History and Current Status of the Russian Space Program 2

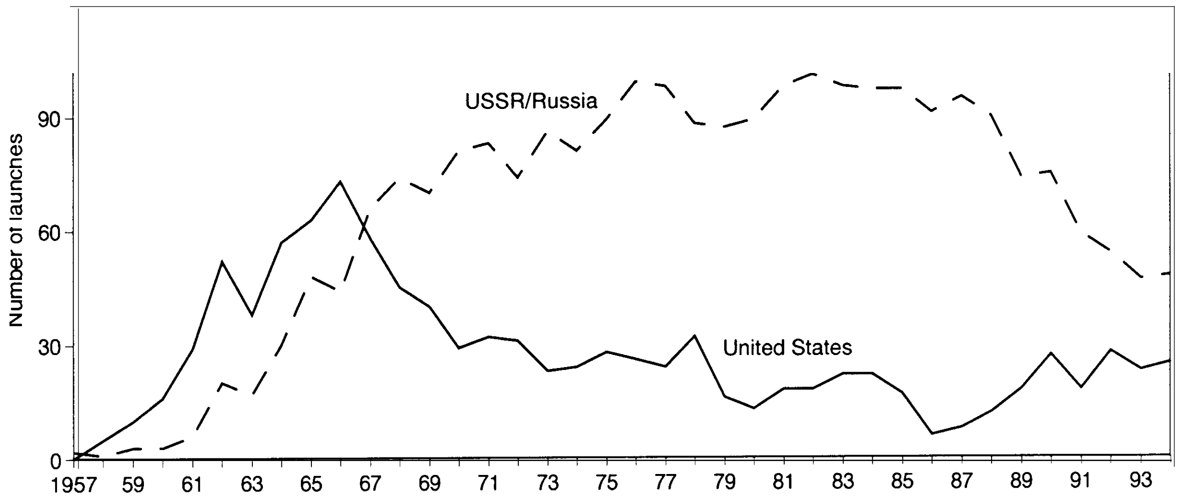
In 1957, the Soviet Union put the first satellite, Sputnik, into orbit. In 1961, it launched the first human, Yurii Gagarin, into space. From that time until its dissolution in 1991, the U.S.S.R. maintained a robust space program, often following lines of development very different from its one major competitor, the United States. However fast the political and economic landscape may be changing in Russia, the speed with which the space program can change and the directions it can take are constrained by how it developed during the Soviet era. This chapter gives a synopsis of the legacy of the Soviet space program.[1] It then describes what we know about the current status and structure of the Russian space program and what direction it might take in the next few years.

THE SOVIET SPACE PROGRAM

Russia's civilian space program is still using equipment and material manufactured and stored before the dissolution of the U.S.S.R., such as stockpiles of Proton rockets, satellites, and the Mir Space Station. Some of the impetus for the high-level production was a desire to equal or surpass U.S. accomplishments in space. Figure 2-1, which shows the number of launches in the United States and in the U.S.S.R. since 1957, not only demonstrates the productive capacity of the U.S.S.R.'s space industry, but also indicates the difference in design philosophies of the two countries. Where the United States built long-lived, technically

[1] Much of the material in this chapter is drawn from N.L. Johnson and D.M. Rodvold, *Europe and Asia in Space, 1991-1992,* DC-TR-2191.103-1 (Colorado Springs, CO: Kaman Sciences Corporation, 1993).

FIGURE 2-1: Successful U.S. and U.S.S.R./Russian Launches



SOURCE: Marcia S. Smith, *Space Activities of the United States, CIS, and Other Launching Countries/Organizations: 1957-1993,* Congressional Research Service Issue Briefs, Washington, DC, Mar 29, 1994.

sophisticated payloads, the U.S.S.R. built much shorter-lived satellites that required more frequent replacement.

The difference in design philosophy between the two countries goes back to the origins of their space programs. At the end of World War II, the German rocket scientists from Peenemünde, who were responsible for the V-2 Rocket, were part of the spoils of war divided between the United States and the U.S.S.R. Both countries used the experience and skills of these men to set up their ballistic-missile programs. Because the Soviet hydrogen bomb was so much larger and heavier than the one developed in the United States, it required a larger, more powerful rocket to carry it. In fact, the Soviet Union produced the first intercontinental ballistic missile (ICBM) in the world, which was known in the West as the R-7. The Soviets' expertise in producing rockets with large lift capacities then made it possible for them to be the first to produce launchers that could carry humans into orbit.

The successful production of rockets with large lift capacities reduced incentives to make payloads compact and light. To this day, the Russian satellite is less sophisticated in its electronics (Soviet satellites continued to use vacuum tubes long after the West had switched to solid-state components) and heavier than its Western counterparts. The Soviets built satellites with a much shorter design life than was typical in the United States. The requirement to maintain these space systems led to the Soviet Union's remarkable (by Western standards) ability to replace damaged or obsolete satellites. For some types of satellite, the Soviet Union was able to launch a replacement in 24 to 48 hours.

Both in the United States and the Soviet Union, the space program was a symbol of the country's technological superiority and productive capacity. The United States kept its military program out of the public eye and created the National Aeronautics and Space Administration (NASA) as a separate civilian space program, with its own budget, as the focus of the national civilian space effort. The Soviet Union, on the other hand, never created separate civil and military space programs; the same budget supported both efforts. Much of the same infrastructure, production organizations, design bureaus, and personnel were used to service both programs. Furthermore, there was no functioning legislative body that determined the budget; instead, funds went directly from the government to the design bureaus and production organizations via the ministries (figure 2-2). Ultimately, the Central Committee of the Communist Party of the Soviet Union decided what was to be funded. Which projects the Central Committee considered worthy of funding depended in part on what the United States was doing at the time and who among the industrial and military leaders had the government's ear.

The procurement of any system for the space program, civil or military, began with an order from the Council of Ministers. Money was then appropriated for the Ministry of General Machine Building (MOM), which passed it directly to the plant or design bureau chosen to do the work. The same funds would be used to do the systems tests, and if the tests went well, the Military Industrial Commission (VPK) would place the order for large-scale production. Once all the pieces were in place to produce a system that fulfilled requirements and had passed testing, the system's rigidity would deter attempts to infuse innovative and untested technological changes. Often, one well-tested design for a spacecraft would be used in widely disparate parts of the space program. Commonly, a spacecraft designed for the Soviet human space program would be used for robotic purposes. For example, the Soviet Vostok spacecraft, the type that carried Gagarin into orbit, was modified to become the Zenit photographic-reconnaissance spacecraft and, also, the Photon materials-processing platform.

