC "Geofizica-Cosmos" (Moscow) presented attitude determination system devices including sun sensors for the "Glonass" and "Glonass-K" satellites. The specialists and guests of the exhibition could see Earth sensors, one of which will be used on the "Glonass-K".

JSC "Siberian devices and Systems" (Omsk) also demonstrated its production. Among other equipment there were presented the devices installed on the GLONASS system. There were, in particular, a solar array drive mechanism and a louver shutter electric driver, as well as an attitude determination and control system for the "Cosmos" family satellites.

Development and production of the spacecraft electric equipment is one of the main activities carried out by the JSC "Poluys". Its production was presented with the "Agat-9" device, used in the attitude determination and control system for "Glonass-K" satellites; an EPS automatic stabilization complex designed for "Glonass-M" satellites.

Being the only Russian company carrying out full-cycle works in producing antennas, the JSC "NPO PM-Razvitie" (Zheleznogorsk) demonstrated a model of the ground antenna system (1:5). The JSC "NPP KVANT" (Moscow) organized a separate exposition.

The space capabilities of Russia were praise-worthy presented by the companies-members of ISS Corporation whose exposition drew much attention of specialists, mass-media representatives and the guests of the exhibition.

Maintaining The Contacts

From the 21st up to the 23rd of August, the exhibition was accessible only for the specialists, businessmen and VIP-guests. On the first day, the President Vladimir Putin and the first vice-premier Sergey Ivanov, who were mainly interested in a "Glonass-K" full-scale model, visited the "ISS" exposition. The head of the Federal Space Agency, Anatolij Perminov, told them about the characteristics of the prospective spacecraft and about the main stages of the Federal purpose-oriented program, which is aimed at replenishing the Global Navigation Satellite system GLONASS.

A day later the representatives of the National Space Agency of Kazakhstan visited the exhibition. Nickolay Testoedov participated the meeting of the heads of two space agencies: Talgat Musabaev (Kazcosmos) and Anatolij Perminov (Roscosmos).

After the meeting, which was in fact devoted to Kazakhstan and Russian cooperative exploration of the space, the Kazakhstan delegation visited the exposition of the Information Satellite Systems Company.

During the aerospace show in Moscow, Nickolay Testoedov carried on negotiations and held several official meetings where the questions of further cooperation were discussed with the representatives of such well-known companies as "Thales Alenia Space", "Intersputnik", "EADS Astrium" (Germany), "MDA" (Canada).

Also a meeting with the representatives of Saudi Arabia was held in Zhukovsky.

NPO PM specialists were invited to visit the European Space Agency presentation covering among other projects a new Global Navigation Satellite system GALILEO.

Summing up the results it's worth saying that all companies-members of the "ISS" Corporation managed not only to meet their old companions but also to get into new business contacts and point out new perspectives of cooperation with various foreign companies. To us it's a pledge of our success and a high appraisal of our work.

Kristina USPENSKAYA

The first international aerospace show MAKS was held in1993. Since then the show has won a fame of one of the largest aerospace forums of the world.
This year MAKS was beyond all expectations: it has gathered 787 companies (247 of them were foreign companies) from 39 countries. For the first 3 days 155 thousand people visited MAKS-2007, the total number of guests grew up to 500 thousand people.

Forum "Sochi-2007"

EXHIBITIONS

On the 20th - 23rd of September 2007, NPO PM participated the VI International Investment Forum "Sochi-2007". The first forum was organized in 2002 and now is held every year on initiative of the Trade and Economic Development Ministry and with support of the President of the Russian Federation jointly with the Government, Foreign Affairs Ministry, Commercial and industrial Department.

A SMALL health-resort town of Sochi for several days became a center of meeting for politicians, manufacturers and heads of large companies, also a place where investment projects and achievements in the sphere of high technologies were demonstrated.

The VI International Investment Forum "Sochi-2007" gathered more than 8 thousand participants, presented 39 expositions of the Russian regions and 200 stands of different companies.

The Reshetnev NPO PM was one of the enterprises that presented a united exposition "Science and innovation potential of the Krasnoyarsk region", which shows a dynamic progress of NPO PM integration into economics of the region. The delegation of the Krasnoyarsk region demonstrated their most important investment projects and achievements in the sphere of up-to-date information technologies.

The pavilion area was760 square meters and a large part of it was given to the exposition models of NPO PM. A full-scale model of the prospective spacecraft "Glonass-K" was of the great interest and almost became a central part of the exposition. The guests could also see a model of the "Gonets-M" spacecraft (1:5).

Within the bounds of the Forum "Sochi-2007" NPO PM presented a unique project which is being developed jointly with the Siberian Federal University -

"Center of Space Data Receipt and Processing". Its implementation is important for the development of the whole region, its transport communications and defense capabilities in particular.

On the 21st of September 2007, the President of the Russian Federation visited the exposition of the Krasnoyarsk region. The governor of the region, Alexander Khloponin presented the exposition to the President, Nickolay Testoedov in his turn presented to the President the production of NPO PM. General designer and General director of NPO PM, Nickolay Testoedov told in details about the characteristics of a new spacecraft "Glonass-K" and about the replenishment-and-modernization works which are being carried out for the orbital constellation of the Global Navigation Satellite system.

In the terms of the International Investment forum Nickolay Testoedov carried on negotiations with the head of the Siberian Federal University, Evgenij Vaganov. They discussed the questions of cooperation in scientific and practical work.

To NPO PM the International Investment Forum "Sochi-2007" was a significant event. Being one of the five leading enterprises of the Krasnoyarsk region NPO PM confirmed the Siberian capabilities in developing high technologies and innovative projects.

Kristina USPENSKAYA

Glonass-K — a prospective satellite of the current GLONASS system

Today the whole world is focusing on creating global navigation satellite systems. Besides the USA and Russia, other countries (Europe, China and India) are also developing their own satellite systems. In this regard, the markets of navigation services are becoming more competitive requiring not only considerable modernization but also further development of already existing Russian satellite-based navigation system GLONASS. This is the task of the "Federal purpose-oriented program (2002-2011)" that foresees development of a new generation spacecraft "Glonass-K". We asked General designer and General director of NPO PM, Nickolay Testoedov to share his views on this point.

– What is the main difference between "Glonass-K" and the satellites "Glonass" and "Glonass-M"?

– "Glonass-K" is a navigation satellite of a new generation, which can be as competitive as other foreign satellites. "Glonass-K" has some principle differences from the other satellites now used to replenish the orbital constellation of the GLONASS system.

This satellite is of unsealed design. For specialists it means transferring to a new ideology of satellite building. We are beginning to create a number of new spacecraft the same way it is done in western companies. Before this moment each of us had their own traditions in satellite-building.

The "Glonass-K" satellite lifetime will be 10 years, which is longer comparing with the first GLONASS satellites with a 3 year-lifetime, or the "Glonass-M" spacecraft replenishing the orbital constellation, today have a 7 year-lifetime. Besides, the mass of "Glonass-M" is 1450 kg, and the mass of "Glonass-K" will be as little as 850 kg.

