Chapter 22:

International Perspectives: Russia

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Russia spent the year 2007 commemorating its half-century of activity in space and the men who helped make it happen. Events celebrated included the 150th anniversary of Konstantin Tsiolkovsky's birth, the birth centenary of Sergei Korolev, and the 50-year anniversary of the launch of the world's first artificial satellite in the Soviet Union. But with good reason, Russia was also celebrating the improving prospects for its space future. Lamentable hangovers from its more recent "space slump" have been fading away, although not entirely.

Not far from the main launch pad at the Baykonur cosmodrome—a pad that hosted the Sputnik blastoff on October 4, 1957, and the Yuri Gagarin blastoff on April 12, 1961, and that still hosts Soyuz booster launches—stands a simple obelisk. It is surmounted by a full-size metal sculpture of Sputnik and supports a small plaque that reads, "Here through the genius of Soviet man began the relentless assault on space." But the succeeding 50 years saw a mixture of relentless assault and single-minded perseverance with wasteful detours, dead-ended spectacles, desperate gambles, and shriveling budgets. Interplanetary probes pioneered the routes to nearby planets but could reach no farther. Operating lifetimes of affordable satellites were so short that mass quantities had to be successively launched into orbit—with the unintended benefit of providing a major surge (or casualty replacement) capability for military systems. Endurance marathons on manned space stations and resolute repair missions in the face of daunting breakdowns demonstrated the resilience of manned spaceflight—and the inability of the Soviet economy to industrially exploit the opportunities of the space frontier.

Many space strategies have evolved to keep pace with these changing circumstances. Where once the Soviet Union saw itself as a lone pioneer leading humanity into space, Russia now portrays itself as an essential partner of other spacefaring nations. Where once Soviet scientists foresaw national wealth from exploiting space conditions and space-based vantage points, Russian government planners now see their main space-related cash flow in sales of know-how, goods, and services to other spacefaring powers. Where once fleets of military space systems were seen as force multipliers for the Soviet armed forces on expansive missions, a much more constrained Russian military establishment now struggles not to be left hopelessly behind by U.S. and other national military space infrastructures, even as its fear of military confrontation ebbs.

Fifty years on, top Russian leaders have paid homage to the value of the country's space activities. "The industry is an integral part of the national defense industry and one of the flagship national industrial branches," Russian deputy prime minister and defense minister Sergei Ivanov said recently while addressing Russia's Defense Industry

Commission in Moscow.[1] "Thus, space industry development is a must for ensuring Russia's independent space exploration." At another event, Ivanov stressed the role of a nation's military-industrial complex as "a locomotive of high technology, economy and knowledge practically in all countries of the world," [2] and added, "We are not an exception from this rule, because over half of the country's total scientific potential is still concentrated in the defense and industrial complex sphere."

Russian President Vladimir Putin directed the head of the Federal Space Agency, Anatoli Perminov, to work out a 30-year strategy extending to about 2040. "He wants the guidelines of the development of space exploration in the country determined," Perminov explained. "That includes above all the development of existing launching sites, the group of space assets in orbit in different departments—communications, remote sensing, weather watch and so on. Naturally, some work is to be done for defense that includes new carrier rockets and the ground infrastructure and control of space systems in orbit."

To examine the route from where Russia is in space to where it wants to be, it is useful to survey the human, financial, administrative, and technical resources at its disposal, and then extrapolate from there.

The Human Factor

The fundamental basis for any activity is the team of people who are to carry it out. Here, Russia is still struggling with personnel management issues that stretch back to the very beginning of the space era. A successful resolution of these issues—still in doubt—is fundamental to any hope of success in the coming decades.

To a far greater extent than in the United States, Russia created and then depended on a large cadre of specialists hired as young people in the Sputnik era. They worked together for decades and knew each others' specialties. Along the way, they brought in a few apprentices, but as a rule they relied on their own experience, memories, intuition, and expertise, which were rarely documented in a form accessible to others.

As a result, the average age of space workers in many key facilities in the 1990s was only a few years less than the average male life expectancy of 59. If 20-year-old military draftees in the Russian Space Forces are counted, a lower value can be obtained (47 is the current official average age), but unquestionably this remains a critical challenge for the coming decade when half a century of expertise must be transferred or lost (and then slowly and painfully reacquired).

"Staffing is a painful problem for us," Perminov said at a news conference in 2006. "It has always been a big problem and it is particularly an acute problem now."[3] "If there is no inflow of young specialists," Russian prime minister Mikhail Fradkov had told reporters in July 2005, "everything could be lost, regardless of the money invested." [4]

Sergei Ivanov had told newsmen much the same thing in late 2006. The chiefs of defense enterprises, he said, are concerned "not so much about financing as about who will work,

where to get qualified personnel." One press report attributed to Ivanov the idea that "a shortfall of such cadre is increasingly apparent."[5] Ivanov concluded, "The shortage of personnel is the main problem facing the rocket and space industry."[6]

Perminov has directly addressed his strategy for finding such employees. They come from institutes such as Bauman University and the Moscow Aviation Institute, as well as from the military. "They mostly work at space launch sites, in particular, Baykonur," Perminov noted. [7] But new employees in their late 40s will not help drive down the average age of the team.

