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GALILEO PROJECT IN AMERICA-EU-RUSSIA RELATIONS

The impact of the *GALILEO* project on the relations between the United States, the EU and Russia should be discussed in the context of the geostrategic situation and military balance. That is why this article looks at the growing role of space and its impact on future military capability of the leading nations.

KEY ADVANTAGES OF SPACE CAPABILITY IN A MULTIPOLAR WORLD

The world is going through a period every bit as momentous as the late 1980s-early 1990s, which saw the collapse of the world order dominated by two superpowers – a bipolar world. The reign of a single superpower that came to replace it – a unipolar world – is now beginning to crumble. But the new world order that is now taking shape can best be described as "dynamically unstable"[1] rather than multipolar.

The leading nations are ramping up their military spending,[2] which, according to the Stockholm International Peace Research Institute (SIPRI), surpassed Cold War levels in 2006.

The old idea of creating a large-scale missile defense system is gaining traction among the American politicians and top brass, while the European nations are pondering a similar system for their own region. The reason for that, it seems, is recent breakthroughs in information and space technology, rather than the proliferation of missile technology itself.

Given all this, the new American space strategy[3] adopted in 2006 deserves careful study.

The situation in space exploration is quite unique. Space is becoming ever more important for the United States. Global economic interests in a globalizing world require real-time global control. For its part, such control requires an accurate monitoring system on a planetary scale, including near-Earth space, which enables rapid decisionmaking and swift action. This kind of system can be deployed only in space. And interest in this system has been coming mostly from big business – that is why it is chiefly the private sector that has been funding space programs in recent years, not the government or the Pentagon. But big business always requires defense – and in this particular case, it is space defense we are talking about.

The Pentagon, however, also has important interests in space. The Department of Defense primarily requires the information component of these space systems, most of which are funded by the private sector. The hopes of transforming the American armed forces depend on making use of the information potential of space systems.

A global space-based information and control super-system is required to implement the fundamental idea of network wars.

Careful study reveals that the modern American space program is not just a set of separate systems, each serving its own function. It is in fact a unique information super-system making use of the synergies between its individual elements.[4]

For example, the Russian *GLONASS* can never achieve the military capability of the American *GPS* system, because *GPS* is part of an overarching super-system, while *GLONASS* is just a separate hi-tech system.

This space-based information super-system offers America a new global competitive edge, and it was achieved thanks to America's competitive advantages in other areas such as finance and technology. The new American national space strategy aims to reinforce this new competitive edge and make use of it.

SPACE TURNING INTO KEY PLATFORM FOR FUTURE WARFARE

The leading nations of the world believe that the idea of network-centric warfare based on global information capability will be at the core of the armed forces of the future multipolar world.

The essence of network warfare is making use of superior information capability and networked military formations to achieve victory rather than relying on sheer numbers or superior firepower.

In a network war, the combat field is transformed into a new combat space. In addition to traditional targets for conventional weapons, this space includes new virtual targets such as emotions, perceptions, the mind of the enemy, etc. Network warfare is impossible without global communication between geographically dispersed combat units that work as a single network rather than relying on the traditional top-down command system. Making use of space capability to create a global communication system is the best way of turning information superiority into military superiority, by linking intelligent objects into a single information system on the theater of military operations.[5]

The first space system that can be classified as a true system (a system that has reached the limit in at least one characteristic) is the Space-Based Radio Navigation System (SRNS) based on a layered and differentiated fleet of satellites.[6]

Once this navigation system becomes part of the weapons control circuit, all the connected weapons systems immediately become true systems. The effects of that will become ever more significant as space communication, relay and information-gathering systems reach their full potential.

This process marks the beginning of the formation of a new information-warfare technosphere of true multi-level weapons systems.[7]

The U.S. leadership believes that America's experience in information warfare will enable it to make a big step forward in shifting the strategic balance of forces in America's favor.

It must also be taken into account that the orbital fleet of each space-based information system that becomes part of the information-warfare weapons control circuit must have at least three layers. So it is no coincidence that the United States plans to deploy more than 1,800 satellites over the next decade.[8] However, using only military satellites for that purpose could be undesirable for economic and diplomatic reasons.

The alternative to that is the dual-purpose space-based information systems which, in addition to their civilian and commercial uses, also serve the needs of the military. The potential for such dual use of these systems has been repeatedly demonstrated, and to great effect, during the local wars and armed conflicts of the late 20th and early 21st century.