THE RUSSIAN SPACE PROGRAM

The Breakup of the U.S.S.R.

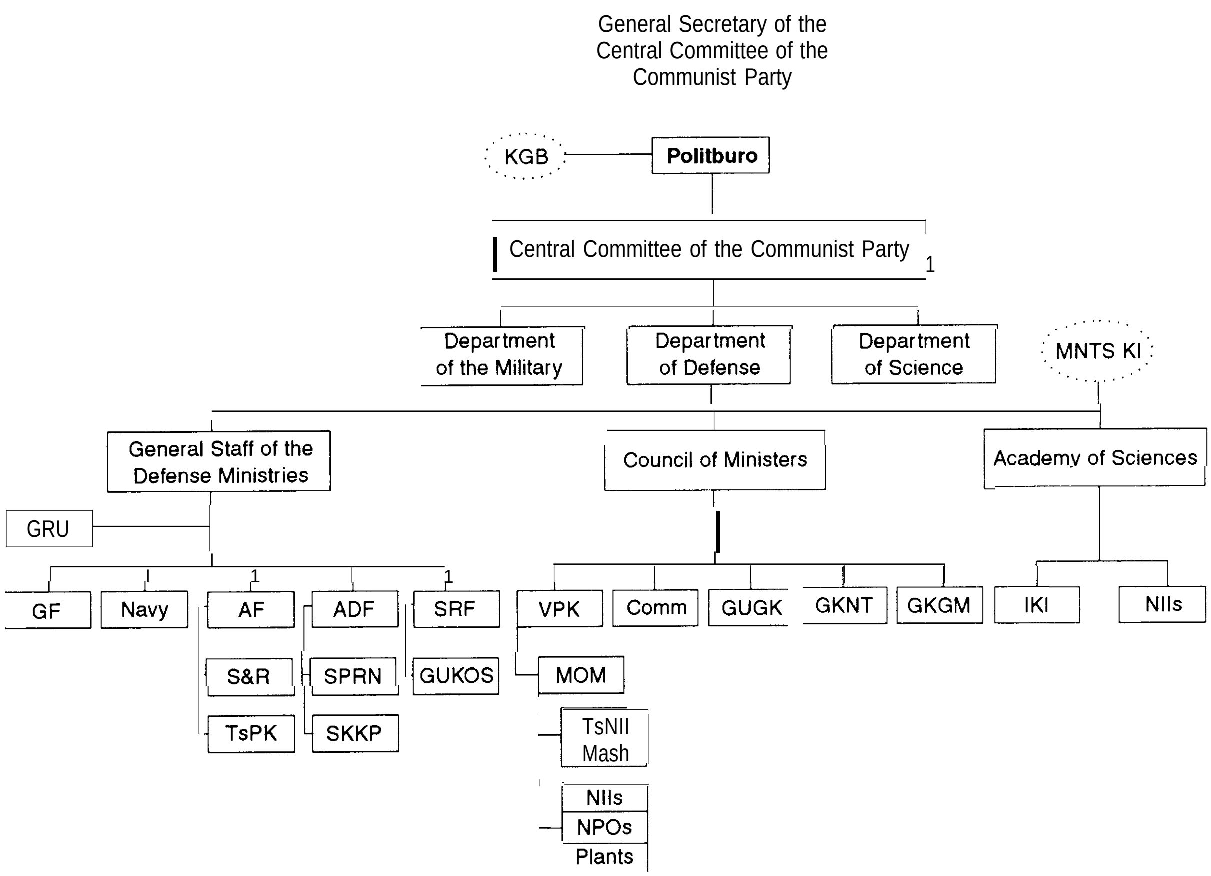
In December of 1991, the Union of Soviet Socialist Republics was dissolved. Of the 15 republics of the U.S.S.R., the three Slavic states (Russia, Ukraine, and Belarus) joined the Commonwealth of Independent States (CIS) on December 8; the five central Asian states (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan) and the three transcaucasian states (Armenia, Azerbaijan, and Moldava) joined on December 28; and Georgia joined in 1993. The Baltic states (Latvia, Lithuania, and Estonia) are not members of the CIS. At the end of December 1991, to keep the former Soviet space program intact, Russia led an attempt to form a CIS space agency.[2] That organization has turned out not to be influential, and although Ukraine, Kazakhstan, Azerbaijan, and Uzbekistan have all formed their own space agencies, Russia is by far the dominant player in the post-Soviet space program.

With the dissolution of the U.S.S.R. has come the daunting task of establishing a new form of government in Russia and, after decades of economic and political isolation from the West, altering a command economy to make it competitive with Western markets. The Politburo and Secretariat of the Communist Party are no longer the chief decisionmakers in Russia. A newly instated[3] Duma, or legislative assembly, controls the appropriations process, while the executive ministries are subordinate to the prime minister, who is

[2] The "Minsk Space Agreement," signed December 30, 1991, by representatives of the republics of Azerbaijan, Armenia, Belarus, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan, and the Russian Federation, lays out general guidelines for continuing the U.S.S.R.'s space program through combined use of resources and proportionate funding. Ukraine signed in the summer of 1992. The document itself is kept in the archives of the Belarus Republic in the capital city of Minsk.

[3] On September 21, 1993, Russian President Boris Yeltsin dissolved the Supreme Soviet of the Russian Federation. Two weeks later, on October 3 and 4, he used the Russian Army to suppress resistance to his order by a group of deputies from the dissolved Soviet. Yeltsin ordered a referendum on a new constitution and elections on December 12, 1993. The resulting election created a bicameral legislature, which had as its upper house the Federation Council and as its lower house the historically named State Duma. For an account of the conflict and the elections, see J. Nichol, Congressional Research Service, *Russia's Violent Showdown: Chronology of Events, September 21-October 4, 1993,* 93-879 F (Washington, DC: October 1993), and J. Nichol, Congressional Research Service, *Russian Legislative Elections and Constitutional Referendum: Outcome and Implications for U.S. Interests,* 94-19 FAN (Washington, DC: January 1993).

FIGURE 2-2: Management Structure of Soviet Space Activity, 1960s-1980s



KEY: ADF=Air Defense Forces; AF=Air Force, GF=Ground Forces, GKGM= State Committee for Geodesy and Mapping, GKNT= State Committee for Science and Technology, GRU=State Intelligence Directorate (Military Intelligence), GUGK= State Directorate for Hydrometrology, GU-KOS=State Directorate for Space Means, IKI = Institute of Space Research, MNTS KI = Interdepartmental Scientific and Technical Council on Space Research, MOM= Ministry of General Machine Building; NII=Scientific Research Institute, NPO=Scientific Production Organization, S& R= Search and Rescue; SKKP= System for Monitoring Outer Space, SPRN= System for Warning of Missile Attack, SRF=Space Rocket Forces, TsPK=Gagarin Cosmonaut Training Center; VPK=Military Industrial Commission.