The "Glonass-K" satellite will transmit 5 navigation signals instead of 2. On the one hand it will improve accuracy of the navigation parameters. On the other hand, the satellite will transmit a signal that could be received by both domestic and GPS receivers and enlarge capabilities of the GLONASS system.

The devices to be installed on the "Glonass-K" will provide more accurate estimations of the horizontal and vertical coordinates determination, this way the "Glonass-K" satellite may become multifunctional.

– When will the first "Glonass-K" satellite be launched?

– The first "Glonass-K" is set to launch in 2010 from the Russian "Plesetsk" launch site. Therefore the relevant expanses can be several times less than those for the launches from the Kazakhstan "Baikonour" launch site. The "Soyuz-2" launcher with the "Frigate" booster will inject the satellites into orbit. With this launcher we'll twice reduce the launch cost. In future we are going to use a new launcher "Angara" which is being created so far. In prospect the orbital constellation will only comprise "Glonass-K" (24 satellites with 10 year-lifetime).

– As we know "Glonass-K" is being developed with the help of Russian new technologies, so can we say that it is going to be a national project?

– To create a satellite we apply only to Russian modernized equipment designed by the specialists of our company and the specialists from Saint Petersburg. The parameters of "Glonass-K" follow to the accuracy-improving scheme of the GLONASS system to be completed by 2014 according to Roscosmos. This program covers a number of satellites, their service accuracy, ground facilities, software programs, updating of the Earth parameters, shape and way of rotation. We plan that by 2011 the GLONASS system will provide accurate data, as it does the GPS system. Since "Glonass-K" is a part of the Global Navigation System, there's always an opportunity to set the satellite with other functions. In future we plan to provide "Glonass-K" with special equipment enlarging the number of capabilities of the whole system and enabling them to carry out additional tasks, including search and rescue works. The "Glonass-K" structure consists of honeycomb panels made of a thin skin and light filler and which allow reducing a satellite mass preserving all required characteristics. Yesterday we bought honeycomb panels from Western companies, today we sell honeycomb panels to Western companies. I would like to underline it once again: "Glonass-K" is a completely national satellite; it will have no devices or equipment bought from the western manufacturers.

– "Glonass-K" is the first satellite based on an unsealed platform. Why has it become possible to launch a satellite into the open space being unprotected from the space factors? What makes an unsealed design better than a sealed one?

– It's like to go somewhere by car instead of a bicycle. A new period of our life provokes new technical solutions. The electronic parts used for spacecraft developed 40-50 years ago didn't allow the equipment to work in vacuum, in a wide range of temperatures. So there had to be produced a sealed container with comfortable conditions for the equipment. The equipment, which is produced today, can work under vacuum conditions. Unsealed satellite design allows to reject those systems, which were obligatory for the satellites based on sealed platforms. Think about the price of a ventilation system that has to work constantly for 10 years. Materials and constructions are put to the test, redundant electric supply subsystem is used, and special bearing kits are designed. All this demands to spend so much efforts and resources, that sometimes it's easier to change the whole concept of a satellite. Today parts internationally available allow producing satellites with unsealed platforms.

– When will a next model of navigation satellites "Glonass-KM" be developed?

– A navigation spacecraft "Glonass-KM" is being designed. Its parameters will be better than those of "Glonass-K", in particular accuracy performance, enlarging the mission functions and lifetime period. The flight tests are scheduled to begin in 2015.

Irina CHAIKINA

V. E. CHEBOTAREV,
TS candidate, principle design-engineer of the General Spacecraft & System Engineering department, Reshetnev NPO PM

NAVIGATION SATELLITE SYSTEMS

Navigation is a science determining the ways and methods how to select a route and to follow the selected route. The navigation tasks are to find a safe and efficient route, to determine a position, direction and velocity of an object, and other movement parameters.

From compass to GLONASS

Since time immemorial, to determine their position on the Earth surface, people used the brightest luminaries including the Sun, the Moon and stars. During their rise, transit and set it is possible to visually determine the general direction of a movement. The invention of a compass allowed to solve the same task without paying attention what weather conditions and time of a day are. After the theoretical principles of celestial mechanics being developed and dedicated astronomical calendars being established showing the predicted positions of luminaries in the celestial sphere over a rather long-term period (a year and longer), the possibility to determine the position of an object on the Earth's surface emerged.

The invention of a wireless radio communication allowed to support an all-weather global radio navigation. Located all over the world, radio-stations emitting pulse signals (each station operates within the time interval individually allocated) establish a global radio navigation field for any type users equipped with receivers. This field only ensures the determination of a user's latitude and longitude with accuracy of several kilometers.

First generation of navigation satellite systems

The beginning of a space era allowed satellites to be used for the purposes of navigation determinations for various types of mobile - primary maritime - users. The methods of using satellites as radio navigation points were developed, and the ways of the relevant implementation were established. The first Soviet navigation satellite was launched on 23 November 1967. In early 1970s, full-scale navigation satellite systems each of 4 to 6 satellites were deployed in orbits.

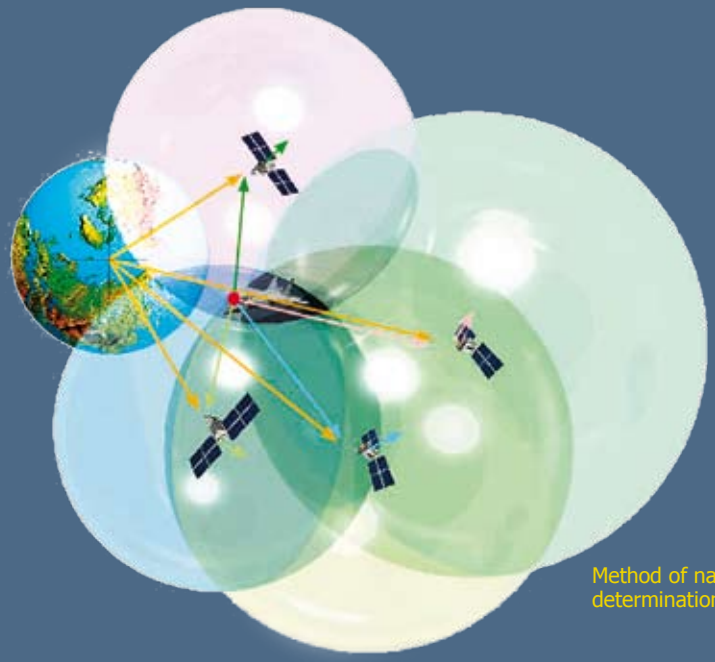
For the first navigation satellites the near-circular orbits with altitude of 750-1000 km and inclination of 74-83° were selected. Such an orbit enables a satellite, during 12 hours, to observe the whole surface of the Earth. As a result, the 1G satellite radio navigation systems arranged in an orbital constellation of 4-6 satellites ensured a global all-weather navigation (including determination of planned latitudinal and longitudinal coordinates) and transmitted time correction signals with a periodicity of about 90 minutes (on the equator) and accuracy of about 100 meters. In the polar areas, the periodicity of navigation determinations was 30 minutes.