That is why America's new strategy of using its space forces includes the concept of "global partnership" in addition to "control of space", "global power projection" and "full integration of the armed forces." This concept is based on pooling the capabilities of civilian, commercial, scientific and international space systems to boost America's military space capability.

The space effort is also helping the spread of information technology around the globe. Nations are deploying expensive systems in orbit, which constitute an important part of their national infrastructure.

The scale of this effort is illustrated by the fact that roughly 180 nations are participating in some kind of space-related projects.[9] About 40 of them are working on developing military uses of space technology, 30 have their own national space programs, and 19 have the facilities and technology to build their own space vehicles. But apart from Russia, only the United States, France, China, Japan, and India have the kind of space infrastructure that is required for independent exploration and practical use of space.

The world now has a total of about 700 satellites in orbit, worth billions of dollars. A large part of those is military satellites. More than a thousand companies around the globe are involved in the space sector. Massive amounts of money are being spent on military space programs – $21 billion a year in the United States alone. The spy satellite program accounts for about 20 percent of that figure.

U.S. experts are reviewing the forecast for the total number of satellite launches made in the U.S. Space Command 's "*Vision for 2020*". They now believe that a total of 2,200 payloads will be put into orbit in the next decade rather than 1,800.

Space is becoming a serious and profitable multi-billion-dollar sector, and the platform for the armed forces of the future.

EU – NEW POWERFUL PLAYER ON GEOPOLITICAL ARENA

During the 1990s, European nations saw no real reason to worry about their own security. The Soviet threat had disappeared, and NATO was taking care of long-term strategic tasks. Not until 1999, when the Kosovo crisis broke out, did the Europeans remember about the so-called Petersberg tasks, and put the idea of a European armed force back on the agenda.

The central element of the European security and defense policy is the creation of an efficient command system for the European rapid reaction force. The EU Council of Ministers also approved the creation of the Military Committee and Military HQ of the European Union.[10]

In June 2003, following a request from the United Nations, the EU sent 1,800 servicemen into the Democratic Republic of Congo. The operation, codenamed *Artemis*, became the first precedent of the EU using its military strength outside the European continent.

Although the creation of a rapid reaction force became the first common European military initiative, it is still a far cry from a true European army. The national governments still retain command of their own forces in the European rapid reaction force, and essentially the EU member states are merely allowing Brussels the use of their own troops. Meanwhile, the EU is increasingly becoming a single state, and the creation of a proper European army at some point seems inevitable.

That necessitates a change of emphasis for the European space effort from research and commercial space launches to military applications. The key requirement for the new European space strategy is ending the dependence on the United States and preventing other competitors from building their own space infrastructure.

The *GALILEO* program is the first practical step in this effort. Proposed by the European Commission and the European Space Agency (ESA), the program is designed to build Europe's own global satellite navigation system that would compete primarily with *GPS*.

The EU Council of Ministers approved the decision to build a civilian satellite navigation system in February 1999.[11] The new program, with a budget of €80 million, was soon named *GALILEO*. The total cost of the fully deployed system (30 satellites and the ground segment) is estimated at €3.8 billion.

The project's official aim is to facilitate the development of a new generation of international services in transport, telecommunications, environment and maritime navigation.

But few were deceived by the proclaimed *humanitarian* purpose of *GALILEO*. Although the system is designated as civilian, its specifications are designed for military use. America's *GPS* system and Russia's *GLONASS* were also designed primarily for military purposes. Even now the American armed forces consider *GPS* to be one of their key advantages in modern warfare, enabling them to use reliable and relatively inexpensive precision weapons.

The geography of the nations involved in *GALILEO* is not confined to the European Union. China, India, Ukraine, and Israel have already become active participants in the project. Negotiations are under way with Argentina, Morocco, Mexico, Norway, Chile, South Korea, Malaysia, Canada, and Australia.

The EU and other nations who want their own place in the sun need their own space capability that is not dependent on the United States or Russia. France's former president Jacques Chirac reflected the prevailing mood among the project's participants when he said back at the start of this decade that *GALILEO*'s failure would eventually turn Europe into an economic vassal of the United States. "We don't like monopolies," was the EU leaders' response to Washington's attempts to block the project.

Despite Washington's assurances that the existence of the American *GPS* (*NAVSTAR*) system makes *GALILEO* redundant, the Europeans and their partners in the project are rightly concerned by the possibility of being made hostage to the sharp turns of America's foreign policy. The United States reserves the right to switch the system off or degrade the accuracy of its positioning signal over those regions that it deems "problematic" – the *GPS* system has that functionality built in.

