The Rebirth of the Russian Space Program

50 Years After Sputnik, New Frontiers

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Author's preface

The rebirth of the Russian space program marks an important event: 50 years since the first Sputnik was launched on 4th October 1957. At that time, few could have imagined the dramatic events that lay head. The Soviet Union achieved all the great firsts in cosmonautics—the first satellite in orbit, the first animal in orbit, the first laboratory in orbit, the first probe to the Moon, the first probe to photograph its far side, the first soft landing on the moon, the first man in space, the first woman in space, the first spacewalk. Except one, the first human landing on the Moon. In 1964, the Soviet Union decided to contest the decision of the United States to put the first person on the Moon. The Soviet Union engaged in that race far too late, with divided organization, and made a gallant but doomed challenge to Apollo.

Undaunted, the Soviet Union rebuilt its space program around orbiting stations, building the first one, Salyut, and then the first permanent home in space, Mir. The Soviet Union still achieved many more firsts: the first lunar rover, the first soft landing on Venus, the first soft landing on Mars, the first recovery of samples from the Moon by automatic spacecraft.

The original book in this series *Race into space—a history of the Soviet space programme* (1988) was written during the heyday of the Soviet space program, when the Soviet Union was launching over a hundred satellites a year and had a vast program for the manned and unmanned exploration of space and its application for practical benefits on Earth. The second book in the series, *The new Russian space program* (1995) was compiled during the shock adjustment of the former Soviet space program to the strained economic realities of life in the Russian Federation. *The new Russian space program* took advantage of all the new information that had come to light about Soviet history: thanks to the policy of openness (*glasnost*) begun by the last president of the Soviet Union, Mikhail Gorbachev, we were now at last able to learn about what had really taken place during the time of the Soviet period, as secrets emerged into the light of day. The third book of this series, *Russia in space—the failed frontier?* (2001) looked at the Russian space program in the period from 1992, when

the Russian Federation came into existence. The title of course posed a question: Had the Russian romance with cosmonautics run its course and "failed"? This book chronicled the decline and difficulties of the 1990s, but also showed how the program had adapted, survived and, sometimes grimly, held on.

Now, the fourth book in the series, *The rebirth of the Russian space program* looks at the Russian space program at a convenient marking point, fifty years after Sputnik. It chronicles developments since the turn of the century, takes a look at the Russian program as it is now and looks toward the future. This account focuses on the years 2000 to 2006. Readers who wish to study the earlier history should return to *Race into space* (for the Soviet period), *The new Russian space programme* (for the transition) and *Russia in space—the failed frontier?* (for the 1990s). By way of definitions, this book covers primarily the Russian Federation—but it does take in those parts of the Ukrainian space program rooted in the old Soviet program.

The rebirth of the Russian space program coincides not only with Sputnik but with the announcement by the government of the federation of a space plan to last to 2015, an attempt to reinstitute goal-orientated planning in the program. If one looks at the number of launches per year, Russia remains the leading spacefaring nation in the world. At the same time, it is obvious that the Russian Federation's space program has none of the ambition of the American space program, which has now sent extraordinary missions to all the corners of the solar system and plans to return astronauts to the Moon and send them onward to Mars. Unlike the 1960s and 1980s, present-day Russia has neither the capacity nor the will to challenge American leadership of space exploration (the Chinese probably do, but that is another story). At the same time, Russia will remain one of the world's space superpowers, a builder of space stations, a formidable contributor to the world space industry and science. As this book shows, the Russian space program is full of activity and life. Fifty years after Sputnik, the dream lives on.