The space systems of this type completely satisfy the demands in navigation determination for watercraft and some users on ground who only need to be provided with coordinates on the Earth surface (latitude and longitude) and do not require urgent navigation determinations. Space navigation systems use a Doppler method of navigation determinations with passive measurement mode (one way mode, without emitting user's signals), thus allowing navigation signals to be received by unlimited number of users equipped with dedicated navigation devices. Radio technical means of the ground control segment (GCS) ensure the measurement of spacecraft motion parameters and check coincidence of the on board time with the "ground" time. The measurement results are used to compute the orbit parameters and to predict the satellite motion along the specified orbit for several days in advance (ephemerids), and the on board clock offset level. The obtained ephemerid and time information is uploaded into the on board software program and then, with time passes, is transmitted within a navigation signal to a user. The GCS tasks also include the control of a satellite by radio commands or by time tag commands within the specified period of time, simultaneously monitoring the satellite status.

Navigation rescue satellites

The increased scopes and intensity of freight flow, followed with increased number of shipwreck and aircraft accidents provided for the necessity of combining the efforts of the world community in creating a global fast-acting search and rescue system based on the first generation navigation satellite systems. In 1977, scientific and research teams in the USSR, USA, Canada and France started developing such systems (COSPAS-SARSAT) (first satellites "Cosmos-1000" and "NOAA-8" were launched in 1978 and 1982; since 1989 Russian "Nadezhda" family satellites were launched). The sequence of the COSPAS-SARSAT space system operation was the following: a radio buoy heaved on a distressed ship sent a signal to the satellite being then retransmitted to the station nearest to the ship. At the

station the information was processed, the radio buoy coordinates were computed and transmitted to national centres, and then - to the search and rescue service. Since 1982, the system was commissioned including four satellites in the circular orbits with the altitude of about 1000 km. By now, several thousands of people were rescued with the help of the system above.



Method of navigation determinations

Second generation navigation satellite systems

The operation of the first generation navigation satellite systems, on one hand, demonstrated the potential capabilities of the space navigation and attracted attention of various users, on the other hand, detected the operational limitations of such type systems.

The second generation navigation satellite systems were designed to meet the needs of mobile user types including maritime, ground, aviation and space users. This was resulted in main requirements to satellite navigation systems, namely, global coverage area (Earth surface, near-Earth and space environment) specified; service to be rendered at any time whatever season, day or weather conditions are; provision of high-accuracy determination of spatial coordinates and velocity at any time. The first launches of 2G satellite systems were in 1978 (NAVSTAR satellites) and in 1982 (GLONASS satellites).

Totally, two second generation global navigation satellite systems were created including USA GPS - in 1993 and Russian GLONASS (GLObal NAvigation Satellite System) - in 1995. Today, 2G navigation systems completely substituted the previous systems. The cost of development of such multi-satellite systems is several billions of US dollars. In terms of major characteristics (accuracy, efficiency, availability, reliability), both systems are equivalent, the same for the operation principles.

The nominal configuration of the GLONASS orbital constellation comprises 24 satellites in orbits with the inclination of 64.8° and arranged in three orbital planes spatially separated by 120° (RAAN) (eight satellites in each plane). Within the orbital plane the satellites are arranged uniformly, in 45°; such relative position being maintained within the specified limits (±5°). The satellites in adjacent orbital planes are shifted versus the main plane by 15° for the latitude argument (in the orbital plane). The nominal revolution period of each satellite is 11 h 15 min 44 s (the orbit altitude is 19140 km) and is kept with high accuracy while satellite drifting to the specified orbital slot, using jet thrusters of the satellite. This approach allows not performing the further orbit correction over a long-term mission life of the satellite.

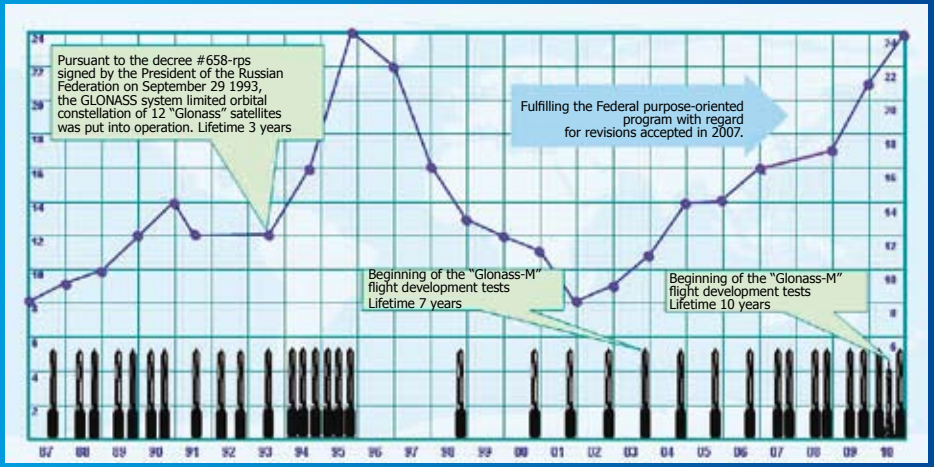
Initially, for the USA GPS the same orbital constellation arrangement was tested, however, then a new arrangement was preferred with six planes (inclination of 55°) each comprising four satellites in the orbit of 20200 km high. This difference in the orbital constellation arrangement is stipulated by the following factors:

- the GLONASS system provides the better navigation accuracy for the users in high latitudes, which is more preferable for the Russian users;
- the multi-satellite injection scheme (three satellites by one launcher) adopted for the GLONASS system is more economically attractive;
- usage of the ground control segment facilities located in the North latitudes accompanied with high-accurate ephemerid & time determination, is more effective in the GLONASS system.

As the main portion of the USA territory is located in the low latitudes, the mentioned advantages of the GLONASS system become the disadvantages for the users located on the USA territory. That is why the GPS system has quite different arrangement scheme.

Navigation signals radiated by GPS and GLONASS satellites have common features and significant differences in terms of the frequency ranges and the structure of the navigation information. To eliminate ionospheric errors within the ranging data, the satellites transmit signals in two frequencies, with that in each frequency there are transmitted two type signals, namely, of nominal and precise accuracy. The nominal accuracy signals are intended for civil users. The precise accuracy signals are modulated with a special code and are available to

The GLONASS replenishment and maintenance program



Spacecraft "Glonass-M"

special users only. To exclude interferences imposed by various on board electronic systems, their frequency ranges are separated. Simultaneous signal reception from four and more satellites is ensured by insertion of various characters used for signals transmitted by each satellite. The usage of various characters within GLONASS system is based on the frequency separation of signals, within GPS - on the code separation.

The space segment of the GPS system is continuously improved: the first NAVSTAR satellites Block-I (1978) and Block-ll (1989) were substituted with Block-IIF (2002) featuring better operational performances. Today, the new generation NAVSTAR Block-Ill is under development.