SOURCE: Maxim Tarasenko, Moscow Institute of Physics and Technology, 1994.

appointed by the president. As a consequence, the Russian space program faces difficulties in organizing a network of facilities that stretches across several independent countries. As long as the non-Russian republics were part of the U. S. S. R., facilities such as design bureaus, factories, a launch facility (cosmodrome), and many sites used for satellite telemetry and tracking were available to the ruling body in Moscow for its use. Now, the independent republics are in a position to demand payment for facilities on their land, for hardware, and for services.

Very few of the facilities outside Russia can be considered indispensable to the survival of its space program. However, the Baikonur Cosmodrome is one facility that Russia would have a

Box 2-1: Space Facilities and Organizations Outside Russia

Launch facility

The only launch facility in the former Soviet Union now outside Russia is the Baikonur Cosmodrome, in Tyuratam, Kazakhstan.

Organization for launch-vehicle and satellite design and manufacture

NPO Yuzhnoye (formerly the Yangel Design Bureau) is located in Dniepropetrovsk, Ukraine. Yuzhnoye produces the SS-18 and SS-24 ballistic missiles and the SL-11 (Tsyklon-M), SL-14 (Tsyklon), and SL-16 (Zenit) launchers. It also produces remote-sensing, intelligence, and weather satellites. At one time, NPO Yuzhnoye had nearly 30,000 employees.

Spacecraft command-and-control centers

The Space Command, Control, and Tracking System (KIK) has its main control centers near Moscow: 1) the Flight Control Center (TsUP) at Kaliningrad, which handles planetary missions, the Mir Space Station, and Soyuz missions to Mir, and 2) the Satellite Control Center (TsUS) at Golitsino, which handles all civilian and military satellites. KIK also has sites outside Russia in Georgia, Kazakhstan, Ukraine, and Uzbekistan. It controls the nearly 180 currently active Russian and Commonwealth of Independent States satellites. A subset of these sites is also used as the primary support network for the Mir Space Station.

The Long-Range Space Communications System (TsDKC), which controls scientific spacecraft in high Earth orbit or in interplanetary flight, has sites in Russia and Ukraine.

Space-surveillance facilities

The System for Monitoring Outer Space (SKKP)[1] and the System for Warning of Missile Attacks (SPRN) use HEN HOUSE and Large Phased Array Radar developed in the 1960s and 1980s. Sites outside Russia are in the Ukraine, Kazakhstan, Azerbaijan, and Latvia. SKKP also uses seven optical sensors located in Russia, Kazakhstan, Tajikistan, and Ukraine, and it uses five electro-optical sensors located in Russia, Armenia, Georgia, Turkmenia, and Ukraine.

[1] This facility is now referred to officially as the Space Surveillance System.

SOURCE: Kaman Sciences Corporation, 1994.

hard time replacing quickly.[4] Rather than build a new launch complex, the Russian government has decided that it is more effective and cheaper, for the time being, to lease the cosmodrome from Kazakhstan for the next 20 years at least.[5] Most of the spacecraft command, tracking, and control stations outside Russia have been taken offline and are being replaced with space-based autorelay satellites.[6] Russia must now deal with the production organizations and design bureaus that lie outside its borders as it would with any other foreign enterprise. Box 2-1 shows some of the facilities and organizations that now lie outside Russia.

[4] Although Baikonur is the usual name for the cosmodrome located near the Tyuratam railway station in Kazakhstan, the town of Baikonur lies some 320 km (200 miles) northeast of the cosmodrome.

[5] The Military Space Forces (VKS) and the Russian Space Agency (RSA) are struggling over whether or not to establish a new cosmodrome at the old ballistic-missile site in Svobodny. The VKS wants the security of launching all military payloads from Russian soil, but the RSA does not want its funding diluted by having money diverted away from Baikonur.

[6] The command and tracking stations in Ukraine are still online.

After drawn-out negotiations dating back to 1992, Prime Minister Viktor Chernomyrdin of Russia and his Kazakh counterpart, Akezhan Kazhegeldin, signed a treaty on December 10, 1994, that leases to Russia the use and control of Baikonur until the year 2014, with the possibility for a 10-year extension of the lease. In the near future, those same parties are expected to sign an agreement leasing to Russia several military test ranges that lie in Kazakh territory. One plan under consideration would convert the ballistic-missile launch site at Svobodny into a space-launch facility to reduce or eliminate dependence on Baikonur.[7]

The Russian Space Agency

With the dissolution of the U.S.S.R., a new governmental structure and, two years later, a new constitution were established in Russia. Russia's legislative structures started to play a more significant role in governing, and the executive branch revised its structure. (See figure 2-3 for the organization of the revised government as it bears on the space program.) Because of the importance of the space program to Russia's defense and economic well-being and because the space industry would have to compete in the world market to survive, the Russian government empowered a separate agency to control the direction of the state space program and to act as the representative of the Russian space program in dealings with the Newly Independent States (NIS) and other foreign countries.

The Russian Space Agency (RSA) was established by decree of the president of Russia on February 25, 1992, and was given its charter[8] by the legislative branch on October 6, 1993, with a mandate to "make efficient use of Russia's space-rocket complex in the interests of the Russian Federation's socio-economic development, security and international cooperation. . . ."[9] RSA is supposed to be funded as a separate item in the Russian federal budget, as it was in 1993 and is expected to be in 1995. In 1994, the funding for RSA was not a separate line item but came through the Ministry of Science. RSA's organizational structure, which is similar to NASA's, is shown in figure 2-4.[10] Under the Soviet system, there had never been any agency whose sole purpose was to formulate and implement government space policy. The existence of such an agency has changed the way the space program is run in several ways:

- *It is now possible to separate the civil and military parts of Russia's space program.* Though the military still commands a large portion of resources in the space program, Russia is moving away from having Space Forces personnel operate all launch and operations facilities. Within the next two years, RSA will be responsible for paying civilian personnel to take over functions that have to do with civilian launches and the maintenance and operation of civilian satellites and of the Mir Space Station. At present, RSA pays the salaries of 16,000 servicemen, who, although they are no longer paid by the Space Forces, are still under the command of the Commander of the Space Forces.
- *Russian facilities are now more accessible to the West because: 1) the military part of the program has been separated out, which makes transfer of sensitive military technology easier to control, and 2) fewer government departments have to sign off on a cooperative venture.* Furthermore, RSA provides a single point of contact for any organization wanting to do