Brian Harvey
Dublin, Ireland, 2007

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About the book

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Abbreviations and acronyms

3SL	Three-stage Sea Launch (Zenit)
CADB	Chemical Automatics Design Bureau
CIS	Commonwealth of Independent States
CNES	Centre National d'Études Spatiales
comsat	communications satellite
COROT	COnvection, ROtation and planetary Transits
COSPAR	COmmittee on SPace Research
COSPAS-SARSAT	Search and Rescue Satellite System
CSTS	Crew Space Transportation System
DELTA	Dutch Expedition for Life, Technology and Atmospheric (research program)
DK	Dmitri Kozlov (satellite)
DMC	Disaster Monitoring Constellation
DMS-R	Data Management System
DS	Dnepropetrovsky Sputnik
DSP	Defence Support Program
elint	electronic intelligence
ELS	Ensemble de Lancement Soyuz
EOB	Electronic Order of Battle
EORSAT	Elint Ocean Reconnaissance SATellite
ESA	European Space Agency
EVA	Extra Vehicular Activity
FG	Forsunochnaya Golovka (Fuel Injector)
FGB	*Funkstionalii Gruzovoi Blok* (Functional Cargo Block)
FLPP	Future Launcher Preparatory Program
FLTP	Future Launchers Technology Program
GDL	Gas Dynamics Laboratory
GFZ	Geoforschungszeutrum (Geological Research Centre)

GLONASS	*Globalnaya Navigatsionnaya Sputnikovaya Sistema*
GPS	Global Positioning System
GRACE	Gravity Recovery And Climate Experiment
GRU	Glavnoye Razvedyvatelnoye Upravleniye (main military intelligence directorate)
GSLV	GeoSynchronous Launch Vehicle
HIV	Human Immunodeficiency Virus
IAF	International Astronautical Federation
ICM	Interim Control Module
IKI	Institute for Space Research
ILS	International Launch Services
IM	*Issledovatl Modul*
IMBP	Institute for Medical and Biological Problems
INDEX	INnovative technology Demonstration EXperimental (satellite)
INMARSAT	International Mobile Satellite Organization
IP	Instrument Point
IRDT	Inflatable Reentry and Descent Technology
ISS	International Space Station
JPL	Jet Propulsion Laboratory
KB	Design bureau
KBKhA	*KB KhimAutomatiki* (Chemical Automatics Design Bureau)
KH	Key Hole (code name for American reconnaissance satellites)
KOMPASS	Complex orbital magneto plasma autonomous small satellite
Koronas	Comprehensive Orbital Near Earth Observations of the Active Sun
KTOK	Ccomplex for simulators for spaceships
MARSPOST	MARS Piloted Orbital STation
metsat	meteorological satellite
MIK	Integration and test building hall
MOM	*Ministerstvo Obshchego Machinostroyeniye* (Ministry of General Machine Building)
MPLM	Multi-Purpose Laboratory Module
MSNBC	Microsoft and NBC Universal News
NASA	National Aeronautics and Space Administration
NEM	*Nauk Energiya Modul*
NII	*Nauk Issledovatl Institut* (scientific research institute)
NIP	Scientific instrument points
NITsPlaneta	Scientific Research Center of Space Meteorology
NPO	Scientific and production association
NSAU	National Space Agency of Ukraine
OICETS	Optical Interorbit Communications Engineering Test Satellite

OKB	*Opytnoye Konstruktorskoye Buro* (experimental design bureau)
OSETS	*Orbitalny Sborochno Eksploratsionny Tsentr* (Orbital Assembly and Operations Centre)
PAMELA	Payload for Anti Matter Exploration and Light nuclei Astrophysics
RAN	Russian Academy of Sciences
RD	*Raketny Dvigatel* (rocket motor)
RGRL	Roentgen Gamma Rosita Lobster
RKA	Russian Space Agency
RKK	Rocket Cosmic Corporation
SKKP	System for Monitoring Space
SpKs	*Spuskayemaya Kapsula*
SRN	State security
SSTL	Surrey Satellite Technology Ltd.
START	STrategic Arms Reduction Talks
T	Transport (Soyuz version)
TDRS	Tracking and Data Relay System
TM	Transport Modified (Soyuz version)
TMA	*Transport Modified Anthropometric* (Soyuz version)
TMK	Tizhuly Mezhplanetny Korabl (Heavy Interplanetary Spaceship)
TORU	*Tele Operatorny Rezhim Upravleniye* (Television Remote Control)
TsAGI	Central Institute for Aero Hydrodynamics
TsDUC	Center for Long-Range Space Communications
TsPK	Yuri Gagarin Cosmonaut Training Center
TsSKB	*Tsentralnoye Spetsializorovannoye Konstruktorskoye Buro* (Central Specialized Design Bureau)
TsUP	*Tsentr Upravleniye Polyotami*
TUB	Technical University of Berlin
UDM	Universal Docking Module
UDMH	Unsymetrical Dimethyl Methyl Hydrazine
US A	*Upravleniye Sputnik* (controlled sputnik, "active")
US P	*Upravleniye Sputnik* (controlled sputnik, "passive')
VDNK	Exhibition of Economic & Scientific Achievements
VEGA	Venus Halley
VHF	Very High Frequency
VMK	Recoverable Maneuverable Capsules
VPK	Commission on Military Industrial Issues 280