The GLONASS system is also the subject to the modernization. In accordance with the Federal Purpose-oriented Program "Global navigation system" (for 2002-2011), the system modernization shall be carried out in two steps. The first step covers the development of a modernized Glonass-M satellite, with the subsequent increase in number of satellites in the orbital constellation up to 18. The second step (2006-2011) foresees the creation of small-sized GLONASS-K satellites having small masses, with the subsequent increase in number of satellites in the orbital constellation up to the nominal configuration (24 satellites) being maintained with periodic launches of GLONASS-K satellites to replace the failed ones. In the orbits of 20000 km high, the satellites may stay for 1 million years, even after the end of mission life. The first GLONASS-M satellite (with other two GLONASS satellites) was launched on December 10, 2003. In October and December 2007, six GLONASS-M satellites will be launched. As a result, the GLONASS orbital constellation can be completed to 18 satellites and will provide navigation services to users located on the entire Russian territory.

The GLONASS-K satellites are the new generation of non-pressurized design satellites. They will have better mission performances and a mission life of 10 years. The launch of two GLONASS-K satellites is scheduled for 2010.

Capabilities of the 2G systems

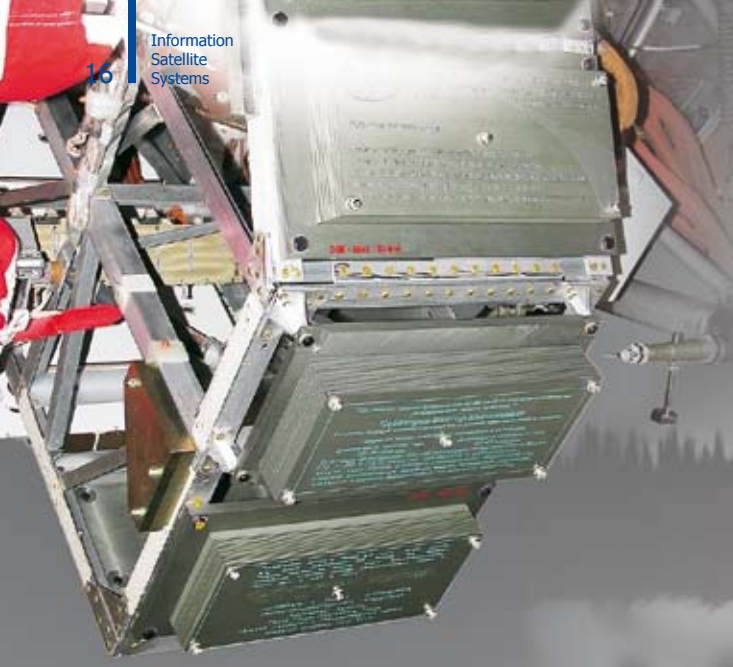
The high quality of the navigation determinations provided by the second generation space navigation systems enabled the navigation technologies to be internationally implemented into all transport means (maritime, ground, air, space vehicles) belonging to various agencies and ministries (civil and military). Today, as mentioned above, two global space systems GPS and GLONASS being compatible in terms of the quality of the navigation determinations provided are in use, intended for the needs of civil users as well. The main differences are in the technical implementation, algorithms of forming navigation signals on board a satellite, in time/coordinate reference systems, different signal frequencies and structures of navigation information provided to users. However, the design principles, architecture and types of the services rendered by two systems are very much alike. This allowed to combine two independently functioning systems together by developing an integrated GPS/GLONASS user equipment. With that, the efficiency of the navigation determination was improved as the combination of two orbital constellation resulted in the increase of the satellites within the visibility area, thus compensating the shielding effects occurred when a user is under arduous conditions (mountains, urban buildings). Besides, noise stability, accuracy (with the optimal number of satellites selected for use) and reliability of navigation signals were improved through the capability to reject satellites showing invalid navigation signals.

Despite rather high accuracy of navigation determinations (of 10m) ensured by both systems, they will be completed with functional augmentations in differential mode, today under development.

The functional augmentations comprise ground compensating stations placed in the locations with the known coordinates. They perform the ranging measurements to all visible satellites, determine differential corrections between the computed coordinated and the known ones, then transmit them to users. The differential mode allows to improve the relative accuracy of navigation determinations to 1-5 m (in the near field of a compensating station). Therefore, the method can be used to ensure the navigation determinations to aircraft near airports where maritime stations are located, etc.

Currently existing unified Earth radio navigation field created by space systems GPS and GLONASS, their differential augmentations, ground segments of short-range and long-range aviation, ensures high-accurate fast-acting global navigation determination of mobile objects of any type and grade, as well as a fast-acting geodesic reference to a terrain.

Providing users with navigation equipment and additional radio communications channel to a ground dispatch service allows to arrange fast-acting and reliable monitoring of flow of ground, maritime and air traffic. Release of affordable commercially available navigation equipment will allow everybody to become a user of space services, publicly available and free of charge.



These years we are enjoying new opportunities of traveling over the space. You shouldn't take it literally of course. But you should know: perpetuate your name or eternize your memory for the future civilizations, is not a dream anymore, it has become a reality... NPO PM and the Fund "In memory of M.F. Reshetnev" come forward offering the information plates - their production and installation on satellites "Glonass-M".

SPACE MEMORY

The INFORMATION plates are aluminum boards (120x260x1 mm) with letter-and-graphic information etched on their surface. The boards are assembled in piles. Number of boards in a pile varies to stabilize the whole mass of a satellite.

The assembled piles are positioned within an antenna unit in places preselected.

Installing the information plates on the navigation spacecraft, NPO PM solves a number of questions: first, the plates are made in order to perpetuate Russia, its role and place in the international space community; to underline the significance of the national space achievements including satellite communications, navigation, geodesy. Second, they are made in order to memorize the outstanding scientists and those who created space technologies that we use today, to represent the companies and their people who developed and applied those technologies and who are still working on them. Third, the plates are to get students and young scientists interested in developing space technologies.

NPO PM defines what kind of information lying within the range of its interests should be etched on the plates. It may be the information about the Earth, human civilization or about those people who worked or is still working on the development and exploration of the GLONASS system, or the information concerning aerospace-related education.

As a new payload is being developed a number of plates may become lesser, so placing an order for an information plate shouldn't be prolonged. Information about the plates installed on the spacecraft "Glonass-M" is here: http://glonass.npopm.ru/?cid=18

Four spacecraft "Glonass-M" launched in 2004-2006 had 23 information plates. Eight of them had the names of people working in the Corporation, who contributed to the development of these satellites.

The secretary of the information plates Committee and the design-engineer of NPO PM Victor Chebotarev said: "... installing personal information plates on the spacecraft with a long lifetime period - "Glonass-M", an idea itself, is very attractive. We were rather enthusiastic about the first interviews with the journalists standing near the satellite with the information plates installed... On two spacecraft "Glonass-M" launched this year (on the 26th of October) were installed 26 information plates (on the satellite #19 – 11 information plates and on the satellite #18 – 15 plates). One of the plates is dedicated to the 50th anniversary of the Space era".