Recruitment remains hit-or-miss, with some organizations showing large influxes of young people, as long as the cash flow remains healthy. But to a large extent, every new employee is a potential ex-employee to a degree rarely seen in the previous generation. In those days, there were few other jobs with as much prestige, intellectual stimulation, or access to exclusive privileges, but today that has all changed, and young people know it. There are enthusiasts and loyalists—often the children of current or past workers—but there just are not enough of them to even replace the bodies, much less the experienced minds, now hemorrhaging irretrievably from the industry.

The way in which Russian space workers are organized into teams has also evolved. Under the Soviet regime, federal agencies and industrial enterprises were often arbitrarily yoked together on projects that operated by fiat, not by budget (there was no quantitative "cash flow" to gauge levels of effort). Conflicts and alliances developed in an almost byzantine style (some mergers were actually sealed by marriages, or even what looked like exchanges of hostages). Operating as quasi-autonomous satrapies, space and rocket firms were vertically integrated, often possessing their own support industries, hospitals, and even their own food supplies.

Major Players

Only in 1993, in response to negotiations with the United States, did Moscow convert an administrative ministry into an executive agency with its own budget—the "Russian Space Agency," or Roskosmos (the name has evolved over the years). A parallel military command, usually called some variation of "Russian military space forces" and transferred among major branches of the armed forces every few years, handled infrastructure operations and military-related space vehicles. Both agencies dealt with a crazy-quilt array of academic and industrial entities.

The most important firms are:

- Energiya Rocket and Space Corporation, Moscow: human spacecraft, Progress freighters, Block-D upper stages, and communications satellites, and operates Mission Control Center. Management was replaced recently in a "hostile takeover" by the Russian Space Agency.
- Khrunichev State Research and Production Space Center, Moscow: Proton rockets, space station large modules, Rokot intercontinental ballistic missile

(ICBM)–derived small launchers, and small satellites. This firm is the developer of the Angara booster family. Its finances are shaky.

- Progress State Research and Production Rocket Space Center, Samara: Soyuz booster fabrication and reconnaissance satellites
- Applied Mechanics Scientific and Production Organization, Krasnoyarsk: communications and navigation satellites
- Lavochkin Design Bureau, Moscow-Khimki: lunar and planetary probes, military reconnaissance satellites, and other small satellites
- Moscow Institute of Thermal Technologies: sole remaining active ICBM/submarine-launched ballistic missile (SLBM) manufacturer (Topol, Bulava missiles, START–1 small satellite launcher)
- Production Association Polyot, Omsk: Kosmos satellite launcher, global navigation satellite system (GLONASS) navigation satellites, Angara booster elements
- Gagarin Cosmonaut Training Center, Zvyozdny: cosmonaut training. Currently undergoing a tumultuous transfer from military to civilian management.
- Krasnoznamensk (Golytsino-2), near Moscow: central space communications and control hub, operated by military space forces.

Other smaller entities build weather and Earth resources satellites, perform basic research, and provide support services.

A major challenge today is the consolidation of hundreds of these groups, large and small, that make up the Russian space industrial base. Perminov recently put the total at "about 112 spearhead enterprises," and his job is to reduce this number to a dozen. Specific skills are to be retained, while duplication in support technologies is to be eliminated.

Andrei Kislyakov, a retired space official who now writes for the Novosti news agency, has described the lack of progress toward this goal over the past several years: "On October 11, 2001, the Russian government approved the federal target program 'Overhauling and Expanding the Defense Industry in 2002–2006.' A conference on July 6 [2006] that discussed the same issue indicated there had been no achievements in this sphere. . . . Anatoly Perminov said Russia's 100-plus space-rocket companies will be merged into 10 integrated companies, and the entire industry will have just 3 or 4 corporations by 2015. It is a tried and tested way. Unfortunately, they are only now starting to implement this plan, rather than in 2001." [8]

Budgetary Concerns

These enterprises and their overseeing bureaucracies had been operating on dwindling funds since the late 1980s—an impoverishment that grew even worse with the collapse of the Soviet Union and the loss of many industrial elements to newly independent nations. But the 20-year-long specter of poverty has faded. According to Perminov, "This year [2006] for the first time the entire sum allocated for the federal space program, as far as the Federal Space Agency is concerned, has been disbursed."[9]

This financial well-being is largely based on reliance on what is euphemistically called "extra-budget sources" (in reality, sales to Western customers). "This year [2006] 23 billion rubles has been provided for the federal space program," Perminov explained. "Next year it will be 24.4 billion rubles, with no account of extra revenues. Combined with other programs, this makes a total of 35 billion to 36 billion rubles." [10] That means that about 12 billion rubles, or a third of the total space budget, has to be raised commercially.

This fraction has remained fairly constant in recent years. In 2006, for the period 2006 to 2015, 305 billion rubles (about $10 billion) had been allocated, with the expectation that an additional 130 billion rubles will come from "off-budget sources." That equals about $400 million per year of foreign funding, or about 30 percent of the operating funds (by comparison, from 1996 to 2000, 60 percent of the space budget was foreign funding, and in the first half of this decade, the figure has been about 30 percent). [11]

At least the space industry can again pay its workers. "As for salaries, we have done away with this problem," Perminov declared. "This year [2006] there are no enterprises with arrears of wages." Salaries range from 11,000 rubles to 20,000 rubles, not generous in Russian terms by any means—but a living wage, especially in two-income families.[12]

Launch Sites

Baykonur

The primary Russian space launch facility at Baykonur is undergoing profound transition as operating elements of the Russian Military Space Forces hand over facilities to the civilian Federal Space Agency. Progressive infrastructure collapse has been locally reversed through investments by commercial satellite launch groups. Political arrangements with the government of Kazakhstan have stabilized, although both Russian and Kazakh officials have begun expressing anxiety about signs of Islamic extremist activities among the local population.