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Almost the end

The 25th June 1997 was a really, really bad day in the Russian space program. It is not too much to say that it all nearly came to an end that one day.

On board the Mir space station, the flagship project of the Soviet and Russian space fleet, it started as a routine day. Mir was in its twelfth year circling the Earth. Crewing the station were two cosmonauts, Vasili Tsibliev and Alexander Lazutkin, as well as an American visitor, British-born Michael Foale. Tsibliev and Lazutkin had come on board in March, Foale the previous month. They had made Mir their home and there they lived, ate, slept, watched the Earth, exercised to combat weightlessness and carried out the many experiments for which the orbital station had been built. Mir was a huge complex, more than 100 tonnes in weight, comprising a base block (Mir) modules (Kvant, Kvant 2, Krystall, Spektr, Priroda), manned spacecraft (Soyuz), unmanned freighters called Progress and beams and girders. There was a central node where modules docked, control panels, laboratories, gardens, exercise machines and sleeping berths. Air and electricity cables snaked around the walls and through the tunnels. Mir was made homely by posters on the walls, a video library, even a bookshelf.

The principal task of the day for Vasili Tsibliev was to guide in to Mir's docking port a robot spacecraft, Progress M-34, using a remote controller called TORU. Normally, unmanned Progress spacecraft came in using an automated Ukrainian system called Kurs, but since the break-up of the Soviet Union the Ukrainians charged a huge amount for Kurs docking systems, so the Russians were trying something cheaper. The TORU was a small joystick, very much like a controller used by a child on a computer game or play station. In front of him was a television picture, beaming him the image of Mir from Progress as it closed in, along with display data and grids superimposed on the screen. Using the TORU controller, he would send radio commands to Progress to fire its thrusters to move faster, slower, up

or down, left or right. TORU was a simple, effective system, costing a hundredth the price of the old Kurs.

The TORU had not been used before and Vasili Tsibliev, the space station commander, was apprehensive, but it was no more challenging than hundreds of similar tasks that he had undertaken while a cosmonaut. That was what he was trained for. The previous day he had commanded the seven-tonne Progress M-34 freighter to separate from the orbital station and let it drift away for a couple of kilometers. Now, he sent the signal for it to come back, guided in by the TORU.

What seems to have happened was this. Tsibliev commanded the freighter to come in. He asked his colleague Alexander Lazutkin to position himself near one of the windows to help him spot the arriving Progress. On the television set, it was extraordinarily difficult for the Progress television to pick out Mir from a distance against the speckled clouds of Earth underneath. Progress seemed to come in too slowly. So, Tsibliev fired its thrusters to make it come in faster. Tsibliev and Lazutkin used a set of squares on the screen to measure the distance (a square on the grid meant it was 5 km out). Using a combination of the grid, a stopwatch and the television camera, Tsibliev steered Progress in. When it was 1 km out, or so he thought, Tsibliev applied a standard braking maneuver, in order to slow Progress to walking pace for the final approach. All the time, he had Lazutkin watching out. On the screen, Mir was much bigger now, filling four grids on the square. This time, Tsibliev was alarmed at its rapid rate of approach. He fired the thrusters repeatedly to slow the freighter, but to no avail. He and Lazutkin dashed from one window to the other, trying to spot Progress and they enlisted the visiting astronaut Michael Foale in the effort. According to the plan, Progress should now have been 400 m out.

But it was too late. Lazutkin at last spotted the Progress, not at the 400 m on the worksheet but at 150 m and closing rapidly. "It's here already!" yelled Lazutkin.

