Russia's Last Shot at Space

Once the Soviet Union and the United States were locked in a breakneck space race where no expense was spared. After last year's loss of the Mars '96 mission, Russia is almost out of the running

MOSCOW—For Russian space scientists, 16 November 1996 is a date they will never forget: A probe to Mars lifted off late that evening, an ambitious mission that would have put some pride back in Russia's tattered space science program. But it was not to be. Barely 4 hours after it lifted off, the $300 million Mars '96 mission plummeted back to Earth, scattering wreckage somewhere in South America or the Pacific Ocean. The spectacular setback was a huge blow to the hundreds of scientists in 20 countries involved in Mars '96, but the epicenter of the catastrophe was undoubtedly Moscow's Institute for Space Research (IKI). IKI had bet heavily on the mission, organizing the effort and spending most of its funding throughout the 1990s on its scientific payload. After the demise of Mars '96, says IKI director Albert Galeev, "we thought we were going to die."

Half a year later, IKI is still on the critical list—as are most former Soviet space and aeronautics research institutes. Their lifeblood in Soviet times, contracts from defense industries, has all but evaporated. Meanwhile, the Russian Space Agency (RKA), which controls most of the $803 million civil space budget for 1997, has been forced to slash spending by 55% this year—with the exception of funds to maintain Russia's commitment to the international space station—under a government effort to eliminate Russia's yawning budget deficit (*Science*, 13 June, p. 1639). Under these conditions, the former Soviet Union's elite aerospace facilities are forging ties with the West in the hope of preserving basic know-how (see sidebar).

Although IKI also collaborates with the West, its expensive missions nonetheless require a lot of financial muscle from Russia—help that is now in short supply. The once-wealthy institute has been reduced to a pauper: It must fork over nearly half its estimated $8.6 million 1997 R&D budget to contractors who still have not been paid for Mars '96. Consuming much of the rest is a single project, Spectrum-X-Gamma—a high-energy astrophysics observatory scheduled for launch in late 1998 or early 1999. And any new initiatives are at the mercy of the insatiable needs of the international space station. Earlier this year, NASA threatened to cut Russia out of the space station program because of missed deadlines and Russia's failure to pay its share of the costs. It relented only when the Russian government came up with long-promised money, but now RKA is putting the squeeze on all other space funding to meet its commitments to the space station. "The preference of the space agency certainly doesn't lie in fundamental science," says Galeev.

Boom and bust

IKI's plight is a far cry from the heady 1960s and '70s, when Russian space science thrived during the space race between the Soviet Union and the United States. "In the old days, there were practically no restrictions on the space science budget," says IKI planetary scientist Vasilii Moroz. The only difficulty, he says, was that "we didn't have enough people." The good times continued well into the 1980s: RELIKT, a satellite launched in 1983 to measure microwaves, served as a model for NASA's hugely successful Cosmic Microwave Background Explorer, and the Vega missions in 1986 collected the first images and data from the nucleus of Halley's Comet.

The first big blows came in 1988 and '89, when two missions to the martian moon Phobos developed computer glitches that sent one spacecraft tumbling out of control and jammed up communications for the other. In 1990, for the first time, Soviet planners canceled a major space science project—Regatta, which would have observed solar flares from the L1 Lagrangian point. The following year, the Soviet Union itself fell apart. In 1992, the newly formed RKA pulled the plug on the Buran space shuttle program after its maiden flight and scaled down funding for basic science. "It was awful," says IKI planetary scientist Viacheslav Linkin. "We lost a lot in the early 1990s." Indeed, the changes cost IKI about two-thirds of its budget, he says.

But the privations of the early 1990s in no way prepared IKI for the shock of losing its premier mission, Mars '96. The 20-nation collaboration was meant to map large parts of the planet's surface as well as study its climate, atmosphere, and seismic activity. IKI began serious work on the project, then dubbed Mars '94, in 1992 but missed the planned launch window thanks to construction delays caused by inadequate financing (*Science*, 27 May 1994, p. 1271). Once the mission finally lifted off, the rocket's upper stage failed to ignite, destroying the spacecraft. The failure was "psychologically terrible," says Sergei Khromov, an IKI planetary scientist who now serves as