"A lot of work has been done to transfer Baykonur facilities from the Defense Ministry to Roskosmos," Perminov noted in December 2006. "A total of 62 facilities were handed over this year and the remaining ones will be handed over by the end of 2007. All the facilities have been accepted, and operational units have been appointed."[13]

Management and maintenance of decaying structures have been a challenge. When the massive Building 254, built in the late 1970s to house the Buran shuttle, was converted to processing modules and spacecraft for the International Space Station, the Buran orbiter that had made the program's single orbital flight in late 1988 was moved to Building 112 next door (it was built in the mid-1960s for the abortive Soviet man-to-the-Moon program). A low bay of that building had already been converted to house payload processing for the commercial Soyuz launch company Starsem, and an adjoining medium bay was modified to process Soyuz booster processing after the condition of the original assembly hall (built in 1956) deteriorated dangerously. But the high bay area housing the

Buran collapsed in 2001, killing six workers and destroying the flown shuttle. Yet the pressing need for booster processing facilities—and the availability of investment funds—led to the decision to repair and reopen one of the two collapsed high bays.

Plesetsk

The mainly military space and missile launch facility north of Moscow has also been undergoing significant infrastructure enhancement, both in space operations and in worker living conditions. In particular, launch pads for Russia's first new booster in more than 20 years, the Angara family, are nearing completion.

Sergey Ivanov has described the Angara launch site as a "task of state importance" and asserted that the new pads will give Russia "a guaranteed, and independent from any political or economic circumstances, access to outer space." Once operational, the pads will allow the transfer of military and dual-purpose spacecraft launches from Baykonur to Plesetsk.[14] This will involve launchings into all operational orbits including geosynchronous (24-hour equatorial), either through use of a larger plane change during direct ascent or via fuel-efficient but operationally complex orbital plane change maneuvers utilizing lunar fly-by (currently, such orbits can only be reached from Baykonur).

Kapustin Yar

Russia's original missile launch facility on the lower Volga River continues in operation for military missile (including antiaircraft) testing, and spartan living conditions have slightly improved according to press reports in 2006. It retains the capability for small satellite launchings.

Svobodny

The Far East launch site for small commercial satellites, once touted as a replacement for major Baykonur operations but threatened with closure, faced an uncertain future. Regional governor Leonid Korotkov told reporters in December 2006 that he had attended a meeting of the Russia Security Council in Moscow where it was decided not to "liquidate" the center. One of its decisions was to propose to the government and the Defense Ministry "to find forms of the rational use of the cosmodrome in the interests of defense, security and the economy of the country," Korotkov said. "This decision gives certain hopes for the preservation of the cosmodrome's infrastructure." [15]START–1 satellite launchers (converted ICBMs) operate from the site's Pad 5. In 2009, the Kremlin blessed the creation of a new major launch site near the site, to be called Vostochny and to be capable of human space launches.

Kourou

Development of a Soyuz launch vehicle capability at the French launch site in French Guiana is proceeding. In a formal ceremony in February 2007, Russian officials laid a

stone from the Sputnik pad in Baykonur at the Kourou space launch site. [16] The Russian side is investing 121 million euros of its own money build the Kourou facility. The total cost, shared with the European Space Agency, is more than 300 million euros, with a first launch expected in late 2009 and more than five launches per year (including potentially manned launchings) subsequently. [17]

Dombarovsky

A new satellite launch site was introduced in mid-2006 with the orbiting of a commercial payload (Bigelow Aerospace's Genesis-1 inflatable habitat prototype) aboard a modified Satan SS–18 ICBM (called Dnepr with the addition of a third stage) from the missile field in southwest Siberia. A special hotel and payload processing hangar has been built in the support town of Yasny for foreign customers, and more launchings are planned. Use of the military base simplifies launch preparations and eliminates issues of environmental concerns by the Kazakh government, especially useful in light of the mid-2006 launch failure of the same category of booster from Baykonur that resulted in significant contamination issues in a sparsely populated region south of Baykonur.

Sea Launch

The international consortium that launches Ukrainian-built Zenit rockets from a floating platform based in California continues in operation despite a lift-off booster explosion in early 2007 that damaged the platform. The project had already been facing major cash flow problems due to the inability to perform a critical originally intended mission function—to reload the launch platform with a second launch vehicle and payload while at sea. With launches limited to a single shot per time-consuming cruise, earnings are severely constrained.

Russia's interest is with the use of a Russian-built upper stage, the D block, a booster that has been phased out of most other Russian launches (on Proton it has mostly been replaced with a competing vendor's upper stage, called Briz), resulting in significant income loss to its manufacturer, the Energiya Rocket and Space Corporation.