Vasili Tsibliev

Michael Foale

Progress careered into one of the laboratory modules at some speed, crumpled its solar panels and drifted off to the side. Next thing, the astronauts felt a pop in their ears: the pressure in the station had begun to drop. The station had been hit and was punctured. Air was hissing out of the space station. The master alarm at once rang out. The space station's manual stated that a pressure loss would empty air out of the station in 18 min: they would have to either evacuate the station within that time, or seal the leak or they would be dead. Tsibliev yelled to Foale in Russian: "Va korabl!" Foale understood Russian, but in English this meant: get into the attached Soyuz spaceship to return to Earth!

Foale pushed himself quickly down the tunnel, into the node, into Soyuz at the far end. Once there, he removed the hoses and cables going from the node into Soyuz, so as to prepare it for emergency descent. Once he got there, he realized that his colleagues had no immediate plans to join him in a fast plunge back to Earth: they were trying to save the station first. You did not just abandon the pride of the Russian space fleet without a fight.

Michael Foale was soon to realize that it was the Spektr laboratory that had taken the hit. Spektr was, after all, his module, where he slept and carried out his experiments. In theory, it was simple enough to close the hatch between Spektr and the node, but the hatchway was full of cables and ducts. He at once rejoined his colleagues. Lazutkin and Foale used a knife to cut the cables, sparks flying and tried to close the hatch between the node and the module. It would not close—because the escaping air was pulling it outward. However, the two men found a hatch cover on their side which they jammed in its place from the node side, the escaping air sealing it in. The leak was now on the other side of the hatch and they were saved. The job took 14 min and the air stopped venting at once. Pressure had fallen from 760 mm to 693 mm.

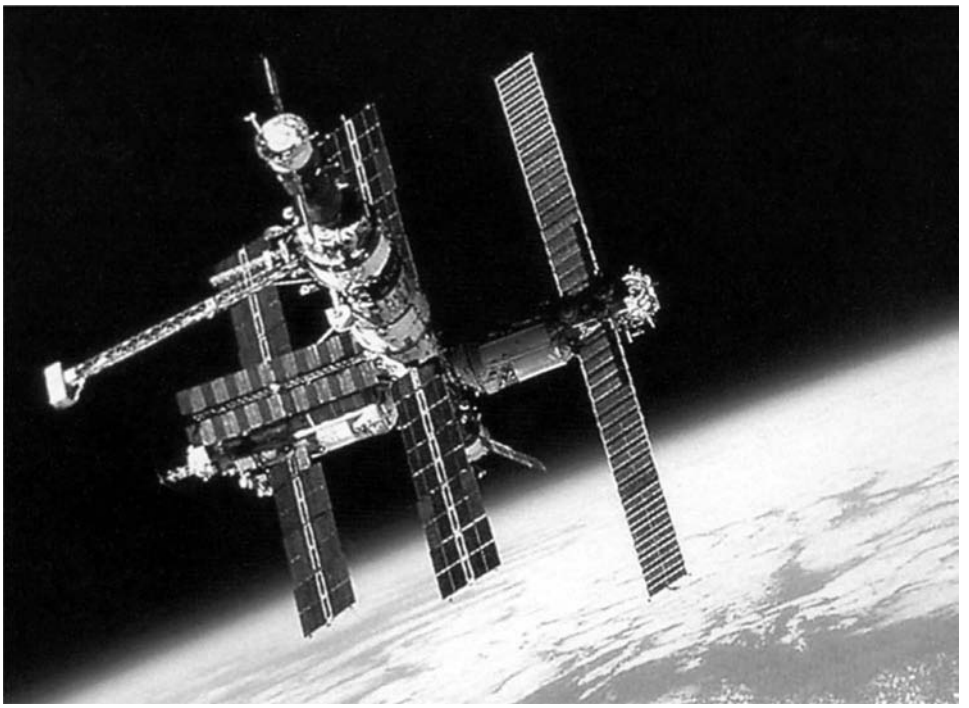
Disaster had been averted, but a whole series of knock-on problems had only just begun. Cutting the cables from Spektr meant that the main part of Mir lost all the solar electric power coming from Spektr. This was considerable, for Spektr had four large panels which supplied 40% of Mir's energy requirements. Tsibliev, Lazutkin and Foale powered down Mir's equipment, abandoned scientific work for the time being and learned to live by torchlight. Experiments and non-essential equipment were powered down.