FATE OF MAJOR RUSSIAN SPACE SCIENCE PROJECTS SCHEDULED OR UNDER CONSIDERATION IN 1990

Mission	Purpose	Planned Launch	Status
Mars '94	Planetary exploration	1994	Blew up after launch, 16/11/96
Mars '96-Aster	Planetary exploration	1996	Abandoned
Mars '98	Planetary exploration	1998	Abandoned
Mars 2001	Planetary exploration	2001	Uncertain
Phobos probe	Sample return	TBA	Uncertain
Mercury probe	Planetary exploration	2003	Abandoned
Polar orbiter	Lunar exploration	1993	Abandoned
Moon 2000	Lunar exploration	2000	Uncertain
Vesta	Asteroid exploration	1994	Abandoned
Relikt-2	Cosmic microwave background	1994	Abandoned
Radioastron	Radioastronomy	1995–97	Abandoned
Spectrum-X-Gamma	X-ray and gamma-ray astronomy	1992	Delayed to 1999
Spectrum UV	UV astronomy	1995	Abandoned
Interball	Solar-terrestrial plasma physics	1990–91	Launched in 1995–96
Tsiolkovsky	Solar physics	TBA	Uncertain
Regatta	Solar observation	1992	Abandoned
Corona	Solar and planetary physics	1995	Abandoned

SOURCES: CONGRESSIONAL RESEARCH SERVICE; IKI

Space Research Centers Search for New Frontier

ZHUKOVSKY, RUSSIA, AND KHARKOV, UKRAINE—As the Soviet Union began to unravel in the late 1980s and funding for space science began to decline, the central space facilities such as IKI—Moscow's Institute for Space Research (see main text)—were not the only centers to suffer. Across the Soviet Union, institutes supported directly and indirectly by the civilian and military space efforts suddenly found themselves without a patron.


TsAGI

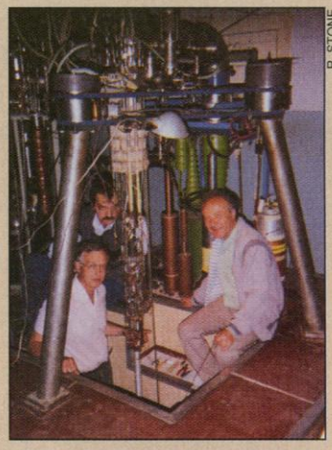
Tunnel vision. A 24-meter-wide, 1939-vintage wind tunnel, TsAGI's oldest and largest.

For example, staff at the Central Aerohydrodynamic Institute (TsAGI)—a research powerhouse in the closed city of Zhukovsky near Moscow that designed and tested much of the Soviet fleet of civilian and military aircraft and helped design the Buran space shuttle—were told that military money for their work would soon dry up. They were ordered to start hunting for projects and sponsors outside aviation. Industrial funding did indeed all but disappear by the early 1990s, and half of TsAGI's 12,000-strong staff was laid off, although most of its scientists and engineers stayed.

Some centers, such as the Institute for Low-Temperature Physics and Engineering (ILT) in Kharkov, Ukraine, were in an even worse situation. Although officially an institute of the Soviet Academy of Sciences, ILT received 85% of its funding in contracts from the space industry. "All our buildings were built with money from the space program," says ILT director Victor Eremenko. When Ukraine became independent in 1991, that funding stopped abruptly. "It was a financial shock," says Vitaly Dmitriev, head of ILT's physics division. "We couldn't use our applied knowledge," adds ILT physicist Vadim Manzhelii. The institute moved quickly to steer its work into nonspace activities. At first the transition was difficult: ILT's applied division—which manufactured cryogenic instruments and devices for the space industry—"received no orders at all" in 1992 and 1993, says division chief Stanislav Bondarenko. As a result, Bondarenko was forced to cut half his staff in those lean years.

The situation has at least stabilized, says TsAGI director Vladimir Neiland. ILT and TsAGI managed to get through these lean years by carving a new niche for themselves. In its heyday, TsAGI was one of the biggest research facilities in the Soviet Union. TsAGI was known in the West, says James Bridges, an acoustics researcher at NASA's Lewis Research Center in Cleveland, "as a Russian equivalent of NASA," particularly as an amalgamation of NASA's Ames, Langley, and Lewis facilities.