Rumors persist that Ukraine, eager to establish a Zenit launch capability at the Brazilian Alcantara launch site, is considering moving Sea Launch operations permanently to Brazil, where the existing floating launch platform could be anchored just offshore of Alcantara and could be rapidly reloaded after each commercial launch. In late 2006, Ukraine completed fabrication of a launch platform for the smaller Tsyklon-4 booster, intended for installation at Alcantara to allow commercial launchings on behalf of the two-nation Alcantara-Tsyklon-Space corporation. [18]

Submarine-launched Boosters

A converted SLBM booster, renamed Shtil, carried a small German science satellite into orbit most recently on May 26, 2006, launched from the submarine *Ekaterinberg* in the Barents Sea. But launch failures have bedeviled this attempted conversion of rockets

from the Makeyev Bureau. The old rocket factory had been the manufacturer of all but the most recent submarine missiles but is now facing bankruptcy after transfer of all future military missile contracts to another vendor. Operational advantages of this submarine option appear dubious, and cost advantages are far outweighed by the daunting failure rate, arguably a consequence of the financial collapse of the missile firm that is desperately seeking to avoid dissolution.

Launch Vehicles

Russia's family of satellite launch vehicles has been undergoing significant upgrading, but plans to shift to a new generation of launchers—the Angara series—continue to recede into the indefinite future.

Soyuz-2

This is the biggest recent success story for Russian space rocketry. Three successful missions with this upgraded booster occurred in 2006, and more are planned (including from Kourou). The upgrades include a digital control system that flies a more efficient ascent profile and allows a reduction in unburned propellant, a new telemetry system, addition of wider and longer payload farings, replacement of non-Russian vendors, more efficient main stage engines, and an entirely new third-stage rocket engine. Combined, these improvements increase the payload of the vehicle by 1,200 kilograms (almost 20 percent). The booster is designed for human launches as well.

This upgrade will allow years of future use for a booster that has, in its basic form, been launched almost 1,800 times in the past 50 years. One of its anticipated future missions, using a Fregat fourth stage, will be to carry a pair of replacements of improved GLONASS-K navigation satellites in 2010, a significant cost reduction of the three-per-launch Proton missions now needed. [19]

Proton

Russia's most powerful launch vehicle (approximately 20 tons in low Earth orbit) continues in use, in recent years exclusively for geosynchronous-bound missions. The Proton-M upgrade is now entering service and, as with the Soyuz-2, uses a digital flight control system and upgraded first-stage engines, resulting in a 6 percent payload performance improvement. The next major upgrade in development will be a cryogenic upper stage.[20]Once operational, it will make the Proton competitive with Ariane-V for geosynchronous orbit missions.

Angara

The long-anticipated "ecologically friendly" booster family called Angara had been held up for years as Russia sought Western funding. "This system has been in development for more than a decade," Russian Space Forces commander Colonel General Vladimir

Popovkin told reporters. "Eventually, an understanding has been reached on how it should be funded and when it should be created." [21]

Russia spent 1.8 billion rubles ($75 million) on space center development in 2007, most of it at Plesetsk, and most of that for the Angara launch support complex. This money came from the Defense Ministry budget, not the Russian Space Agency. [22]

Angara is being built by the Khrunichev State Research and Production Space Center, the builders of the Proton system. But unlike the military-derived missiles that use highly toxic hypergolic propellants, Angara is to use more benign kerosene and liquid oxygen. Depending on the number of engines and strap-on stages, the system will offer small, medium, and large (Angara-5) versions [23] and will replace the Proton rocket (and Soyuz as well, perhaps) about 10 years from now. A special Angara-5 version called Baiterek will operate under Kazakh auspices from Baykonur, and one Proton launch pad is already undergoing modifications.

These delays are more than merely inconvenient—they threaten the very financial rationale for the project. Roskosmos official Aleksandr Chulkov had told *Izvestia* in August 2005 that funding problems continued to delay the new launch vehicle family. "The Angara rocket, however promising it may be, will not be ready in the next three years," he admitted. By then, he warned, competition from comparable boosters in China, India, and Ukraine may have locked up the international market: "Ukrainian rockets are serious competitors for Russian cosmonautics, and it will be very difficult to take away the leading position which we ensured for them." As a result of the delays, paying customers such as Panamsat have cancelled launch contracts worth in aggregate up to $700 million in the past 2 years. They have switched to other rockets and may never come back to Angara.

URAL

A joint Russo-French project called URAL aims at a fully reusable advanced launch vehicle burning liquid hydrogen and methane. Whether it is an actual hardware development project or a foreign-subsidized hobby shop for underemployed Russian space engineers is impossible to tell.

Air Launch

A project involving an Antonov-124 aircraft and a two-stage satellite launcher called Polyot has been in the works for a number of years but moved closer to reality in 2006 with the beginning of construction of ground facilities on Biak Island in Indonesia. Flight tests are promised for 2009 with an operational launch the following year.

Satellite Deployments

Russia's collection of about 100 operational satellites displays some striking features that are consequences of the severe budget constraints of the past 20 years. The number of

science satellites, or the number of specific applications satellites, is seriously deficient. Networks of military satellites—such as early warning and navigation systems—have also been severely degraded.

In the late 1990s, as orbiting payloads broke down or exhausted their control propellants, gaps appeared in the applications networks (*constellations* in U.S. terminology, *groupings* in Russian). Despite new launches after 2000, failure rates exceeded replacement rates. "Two years ago, it was our understanding that it was simply going to collapse," Perminov said in November 2006. "Now that failure has been stalled." [24]In December 2006, Perminov claimed that the situation had stopped deteriorating and was turning around: "Regarding the composition of space assets in orbit—the composition has improved, but mainly in terms of quality. As of today, 53 percent of space vehicles are operating within their design life spans. Last year that parameter was not so good." [25]

Figures released by Perminov indicate that the existing Russian deployment of satellite constellations (involving 96 spacecraft, a quarter the size of the U.S. contingent) meets only 26 percent of the defined needs of Russia. Funding of future replacement vehicles is supposed to raise that level to 51 percent by 2010 and to 90 percent by 2015. Another Russian space official said that only 39 of 99 existing spacecraft were "fully operational," while the rest were operating in degraded mode well beyond their design lifetimes.