Mission control was informed on a crackly line during the next pass over Russian territory. Gradually, the three men tried to restore the situation and within two days they had got pressure on the station back up to 770 mm. But, just as they were beginning to return to normal, the station drifted out of alignment from the Sun and lost all its remaining solar power on 3rd July. Its gyrodynes powered down. Though stable, Mir was now drifting helplessly in Earth orbit, unable to lock on to the Sun and acquire its electricity-giving powers. The ventilation system was silent. The normal clatter and hum of the orbiting station was replaced by dead calm. With vents turned off, Mir became a silent station, eerily so, like a ship drifting in the horse latitudes of old.

So they climbed in the small Soyuz cabin, the spaceship that would bring them back to Earth, and used its scarce fuel to turn the whole complex toward the Sun. This did the trick and Mir's panels were able to acquire sufficient sunlight to get a flicker of power back into the system. They locked on. It took a full day to power the station up again. Foale had used up 70 kg of Soyuz' fuel reserves in doing so.

But then on 16th July, Alexander Lazutkin, in the course of normal operations controlling the station, accidentally pulled out the main computer cable in the guidance system. This sparked another master alarm and, worse, shut the system's navigation system down, causing Mir to drift out of alignment and lose power. This time the cosmonauts knew what to do and got Mir back on line again within a day. Once again they had to retreat to the Soyuz, explain the situation to ground control on Soyuz' radio and use the Soyuz thrusters.

Alexander Lazutkin



Mir

Two days later, Vasili Tsibliev was to suffer a personal setback. As he ran his daily exercises, the doctors at ground control detected an irregularity in his heartbeat. Quite simply, the strain of the events of the previous weeks had got to him. Plans to do an internal spacewalk to fix the leak on Spektr were shelved, for this crew anyway.

At this stage, things on Mir could not get much worse. Round the world, the media had followed events on the station, running apocalyptical headings about the disaster-prone space station. Some Americans wanted their astronauts withdrawn from the Mir program: it was just too dangerous.

THE ADMIRATION OF THE WORLD

During the Mir crisis, it was hard to avoid the conclusion that the Russian space program was now close to collapse. But, ten years earlier, in 1987, the Soviet space program had been the admiration of the world. Even the Americans had been forced to admire and one had no further to look than some of the great barometers of American opinion. The *National Geographical Magazine* had just run an issue *The Soviets in space* (October 1986). *Time* magazine ran a self-explanatory headline *Surging ahead* (5th October 1987).

In 1987, about 400,000 people worked for the Soviet space program—in the assembly lines in Moscow, in rocket factories in Dnepropetrovsk and Kyubyshev, in scientific institutes scattered around the country, in production plants and in the worldwide land and sea-based tracking network. The three cosmodromes of Baikonour, Plesetsk and Kapustin Yar launched a hundred satellites a year (102 in one year), an average of two a week. There were military satellites for photo-reconnaissance, electronic intelligence and even for spies abroad to send their messages home. In the area of applications, Soviet satellites circled the Earth for communications (Molniya), weather-forecasting (Meteor) and television (Raduga, Gorizont, Ekran). In science, missions were flown with monkeys and other animals (Bion) and to carry out materials-processing in zero gravity (Foton).

The last Soviet deep space mission had been stunning. Two spaceships had been sent to Venus, where probes had already landed on the planet, drilling and analyzing its rocks, while other probes had made radar maps. Now VEGA 1 and 2 were launched there. When they arrived, they dropped landers down to the surface, one to a lowland area, the Mermaid Plains, the other to highlands, Aphrodite, to measure the atmosphere and surface. VEGA 1 and 2 dropped balloons into the atmosphere to travel a bumpy two days in its acid clouds. Meantime, the mother ships altered course across the solar system, intercepting Comet Halley and taking amazing blue, red and white pictures of its close encounter relayed live to a mission control full of foreign scientists.