This track record stood it in good stead: When Russia's science ministry launched a program in 1993 to fund 60 elite research centers, TsAGI was at the top of the list and now receives a third of its budget from the ministry. And the institute has become more adept at marketing its extensive facilities—including 58 wind tunnels—to Western firms. TsAGI now has nearly 200 foreign contracts, which make up about 30% of its budget. "They have world-class facilities," says Stephen Hopkins, deputy director of the Center for International Aerospace Cooperation of ANSER, a think tank based in Arlington, Virginia. Many TsAGI scientists have also strayed from aerospace research in search of new markets—everything from using shock waves to dehull rice to developing ultrasonic medical instruments and high-pressure devices for extracting oil. A few TsAGI staff members have been forced to turn to a low-tech career: running a bakery at the institute.


R. STONE

Supercold warriors. ILT's device cools samples to several millikelvins, cold enough to freeze helium.

Originally, ILT specialized in simulating space conditions in the lab and developing spacecraft cryogenic systems. Now, ILT researchers have found their feet by converting to nonspace projects. For instance, a cryogenic air compressor developed for use aboard spacecraft is now being tested for use in the oil and gas industry. The compressor is being used to raise the pressure of natural gas fields to ease extraction. ILT applied scientists have also designed a liquid-nitrogen refrigeration system for trucks: Ukraine now has a fleet of more than 100 such vehicles.

ILT's basic researchers have also managed to stay afloat after the breakup, thanks to help from the West. ILT won 44 long-term grants from the International Science Foundation, more than any other institute in Ukraine. And ILT now has three awards from the U.S. Civilian Research and Development Foundation, a fund designed to promote defense conversion. Apart from such grants, ILT has received little funding to shift its activities to civilian research. "We've converted by ourselves," says Eremenko.

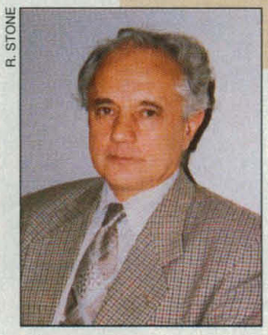
While resourcefulness is keeping these centers afloat, researchers who once led the world in aerospace technology say it is frustrating to be working as hired hands. "We have ideas that can be developed for the military, but no orders," says Neiland. And Russia's civilian air industry offers little hope of salvation: Aeroflot International Airlines agreed to buy 10 Boeing 737s for $440 million last April. ILT scientists are simply hoping to keep themselves afloat until Ukraine's economy improves. Says ILT's Nikolay Glushchuk, "Hope dies last." –R.S.

international director for the Russian Foundation for Basic Research.

Neither IKI nor its teams of international partners have fully recovered. The Russian government assembled a commission to investigate the failure, headed by Vladimir Utkin, director-general of the Central Institute of Machine Building in Moscow. But the commission soon discovered that budget problems had prevented RKA from siting a tracking ship in the Pacific to receive telemetry data from the spacecraft during the launch. "They had no data on which to base an analysis," says Wes Huntress, NASA's head of space science. "They can only guess what went wrong." Last December the panel, unable to determine what caused the malfunction, offered what it considered to be six equally plausible scenarios. Such ambiguity riled Russia's foreign space partners, who were torn

between asking IKI to refly Mars '96 with backup instruments or to pull the plug on the mission. "How the hell were we supposed to know which option was better for us?" asks a European Space Agency official. In the end, IKI returned the backup instruments after failing to win RKA's support for a Mars '96 reflight.

In the wake of Mars '96, IKI's planetary science program has been almost completely gutted. A proposed joint mission to Mars in 2001, with the United States providing the spacecraft and Russia providing the lander and rover, looks shaky, and NASA scientists are now working on their own rover. "We can't count on the Russians being there, so we've redefined our mission," says Huntress, who says he expects to hear more about Russia's plans at a joint meeting in September or October. If Russia still wants to collaborate, says Huntress, "the ball's in their court."



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The only other significant project that IKI's planetary division supports on its shoestring budget and staff—four of its top scientists have left in the last few years—is the development of a new type of spacecraft to be assembled and launched from a space station. IKI, NPO Energia, and TsNIIMash, a design bureau that is developing a new electrical propulsion system powered by solar arrays, are planning to launch a prototype from the Mir space station late next year that will orbit Earth. It is, however, meager fare for an institute that once roamed the solar system with confidence. "I'm very worried that their planetary program is rolling off the cliff," says Huntress.

Kings of a small heap

While IKI's planetary scientists "struggle for survival," as IKI's Galeev puts it, their astrophysics colleagues are preparing for their own major test: Spectrum-X-Gamma. IKI is leading this $735 million satellite program—slated for launch by 1999, 7 years behind schedule—that is equipped with 24 x-ray detectors. Spectrum is designed to study quasars, candidate black holes, supernovas, and diffuse x-ray background radiation, the origin of which is still a mystery. "It is our dream to see a supernova occur in our galaxy," says Michael Pavlinsky, IKI's lead Spectrum scientist.