It is astonishing to note that Russia does not have a single functioning weather satellite in orbit. Russian meteorologists have had to purchase their images from foreign satellites. A new-model Meteor payload was to be launched in 2007, but the launch slipped into 2009. Ultimately, three will be placed in polar orbit and two in geosynchronous orbit.[26]

In terms of civilian remote sensing satellites, the dearth of payloads is finally being remedied. Perminov boasted of a remote Earth sensing Resurs-DK with a resolution of 1 meter, launched in 2006. "We faced a systemic crisis last year [2005]," he admitted. "At the start of last year we didn't have a single remote Earth sensing probe. And the launching of that probe—and it is now in operation and bringing good results and provides a high quality of pictures."[27]

Russia has also continued to operate the experimental small-size Monitor-E opto-electronic surveillance satellite, which uses panchromatic cameras (with a resolution of about 10 meters) and spectral-zone cameras (with a resolution of 22–24 meters) to fill commercial orders, according to Novosti commentator Yuri Zaitsev.[28]

For military photoreconnaissance satellites, recent years have been very hard, with long gaps when no observation satellites of any kind were in orbit. Russia "periodically launches the Yenisey, Araks, Neman, and Oko heavy and medium optical reconnaissance satellites," noted journalist Viktor Myasnikov, who continued:

> But they were all developed in the last century and are distinguished by a short period of operation in orbit. And even then [they] do not always make it to the end. It is believed that all Russia's spacecraft, regardless of

> purpose—reconnaissance, meteorological, communications, and so forth—trail their American and European counterparts by two or three generations. And it is not a question of a lack of money but of backward scientific policy oriented toward instant impact, not the long-term development of new ideas.[29]

Russia intends to remedy that backwardness by promoting its global positioning system (GPS)-equivalent, GLONASS. But when it comes to commercial applications of an originally all-military project, they are running into structural hurdles. One basic problem was the espionage laws that, until January 1, 2007, made it illegal for Russian citizens to even *know* their true latitude and longitude to the accuracy that GLONASS can provide.

Reporter Yuri Gavrilov described the spacecraft-specific problem in December 2006:

> The collapse of defense enterprises in the middle of the last decade and the relatively short lifespan of domestic satellites—around 3 years—have turned into serious problems in space. Today only 14 GLONASS satellites fly around the Earth; moreover, only 4 of them are new-generation satellites with an operating endurance of 7 years. Every satellite costs more than $10 million; its launch and operation require another $35 million. It is clear that the military will not be able to cope with this task alone.[30]

"We hope we will have 18 spacecraft in orbit by late 2007–early 2008, and there will be a whole orbital group of 24 spacecraft by late 2009," he went on. Perminov said the main task now is "to create ground equipment for ordinary people so that they could enjoy the fruit of this space system." [31]

Sergei Ivanov raised this theme at a conference at the St. Petersburg Institute of Radio-Navigation and Time. He was there to consult with specialists on how to carry out the president's directive to accelerate the bringing of the dual-use navigation system online. According to the new program, both military and civilian users were to have access to GLONASS by the end of 2007. Civilian users are supposed to make up 80 percent of the users in the country. "Without being able to enter the market and provide citizens and their children with the opportunity of navigational support, as is already done, the system will not function as we want," Ivanov told reporters. "The very main thing is the influence of GLONASS on the socio-economic development of the country and providing it with greater transparency and less corruption." [32]

Space analyst Yuri Zaitsev of *Novosti*, among others, has highlighted the flaw in the commercialization strategy—nobody in Russia is really making GLONASS receivers for public purchase:

> Unfortunately, the system's ground segment still leaves a lot to be desired. Starting on January 1, 2007, all restrictions on the purchase and use of GPS receivers will be lifted all over Russia, but batch production of them

> has not yet been launched. Moreover, electronic maps of all of Russian territory will only be compiled by late 2007. Consequently, commercial use of the global positioning system for civilian purposes is still out of the question.[33]

Zaitsev has indicated another reason for skepticism that Moscow's top-down approach to motivating potential private GLONASS users will ever work. Two decades earlier, the Soviet Union teamed up with Western countries in deploying orbital transponders to enable search and rescue for downed aircraft (SARSAT, or "search and rescue satellite-aided tracking"). Hundreds of thousands of such beacons have been installed on Western aircraft and boats, but as recently as 2006, Zaitsev notes, only "a few hundred" SARSAT-compatible beacons had ever been installed on Russian vehicles of all types, and many of them probably are no longer functioning.

Resumption of Science Missions

Zaitsev pointed out that although "unfortunately, no full-fledged scientific satellites have been launched in Russia this year," Russian scientists still were able to utilize science data from their instruments aboard other space probes. Also, in exchange for providing a launch vehicle, "they have priority rights for the use of 25 percent of observation time aboard the International Gamma Ray Astrophysics Laboratory, which has enabled them to find out the nature of the cosmic microwave background radiation spread evenly throughout the Milky Way galaxy." [34] Still, this led to widespread complaints from within Russia's space science community.