1987 saw the launch of the most powerful rocket in the world, the Energiya, the ultimate creation of the chief designer of the Soviet space program, Valentin Glushko. He had been building rocket engines in Leningrad since the 1920s and in May 1987 his Energiya made its first flight. The new Energiya—a name meaning "energy" in Russian—took 12 sec to build up to full thrust. Weighing 2,000 tonnes, 60 m high, with eight engines, a thrust of 170 m horsepower, Energiya illuminated gantries, observers and towers for miles around as it headed skywards. Energiya could put 140 tonnes into Earth orbit, perfect for putting up a huge orbital station. Indeed, one was already in design. A CIA briefing conceded that the Soviet Union now had the means to send people to Mars. They had harbored the motive for a long time.

The Mir space station was already in orbit. Two or three people were normally on Mir at any one time. At a time when the American space shuttle flew for only a week or two weeks at a time, the average Russian spaceflight was six months. Two cosmonauts were about to spend a full year on board. Fifty cosmonauts belonged to the space squad and a small group was in an advanced state of training to bring aloft, courtesy of Energiya, the large space shuttle, the Buran, which was indeed to make its maiden flight the following year.

No wonder 1987 was a year of great ambition too. *The USSR in outer space: the year 2005* drew pictures of a huge orbital station serviced by a large space shuttle. Applications satellites circled the Earth while deep-space probes set out for distant destinations. Rovers roamed the plains of Mars to bring samples to rockets that fired their cargoes back to Earth. Astronomical observatories peered to the far depths of the universe.

Buran launch

THE COLLAPSE

1987 has a surreal quality about it now. Ironically, it was the General Secretary of the Communist Party of the Soviet Union, Mikhail Gorbachev, who played an unwitting role in the program's near-collapse. Gorbachev was a keen supporter of the space program and had visited Baikonour to see Energiya just before take-off, hailing it as the achievement of Vladimir Lenin's dream of a socially progressive and technically advanced civilization. The following year, 1988, saw a party conference, where, under Gorbachev's program of openness (*glasnost*) and reform (*perestroika*), Soviet citizens had the opportunity to say what they really thought.

The old Soviet Union and the new clashed head to head the following April, 1989, when contact was lost with the second of two probes sent to Mars the previous summer. At the post-mission press conference, the old guard fought hard for a traditional explanation that the probe had been the victim of external forces ("solar storms in the Martian environment"). Most of the scientists, though, knew that the program had been mismanaged and in the spirit of *glasnost* demanded that the truth be brought out into the open. Now *glasnost* permitted many of the scientists to voice their pent-up frustration with aspects of the space program and the debate drew in a much wider audience. Public opinion, liberated under *perestroika*, turned on a secretive space program mismanaged by self-serving apparatchiks when many basic consumer goods were in short supply. During the 1989 elections, candidates pledging to cut the space budget were endorsed by the electorate. For the first time, the space program had to fight for its place on the floor of the parliament. Long-time space commentator Boris Belitsky noted: "The failure of Phobos 2 damaged space research in the eyes of the public. In the general election, several candidates proposed cuts. Failure came badly to people fed on a diet of success." In April 1990, in response, the government cut the Soviet space budget by something between R300m and R220m. This was the beginning of a long, doleful period of relentless decline.

The contraction of the space program took place in three phases. The space program had actually begun to retreat at the end of the Soviet period, in the course of 1989–90. 1989 turned out to be the peak of Soviet space spending when it stood at R6.9bn and was estimated to account for 1.5% of gross national product.

Retrenchment had most effect on the planned second flight of the Soviet space shuttle, the Buran, which had made its maiden flight automatically in November 1988. This flight was delayed until 1992, but, as it became apparent that it would likely never take place at all, workers began to leave the sheds preparing the mission at Baikonour. Then, the next planned Mars mission, Mars 94, was put back two years and other scientific projects, like the Spektr observatory, were delayed. Other planned missions to the planets and the asteroids began to disappear from the flight manifests. The annual number of launchings had already fallen from 102 a year, during the peak of the 1980s, to 75 in 1990. The number fell again, to 59, during the following year, the final one of Soviet rule.

The next contraction took place in 1992 when the Soviet Union was replaced, on 1st January, by the Russian Federation and the Commonwealth of Independent States (CIS). Within a month, the worldwide seaborne tracking fleet was recalled. The main problem was that hard currency must be paid whenever it put into foreign ports, hard currency which the country no longer had, so the ships were brought back to their home ports in the Baltic and Black Sea.

