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Russia's robotic space renaissance

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The demise of the Soviet Union left its much-vaunted space program underfunded and in disarray. Technical, monetary, and management problems have continued to plague Russia's efforts during the difficult transition to a new era. Several high-visibility undertakings, such as the Phobos-Grunt Mars mission of 2011, have ended in failure. Nonetheless, recent activities indicate that ambitious plans are in the offing for the country's robotic lunar and planetary exploration efforts.

A revamping of Russia's robotic space exploration program appears to be under way, perhaps even a rebirth for the country's interplanetary endeavors. To some extent this 21st-century revival mirrors the former Soviet Union's missions to a variety of destinations beyond LEO.

First on the agenda of Roscosmos, the Russian Federal Space Agency, are lunar missions. Longer range plans include the design of an aggressive Venus mission, an attempt at the first landing on Mercury, and a rekindling of Mars exploration. Add to this a reported Russian Jupiter research project that would place a lander on the Jovian moon Ganymede by 2023.

But are these grand plans on solid footing, given Russia's spotty track record over the years, underscored by the botched Phobos-Grunt mission to Mars? That aggressive undertaking, launched in November 2011, ended when the probe plunged back to Earth in an uncontrolled reentry some two months later—felled by the tug of gravity, yes, but also by technical and management slip-ups.

Years earlier, the country's ambitious Mars 96 mission suffered a similar fate, crash landing just one day after liftoff, possibly in South America. The jam-packed probe carried a Mars orbiter, surface stations, and surface penetrators.

Nonetheless, history shows that the Soviet space program, fueled by Cold War rivalries, scored significant achievements at the Moon, Venus, and Mars.

But today, the situation is different.

Notably absent

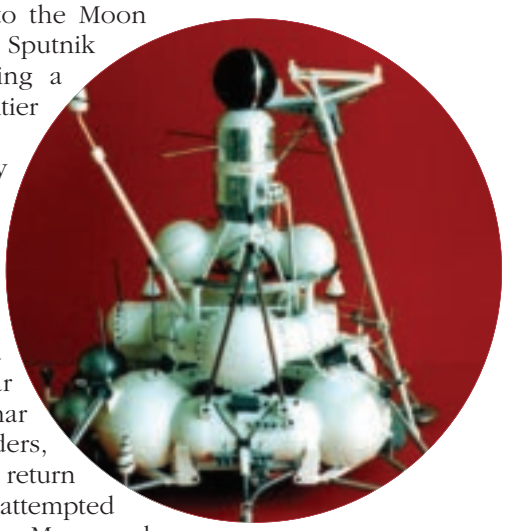
"I personally am very excited to see the Russians building on their outstanding success of the past and returning to earlier destinations where they were major innovators in science and technology," says Stephen Mackwell, director of the Lunar and Planetary Institute in Houston, Texas.

Mackwell notes that the Soviet Union was a key player in the early age of robotic and human solar system exploration. One might argue, he says, that the U.S. would never have sent astronauts to the Moon had the Soviets not launched Sputnik and set the course for taking a strategic lead in the new frontier of space.

"While the Soviets' early lead in space was clearly surpassed by the United States with the phenomenal Gemini and Apollo programs, Russia was a major early driver for lunar exploration with its Luna and Zond programs of lunar impactors, flybys, circumlunar spacecraft, orbiters, landers, rovers, and, ultimately, sample return missions. In total, the Soviets attempted over 45 robotic missions to the Moon and had considerable successes, including the only robotic sample return from the lunar surface," says Mackwell.

"Unfortunately, the Soviet lunar program ceased in 1976, a few years after the United States abandoned its lunar missions. While the scientific community never lost interest in the Moon, and vibrant studies of lunar samples continued...it was only in the 1990s that we saw a resurgence of interest in lunar missions.