But this may soon change, since the Russian Space Agency has added budget line items for future missions. Russia's Lavochkin Bureau, which built the Soviet lunar and planetary probes of the early space age, now has government contracts for nine deep-space probes.

In 2007, the first of these, a Spektr observatory with a 12-meter-diameter dish antenna, was to have been launched into high Earth orbit, but it has been delayed. Russia is also dusting off (and replacing lifetime-expired components in) an already mostly built payload called RadioAstron. It will be followed by Spektr-UF, which will carry an ultraviolet telescope with 20 times the sensitivity of Hubble's instruments into a very high orbit that allows continuous observations with much-reduced Earth interference. A space infrared observatory named Millemetron has also been approved for launch by 2015. It will use a cryogenically-cooled 12-meter-diameter mirror that will be deployed after launch into a high Earth orbit.

A Spektr payload devoted to X-ray astronomy, formerly called Spektr-Roentgen-Gamma, has been folded in with similar European projects and now carries the ungainly title Spektr-RG/eRosita/Lobster. The payload will be carried into a low equatorial orbit by a Soyuz-2 booster to be launched from Kourou.

Several planetary missions have been funded, the first in more than a decade. The Fobos-Grunt 3-year round-trip mission, scheduled to begin in 2009, will leave a long-lived Russian-built science orbiter near Mars, along with a Chinese hitchhiker beacon. The probe is expected to be followed in 2011–2012 by a set of small Mars surface landers. And a Moon orbiter called Luna-Glob has been contracted with a Moscow geochemistry institute that has been out of the lunar science business for almost 30 years. The probe will search for lunar polar ice [35] and will detect gravitational irregularities to help map the Moon's internal structure.

A probe named Intergeliozond has also been approved for an attempt to reach nearer the Sun's surface than any previous space mission. After a Venus swing-by, the probe's perihelion would be 42,000,000 kilometers away, and further fly-by maneuvers will cut that distance in half, and ultimately even far lower. An ion drive will also twist the orbital plane until it passes over the solar polar regions.

The Soviet Union's greatest deep-space successes were with its missions to Venus, and they will be resumed by a probe called Venera-D that will orbit the planet conducting remote observations. Serious studies have resumed for a long-lifetime Venus surface mission, but no formal project has been approved so far.

Manned Program and Vehicles

Soyuz Manned Spacecraft

Introduced 40 years ago, the Soyuz has undergone numerous modifications and upgrades. Most significantly, an entirely new generation of Soyuz has been officially approved for introduction in 2011–2012. This project clearly indicates that follow-on human space vehicles (for example, the Kliper project) are much further away.

The new Soyuz will be designed with a flight control system making one-man operation the norm so that two nonprofessional passengers can be carried safely. Major hardware changes will be made in the craft's service module and other systems in the command module. It will double the current 180-day on-orbit dwell capability. It will also be capable of being manufactured in a lunar variant, including a stronger heat shield, thermal control system, and longer-range communications capabilities. These options are nominally in support of a serious offer to make a commercial circumlunar mission for space tourists—but at a price of $400 million for two seats.

Sharing many basic systems with Soyuz is the robotic supply craft called Progress. Introduced 30 years ago for use with Salyut and Mir space stations, the vehicle has seen more than 100 missions, every one of which has succeeded (occasionally on the second, and once on the third, docking attempt). It delivers about 2,300 kilograms of payload to the space station.

Utilization and Expansion of International Space Station

Russia plans to double production of Soyuz and Progress vehicles in 2009 to support a six-person crew on the International Space Station (ISS) and to transport U.S. personnel in the period after shuttle retirement but prior to the beginning of Orion missions—perhaps 5 years or longer. The National Aeronautics and Space Administration (NASA) has agreed to a Soyuz launch price of $65 million (three seats) and will purchase seats for cash during this period. A contract for services worth more than $800 million was signed early in 2007.

In late 2006, the design for Russia's next add-on ISS module, called the Multipurpose Laboratory Module, was finalized. Originally intended to be basically a rebuilt spare Functional Control Block module in storage at the Khrunichev plant (like the unit that served as the base of the initial ISS orbital assembly), it now will utilize more control systems provided by Energiya-RCC (based on their Yamal bus) in order to reduce the space allocated to equipment that is applicable only to the initial rendezvous and docking phase. This will double the available volume for scientific equipment.[36] The unit will be docked to one of the side-facing service module ports sometime in 2009–2010. Another module will provide a fourth docking port to support the higher traffic rates.

Russia plans to support and help operate the ISS through at least 2020. But it remains to be seen whether the scientific returns from its participation will have any more impact on Russian industrial technology than did the ambitious program of orbital research in the 1980s—that is, zero.

It is just as likely that Russia sees its ISS role as dues for membership in the high-status club of top world spaceflight players. It is also relatively cheap insurance that the massively profitable foreign space sales activities will continue without interference by the governments of the United States and the European Union.

Kliper

Supporting the theory that Russia's main space efforts are aimed at securing additional foreign funds is the recent history of the much-touted Kliper six-person spacecraft. Officials have stated that it has been "approved for development" in the years after the Soyuz upgrade becomes operational, but significant design work is now being redone, and the hoped-for European and Japanese funding has not yet materialized.