Kristina USPENSKAYA

JSC “Research & Production Enterprise “Geofizika-Cosmos” (Moscow)

JSC “Research & Production Center “Polyus” (Tomsk)

JSC “Research & Production Enterprise “Kvant” (Moscow)

JSC “Research & Production Enterprise of Space Instrument-making” (Rostov-on-Don)

JSC “Siberian Devices and Systems” (Omsk)

JSC “Testing Technical Center - NPO PM” (Zheleznogorsk)

JSC “NPO PM - Small Design Bureau” (Zheleznogorsk)

JSC “NPO PM - Razvitie” (Zheleznogorsk)

JSC “Sibpromproekt” (Zheleznogorsk)

RESHETNEV COMPANY

After the documents on privatization are signed and a legal corporate body is registered, FSUE “Academician Reshetnev Research & Production association of applied mechanics” will become a head-company of the integrated structure “Information Satellite Systems”. The Corporation will comprise 9 more space companies.

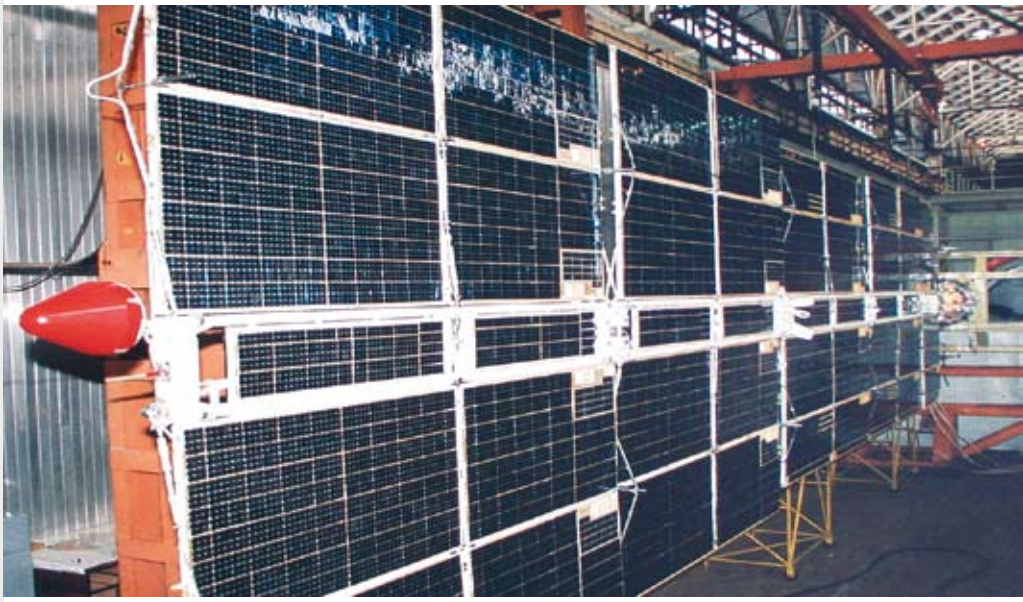
ONE TEAM

Semenov Valery Vasilievitch,
JSC "NPP Kvant", General director.

Born on the 17th of September in 1948. Candidate of economic science.

Has being working in space industry since 1963. Began as a metal-worker at the Lavochkin machine-building plant. In 1967 was called up for military service. Later came back to the plant. Worked his way up from an assembling metal-worker to a shop superintendent. Without discontinuing his work graduated the All-Union external institute of machine building in 1976.
During 1982-1987 worked as a leading engineer at the Administration Board of the Ministry of general machine building. In 1987 was assigned to Lavochkin NPO to fill a position of a chief mechanic, later on of a commercial manager and deputy general director.
During 2003-2004 held the position of STK "Soyuz" deputy general director (Moscow). In 2004 became a general director of the JSC "Kvant-N", since October 2004 has been working as a general director of FSUE NPP "Kvant" (in April 2007 announced as the JSC "NPP "Kvant").

Research and Production enterprise "Kvant" is one of the leading Russian companies developing the methods of energy conversion (chemical, solar, thermal) into electric energy to be used as a basis for the independent power-supply resources and diagnostic facilities widely used in different spheres of science, engineering and production.



ENERGY OF SPACE WINGS

The "KVANT" history began in 1919 when in accordance with the decree of the Central Engineering Administration Board of the Red Army, a former private workshop was rearranged into a production facility to manufacture galvanic cell and batteries. In due course, on consolidating the well-known All-Union scientific & research, design & development, and technology institute of power-supply sources (VNIIT) and a factory "Foton", the research and production enterprise "Kvant" became one of the largest Soviet enterprises. Most of their developments were applied to in practice. They went through serial production at five enterprises in Russia and some subsidiary companies in the Union republics.

Today, the "widely spread wings" of the Kvant solar arrays have become a constant attribute for most of national and foreign spacecraft. On the 4th of October 1957, Kvant happened to be among the first enterprises whose products were launched into space. The first satellite launched on that day, was equipped with a Kvant power-supply unit consisted of three arrays comprising silver and zinc cells. A month later, on the 3rd of November a second satellite was launched into orbit. It was equipped with various-purpose power-supply units produced by VNIIT (Kvant).

Further enlargement of the astronautics sphere required new power-supply sources that could maintain spacecraft for quite a long time without fuel consumption. The third satellite launched on the 15th of May 1958, was already

equipped with solar arrays developed by the specialists of the All-Union power sources scientific & research institute. The solution implemented was smart enough as for the most spacecraft the problem of power-supply was solved for many years in advance. Power-supply systems developed and manufactured by Kvant were also installed on "Vostok", the first manned spacecraft.

The next significant event took place on November 17, 1970, when "Lunokhod-1" (moon research vehicle) was transported to the Moon. It was the first vehicle in the world that had gallium arsenide solar arrays (developed by VNIIT), which could survive high temperatures (exceeding 150°) and provide an almost inexhaustible power-supply for a spacecraft. The space station "Salyut" launched into orbit on the 19th of April 1973, was also equipped with such arrays.

For almost a fifty-year history the "Kvant" solar arrays initially being small components with voltage of 1 W, later became high-powered (hundreds of kW) large panels intended for advanced space stations. Their design has also been improved. By now, the enterprise has developed and produced more than 2000 solar arrays intended for spacecraft of various purposes. The "Kvant" solar arrays were installed on "Salyut" and "Mir" orbit stations, unmanned interplanetary spacecraft, "Venus", "Mars" and "Fobos" family stations; and on a great number of satellites.

Today, "Kvant" contributes to several space programs with photo-energy subsystems, among which there are:

The Russian segment of the International Space Station, comprising "Zarya" and "Zvezda" modules equipped with array cells featuring with two-sided sensitivity;

Platforms for GEO satellites "Sesat", "Express-A", "Express-AM", "Kazsat";

Earth remote sensing and meteorology satellites "Monitor-A", "Meteor-Z" and many others.

Due to its large scientific and manufacture experience and capabilities, the enterprise has become a leader in several directions of the autonomous power engineering. The range of a product development and manufacture is extremely wide. It includes solar cells and arrays, used on spacecraft; autonomous ecological photoelectric elements intended to ensure power supply to various ground users; thermal-electric conditioners for railway vehicles, trucks, and subway.