Analysts say the global satellite navigation market will continue to grow over the next decade. According to the Center for Industrial Economics and Knowledge at the Taiwan Institute of Technology Research, the total satellite navigation market will be worth $10 billion by 2010, and then pick up the pace even more to reach $750 billion by 2017. The size of the market was estimated at about $3.5 billion dollars in 2003.

PricewaterhouseCoopers, and international consulting agency, estimates that the project's yield ratio over a 20-year period will be 4.6 – much better than any other large European infrastructure project. *GALILEO* is expected to create more than 100,000 jobs and support a market for equipment and related services worth some €9 billion.

GALILEO will be run by a civilian agency. However, in addition to the mass market consumers and commercial customers it will also be used by special high-level customers such as the police, the emergency services, etc. That suggests that in addition to the open signal, *GALILEO* will also have a restricted signal, just like America's *GPS* or Russia's *GLONASS*.

Developers are also mindful that over the past few years the emphasis in navigation services has shifted from aviation and shipping to land transport.

There are also numerous non-transport applications for *GALILEO*, including agriculture, sea shelf and open seas exploration, land surveying, etc. The market for an accurate timing signal service, used primarily by the telecommunications industry and for accurate frequency alignment in powerful energy systems, also holds great promise.

In civil aviation, *GALILEO* is expected to augment air traffic control, reduce travel time, improve airport access and generally facilitate more efficient use of aircraft and ground infrastructure. The system will meet the CAT-I precision approach and landing requirements in most airports, improve safety and substantially reduce the cost of the ground infrastructure.

The macroeconomic benefits of *GALILEO* include sales within the EU, exports to other regions and services that will create jobs within the European Union. Experts have looked at two scenarios for Europe – using *GALILEO* along with *GPS*, and relying solely on *GPS*.

They found that the use of *GALILEO* will give Europe greater social benefits. Cutting journey time for land transport by just 1 percent will ease congestion, reduce pollution, cut the number of traffic accidents and provide other benefits worth a total of €200 billion.

The European Global Navigation Satellite System (GNSS) will be implemented in two stages: GNSS 1 and GNSS 2. The first stage includes the creation of the European Geostationary Navigation Overlay System (EGNOS), which will offer the same services as *GPS* and *GLONASS* up until 2015–2018. GNS 2, which is the main part of the project, is based on a new satellite constellation named *GALILEO*. The satellites were supposed to be deployed in 2007–2008, but there are only two that has been put into orbit so far, and even those satellites' signal access codes have already been hacked.

EGNOS offers improved *GPS/GLONASS* navigation (thanks to the addition of *GPS*-like signals generated by geostationary satellites) and timely reporting on the reliability and accuracy of the signals. Improving service in an individual geographic region is achieved with the help of an additional satellite (which is redundant to a certain degree). It sends a signal in the L1 band, available around the globe apart from the Polar regions.

The EGNOS orbital fleet consists of three Inmarsat-3 satellites, which will be equipped with a transparent transponder of navigation signals working in the C/L Band (6.4/1.5 GHz) on 1575.42 ± 2.2 MHz. It will transmit the C/A code, navigation signal and satellite constellation health status.

The navigation complex of the EGNOS system is far simpler than that of the *GPS* or *GLONASS* satellites. The C-band signal sent by the Inmarsat-3 satellites is received by the system's ground control stations. The L-band signal is received by *GPS/GLONASS* users. The additional navigation signal improves availability, while information about the integrity of navigation messages improves reliability and accuracy.

The structure of the EGNOS signal guarantees that the risk of loss of integrity will be below 2x10–7 at any given 150 second interval, while the maximum time-to-alarm will be no more than 6 seconds (loss of integrity is the inability of the system to alert the users in a timely manner about the possible inaccuracy of the signal). The estimated risk of interruption of the service is 10–5 per hour (uninterrupted service is defined here as maintaining functionality and quality of the service within specifications throughout the whole period).

GALILEO was designed to be interoperable with other communication and navigation systems, which is especially important when signal reception is poor or when additional information needs to be transmitted. *GALILEO* can be integrated with the Loran-C and EUROFIX terrestrial navigation systems, as well as the space communication systems which have their own positioning subsystems (*Globalstar, Orbcomm*), and wireless communication standards (*GSM, UMTS*) that store information about the handset's location.