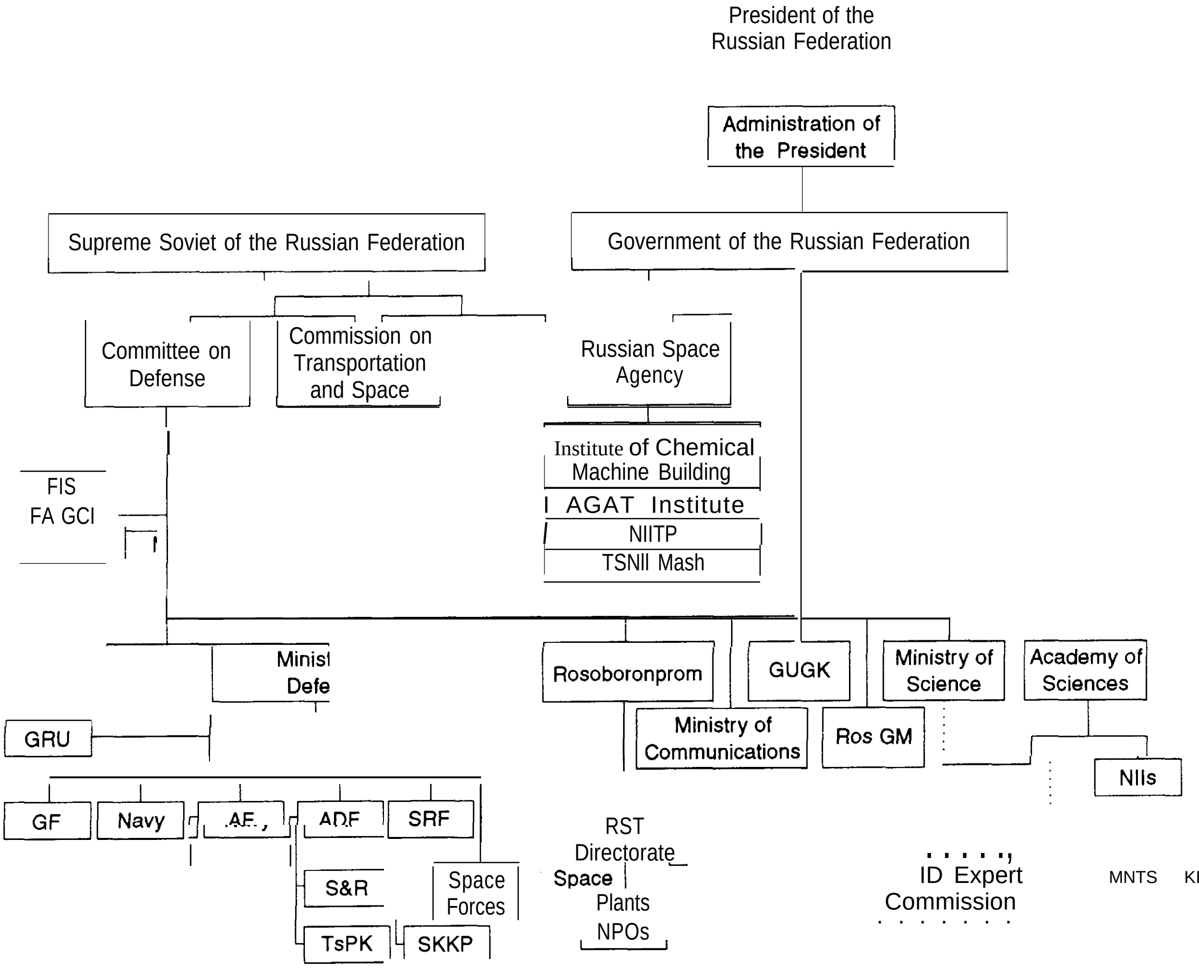
[7] "New Launch Base Sought," *Aviation Week & Space Technology*, p. 54, Jan. 2, 1995.

[8] Law of the Russian Federation on Space Activity, Section II, Article 6, October 1993.

[9] Boris Yeltsin, Decree Establishing the Russian Space Agency, Moscow, February 1992.

[10] However, RSA is an organization of only 200 people, compared with NASA's workforce of 22,000. Lynn Cline, Director, Space Flight Division, Office of External Relations, NASA, points out that it is impossible for RSA to oversee implementation of cooperative agreements and contract awards in the way that NASA does, simply because of its small size.