Besides, "Kvant" developed a large number of single-shot chemical current sources, including sources with long conservation period and momentary activation, as well as multi-shot chemical current sources with additional charging (cells) or mechanical replacement of electrodes. The enterprise produces ecologically approved permanent chemical power generators with constant supply of gaseous chemical fuel cells intended for electric buses, submersible craft and stationary plants. The specialists of the company created combined systems of independent electric power supply systems for the hard-to-reach regions, and electric drive systems for electric cars. Most of the here-created products have no analogues in the world.

Today, "Kvant" is an active participant of development programs concerning alternative power supply systems to be used during Olympic games in Sochi; cooperates with "Transmashholding" company that is going to set a fuel cell electric module for the railway to carry passengers round Moscow. "Kvant" has also presented its own design of this kind of transport.

Following the long-term traditions the research and production enterprise "Kvant" is keeping on to combine progressive technologies with such everlasting values as responsibility, quality and reliability.

Vladimir Nickolayevitch Gladushchenko
JSC "RPC "Polyus", General director

Born on the 23rd of June in 1948, in Tomsk city. In 1972 graduated Tomskij polytechnic institute with specialization "Electric networks and systems".

His whole life is tightly bound up with "RPC Polyus". It was here that he began to work as a test-electrician, later became a junior research assistant, senior engineer, head of sector, head of department, general director deputy for common aspects, general director deputy in management, economics and finance, acted as a general director. In April 2006 Vladimir Nickolayevitch Gladushchenko became a general director of the enterprise.

HIGH TECHNOLOGY PRODUCTION of the JSC "Polyus"

JSC "Research and Production Center "Polyus" was firstly established in 1951 as the Tomskij subsidiary enterprise of the All-Union research and development Institute of electro mechanics (TF VNIIAM). For 56 years the enterprise has created hundreds of space devices for different purposes among which there were the set of on-ground monitor and test equipment used in 1961 during pre-launching works for the first earth astronaut flight (Y. Gagarin); unique on-board devices designed for self-acting spacecraft and manned space stations.

In 1957 the traditionally used electric machine on-board power resources were substituted by semi-conducting ones. Supported by the leading research institute, the idea was realized by "Polyus". Therefore in Tomsk appeared a scientific-and-technologic basis together with manufacture of energy electronics applied to self-efficient plant control precise systems. This experience became the basis for developing a number of devices, including the on-board triple-phase inverter providing power-supply to the control system of the launcher "11K65". As a result, the produced part became the first step towards a long and resulting cooperation of "Polyus" and "NPO PM".

During 1960-63 the TF VNIIAM participated development of a wheel actuator designed for the first World electro mechanic attitude control system installed on the VNIIAM experimental satellite "Omega". Concerning the results of the mentioned above works, VNIIAM started developing wheel-engines "126M2», which were first applied to meteorological satellites "Meteor-1" and "Meteor-2".

Later there were developed and successfully put into operation wheel actuators 17M71, 14M425, 14M240 for the GLONASS system satellites, gyro-stabilizing devices 11M231, 17L21, Agat-5 for geostationary satellites.

Today the gyrodines14M340, GD-2-20 are being developed. The devices being produced during last years can operate on spacecraft with unsealed platforms; obtain multiplex data transmitting channels and high-performance technical characteristics.

Due to the RFP from the Central Special Design Bureau (Samara) in 1966-1967 the enterprise started developing the crystal-controlled driving oscillators and devices to provide power-supply to the attitude determination and control systems of the spacecraft "Zenit". In 1968 they completed test and design works relating to charge control devices. The devices were designed for the primary power supply resources of the "Zenit" family spacecraft that is still produced.

According to the RFP form NPO PM, in 1976 the enterprise started developing a system that would comprise automatic equipment, power supply and pulse light warning devices to be used for a geodesy navigation satellite. The system could provide a celestial geodesy global chart displaying the coordinates with accuracy up to several meters. At the same time they created a new onboard power supply system revealing new functional capabilities, high reliability, new mass and clearance characteristics. Here for the first time in the world were used nickel-hydrogen batteries. The enterprise specialists created a completely new complex of automatic and stabilization devices to be applied to the system.

In 1979 they started developing a unit that included energy converting equipment of a spacecraft power-supply system. The system was designed for the satellites comprising the Russian navigation system GLONASS.

In 80-s the enterprise unveiled a new scientific-and-technological aspect - creating power-supply and control systems (PSCS) for spacecraft propulsion units. Looking for original scientific methods of engine power-supply, optimization of spacecraft propulsion and attitude determination systems, forming a complex of technical specifications – all this favored to effective operation of PSCS with electro jet propulsion units with an impulse plasma engine basis. As a result the resource capability increased 5 or 7 times. Since 1990 this system was implemented for the "Gals", "Express", "Express-A", "Express-AM" satellites.

After NPO PM had signed a contract with Eutelsat (the European satellite communications organization) "RPC" Polyus had to study international quality standards concerning creation and qualification of a product. The enterprise specialists developed an angular velocity instrument and a gyro actuator device used in attitude determination and control systems of the Sesat spacecraft, also in power-supply and control systems of electro reactive propulsion units. Besides they created effective one-shot short-circuit devices just for the Sesat storage batteries. In 2006 "Polyus" developed and produced a technological prototype of a PSCS with conductive heat rejection.

One of the most interesting research works being carried out here - is creating charge and discharge devices for the lithium-ion storage batteries. To further develop one of the main scientific-and-technological aspects, the electro wheel actuator device and the gyroscopic stabilizing device are being developed to provide high accuracy of spacecraft orientation. More over "Polyus" has made the initial design of controlled parametric wheels and gyrodines. This initial design will make a basis for further investigations related to attitude determination system of different spacecraft, including controlling wheel-engines for micro satellites.

Today the main activities of the enterprise related to space application are experimental development, production and delivery of:

- electro mechanical actuator devices for attitude determination system and gyro angular velocity instrument;
- adaptive autonomous power-supply systems' regulation-and-control equipment;
- plasma engine of orbit correction PSCS;
- power converters and synchronizers for control systems of autonomous units;
- dedicated actuating electric engines and electric drivers;
- dngular and linear displacement sensors.

Motin Vyacheslav Nickolayevitch,
JSC "RPE SI "Kvant",
General director and
General designer.

Born on the 23rd of October in 1937, in Ikryanoe village (Astrahkanskaya oblast).

Graduated military air-technical school, National economy institute of Rostov, took post-graduate courses at Donskoj State Technical University.
Academician, full member of the Russian Engineering Academy, academician of the International Real Economy and informational support Academy. Head of the regional department of the Russian Engineering Academy.
Published more than 50 research works.
Awarded with the Badge of Honour, Order of the Red Banner of Labour, Order of Friendship, title of Honoured Engineer of the Russian Federation.

JSC "Research and Production enterprise of space instrument-making "Kvant" ("RPE SI "Kvant") is a winner of "Russian National Olympus" award, "Odyssey" award established by "Kontenant" Academy and "European Standard". Several times the enterprise competed with other enterprises of the south federal district and won the "the Leader of the XXI century" prize.