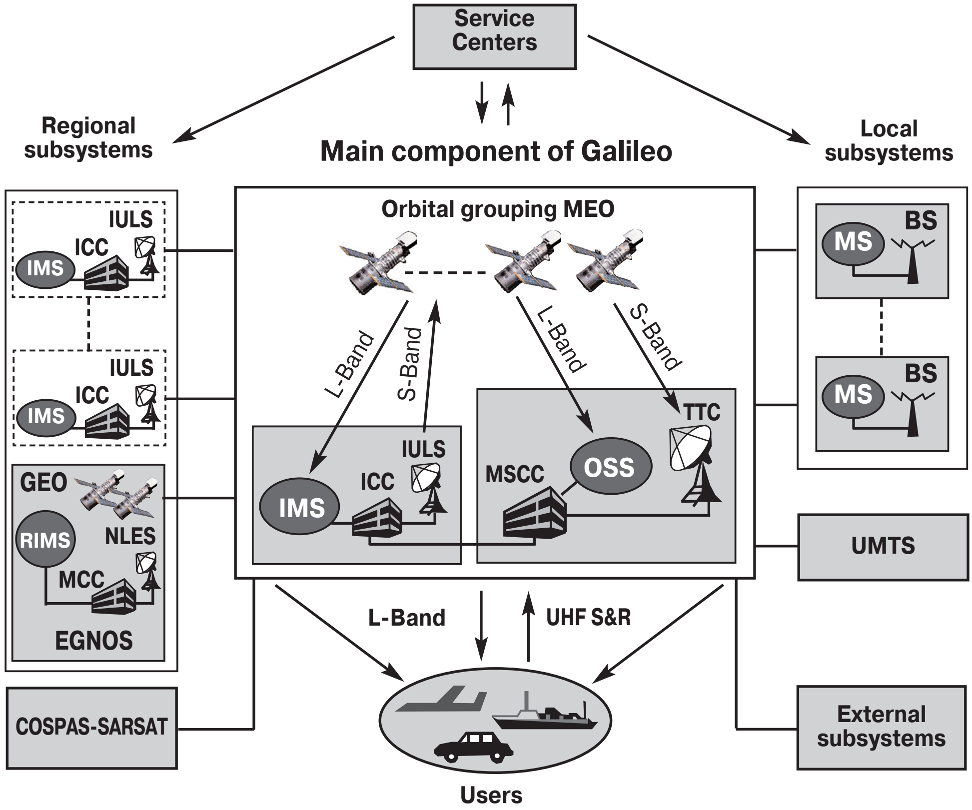
The *GALILEO* system uses open architecture, which will facilitate interoperability with the existing systems such as *GPS* and *GLONASS*, with the EGNOS system, which is still under development, and with various search and rescue services. The list of the navigation services it will offer once fully deployed is much longer than that provided by *GPS* or *GLONASS*. *GALILEO* architecture includes three main segments: the satellite constellation, the ground infrastructure (ground control stations) and user equipment.

The orbital constellation will consist of 30 medium Earth orbit satellites providing global coverage and optimized for the northern latitudes.

The satellites weigh 725 and 1,350 kg (for medium Earth and geostationary orbits respectively). They are shaped as a hexagonal prism (with the base shaped as a trapezium). The wider lateral surface houses the antennas; the other surfaces hold the solar panels (four from each side) that unfold once the satellite is in orbit. Designers say this shape will allow up to six satellites to be put into orbit by a single launcher. The expected lifespan of the satellites is 10 years.

GALILEO's signal structure, which includes narrow-band and wide-band signals, is different from *GPS* or *GLONASS*. The main difference is the higher frequency, which allows for more accurate pseudo range measurements.

Figure 1. ***GALILEO*** **architecture**



IMS – Integrity Monitor Station	MCC – Main Control Center
ICC – Integrity Control Center	NLES – Navigation land Earth Station
IULS – Instruction UpLoad Station	UHF – UHF-Band Search and Rescue
OSS – Orbitography and Synchronization Station	MS – Mobile Station
TTC – Telemetry and Tracking Station	BS – Base Station
GEO – Geostationary Satellite	UMTS – Universal Mobile Telecommunications Signal
RIMS – Ranging and Integrity Monitoring Station	

The International Telecommunications Union (ITU) has allocated an unprecedented number of working frequencies and signals to *GALILEO*: a total of 10 navigation frequencies in the common band called RNSS (Radio Navigation Satellite Service) and one (for the S&R system) in the 1,544...1,545 MHz band.