FIGURE 2-3: Management Structure of Russian Space Activity, 1992-1993



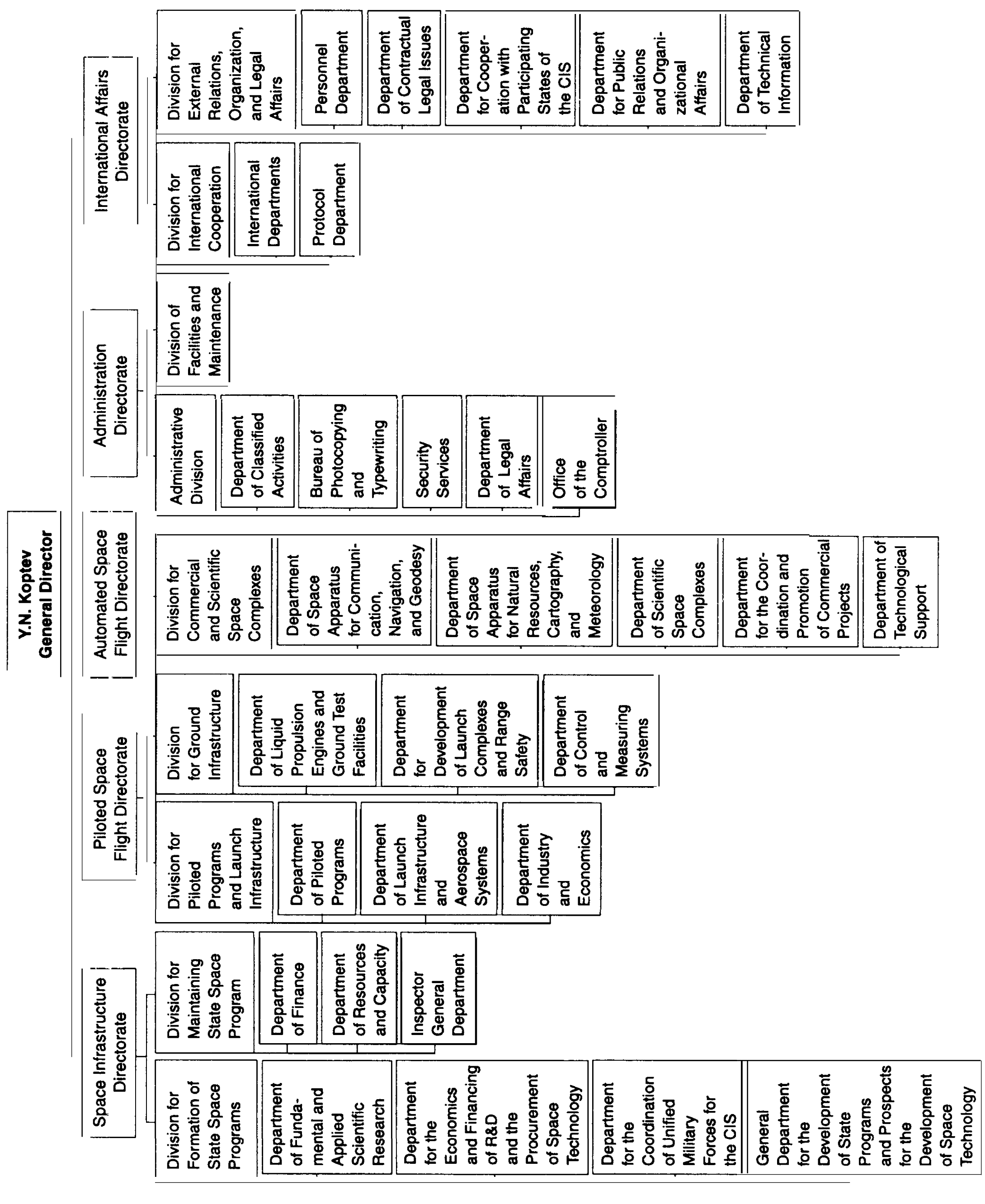
KEY: FA GCI =Federal Agency of Government Communication and Information; FIS=Foreign Intelligence Service; ID=InterDepartmental; MS= Ministry of Security; Ros GM= Russian State Committee of Hydrometrology; RST=Rocket and Space Technology. See figure 2-2 for definitions of other abbreviations,

SOURCE: *Who's Who in Russian Aerospace Activities: A Reference List,* ANSER, Center for International Aerospace Cooperation, December 1994.

business with Russia in commercial space endeavors, if the organization chooses to use it.[11] In that regard, RSA replaces Glavkosmos, which now primarily markets Russian technology. RSA's director, Yuri Koptev, must approve all contracts between foreign entities and the various enterprises of the Russian space program and is reportedly very willing to approve contracts that benefit those enterprises.[12]

[11] There are company-to-company contacts, but RSA involves itself in the negotiations at some level.

[12] Two Russian contacts, one a scientist with Applied Mechanics NPO and a member of the Russian Academy of Sciences, the other an analyst of the Russian space program, both agree that RSA is committed to helping the Russian aerospace industry do as much business with foreign corporations as possible.



SOURCE: *Who's Who in Russian Aerospace Activities: A Reference List*, ANSER, Center for International Aerospace Cooperation, Arlington, VA, December 1994

- *RSA is involved in all phases of the development of a system, from research and development through production.* At its inception, the agency was given authority over several research and production organizations (figure 2-3), including the Central Scientific Research Institute of Machine Building (TsNIIMash), which operates the spacecraft control facilities of the Flight Control Center (TsUP) at Kaliningrad. After a struggle between RSA and several of the larger space enterprises, the Russian government, in a decree signed by Prime Minister Chernomyrdin,[13] gave control of 38 aerospace enterprises to RSA, to be added to the four companies[14] already under RSA control. This action shifted authority for the funding and oversight of those enterprises from the State Committee on Defense Industries to RSA. The change also means that RSA is now responsible for all defense conversion efforts.

RSA could also help make the transition to private enterprise less abrupt. In the recent privatization of one of Russia's largest and most influential space enterprises, Scientific Production Organization (NPO) (now Russian Space Corporation (RSC)) Energia, ownership of 38 percent of the company was retained by the government, that is, by RSA. Of the remaining 62 percent, 10 percent (120,000 shares at 1,000 rubles each) was offered to the employees, 5 percent was given to management, 10 percent was held in reserve, 12 percent was sold at auction, and 25 percent was exchanged for privatization vouchers. As Russian aerospace companies become more established in the world market, the extent to which RSA has to subsidize the infrastructure that supports those enterprises could decrease significantly.

Current Activities

The percentage of the total 1993 Russian Federation space budget devoted to the different areas of Russia's space program is shown in figure 2-5. These resources are used to support Russia's civilian and military objectives, namely,

- exploring space,
- pursuing space science,
- maintaining human presence in space via
  - space station and
  - cargo and logistics vehicles,
- maintaining information space systems, such as
  - navigation satellites,
  - geodetic satellites,
  - telecommunication satellites and
  - observation satellites, and
- maintaining space assets dedicated to national security.

Of these, the severe budgetary constraints of the past few years have curtailed efforts in space science and exploration the most.[15]

Human Spaceflight

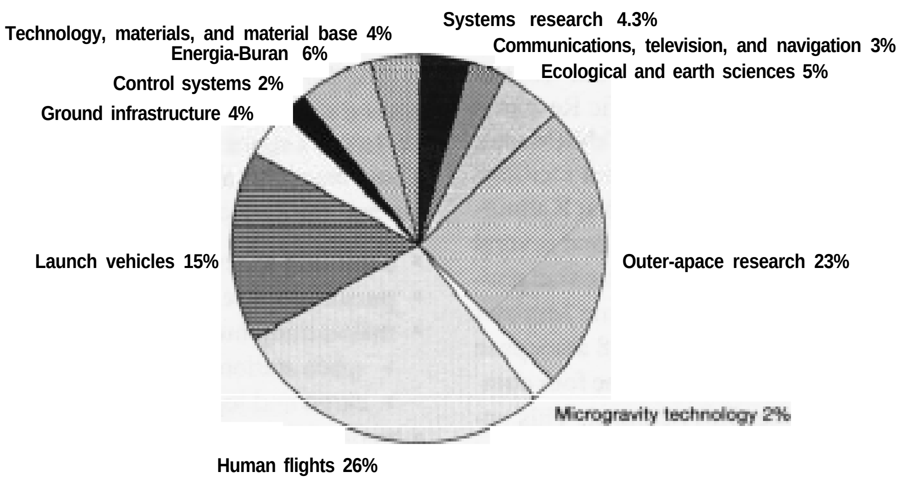
Russia has had a frequent human presence in space since the Salyut program began in 1971. The Salyut Space Stations passed through several different designs before reaching the most recent phase, which is represented by the Mir Space Station. Mir has been in orbit since 1986 and has been permanently occupied since 1989. Although not all of the operations have gone according to plan,

[13] Government of the Russian Federation Decree #866, Moscow, July 25, 1994. The decree states, "The RSA will provide state control and coordination of enterprises and organizations involved in the research, design, and production of rocket and space hardware for various purposes; to determine state scientific, technical, and industrial policy in the areas of rocket and space hardware and to ensure the fulfillment of such policies; and to enable the fulfillment of conversion projects and the structural reorganization of the rocket and space industry."