"This time, however, the broader international community had started to become involved. First the Japanese, and then the Europeans, Chinese, and Indians sent missions to the Moon. The United States too flew a series of missions that made major advances in our understanding of the



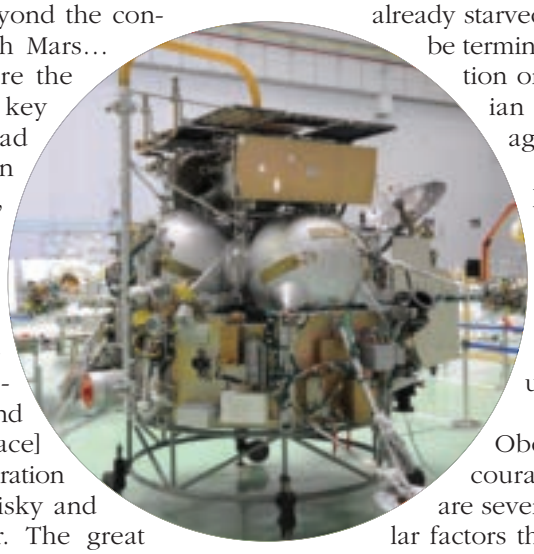
Luna 24 was the last of three successful Soviet lunar sample return missions. The mission returned 170.1 g of lunar samples to the Earth on August 22, 1976.

Moon, the Earth-Moon system, and the evolution of the early solar system," he says.

More recent missions, he observes, also set the stage for an ultimate human return to the Moon, involving longer term plans for habitation and resource utilization. The Russians, however, have been notably absent from these activities.

Resurgence of interest

"Now we are beginning to see a resurgence of interest in both robotic and human exploration of the Moon and other bodies in the solar system, beyond the continued activities with Mars… notably Venus, where the Soviet Union was a key innovator and had great robotic mission success with orbiters, landers, and balloons," says Mackwell. "I am also excited to see Russian interest in participating in human exploration activities beyond [the international space] station. Human exploration has always been a risky and expensive endeavor. The great success of Apollo was driven by national security issues, where major investment was regarded as justified by the international political climate of the time."



Plans for a Russian return to the Moon include the Luna Glob probe. Credit: Lavochkin Association.

But Mackwell views this new century as one in which collaboration, rather than competition, seems to be the best way forward. "Few nations have the fiscal capability or the political will to reach out into space with humans. However, there is great support from the general public for exploration, and capturing the technological capabilities of the Russians and engaging with them in human exploration makes a lot of sense if we are to truly expand our horizons in space."

While the United States is developing new launch vehicles and space transportation systems, Mackwell says, a key missing piece is the ability to land on any object in the solar system with any appreciable gravity. "International partnerships, especially with the Russians, may help significantly with redevelopment of that capability. It would be such a great thing, 50 years after the first Apollo landing, to see Russians and Americans return to the lunar surface together," he concludes.

'Hothouse orchid' theory

James Oberg is a long-time historian and expert on Soviet/Russian space matters. For Russia, he says, the key to acquiring the 21st-century technologies crucial for future spaceflight activities is in efforts led by Sergey Zhukov, a trained but unflown cosmonaut who is pushing well-financed technology development projects.

"Available space funding just isn't enough to maintain, much less modernize, the broad base of Soviet-era space capabilities," Oberg observes. "Many projects have already starved, and still more need to be terminated, to allow concentration on key areas where Russian space efforts may yet again shine."

There are others, however, who view Russia's space program as a 'hothouse orchid,' a flower that needs pampering because it is not hardy enough to grow under natural conditions. This theory, which Oberg does not find encouraging, also holds there are several independent, particular factors that must all appear concurrently for the space program to succeed. These include not just intentional pampering, but other incidental and unintentional factors that also turn out to be critically important to enabling success.

"In this view, the spectacular Soviet-era space successes required the conflation of several highly specific conditions that together created a world-leading capability which has long since faded, and probably can never be rebuilt. Aside from financial largesse, those years saw the best and brightest Soviet engineers and managers flocking to the space effort, because of the historical challenges as well as unique perks—special stores, schools, hospitals, travel—that ordinary Soviet citizens had no hope of otherwise seeing. The entire country was mobilized to provide them with the best materials, minds, and methods," says Oberg. "That's all gone now and will never return. A scaled-back, modest program with respectable specializations is the best they can hope for," he concludes.