The ITU has allocated six frequency segments in the L-band (for medium Earth orbit satellites) and one in the C-band (for geostationary satellites). Under the frequency allocation scheme, all three satellite navigation systems (*GALILEO*, *GPS* and *GLONASS*) use frequencies in closely spaced but non-overlapping segments.

Each navigation satellite of the *GALILEO* system will broadcast two noise-like radio signals in the upper and lower part of the L-band. General access services will rely on the E1 and E2 signals with a chip rate of 2–4 Mchips/sec. These signals are similar to the *GPS* system's C/A code. Two other signals, E5 and E6, will be transmitted with a higher chip rate for commercial customers.

Thanks to the availability of precise signal in two frequency ranges, *GALILEO* customers will be able to determine their position to within 4 meters horizontally and 8 meters vertically, with a confidence interval of 0.95. Using the EGNOS system will increase accuracy to within 1 meter, and to as little as 10 cm in special regimes.

GALILEO's ground infrastructure includes telemetry and ground control stations linked into a global monitoring network. This network will process information so quickly that any failures in the on-board equipment of the satellites will be identified within six seconds. The engineers are hoping that the time required to notify the users of any problems in the work of the navigation satellites will also be substantially reduced.

The ground control and monitoring segment of the system handles the launch of the satellites, their in-orbit validation and operation, and finally their de-orbiting. This segment includes the main Network Control Center (NCC) and the Navigation Systems Control Center (NSCC), which is subordinated to the NCC.

The NSCC coordinates the work of the Ground Control Segment, which includes:

- ❑ Tracking, telemetry and control (TT&C) stations, some of which will also handle the upload of navigation messages via the Upload Stations (ULS); the global component of the system will include five TT&C stations, though experts believe that their number could eventually be reduced to two;

- ❑ Orbitography and Synchronization Stations (OSS), which compute the ephemeris, synchronization and other data; the global part of the system will have 12 OSS stations;

- ❑ Integrity Determination System (IDS), which includes the Integrity Control Center (ICC) and Integrity Monitor Stations (IMS) – its regional component will have 15 IMS stations; the system also includes Integrity Upload Stations (ULS) – which ensure an uninterrupted upload of integrity data to geostationary satellites (up to three regional stations).

GALILEO's key difference from *NAVSTAR* and *GLONASS* is the use of the IDS system, which determines the precision of the navigation and timing signal based on data from the global component of the system, and calculates the necessary corrections and compiles data integrity alerts based on information from the regional component of the system.

The ground segment of the EGNOS system is expected to be integrated into the ground segment of *GALILEO*'s regional component. The architecture of the local component of the system will be defined for each class of users.

The system is expected to offer three levels of navigation service:

- ❑ The free Open Access Service will be available to all users, but it offers no guarantees of positioning or timing signal accuracy; the accuracy of the navigation signal at this level of service can be intentionally degraded in the event of war or international tensions, or if the provider decides to offer the service only to paying customers;

- ❑ Controlled Access Service Level 1 (CAS-1) will be offered to users who require guarantees of accuracy and availability of the positioning and timing signal, as well as commitments of an uninterrupted service from the provider; navigation accuracy can be intentionally degraded at this service level by the provider in the event of war or international tensions;

- ❑ The highest level of service is Controlled Access Service Level 2 (CAS 2) offered to government-financed users with stringent data security and integrity requirements, such as the police, emergency services, the armed forces and other strategic agencies; at this level of service the accuracy of the signal will not be intentionally degraded in the event of war or international tensions.

GALILEO will offer four core types of service. The basic Open Service will be used for positioning of moving objects (including positioning with the help of mobile phones), aviation and maritime navigation, as well as the Universal Time Service. These services will be free of charge.

The Safety-of-Life Service (SLS) will comply with the safety requirements specified by ICAO and other international organizations for applications such as docking ships in port or preventing train collisions. The required probability of successful position fix from the first try is no less than 0.999 for this service.

The third core service is the Public Regulated Service (PRS), which will provide navigation data to government agencies, police, civil defense, law-enforcement and emergency services, etc. The key requirement here is ensuring security from external interference and making it impossible for unregistered users to access the service.

And finally, the Commercial Service (CS) will be offered to paying subscribers. On top of the free Open Service, this will include transmission of additional encrypted data used for applications such as positioning of moving objects.

GALILEO will also implement a separate Search and Rescue Service. Each *GALILEO* satellite can rebroadcast signal from up to 300 distress beacons simultaneously. The signal will be passed on to search and rescue stations on the ground. Positioning accuracy of the existing COSPAS-SARSAT beacons is about 5 km, whereas the figure for *GALILEO*-equipped beacons will be less than 10 meters.