[14] The original four enterprises under RSA control are the Scientific Research Institute of Chemical Machine Building (NIIKhimMash), the AGAT Institute, the Scientific Research Institute of Thermal Processes (NIITP), and the Central Scientific Research Institute of Machine Building (TsNIIMash).

[15] The U.S.-Russian mission to Mars, which was scheduled to fly in 1994, will be lucky to get off the ground as early as 1996. The "Fire and Ice" mission to explore Mercury and Pluto is now highly tentative. It stands to reason that in tight budgetary times, programs deemed less essential will be cut back first, and those programs needed for national security or that can attract outside revenues will be given priority.

FIGURE 2-5: Distribution of the 1993 Russian Space Budget



SOURCE: Kaman Sciences Corporation, 1995.

with several failures of the automatic docking system and occasional problems with power maintenance and environmental control, the Russians have used the Mir station to gain more experience in the adaptation of humans to the space environment than has any other nation.

The Mir Space Station has been used to perform international experiments in science and space engineering. It has been host to astronauts from the United States, England, Germany, Japan, and other countries. The use of the station has given the Russians unequaled experience in the effects of prolonged spaceflight, extravehicular activities, docking, and maintenance of facilities in space. Experiments on Mir include research in the fields of botany, biology, materials science, and physiology, many of which included international participation. Because of their experience with space stations, the United States expects Russia to play a large part in the design and maintenance of the International Space Station.

Civil Space Systems

Russia has approximately 180 operational satellites in over 30 active satellite programs; in addition, many inactive, standby satellites can be brought into use if needed. Box 2-2 summarizes the active systems that are not strictly military.

Natlonal Secudty Space Systems

An early impetus for the development of satellites was to use space for military observation, which is one reason Sputnik created such a scare.[16] Later came the realization that orbiting platforms could be used for early-warning systems and space weapons. The Russian antisatellite systems (ASAT program dates back to 1963, and the first ASAT intercept test was performed in 1968.

Russia currently operates several types of military-reconnaissance satellite[17]:

- Low-Earth-orbit (LEO) high-resolution satellites that fly for up to three months with l-meter

[16] Even before the time of Sputnik, both the United States and the Soviet Union understood the surveillance and communications potential of satellites.

[17] N.L. Johnson, Kaman Sciences Corporation, Colorado Springs, CO, personal communication, February 1995.

(or better) resolution. The photographic film returns to Earth and is picked up.

- Satellites with both photographic film return and digital transmission capabilities. These satellites remain in orbit for up to two months.
- Satellites with lifetimes of a year or more that transmit their digital data to Earth via relay from geosynchronous-orbit (GEO) satellites.
- Topographic mappers that fly for six weeks with 2-meter-panchromatic and 5-meter-color resolutions.
- Vostok-class satellites which fly for two to three weeks and are assumed to function like the Resurs-F remote-sensing satellites (box 2-2).
- A new satellite, designated Kosmos 2290 and launched on the Zenit, which is still under assessment.
- EORSAT (Electronic Ocean Reconnaissance), a four-satellite constellation that flies at altitudes of about 400 km. The system is believed to be able to estimate naval positions to within 2 km.
- Russia flies two other types of electronic intelligence satellite. One, launched on the Tsyklon, flies at an altitude of 650 km; the other, launched on the Zenit, flies at 850 km altitude.

Two constellations support ballistic-missile-attack warning systems, and one supports an ASAT system. One of the early-warning systems has nine satellites in Molniya orbits equipped with infrared sensors (see box 2-2 for an explanation of the Molniya-type orbit); the other has two or three satellites in GEO. The ASAT system operates by waiting for the launch site at Baikonur to pass through the orbital plane of the offending satellite, at which time the ASAT would be launched on an intercept path requiring one or two revolutions, or between 90 and 200 minutes. A conventional explosive device would then destroy the target satellite.

Launch Systems

Russia maintains a versatile fleet of launch vehicles capable of lifting payloads of half a metric ton to 21 metric tons into LEO. All Russian- and Ukrainian-built boosters, their primary launch sites, principal manufacturers, and payload capacities are listed in the table in figure 2-6. These vehicles are launched from the two cosmodromes currently in use, Plesetsk in Russia and Baikonur in Kazakhstan.

Baikonur Cosmodrome

Baikonur is the oldest space-launch facility in the world and has supported more than 968 orbital missions since 1957.[18] Information from visiting westerners and from wire and news reports confirm that the infrastructure is deteriorating, that many buildings where work is going on are unheated, and that certain parts of the complex are in disrepair.[19] There were reports of strikes and protests last winter because of the harshness of conditions and the lack of basic amenities in the neighboring town of Leninsk. Reportedly, bands of thieves were even using camels to pull copper cable from the ground, melting the cable down, and selling the copper for its value as raw material. The Russian press reported that one launch at Baikonur had to be postponed because of the theft of specialized equipment.[20]

The picture is not altogether bleak, though. At the cosmodrome itself, maintenance and modifications are being kept up to allow for the continued launching of all families of booster traditionally launched out of Baikonur. Under the

[18] About 70 missions failed to reach Earth orbit.

[19] See, e.g., *Oversight Visit: Baikonur Cosmodrome*, Chairman's Report of the Committee on Science, Space, and Technology, House of Representatives, 103d Congress, 2d Session (Washington, DC: U.S. Government Printing Office, February 1994), Margaret Shapiro, "Site of First Steps into Space Slips into Poverty," *The Washington Post*, Mar. 19, 1995, p. A1, and Michael Specter, "Where Sputnik Once Soared into History, Hard Times Take Hold," *The New York Times*, Mar. 21, 1995, p. C1.