JSC "RPE SI "Kvant" FACES THE FUTURE WITH CONFIDENCE

The STORY of the enterprise goes back to the 11th of August 1980, the day when was established "Kvant" – a plant producing electro-optical devices for spacecraft orientation and astronavigation systems and included into the research and production enterprise "Geofizika". In 1994 the enterprise was announced as a joint stock company.

Among the main activities of the JSC "RPE SI "Kvant" there are:

- development, production and warranty service of electro-optical devices for spacecraft attitude determination system;
- desearch-and-development works relating to electro-optical device production in favor of the Russian space program;
- production releases for manufacture, technical and special purposes;
- production of large-scale consumer goods.

The JSC "RPE SI "Kvant" has the following structure:

- scientific-and-technological center comprising 4 research-and-development departments, an experimental laboratory, automated control systems department;
- production basis – the main production workshops (mechanical, optical, galvanic plating), assembly shops, devices test and adjustment shops.

Today the enterprise produces 22 types of electro-optical devices for spacecraft attitude control systems.

The devices produced by "RPE SI "Kvant" are installed on such spacecraft as "Glonass-M", "Gonets", "Arkon", "Koupon", "Express", "Ocean", "Nadezhda", "Resource", "Molnia-3", "Bion" and also on Russian modules of the International Space Station, on board of manned

and transport spacecraft ("Soyuz-TMA", "Progress-M"). During its work the enterprise produced more than 2800 spacecraft attitude control devices, 64% of which are earth acquisition devices, 33% - sun acquisition devices, 3% - polar star acquisition devices.

The quality of the devices was proved by long experience of using the devices on manned space stations and spacecraft. For example, the attitude control devices installed on board of the orbit space station "MIR", exceeded their lifetime period 2,6 times. In 2004 the JSC "RPE SI "Kvant" was certificated (#134.01.3.1.000000.25.04) by the Federal system of space equipment certification which again approves its high quality of production. Within the terms of its research-and-development activities the enterprise keeps in close contact with such prominent companies as "Reshetnev Research and Production association of applied mechanics" (NPO PM), the "Rocket and Space Corporation "Energia", "Lavochkin Research and Production Enterprise", "Central Specialized Design Bureau "Progress" ("CSDB "Progress") and others.

Most of the projects developed in scientific-and-technological center were applied to in practice. For example, a production line of transportable ecological optical devices for liquid medium express-analyses, which are used to control reservoir and sewer pollution. In Rostovskaya oblast they use the taximeter developed and produced by the JSC "RPE SI "Kvant". The taximeter not only counts fare but also regulates taxi work schedule.

370 equipment units represent the enterprise production base, where 25% of equipment was imported. Complex regulating and testing are carried out at the specified test bench with automated control systems. There has been put into operation the first line of multifunctional system, which is used to automate design, production and test operations.

The JSC "RPE SI "Kvant" also possesses technologies of parts precise machining, high performance optical parts producing, protective coat plating (special optical, galvanic, varnish, paint), device assembling and adjusting.

Today the JSC "Kvant" is a dynamically developing enterprise. In order to enlarge its space market share the specialists from the scientific-and-technologic center of the enterprise are developing a line of spacecraft attitude control devices of a new generation, which are equivalent to foreign analogues at space technologies markets. The enterprise is also actively developing a line of static devices providing satellite Earth orientation at altitudes of 140-40000 km, and static devices providing satellite Sun orientation. The microbolometric modules and photo sensible CCD scale work as radiation sensors. The information about an object angular position is transmitted in figure code mode, due to 2 coordinates. Accuracy of coordinate determination is 2 angular minutes for Sun sensor and 1 angular minute for Earth sensor. The device lifetime period is not less than 15 years.

The enterprise potential allows to carry out research-and-development works, theoretical researches, tests of new samples, creation of automated systems providing tests and control of quality of a product. The enterprise went through reconstruction and establishment of a new instrument manufacture producing complex high performance tooling with imported equipment. The enterprise has prepared the investment project "Metal and plastic construction manufacturing" that was financed by the enterprise itself.

To further realize new projects relating to all activities of the enterprise, the JSC "Kvant" possesses all necessary: qualified personal, a well-functioning management system, stable infrastructure of the region, reliable partnership with customers and providers, cooperation with leading regional universities and research institutes.

Start of GLONASS

The GLONASS ideology

Navigation system development has always been an indispensable condition to provide defense capabilities of the country. The first navigation spacecraft "Cyclone" produced by request of the Soviet navy forces was launched in 1967. Satellite-based navigation made sailing more secure and ballistic missile data more operative and accurate. The navigation system could provide positioning data within the limits of several hundreds meters. Nevertheless the requirements to space navigation were constantly increasing. In the mid of 70-s there appeared an idea of creating a navigation space system to the favour of defense capability of the country as well as its national economy. Comparing with the previous satellite-based navigation system a new one should provide more precise characteristics and the most complicated thing – the continuity of service for the earth users and objects in the near-earth space. Today navigation receivers are used in cars even in cell phones, so it's difficult to imagine how hard it was to create such a system in late 70-s.

A group of young specialists from NPO PM was entrusted with the project development. The NPO PM specialists proposed more than a hundred of variants for the GLONASS system design. But the final variant was confirmed by Grigorij Chernjavskij, at that time NPO PM deputy general designer. NPO PM first deputy general designer Victor Kosenko remembers: "When he was hospitalized he took a huge pile of proposals with him. He analyzed every variant and commanded right from the hospital: which structure of the GLONASS system should make the basis".

The project envisaged creation of a constantly operating orbit constellation at altitude of 20000 km, which should comprise 24 satellites of the GLONASS system. The constellation was planned to determine an object po-

After implementing the GLONASS system

sitioning within the range of 4 spacecraft. It could provide data relating to positioning, direction and speed of a moving object. Concerning the fact that the GLONASS system should provide more accurate estimations than the "Cyclone" they needed to install more user equipment with special quality control requirements. To maintain a large space constellation in action there was created a system that injected into orbit a cluster of 3 spacecraft with a powerful launcher "Proton".

Cooperation

The GLONASS system design works were carried out by a group of specialists under the leadership of Vladimir Cheremisin. He figuratively called his colleagues, Victor Chebotarev and Georgij Kim, "the chief theorist" and "the chief architect". The position of a leading engineer was given to Evgenij Grigorjev, by that time he had had a good experience of carrying out development works.

In late 70-s the working group released draft design, preliminary data, design documentation, main requirements for development of the spacecraft subsystems. Soon they started preparing for manufacturing. After having assessed capabilities of the Mechanical plant that could efficiently produce a large number of satellites needed for the System and guarantee the fulfillment of the program, the administrative board decided to hand over the satellite production and design documentation development to the Production Enterprise (PE) "Poljot" (Omsk). No one could think then that in 10 years NPO PM would have spare facilities, which would be enough for manufacturing the navigation spacecraft. Many years later when NPO PM started striving for building new navigation spacecraft with a long lifetime period Mikhail Reshetnev would cticisize the decision to hand over the works to the PE "Poljot".

So the design bureau "Poljot" started releasing the drawings, the plant – producing spacecrafts. NPO PM developed antenna feeders and a number of units, and increased spacecraft lifetime period up to 3 years, later up to 5 years.