The deputy chief of Roskosmos, Viktor Remishevsky, acknowledged in October 2006 that "this is the next stage in developing a manned space ship, and that Roskosmos had issued an RFP [request for proposal] for the spacecraft, but then withdrew it." He added that the Russian Space Agency had concluded that the budgetary funds allocated (about 9 billion rubles through 2015, of which 500 million are available by 2010) would not be sufficient to create a six-seat space ship that can fly to the Moon or to a space station, fly from Plesetsk, land on runways, and perform other required functions. Additional nonbudgeted funds are needed to realize the project—tens of billions of rubles—and there were no longer any credible sources of such financing.

In addition, the design teams had settled on a spacecraft that would weigh between 13 and 14 tons, and there is no man-rated booster available. The Angara-3 could do it in theory, but it has been so often delayed that officials were unwilling to fund and develop a manned spacecraft in the hope that the new booster would be done on time.[37]

After years of seeking subsidies and cooperation from European space agencies, Moscow in 2009 formally approved a fully domestically funded follow-on manned spacecraft with requirements very similar to NASA's Orion program. An upgraded Soyuz booster was also selected for the new vehicle, bypassing the Angara program entirely.

Ground Simulations

Another human spaceflight project that looks more like a foreign funding magnet than a serious scientific effort is a planned 500-day isolation study with six volunteers simulating a Mars mission. In 2007, facilities were developed at the Institute for Medical and Biological Problems in Moscow for an exercise, pending receipt of enough European money (and crew volunteers). Past isolation studies have had mixed results (at best) and produced no significantly usable operational or medical insights, but this project began short- and medium-term simulations in 2008–2009 with significant European participation and funding, with the 500-day mission delayed into 2010.

The Parom Ferry

There are also some commercially feasible proposed Russian spacecraft that might well be worthy of outside funding. Probably the most attractive is the small space tug called Parom that has been designed based on existing space hardware to substitute for one of the major capabilities of the soon-to-grounded NASA space shuttle—its ability to bring large cargoes (structural elements, supplies) gently to the space station.

It is useful to do a more detailed treatment of the Parom project because it is a good example of Russian space engineers playing to their strengths and providing specific, critical services to international space activities. As such, it is an illustrative case study in the ways that Russia can successfully exploit and build upon its existing strengths.

With the approaching irrevocable grounding of the space shuttle fleet, space planners must face the need to replace piecemeal as many of its capabilities as possible. And as the construction of the International Space Station has demonstrated, a key ability is not just to carry payloads into orbit, but also to accurately bring them to a desired point in space and attach them to a structure already there.

Without the shuttle acting as such a carrier, each payload designed to visit a space station must have its own navigation, guidance, control, and mating hardware. That hardware, and the power systems and propellant tanks to feed it, often can outweigh the deliverable payload on every launch and then often gets in the way of operations once the delivery has been performed.

Now the Russians have proposed building the Parom, a specific spacecraft that promises to perform these tasks efficiently (and to use another critical word again, *gently*—a trait that makes building the payloads much easier). Functionally, it is the full equivalent of the harbor tugs in major Earthside ports. Cargoes without their own propulsion are towed to locations where they are wanted. The tugboat then moves on to another cargo, stopping occasionally for refueling and maintenance.

The Parom that the Energiya Rocket and Space Corporation (Russia's manufacturer and operator of most human-related space vehicles) wants to build is a Soyuz-sized flying docking tunnel surrounded by propellant tanks, thrusters, solar cells, and avionics bays. It can dock in either direction, can thrust in either direction, and can be refueled repeatedly. Its components are to be designed for a 15-year lifetime involving up to 60 round trips between low orbit and the space station.

The basic mission profile is simplicity itself. Based at a docking bay at the ISS (perhaps only an attach point with minimal interface with the station), it departs for a lower orbit when a station-bound cargo canister (or assembly component) is placed into a parking orbit by any of a number of launch vehicles. The cargo vehicle must have a simple end-mounted mechanism for mechanical attachment and for short-term stabilization and power—nothing more sophisticated is needed. Parom approaches and docks to the cargo vehicle, and then pushes it up to the space station, where it docks its free end to a fully functional port. At that point, Parom's hatches can be opened and crewmembers can enter the cargo canister, if that is the mission. Or propellant can be fed through transfer lines into the station (and into Parom's own tanks, whenever needed).

Alternately, the station's robot arm can grapple the payload, detach it from Parom, and place it where needed—perhaps in an assembly area or over a common berthing mechanism on the U.S. side that allows transfer of full-size science racks or other large cargoes. Or perhaps the payload can be delivered to applications not yet even imagined. Parom is to have the flexibility to accommodate practically anything that anyone can get into a parking orbit, up to a mass of 12 metric tons and possibly more than twice that.

The range of delivery options made available by such a spacecraft is as wide as space itself. Parom could visit free-flying materials processing modules co-orbiting with the ISS, bringing them in for annual servicing and then redeploying them on its way out for a parking orbit pickup. Some Russian designs have Parom providing the space-to-space transport for the proposed Kliper follow-on human spacecraft, also still on the drawing board (and also awaiting funding from foreign partners).

Parom-class tugs could carry satellites into higher orbits for deployment, or emplace and then retrieve co-orbiting science and industrial satellites near the ISS. They could operate autonomously in geosynchronous orbit and even around the Moon, carrying cargo canisters that include additional propellant supplies. In another application, ISS-based Paroms (and more than one may be stationed there once the Russians install additional docking ports) might be able to serve as emergency crew refuges, with portable consumables packages for life support.