[20] Vladimir Ardayev, "Kazakhstan: Depressing Landscape With Fireworks," *Isvestiya*, Moscow, Nov. 3, 1994, p. 4 (Foreign Broadcast Information Service translated text).

Box 2-2: Operational Russian Satellite Systems

Telecommunications satellites

- Molniya ("Lighting") is a constellation of 16 satellites in highly elliptical (eccentricities of about 0.75), semisynchronous orbits used for telephone, telegraph, and television transmission. The Molniya-type orbit was designed by the U. S. S. R., and the satellites view broad regions of the Northern Hemisphere for eight hours out of their 12-hour periods. The Molniya-type orbit has the advantage of giving better coverage of the Earth at high latitudes than does a geostationary orbit. By choosing an orbit with an inclination of 63.4°, the satellite's point of closest approach remains fixed in the Southern Hemisphere, thereby ensuring that the satellite always flies over the same region in the Northern Hemisphere.
- Ekran ("Screen") satellites are geostationary at 99° east longitude and provide television and radio transmission for Russia's far-northern regions. At present, two such satellites are operational.
- Gorizont ('(Horizon") is a high-power telephone, telegraph, television, radio, and fax transmission satellite, which also handles maritime and international communications. Through Gorizont, Russia has become increasingly more integrated into the Western system of communication satellites. When the U.S.S.R. became a member of INTELSAT in 1991, it made Gorizont available to that system, and several Western nations now lease Gorizont transponders. The United States leased transponders during the Persian Gulf War to handle the increased communications traffic in the Middle East.
- Gals is a television broadcasting system made up of one satellite in geosynchronous orbit (GEO). Originally meant as a part of a national program, the satellite is currently serving foreign customers.
- Luch is a three-satellite GEO system used for teleconferencing, television, video data exchange, and telephone links. To date, only two of the three GEO satellites have ever been operational, and the Luch has been used primarily in support of the Mir Space Station.
- Raduga and Geyser (Geyser carries the Potok data-relay system) are constellations of satellites used for military and government communications

Remote-sensing satellites

- Resurs-F1, first flown in 1979 with a nominal lifetime of 14 days, performs low-altitude (250 to 400 km) multispectral photography with cameras of 5- to 8-meter and 15- to 30-meter resolutions, and returns the film.
- Resurs-F2, first flown in 1987 with a nominal lifetime of 30 days, flies at altitudes of 170 to 450 km and returns multispectral photographs with 5- to 8-meter resolution.
- Almaz-1, first flown in 1991 (after a 1987 prototype), has a nominal lifetime of two years, flies at altitudes of 250 to 350 km, and uses a 15- to 30-meter-resolution synthetic aperture radar.
- Resurs-0, first flown in 1985 (with prototypes during 1977-1983), has a nominal lifetime of three years and performs multispectral imagery in Sun-synchronous orbit at altitudes of 600 to 660 km.
- Okean-0, first flown in 1983, with a nominal lifetime of two years, performs multispectral sensing and real aperture radar measurements for oceanographic surveys at altitudes of 630 to 660 km. This satellite can look at ice in the polar regions and spot weak points as an aid to navigation. Okean-0 has also proved useful in search-and-rescue operations.

agreement between the Russian and Kazakh governments whereby Russia will lease the cosmodrome, Russia gains control overall of Baikonur's facilities and will pay the Kazakh government the equivalent of$115 million per year. Some of that money can be in the form of services and support of Leninsk, which is home to the workers who are still employed at Baikonur.

Facilities currently in use at Baikonur are reported to be in good working order and operating

Box 2-2 (Cont'd): Operational Russian Satellite Systems

Meteorological satellites

- Meteor-2, first flown in 1975, carries a scanning photometer, an infrared radiometer, and a radiation measurement complex. It is now being phased out. Meteor-3, first flown in 1984, carries a direct-scanning telephotometer, a store-and-dump scanning telephotometer, a direct-scanning radiometer, a store-and-dump scanning radiometer, a UV spectrometer, a multichannel UV spectrometer (Ozon-M), and a radiation measurement complex, In 1991, the United States and Russia cooperated on a project to place NASA's Total Ozone Mapping Spectrometer (TOMS) on a Meteor-3 spacecraft.
- Electro, once called the Geostationary Operational Meteorological Satellite (GOMS), has been under development since the 1970s. Launched October 31, 1994, it carries a scanning infrared radiometer, a scanning telephotometer, and a radiation measurement complex.

Material processing and biological satellites

- A Photon spacecraft, dedicated to materials science research, has flown every year since 1988, except for 1993. International organizations also make use of the Photon for their microgravity experiments. Bion, like the Photon, uses a Vostok-like recoverable spacecraft to perform life sciences experiments and to return the payload to Earth. Ten Bion flights have occurred over the past 20 years, and the last seven have all had extensive international, including U. S., participation.

[1] The eccentricity of an orbit is a measure of how far that orbit is from being circular (A circular orbit has an eccentricity of zero) Satellites have their greatest velocity at perigee and their smallest velocity at apogee The Molniya orbit is designed to have its perigee in the Southern Hemisphere which puts the apogee in the Northern Hemisphere where the satellite needs to spend most of its time to be most effective.

SOURCE: Kaman Science Corporation, 1994.

with the automated efficiency typical of the Russian launch industry. Baikonur supported 23 missions in 1993; and 30 in 1994. In addition, the U.S. firm of Lockheed Aerospace is building a payload-processing facility in support of its joint-venture subsidiary Lockheed-Khrunichev-Energia, and construction has begun on special buildings dedicated to the processing of Western payloads.