Rubles for deep space rocketry

Asif Siddiqi, associate professor in the Dept. of History at Fordham University in New

York, is a scholarly specialist in Soviet Union/Russian space endeavors. Although the Russians have never lacked ambitious plans, he tells *Aerospace America*, over the past two decades "the payoff has not been significant." Siddiqi does note some small signals, such as cooperation with ESA and India, that suggest Russia is exploring other avenues. However, he does not see any fundamental shift having occurred to change the current paradigm.

Clearly, he says, the Phobos-Grunt disaster was a huge letdown after all the time and effort spent preparing the mission. The Russian space industry in general has been plagued by a range of problems, from quality control issues to brain drain to corruption, as well as the tightening of rubles available for deep space rocketry. That combination creates a very high-risk situation, he says. The upcoming Luna Glob and Luna Resurs missions are being closely watched by the Russian space community, and their outcome will be telling.

"Every couple of years there's discussion within Russia's space media, a sort of handwringing about the average age of engineers in their space program, which is pretty high now. If you are a smart young person in Russia, space is not on the top of your list…not a priority. You would probably be going into software or something like that," says Siddiqi. "Young people see space as a good thing, but it's in the past."

One development to keep an eye on, Siddiqi believes, is the Skolkovo high-tech project—a plan to mimic Silicon Valley and its innovative research and production. Space technology is a major focus of the effort, he notes, "and the whole point of that is basically to feed very smart people back into the space program."

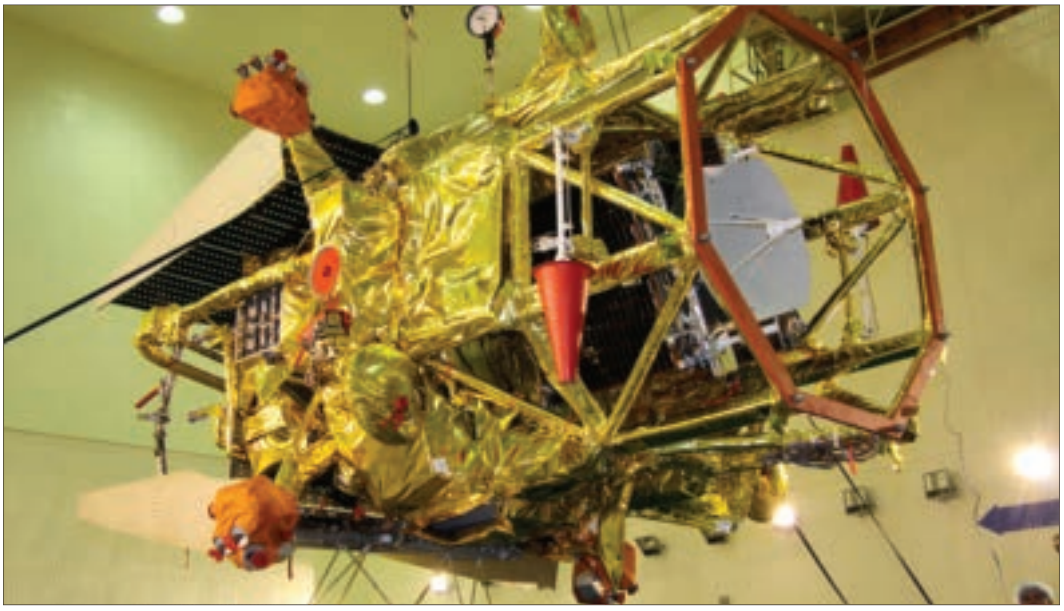
Author and Russian space watcher David Harland offers some similar views. "Although the Russians can employ their Soyuz rocket to send a small payload to Mars—as they did for Mars Express on behalf of the Europeans—they always build heavy 'Christmas tree' probes that require the more capable Proton rocket because they are festooned with instruments, capsules, and landers. Yet, remarkably for this day and age, both Mars 96 and Phobos-Grunt were stranded in Earth orbit by their upper stages. One has to wonder what complexity they have built into their design, by either commission or omission, that makes it so susceptible to failure at this point in the mission…because an escape burn is no longer rocket science!"