GALILEO will be interoperable with *NAVSTAR*, but the European system has four key advantages over the American one:

- ❑ Guaranteed level of service over an agreed period of time for some classes of civilian users in terms of accuracy, availability, continuity and integrity of the navigation and timing signal. The precise specifications of this guaranteed level of service will be agreed between the operator of the system, the service provider and the user. Such guarantee entitles the user to compensation if the quality of the service falls below the agreed specifications. The provision of service guarantees is made possible by data integrity control, which enables the user to rely on the service because the system will issue an integrity alert if the signal goes outside specification.

- ❑ Data integrity control, which improves the overall safety in critical applications; some of the satellites will be broadcasting encrypted integrity reports at the global level received from the ground segment of the system, including the SISA (Signal In Space Accuracy) signal with range error estimates and Integrity Flags in the navigation message, which warn the users about loss of integrity with time-to-alarm of 10 seconds (for normal aircraft landing) or 6 seconds (ICAO CAT-I requirements); the users will also receive warnings about the health of the satellite constellation;

- ❑ Better performance and signal quality because the signal is similar to that used in mobile communications, and also because the signal strength has been increased (in particular, *GALILEO* has higher bandwidth for the signal corresponding to L5 in *GPS*). For users of single-frequency receivers, *GALILEO* offers better ionospheric error correction, which improves navigation accuracy. *GALILEO* also implements user authentication, which ensures legal protection for both the user and the operator when guarantee of service issues arise;

- ❑ *GALILEO* satellites have improved search and rescue functionality – users can be located in real time with a probability better than 0.98 (the satellites pick up the SAR signal on the 406–406.1 MHz frequency and locate it to within 10 meters in less than 10 minutes, while the COSPAS-SARSAT system, which relies on low Earth orbit satellites, can take several hours to locate the signal);

- ❑ Another advantage of *GALILEO* advertised by its designers is accurate positioning in urban environment, where signal from satellites hanging low over the horizon is often obstructed by buildings. The improvement is achieved thanks to *GALILEO* having double the minimum number of satellites required for global coverage.

DIFFERENCES OVER SATELLITE NAVIGATION BETWEEN THE UNITED STATES AND EUROPE

On December 28, 2005, Russia's Space Agency (*Roskosmos*) launched the first experimental *GALILEO* satellite, *GIOVE-A*. The satellite was put into orbit by the *Soyuz-FG* carrier with the *Fregat* upper stage, launched from the Baikonur Cosmodrome, Launch Pad 6, Area 31. The carrier was manufactured by *Progress* design bureau (Samara), and the upper stage by NPO Lavochkin (Khimki). The customer for this launch was *Starsem*.

GIOVE-A (which stands for *GALILEO* In-Orbit Validation Element) was put into its projected orbit of 23,000 km, inclination 56 degrees. The mass of the satellite is 660 kg, length 1.2 meters, diameter 1.1 meter, service life 12 years.

The launch of *GIOVE-A*, its in-orbit testing and validation pursue three tasks. First, it allows Europe to claim the frequency spectrum allocated to *GALILEO* by the ITU. Second, the experimental satellite will be used for validation of critical technologies. And third, the satellite will study the radiation on *GALILEO*'s working orbit.

Although the European civilian system of satellite navigation is only making its first steps, the Americans are worried by *GALILEO*'s potential for competing with *GPS*. The United States has worked against the approval of the decision to deploy the European system, but to no avail.

The Americans have also begun to modernize their own system to raise the accuracy of positioning, synchronization and timing, improve availability of the signal and expand the monitoring and control functionality of the system. The Pentagon spent about $234 million on *GPS* research and development in 2004, $289 million in 2005 and $401 million in 2006.

Experts name two reasons for America's hostility to the European satellite navigation system. The first is that *GALILEO* will compete with *GPS* in the civilian sector. The second is that the deployment of *GALILEO* will have serious implications for the military use of *GPS*. The problem is that the frequency range of the *GPS* military signal (M-code) overlaps with the PRS signal of *GALILEO*. Apart from interference, that will create difficulties for American and allied troops trying to use precise navigation information at times of crisis.