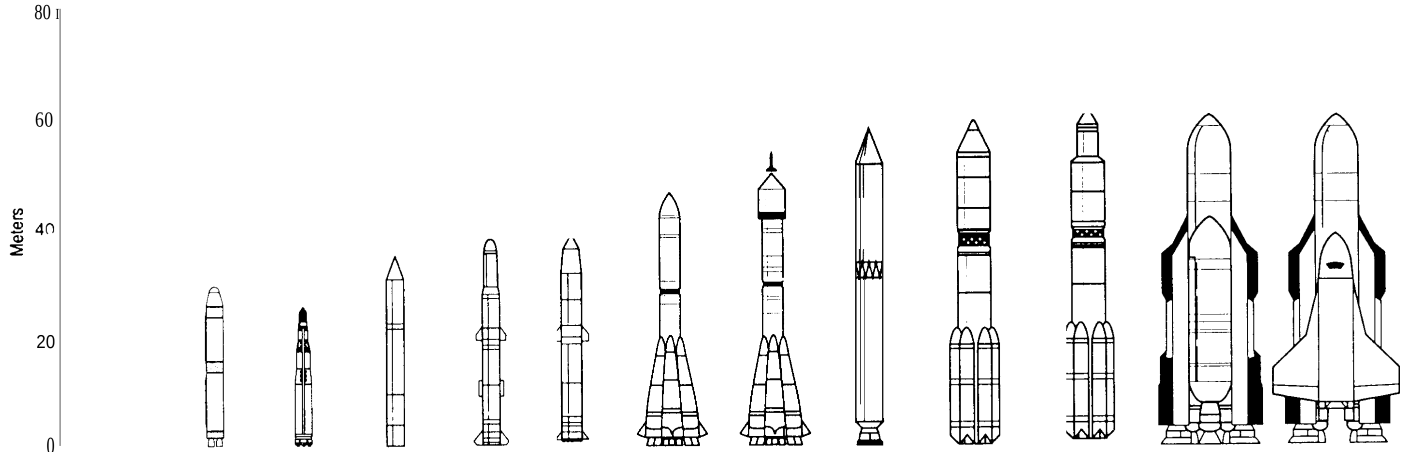
Russia launches five boosters from Baikonur —Rokot, Tsyklon-M, Soyuz, Zenit, and Proton (three-stage and four-stage). Energia, with and without the shuttle Buran, is no longer operational, and the Molniya booster has not flown since 1989. The Baikonur Cosmodrome supports Russian programs in human spaceflight, interplanetary spaceflight, communications and early-warning satellites in GEO, navigation and geodetic satellites, remote-sensing satellites, satellites used for national security purposes, and scientific satellites (including interplanetary satellites).

Plesetsk Cosmodrome

The cosmodrome at Plesetsk was, until last year, the world's busiest space-launch facility. It has averaged one launch per week for the past 10 years, and it has launched nearly 1,400 missions since 1966, including 26 missions in 1993 and 18 in 1994. Plesetsk is capable of supporting launches of Start-1, Kosmos, Tsyklon, Molniya, and Soyuz. Plesetsk supports remote-sensing, meteorological, communications, navigation, and scientific satellites, as well as satellites used for national security purposes.

Some Russian officials would like to see all boosters launched from Russian soil. One plan would upgrade Plesetsk so that it could launch

FIGURE 2-6: Russian and Ukrainian Boosters



Designator	SL-19	SL-18	SL-8	SL-11	SL-14	SL-6	SL-4	SL-16	SL-12	SL-13	SL-17	SL-17
Name	Rokot	Start-1	Kosmos	Tsyklon-M	Tsyklon	Molniya	Soyuz	Zenit	Proton	Proton	Energia*	Energia/Buran*
First Flight	1991	1993	1964	1966	1977	1961	1963	1985	1967	1968	1987	1988
Current Launch Sites	Baikonur	Plesetsk	Plesetsk	Baikonur	Plesetsk	Baikonur Plesetsk	Baikonur Plesetsk	Baikonur	Baikonur	Baikonur	Baikonur	Baikonur
Principal Manufacturer	Salyut Design Bureau	Yuzhnoye NPO	Yuzhnoye NPO	Yuzhnoye NPO	Yuzhnoye NPO	TsSKB Samara	TsSKB Samara	Yuzhnoye NPO	Khrunichev Enterprise	Khrunichev Enterprise	Energia NPO	Energia NPO
Configuration	3-Stage	4-Stage	2-Stage	2-Stage	3-Stage	3-Stage	2-Stage	2-Stage	4-Stage	3-Stage	1-Stage	1-Stage
Stage 1	Ss-19 Stage 1	SS-25 Stage 1	RD-216	RD-218	RD-218	RD-107,108	RD-107,10	RD-170	RD-253	RD-253	RD-0120/171	RD-0120/171
Stage 2	Ss-19 Stage 2	SS-25 Stage 1	N/A	RD-219	RD-219	RD-0110	RD-0110	RD-120	RD-0210,0211	RD-0210,021		
Stage 3	Breeze	SS-25 Stage 1			N/A	N/A			RD-0212	RD-0212		
Stage 4		N/A							Block D/DM			
Payload (tonnes)	2.0 (LEO)	0.5 (LEO)	1.5 (LEO)	3.5 (LEO)	4.0 (LEO)	1.8 (SEO)	7.32 (LEO)	13.7 (LEO)	2.5 (GEO)	20.6 (LEO)	88.0 (LEO)	30.0 (LEO)
Uses	N/A	N/A	Early-warning mission	Military payloads, e.g., ASAT, EORSAT, RORSAT	Meteor, Okean, geodetic	Molniya, Kosmos	All manned; Photon, Bion, Resurs-F, Progress-M	Military ELINT	Solar System exploration, communi-cations navigation, early warning	Space Station components	N/A	Buran Space Shuttle
Precursor	SS-19	SS-25	SS-5 (Skean)	SS-9 (Scarp)	SS-9 (Scarp)	SS-6 (Sapwood)	SS-6 (Sapwood)	None	None	None	None	None

*The Energia and Energia/Buran are not currently operational.

SOURCE: Kaman Sciences Corporation, 1995

TABLE 2-1: Possible Russian Ballistic-Missile Conversion

Name	Ballistic missile	Payload to LEO[1] (metric tons)	Launch site
SS-18K	**SS-18**	4.4	Baikonur
Space Clipper	SS-24	2.	Air launch near Equator
Shtil	SS-N-23	0.95	Air launch near Equator
Reef	SS-N-20	1.5	Air launch
Surf	SS-N-20/SS-N-23	2.4	Sea launch near Equator

[1] Low Earth orbit,

SOURCE: Kaman Sciences Corporation, 1994

every vehicle in the fleet, but the financial constraints make that kind of construction unlikely in the near term. A second proposal is to convert the missile range at Svobodny into a cosmodrome for civilian and military launches. The Russian Duma has not approved the installation of facilities to launch the proposed Angara heavy-lift launch vehicle, but it has not prohibited the planned 1996 operations of the Rokot small-payload launcher. Engineers have already begun converting the old ICBM silos for launching the Rokot, and the first test launch from Svobodny is planned for summer or fall of this year.

Military Conversion

The end of the Cold War leaves Russia with several classes of ballistic missile that could be converted to commercial lift vehicles. Besides the Start-1 and Rokot, which are already operational, Russia will test several conversions in the next few years. Conversion is costly, and the number of systems that become operational will depend on market demand. Table 2-1 shows the ballistic missiles that Russia has considered for conversion to commercial launchers, along with their payload capacities and launch sites.