Practically all of the components of this Parom design have already been flight-tested. The structural framework is easy to build, and the power, control, approach, and docking systems would be outgrowths of existing Soyuz and Progress systems. Those avionics boxes that could not last 15 years can be designed for in-space changeout.

Russia has twice used tugboat-style vehicles to bring components to a space station. For both the Kvant module (Mir, 1987) and the Pirs airlock module (ISS, 2001), the component was mounted atop a detachable propulsion module that later departed. In both cases, however, rendezvous guidance gear was installed on the station-bound component, not on the proto-tugboat that was the ancestor of the Parom design.

In October 2006, Energiya president Nikolay Sevastyanov told a space conference, "We want to lower the cost of cargo supplies by a factor of four." His deputy chief designer, Nikolai Bryukhanov, had recently told reporters that "with consideration for the cost of the development and manufacture of the tug, the system will repay in less than two years of use"—clearly implying that customers would be expected to pay for the service. Once funding was approved, Bryukhanov promised the spacecraft could be ready in 5 years.

The following month, Energiya's plan received the blessing of Russian Federal Space Agency head Anatoly Perminov, who touted its benefits at a press conference and announced plans to conduct its first flight within 3 years (it was not clear if this would be a test flight and proof of concept or the first fully operational vehicle).

The plans are to phase out Progress flights soon afterward, although cargo canisters carrying 4 tons of supplies (instead of the 2.5 tons carried inside each Progress) would then be launched regularly for pickup by the operational Parom tug. How many would eventually be deployed remains unclear; but in the case of logistical support for a post-shuttle space station, Parom could well be the answer to a worrisome problem. And the way that the spacecraft is developed, funded, and operated could be the general operating concept for Russia's expanded successes in space in years to come.

Conclusion

For the foreseeable future, Russia appears committed to internationalization of its main nonmilitary space activities, mainly as a crutch in obtaining services disproportionate to contributed resources ("For 5 percent of the investment we get 30 percent of the resources" is a frequent comment in justification of the space station partnership) and as a badge of major player status in the world.

At the same time, Russia shows no signs of developing a capability for major innovation in spacecraft engineering or of demonstrating more than lip-service interest in quantum advances in space operations capabilities. Incremental progress has been the watchword for decades, usually not by choice but out of necessity because all previous attempts at breakout projects (human lunar flight, advanced robotic Mars probes, the Buran shuttle, the Polyus-Skif family of orbital battle stations) ended in humiliating frustration.

Providing commercial launch services for foreign customers has provided multidimensional benefits to Russia. Beyond the significant cash flow, such activities fund booster upgrades and, in the case of converted military missiles, fund validation of lifetime extension efforts for still-deployed missile weapons.

Military applications of space systems remain uninspired, with critical constellations (such as the missile early warning net) still significantly degraded and likely to remain so for many years. Russian officials have evidently decided that, despite any public posturings over U.S. military threats, there is essentially no prospect of actual hostilities in the foreseeable future and hence little pressure to reconstitute military space assets to a Soviet-era level. Russia retains a nuclear-armed operational antimissile system around Moscow that, if upgraded to hit-to-kill guidance, could provide significant antisatellite capability; it is also developing small robotic rendezvous spacecraft similar to U.S. projects that have potential antisatellite capabilities at any altitude into which they can be launched.

Attempts at domestic commercialization of space-related services, including communications, navigation, and mapping, remain seriously—perhaps irremediably—hamstrung by the recent resurgence of a traditional Russian top-down structure of authority. Bureaucrats are being ordered to implement wider use of space infrastructure, and after many years of rosy reports of progress, Moscow may realize that it is almost all, as usual, a sham.

There is still little indication of successful exploitation of space discoveries and space-developed technologies (what NASA and the Europeans call spin-offs) as a means of improving the technological skills of Russian industry. The space industry, as a component of the national defense industry, remains strictly compartmentalized from Russia's civil economy, and the resurgence of broad espionage laws (and several recent highly publicized convictions) will keep this ghettoization in force. This in turn may require other government measures, from patent purchase to industrial espionage, to acquire technologies that some Russian industries may already possess but are in practice forbidden to share internally.

Russian space-related scientific and exploratory research, after hitting rock bottom a decade ago, is showing signs of a modest rebound. Russian space scientists may be able to resume making respectable contributions to the world scientific literature in the coming decade, another ticket to world-class status that spreads prestige to all of Russia's science reputation.

But even if the main values of the Russian space program remain symbolic, these symbols have computable value to the nation's self-confidence and to the reputation of its technology—either for commercial export or as a reflection of the efficacy of its weapons. The modest but steady resource commitment to the space program reflects the government's assessment of the degree of value, now and in the foreseeable future.

However, none of these intentions has much chance of success unless the Russians find a way out of the looming demographic crisis that mass mortality is confronting them with. In a society and an industry where monopolization of knowledge was power and sharing it often led to legal prosecution, behavior must change, and fast. This must be done so that space workers a decade from now, without the in-the-flesh guidance and advice of the old-timers, will be able to draw on their team knowledge that survived the passing of its original owners and was preserved in an accessible, durable form. The alternative is a return to the learning curve of more frequent oversights, mistakes, and inadequate problem solving of the dawn of the space age—with its daunting costs in time, treasure, prestige, and even human lives.

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