Optimism grows

From inside Russia looking outward, several experts have offered their perspective on the history and future of Russia's robotic lunar and planetary exploration program.

Mikhail Marov is a professor and academician of the Russian Academy of Sciences. Paraphrasing Mark Twain, he calls rumors of the program's demise "exaggerated" and adds that "the situation right now is much more optimistic."

Speaking last October at an Arlington, Virginia, symposium on the 50th anniversary of planetary exploration, Marov noted that the disintegration of the former Soviet



The failed Phobos-Grunt spacecraft did not perform its scheduled burn to begin a trajectory to Mars, later tumbling to Earth in an uncontrolled reentry. Courtesy: National Space Science Data Center.

Russia's Luna Resurs mission is on the books as part of that country's reconnection with lunar exploration. Credit: Lavochkin Association.

Union, followed by social and economic turmoil, had a dramatic impact on Russia's space program, specifically solar system exploration. He emphasized that the country's space budget was drastically reduced, the lion's share going for orbital station operations, support for the Mir space station program, Mir-shuttle dockings, and later, participation in the ISS program.

"Space facilities were partly destroyed, cooperative links broken, and many skilled personnel in space science and technology lost," Marov told attendees of the symposium. In reviewing the launch, subsequent breakdown, and fiery Earth reentry of the Mars-bound Phobos-Grunt mission, he said the failure basically was caused by these destructive factors of the 1990s whose consequences "have not been yet overcome… though lessons were learned."

Speaking at the same symposium was Wesley Huntress, director emeritus at the Geophysical Laboratory of the Carnegie Institution for Science in Washington, D.C. Huntress underscored the "tragic loss of vision, enterprise, and expertise" of the Soviet Union's robotic planetary effort, which had begun "in a spirit of bold adventure and technical genius."

An agreement signed by Roscosmos and ESA details their cooperation on ExoMars, ESA's 2016 and 2018 Mars missions. Roscosmos will provide major contributions, including the descent stage for the 2018 flight, scientific instruments for both missions, and the two Proton rockets that will launch them. Credit: ESA.

The two space scientists noted that the Soviet program was bold and innovative, achieving many firsts in space exploration, but was also riddled with flaws that caused numerous failures. Factors hampering the program included deficient electronics technology, poor system engineering management, insufficient ground systems testing, and a complex, entangled, heavy-handed national system of control and supply, said Huntress.

Robust missions, valuable science

While he cannot speak for the Russian space agency, Marov notes, he can share his understanding of its current situation.

"Yes, we are going to return to the Moon with the new robust and scientifically valuable missions Luna Glob in 2015 and Luna Resurs in 2017." Their federal program is committed to the missions, says Marov, adding, "I personally hope that they will manifest our recovery with [a] lunar-planetary program after [the] turmoil of the former two decades."

Marov says there are also ambitious plans for extended lunar study in future years. In addition, Roscosmos has signed an agreement with ESA about involvement in the European agency's ExoMars program. That agreement, signed last November, details cooperation by the two agencies on ESA's 2016 and 2018 missions to Mars. An orbiter and a stationary lander are planned for 2016. A Russian lander is to deliver the ExoMars rover, planned for 2018. Roscosmos will provide major contributions, including the descent stage for the 2018 flight, scientific instruments for both missions, and the two Proton launchers.

"As far as Venus is concerned," he says, current plans are "sound enough indeed" and are still targeted for the early 2020s.

Tight oversight

As the Russians move beyond the failure of the Phobos-Grunt mission, just how realistic and technologically sound are their plans for rebooting interplanetary probe programs?

"Keep in mind that Phobos-Grunt started as the only interplanetary mission in the program," says Igor Lissov, senior editor of the Russian journal *Novosti Kosmonavtiki* (Cosmonautics News). "They decided to choose a bold mission, and they tried to design it from scratch. They [made] several conceptual errors, which played out at the first possibility," Lissov explains.