Mars '96 has, however, cast a pall over Spectrum. In Russia alone, 30 firms are now contributing to the spacecraft and a whopping 75% of IKI's R&D budget this year will go to Spectrum—up from 20% during Mars '96's construction. "It's an enormous percentage of money," says Galeev. Meeting in Rome last December, representatives of the 16 countries involved in the project had a grim discussion about whether to make alterations to Spectrum, including finding a different launcher—it is scheduled to be lofted on the same kind of rocket (NPO Energia's Proton) that failed last November. "Certainly we are nervous," says Galeev. "But the Proton is still a very reliable launcher."

Despite some hand wringing, the international partners decided to stick with the project in its current form. "There's quite a head of steam behind this project," says x-ray astronomer Alan Wells of Britain's University of Leicester. Indeed, Wells and others point out that the Russians have of late reinstituted rigorous standards of quality control not seen since Soviet days. "It's a direct consequence of the Mars failure," Wells says. Some analysts share this opinion. "I have a lot more faith in Russian space hardware than a lot of other Americans do," says Charles Vick of the Federation of American Scientists.

"The preference of the space agency certainly doesn't lie in fundamental science."

—Albert Galeev

Last April, Pavlinsky's team began testing the instruments, which will be sent later this month to Moscow's Lavochkin Association—the spacecraft's designer. Even if Spectrum succeeds, it is likely to be the last of IKI's big, high-profile missions: After the Mars failure, RKA director Yuri Koptev, following the lead of NASA chief Daniel Goldin, said that he wants to see the rapid development of smaller satellites that could be launched more often.

The only other major operational project on IKI's slate is Interball, two pairs of satellites launched in 1995 and 1996 to study the interaction of the solar wind with Earth's magnetosphere. "After the Mars failure, Interball became one of IKI's first priorities," says Interball scientific coordinator Lev Zelenyi. The long-delayed project was devised in the early 1980s as a way to foster space collaboration between Russia and Eastern European countries, but was hampered by poor funding. The delay proved fortuitous, however. In the mid 1990s, a small fleet of spacecraft was in orbit or in preparation for solar and magnetospheric studies: Interball, the Europe–U.S. SOHO mission, the Japan–U.S. GEOTAIL, and NASA's WIND and POLAR satellites. (Europe's four Cluster satellites, which blew up after launch last summer, were supposed to have rounded out the suite of satellites.) The participating space agencies have agreed to coordinate the operations of all these satellites and share data. "It's the moment of truth for this science—maybe it will never happen again," says Zelenyi.

But Interball, with instrumentation contributed by 20 countries, has had problems of its own. Staff at the control and data acquisition facility—the Western Deep Space Communications Center at Evpatoria, in Ukraine's Crimea region—went on strike for 3 weeks last month, protesting months of overdue wages. The RKA finally paid their wages, and the staff called off their strike on 19 May, allowing Zelenyi's group to begin collecting data again.

Despite the strike, Interball's success—and the hopes pinned on Spectrum—have enabled Russian astrophysicists to win what stable funding there is in IKI's tight science budget. "It's a zero-sum game, astronomers versus planetary scientists, and the planetary scientists are losing," says former IKI director Roald Sagdeev, now a professor at the University of Maryland, College Park.

Dim prospects

The dwindling funds for space science leave Galeev bitter. He estimates that work on the international space station, for which the RKA received a $140 million bank loan last April, will cut the funds for space research this year by about 25% in addition to the 55% sequestered by the government. "Certainly we are quite upset by this," says Galeev. And IKI also faces stiff competition for funds from the Institute of Geophysics, which is developing a proposal for a robotic mission to the moon in 2000, and the Institute of Astronomy.

But the biggest threat to IKI's future may, in the end, be waning interest among the public and politicians. Some members of the Duma, parliament's lower house, have recently been critical of space research, transforming the words of a song popular at the time of Yuri Gagarin's first flight into space. The song's refrain, "Apples should bloom on Mars," divined the expected Soviet colonization of Mars. The legislators' take is that "apples should bloom on Earth." But one look at IKI's crumbling halls and demoralized staff confirms how far Russia has fallen since Gagarin took his historic flight: The bloom has long since faded from Russia's space science.

–Richard Stone