For several years U.S. officials have been using this argument in their discussions with the European Union, urging America's NATO partners to show solidarity. After a number of meetings between European and U.S. representatives, a 10-year agreement on *GPS-GALILEO* cooperation was signed in Dublin on June 26, 2004 by the U.S. Secretary of State and the Vice President of the European Commission for transport and energy, as well as by the Irish foreign minister.

It would have been natural to assume that the agreement signed by these senior officials would put an end to differences between the United States and Europe over satellite navigation. Instead, there have been reports of a very serious confrontation.

Right after the agreement was signed, a deputy chief of the U.S. Air Force issued an official document that essentially defenestrated the deal with the Europeans. Meanwhile, U.S. experts started dropping heavy hints that *GALILEO* signals would have to be jammed in the event of a conflict, and even the *GALILEO* satellites themselves might have to be destroyed.

RUSSIA-EU COOPERATION PROSPECTS IN SPACE AND SATELLITE NAVIGATION: WHAT NEXT?

Speaking about Russia's European policy in 2007, the Russian president's special representative for relations with the EU, Sergey Yastrzhembskiy, said that relations between Russia and the European Union were improving. Bilateral trade was up from $48 billion in 2000 to $231 billion in 2006. Trade turnover had risen by $60 billion in 2005–2006. The EU has become Russia's biggest trading partner.

There is a lot of potential for cooperation with Europe in the space industry. This cooperation goes back to the early days of the Russian space program.[12] The number of joint EU-Russian projects has grown in recent years. These include the Automated Transfer Vehicle (ATV), a supply ship; science missions such as *Integral, Mars-Express* and *Venus-Express*; joint projects in telecommunications such as the *Express* satellites; Russia's participation in *GALILEO*; and the joint project to build a launch pad for the *Soyuz* carries at Kourou (Guiana Space Center). *Roskosmos* also cooperates with ESA on the long-term Solar system exploration program *Aurora*.

On the whole, cooperation between *Roskosmos* and ESA encompasses almost every field of space exploration and offers substantial benefits to both parties.

Russia will launch several more *Express-AM* satellites as part of its Federal Space Program. It is expected that the transponders for these satellites will be supplied by *Alcatel*.

The Russian space program also includes the development of *Sterkh*, a small satellite that will be used in the Russian segment of the international search and rescue service COSPAS-SARSAT. The Russian space equipment designer *RNII KP* is the lead bureau for the entire Russian segment, while the *Polet* bureau is responsible for *Sterkh*.

Roskosmos is also working with *ASI, Alenia Spazio* and *NPO PM* on developing a satellite communication and relay system for air traffic control called SDRS. The system will offer a wide range of communication services to mobile users, and will be used primarily for guiding air traffic over the Polar regions and for maritime navigation in the northern seas. The developers have already finalized the key design principles of the system.

Russia and the EU are now discussing cooperation in the following key areas:

- ❑ Satellite broadband access (Digital Divide);
- ❑ Joint multifunctional system of data communication via a relay satellite;
- ❑ Multiservice satellite communication system for the northern latitudes that would serve the needs of transport, environmental research and monitoring of industrial facilities.

Russia and the EU have set up a working group on cooperation in satellite navigation and augmentation systems. The group has already begun its work.

Another key area of cooperation is manned space missions, including the International Space Station (ISS). ESA's contribution to the project is the *Columbus* module and the ATV supply vehicle, which docks to the Russian segment of the ISS. That makes cooperation between the EU and Russia all the more important, and serious work is under way to integrate the ATV with the Russian segment.

The *Soyuz*-Kourou project has great political significance. The decision to include the *Soyuz-2* carrier in the lineup of European carriers along with *Arian 5* and *Vega*[13] is a key strategic element of our partnership and a very important political step.

Using Russian carriers to put European research, remote-sensing and navigation satellites into orbit is another important area of scientific and commercial cooperation. This includes projects such as *Integral, Venus Express, Mars Express*, etc.

One other key area of future cooperation is exploration of the outer space, including manned missions. Russia and the EU are working together on the *Aurora* program. The first element of this program, the interplanetary station *ExoMars*, was approved by ESA nations at the ministerial level. The launch of the mission is planned for 2013. Negotiations are now under way with Russia on its participation in various parts of the mission.

Russia and the EU can also cooperate in developing next-generation space transport vehicles. Russia is proposing the *Klipper* and *Parom* vehicles, the modified *Soyuz*, and others. Discussions in this area have been under way for quite some time. Last year, ESA ministers approved funding for the next 18–24 months period of studies on creating a joint transport vehicle of the future. Cooperation with Russia in this area will be on a non-commercial basis: each side will pay for its own part of the project. The design specifications require the vehicle to be able to serve the near-Earth orbits as well as travel to the Moon. It must also be capable of launching not just from Baikonur but also from Kourou.