Russia's current lunar exploration program involves three launches of increasing difficulty, notes Lissov, with designers having some leeway to err without ruining all: Luna Glob 1 (a test lander with very limited science payload), Luna Glob 2 (a science orbiter), and Luna Resurs (a polar lander with a sophisticated science payload). "This seems to be a good choice to reestablish our capabilities. Future projects are being listed and discussed, but their chances of full funding and development depend heavily on the success [of the preceding missions]," he says.

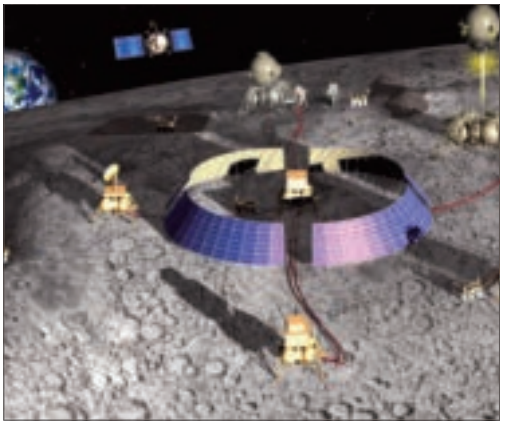
At Lavochkin Association, the group that also created Phobos-Grunt, different people are working on the Luna missions. As far as Lissov can tell, the key persons involved in the failed probe's design have left. "Oversight is tight, and the upper management is more competent," he says.

Funding has been available from the beginning, Lissov says, noting that this was not the case for Phobos-Grunt, which lingered 10 years in the paperwork stage. "So I believe the situation is much better from the budget, programmatic, and competence sides. Also, we are not bound by planetary windows now, and Lavochkin can test their spacecraft as long as needed….Of course this does not exclude design errors or component failures…but I have much more faith in the Luna Glob/Luna Resurs series than in Phobos-Grunt."

Lunar strategy

Also emphasizing Russia's robotic return to the Moon is James Head, a noted space scientist in the Dept. of Geological Sciences at Brown University. He points to the past track record of the Soviets: Successfully completing three robotic sample return missions (Luna 16, 20, and 24), two very well instrumented robotic lunar rovers, Lunokhod 1 (Luna 17) and Lunokhod 2 (Luna 21), and several orbiters—all undertaken more than 35 years ago. These basic accomplishments, he says, represent a remarkable robotic capability not duplicated by anyone, including the U.S.

"The Russians are building on the original clever and novel engineering designs for these missions, and thinking ahead with a focus on polar landers and on exploring for volatiles in the polar and near-polar regions," Head says. "Sample return missions are very likely to focus on the discoveries of the early polar Luna lander and rover missions, and to involve the return of volatile-containing samples using special devices for preservation and return."



Russia's re-rendezvous with Moon exploration also includes discussion of establishing an international lunar base. Courtesy: IKI.

Head and his colleagues at Brown have been involved for years with their Russian colleagues from the Institute for Space Research and the Vernadsky Institute. Working together they have scoped out candidate landing sites for lunar spacecraft, and also possible destinations for future Lunokhods and sample return missions to the Moon. The lunar strategy is clearly working toward a set of larger Russian national goals, possibly to include a lunar base, Head adds.

Given the apparent abandonment of human and robotic lunar surface exploration by the U.S. for the near future, Head thinks the Russians see a major leadership opportunity as well as a technology driver and are therefore moving out vigorously on their strategy.

"Clearly the Russians have long demonstrated that they have the technological sophistication to engage in expansive space exploration activities," says Roger Launius, senior curator in the Division of Space History at the Smithsonian Institution's National Air and Space Museum. "If they redouble efforts, invest sufficient resources, and structure a realizable long-term strategy for robotic planetary exploration," says Launius, "there is no reason to believe they will not be successful."

However, he also notes that the box score on Soviet/Russian planetary exploration has been checkered, particularly regarding Mars. They have had much greater triumph with Venus and, especially, the Moon.

"What is past does not directly affect the future, of course," adds Launius. "But it will require a concerted effort to restart these activities and be successful with them. We'll see what happens."