The biggest blow fell in June of the following year, 1993, when the Energiya Buran program was finally canceled. Almost twenty years of the best work of the country's leading design institutes had gone into the project, which had produced the world's most powerful rocket, Energiya, flown twice and the Buran shuttle, flown just once. The space program lost 30% of its workforce all in that one year.

1994 was the year in which the money began to come late. After a delay, most of the annual budget arrived at the year's end, leading to a surge in launchings that December. Russia's launch rate remained high, but this was deceptive, for it was due to a production line of rockets and satellites that had been paid for and built earlier. By end 1994, employment was now down to fewer than 300,000. Space spending was down to 0.23% of the national budget, compared with 0.97% spent on space research in the United States.

Newspapers forecast a further deterioration in 1995 and they were right. This time, the money that had arrived late stopped arriving in the first place. Staff in many enterprises were not paid for months. Several space enterprises were, on paper, bankrupt. Rocket launchings were held up because sub-contractors, still unpaid, would not deliver components and fuel until accounts had been settled. There was a radical reduction in the rate of military and unmanned space activities. Communications satellites which exceeded their lifetimes were not replaced. Previously, when military satellites concluded their missions, a replacement satellite was already in orbit, to make sure that coverage of targets of military interest abroad was continuous. Now, gaps appeared and the military found itself either "blind" (without photo-reconnaissance coverage) or "deaf" (without electronic coverage).

The main space magazine in Russia and one of the world's best, *Novosti Kosmonautiki*, commented in October 1996 that hardly any satellites were available

to launch, and even when there were, there were no rockets to launch them. The magazine predicted that Russian space activities would probably end in a year and a half, sometime in 1997–98. This was no wild speculation, for launches that year fell to 23, less than a quarter of what they had been in the 1980s. The United States were now launching more rockets each year, something which had not happened for a generation.

Worse followed. When the much-delayed Mars 96 took off for Mars, the space program lacked the R15m needed to send the tracking ship *Cosmonaut Viktor Patsayev* to the Gulf of Guinea to follow its critical engine burn out of Earth parking orbit to Mars. The engine burn failed and Mars 96 crashed back onto the Andes Mountains. There was a half-hearted committee of investigation, half-hearted because everyone knew that this would be the last Mars probe for a very long time.

The final great contraction took place with the collapse of the ruble in the late 1990s. Now the gap between the space budget and the money that actually arrived was even wider. Only a small proportion of the money promised arrived and then at the very end of the year. Contractors in turn could not pay their suppliers and many activities slowed down or even ground to a halt. This time, there was a resigned acceptance that if government money did not arrive, it would not be coming late: it just would not be coming at all. The numbers in the space industry were now down to a quarter of the Soviet period, about 100,000. For those who remained, wages were at rock bottom: the makers of the Energomash world-beating RD-180 engine had an average wage of R3,000 a month, or $104. The military were no better off: wages in the Golitsyno control center were only R2,000 a month, or just over $60.

With a human situation like this, it was little surprise that technical quality suffered. On 5th July 1999, the normally reliable Proton rocket took off from Baikonour with a Raduga communication satellite. 390 sec later, it veered off course, debris covering a wide area and what television showed was indisputably a twisted rocket body falling into a Karaganda back garden, narrowly missing a resident 39-year-old woman and her five-year-old child. Three months later, on 27th October, another Proton exploded at 277 sec. The Kazakh government demanded €400,000 in compensation for environmental damage. At the root of it: a bad batch of engines due to poor quality control. It took months to introduce a program of quality assurance and re-qualify the errant Proton.

The decline of the Russian space program was most obvious in its physical infrastructure. In Star Town, Moscow, where the cosmonauts lived, new building plans were canceled and little or no renovation was carried out. Training facilities for Buran, including some large buildings, were left open to the elements. Things were worse in the cosmodromes. In Plesetsk there were numerous blackouts because electricity utility companies had not been paid and, to make the point, the companies would withdraw supply just as rockets were prepared for launching. Soldiers were court-martialed for selling military petrol to civilians, but their defence was that it was their only way to get long-owed backpay. In the adjacent town of Mirny, the main city bakery, renowned for its cakes, closed, to be replaced by military bread, not a delicacy!