Cooperation in this area holds strategic importance for both the EU and Russia as it offers them a space capability that is not dependent on the United States. Everyone realizes that depending on just one system is not in their interests, however reliable that single system might be – witness the International Space Station, which would have already been abandoned if it weren't for the Russian *Soyuz* rockets. The same requirement applies to future missions to the Moon and Mars. There must be more than one system, and there must be a certain degree of compatibility and interoperability between these systems.

In March 2007 the Russian Federal Space Agency and the European Space Agency signed a protocol on cooperation during a ceremony at the *Roskosmos* HQ. The protocol outlines several areas of cooperation between *Roskosmos* and ESA, including manned missions.

ESA will use the Russian *Soyuz* carries to put *GALILEO*, *Mars Express* and *Venus Express* spacecraft into orbit, according ESA Director General Jean-Jacques Dordain. He added that *Roskosmos* and ESA were discussing the possibility of jointly developing a next-generation vehicle to deliver cosmonauts to the ISS. The Russian navigation system *GLONASS* and Europe's *GALILEO* will be complementary, compatible and interoperable, *Roskosmos* head Anatoly Perminov told journalists.

He also said that during the talks at *Roskosmos*, an agreement had been reached that "in the future, users will be able to use a single receiver to pick up *GLONASS* and *GALILEO* signals." Under the agreement, designers from both sides will work to ensure compatibility. He added that satellite navigation is just one individual area of cooperation between *Roskosmos* and ESA. The *GALILEO* project was launched in 2000. The system was expected to become operational in 2008, but because of differences between the ESA nations over the funding of the project, the system may not reach full operational capacity for another several years. Negotiations on compatibility and interoperability of *GALILEO* and *GLONASS* are already under way.

Roskosmos and ESA have also decided to begin space flight testing of a big reflector antenna, another joint project. As part of the fundamental space exploration program, the two sides have decided to complete the preparation of an agreement under which Russia will provide a scientific instrument for *BepiColombo*, the European mission to *Mercury*. *Roskosmos* and ESA will also finalize proposals on Russia's participation in *ExoMars*. The two sides will continue the implementation of the project to build a *Soyuz* launch pad at the Guiana Space Center. The agreement stressed "the importance of joint projects in future space launcher technologies."

The two space agencies will carefully study all the aspects of developing a next generation space ship. They have also agreed to set up the eighth working group on standardization.

An agreement has been reached on the directions of international integration in satellite navigation:

- ❑ Integration of the Russian *GLONASS*, the American *GPS* and Europe's *GALILEO* to ensure their interoperability and compatibility in the interests of improving the quality of positioning and timing services (accuracy, integrity, availability, etc);
- ❑ Integration of the EGNOS augmentation system for *GPS* and *GLONASS* with Russia's SDKM (System of Differential Correction and Monitoring) for *GLONASS* to substantially improve the accuracy of *GLONASS* positioning and improve the monitoring of *GLONASS* satellites and the entire *GLONASS* system.

Several factors necessitate and facilitate the integration of the two satellite navigation systems:

- ❑ Similar orbital parameters of the two constellations (altitude 19,000–23,000 km, inclination 55–65 degrees, orbital period 11–14 hours, etc);

- ❑ Similar frequency spectrum (1560–1605 MHz L1 and 1150–1280 MHz L2 and L5), as well as similar signal code structure which uses phase manipulation and pseudo random sequences;
- ❑ Similar strength of the main signals (-163...-152 dBW), which is below the level of self-noise;
- ❑ Similar principles of synchronization and measurement of navigation parameters;
- ❑ Similar system of coordinates;
- ❑ The *GPS* and *GLONASS* systems were created and modernized almost simultaneously; the experience gained during the development of these systems can be used by the designers of *GALILEO*;
- ❑ The U.S., Russian and EU authorities are prepared to offer their systems' services internationally to various groups of users.

Despite the spirit of competition between *GPS* and *GALILEO*, increasing the number of navigation satellites in orbit can only improve the quality of the service for the end user in terms of accuracy of positioning, continuity of the signal, noise tolerance, etc. And if the Russian *GLONASS* system is also fully deployed before the end of this decade (which looks entirely realistic), there will be 80 navigation satellites of the three different navigation systems in orbit, offering users truly unique opportunities.

Notes

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