In the mid of 1980 NPO PM began to receive assembly units to provide ground development tests. As the first tests showed: the configuration, particularly the mechanical subsystems (shutters control linkage, solar array panels hold-down and release devices) were of low quality. To save the situation Mikhail Reshetnev commanded to the NPO PM specialists who worked on mechanical subsystems, to settle down to works the NPO PM designers. In spite of the selfless work of the designers and test engineers from Krasnoyarsk and Omsk, they couldn't keep to the development schedule. But the developed spacecraft were completely different from the first prototypes that came to Krasnoyarsk-26. A great part of development works was carried out by working groups of V.I. Khalimanovitch and G.M. Sokolov.

The 4 meters high construction comprising 3 spacecraft (each spacecraft 1400 kg) was installed on a common separation system. The satellites were installed very close to each other. They needed large spring rates to protect the construction at the stage of payloads impact. The NPO PM specialists carried out a number of works to implement new, high-modulus composites into space technology. These composites are still often used in spacecraft structures.

The separation subsystem's truss was made of boron aluminum. Its weight was 30% less than aluminum truss; it complied with spring rate requirements and unexpectedly turned out to be a good attenuator smoothing all sud-

Kazeev Vasiliy Romanovitch,
NPO PM leading engineer

In fact we were pioneers in creating the first satellite of the planned global navigation system. "Navstar" – an American navigation satellite could be an analogue for our spacecraft. But we had a different technological basis, package performance (American devices could work in the open space), launching vehicles. So there was nothing we could borrow from American systems and we had to go our own way. When working on the spacecraft design we were like competing with the Americans. We were trying to make a better spacecraft than the American "Navstar". The specialists of the design department and the group chief G. Kim were the main pace-setters.

In the process of building "Glonass" satellites our specialists came upon new engineering solutions, which further were applied to other spacecraft. For instance, our working group came upon such solutions while creating the temperature control system.

Since the "Glonass" satellites were planned to launch in a cluster of three spacecraft with one launch vehicle, we laid down strict requirements for the spacecraft mass and dimensions. Concerning the level of spacecraft heat dissipation, the traditionally used system of gas-liquid contour required a spacecraft mass of 120 kg. To decrease the mass and preserve temperature conditions, we decided to install the most heat-tensed equipment out the container with direct radiant cooling of the equipment cases. In result the spacecraft temperature control system mass was diminished up to 40 kg. This solution was further applied to the satellites of "Loutch" and "Glonass-M" families.

It was for the first time that during the spacecraft development we set and solved a problem of gas temperature stabilization ±1°C in spacecraft pressurized container, which influences atomic frequency standard.

I'd like to mention the people who contributed a lot into creation of the temperature control system: O. Zagar, G. Panov, V. Shramko.

denly-applied vibration loads. Development of this kind of material and using it in construction-building became possible thanks to K.G. Smirnov-Vasiljev, G.M. Sokolov, A.M. Poskatchej, F.K. Fedoseev and other specialists.

Spacecraft launch

On the 12th of October 1982 the first Glonass satellite was launched into orbit. TASS reported: "on the 12th f October 1982 the Soviet Union launched artificial earth satellites "Kosmos-1413", "Kosmos-1414", and "Kosmos-1415" All three satellites were injected into orbit with one launcher. The satellites are to provide development test of the parts and equipment of the space navigation system. The system was created to determine positioning of civil aviation aircrafts, navy transport and fishing-boats of the Soviet Union".

Since only one spacecraft was ready for launching, two other places in the carrier-rocket were given to the cargo simulators, which confused the American specialists.

Victor Kosenko, the first deputy general designer tells: "in American press there appeared articles telling that Russians had launched some unknown objects: one satellite and two secret objects. They couldn't get the idea of those simulators for quite a long time".

After the spacecraft launch they started long-term flight-testing and developing the Glonass positioning systems. When the first Glonass satellite was being developed the most difficult tasks were solved by the group of specialists under leadership of Yurij Knjazkin. The equipment produced by the co-operating plants wasn't enough developed, it often failed in orbit. Possibly it was the main reason of prolonged test works.

Later the specialists would have to strive for spacecraft building, to search new technical solutions, to provide new spacecraft launches. In early 1991 they signed up the statement concerning the end of the GLONASS flight-testing, though the resolution project of putting the system into action was rambling different courts for two years. In September 1993 the President signed the resolution without gratitude or appraisal. At that time the system didn't receive a proper rating.

It is today that recovery of the system, either its modernization or development, focuses much attention. Very soon the GLONASS system will make a basis for the informational and digital space, which will push Russia forward in development of economics and technology, and provide defense capabilities of the State in new conditions.

Natalia VNOUKOVA

Based on materials of the books "40 Space years", "Academician M.F. Reshetnev" and the film "Space navigator"

Lyashenko Valerij Polikarpovitch,
NPO PM chief of section:

The first "Glonass" satellite was launched on the 12th of October 1982. It was an important step forward in development of the enterprise. Certainly by that time we had been experienced in making and operating the navigation systems that were based on automatically operated low-altitude spacecrafts "Cicada" and "Cyclone". But "Glonass" was completely different from the previous spacecraft. In fact it required a new ground control system, including several ground control points of command-measuring systems, central synchronizing system and a new GLONASS control center based on a complex of two computers (EC1033). We needed to develop new software to treat the telemetric information, control the satellite, and solve ballistic tasks. It took military and civil specialists almost a year to assembly the equipment, install and adjust software, carry out preliminary complex tests in the GLONASS system control center, train the personnel. All the works were carried out under leadership of Y. Knjazkin. The spacecraft "Glonass" # 11 was accurately prepared for launching. Possible abnormal situations were discussed, including failure of construction parts deployment, spacecraft orientation problems and others. At that time there was an operation-and-technical support group and our specialists could be sent there to work for months. Once NPO PM sent its 60-70 specialists to the GLONASS system control center to carry out prelaunching works. The team comprised the people specialized in all spacecraft systems and software development. The team included department chiefs responsible for each system: G. Titov, A. Bober, G. Evenov, G. Kupfer. At that time there weren't any automated systems connecting NPO PM and the GLONASS system control center and every decision had to be taken right there, at the system control center.

Spacecraft control and data analyses works were carried out under the leadership of B. Nickolayev. We worked in one sector together with the specialists who provided electric tests at manufacturing plant. The situation gave us advantages: we had a chance to investigate the spacecraft and understand how it worked.

Successful operation of the spacecraft during the first communication sessions confirmed that a great number of people hadn't worked in vain: we managed to maintain spacecraft communication, receive and process telemetry; and the spacecraft was successfully sun and earth oriented. Though later we had to complete development works, correct numerous mistakes revealed during on board and on Earth operations, but we had done the most important thing: started creating an extremely needed space system.

The 25th

anniversary
of the first
“Glonass”
satellite launch

Recovery, modernization and development of the Global Navigation Satellite System GLONASS is one of the priority tasks of the Russian space industry.

http://glonass.npopm.ru

GLONASS – the system that has won the international recognition!