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Chapter 18

V. M. Kovtunenko and India: The Relations through Space—Toward the 35th Anniversary of Soviet–Indian Cooperation*

V. F. Prisniakov,†
V. I. Dranovsky,‡ S. S. Kavelin,‡ A. M. Popel‡ and V. P. Platonov§

Abstract

This chapter is devoted to the famous 35-year history of remarkable cooperation between Soviet and Indian experts and to the great personal contribution of V. Kovtunenko to the origins of Indian space technology. Technical aspects of this cooperation, the obtained results, and its contribution to the promotion of space research in India are analyzed. The chapter details the origins of the agreement providing the Indian party with advisory and technical help in creating scientific spacecraft and launch assistance with the Soviet booster rocket. The potential of Indian space science is shown. Finally, the chapter recounts the visit of the Indian President to Design Bureau (DB) Pivdenne in Dnepropetrovsk and outlines potential opportunities of the revival of space cooperation between Ukraine and India.

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† Institute of Geotechnical Mechanics, National Academy of Science, Dnepropetrovsk, Ukraine. [**Publisher's note:** Dr. Prisniakov passed away on 28 November 2009.]

‡ Design Bureau "Pivdenne," Dnepropetrovsk, Ukraine.

§ Chief-editor of "Prospect," Dnepropetrovsk, Ukraine.

Introduction

Moscow, 1971: The Beginning of Cooperation

In 1971, the governments of the USSR* and India signed an agreement to cooperate in the field of space research. Subsequently, on 10 May 1972, the Academy of Sciences of the USSR and the Indian Space Research Organisation (ISRO) signed an agreement on providing advisory and technical assistance to India in creating scientific spacecraft and launch assistance with the Soviet booster rocket. Such cooperation between the Soviet Union and a capitalist country in the highly classified field of rocket technology was a completely new and rare phenomenon and highly unusual for the country behind the iron curtain. The fact that this cooperation came about can be explained, on the one hand, by the Indian desire to participate in the development of space activities and by the political aspirations of the Soviet Union to seize this opportunity, on the other. That such cooperation materialized was thanks to the efforts of Professor V. Kovtunenko and of Academician B. Petrov, as well as to the thousand-year-old "space spirit" of the Indian people, and in no small measure thanks to the longstanding friendship between the Soviet Union and India and the tolerance inherent in the Indian people, allowing for such friendship during that era.

India

Mankind's age-old dream of space travel became a reality with the launch of the first satellite in 1957 and even more so by the spaceflight of Yuri Gagarin in 1961. Mankind's realization of the space dream was eloquently conveyed by the tremendous charm of Yuri Gagarin who traveled around the globe, infecting all walks of people with the desire to unlock the secrets of the universe.

Yuri Gagarin's triumphal visit to India in December 1961, culminating in his meeting with the country's top leadership, including Prime Minister Nehru, I. Gandhi, Indian President Prasad and hundreds of thousands of ordinary people, including schoolboys 5,000 km across India, literally awakened the "space spirit" of the Indian people, which had laid dormant for at least a thousand years.

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* Union of Soviet Socialist Republics, or Soviet Union.

Figure 18–1: December 1961. Yuri Gagarin in India.

1968: Beginning of India's Road to Space

Flying vehicles, the materials of which they are made, devices they carried, and their power sources were mentioned in ancient epics, such as the "Ramayana" as early as thousands of years before this era. There is much talk of spaceflight in the book *Vimanik Prakaranam* (Sanskrit for "treatise about flight"), written by the great Indian sage Bharadvadj three millennia ago. In his book, M. Gruntman mentions that the great Timur (Tamerlane) faced rocket fire when he invaded India in 1398 [10]. Therefore, the space seeds that were planted in the 1960s fell on fertile soil prepared millennia before.

India's present road to space started in 1968 with the United Nations (UN) conference on the Peaceful Uses of Outer Space, in Austria. By that time, 10 years into the space age, only 254 devices with a total mass of 1,400 tons had been launched into Earth orbit. But each and every satellite was transmitting invaluable information, changing the life of the fast-growing world population. The heads of the Indian space program had a very clear understanding of the potential uses of space. Vikram Sarabhai, the "Indian Tsiolkovsky," considered that his country had every opportunity to become one of the great space-faring nations. He stressed that space research and social progress were indissoluble:

> . . . A balance between the first and the second can be achieved if the consumer and his needs are taken into account. Space technology promotes progress. Artificial earth satellites have many uses necessary for a modern civilization. [2]

During its first 10 years, Indian space research developed under the leadership of the outstanding scientist and public figure, Chairman of the Department of Atomic Energy, Vikram Sarabhai, with the approval of Prime Minister I. Gandhi.

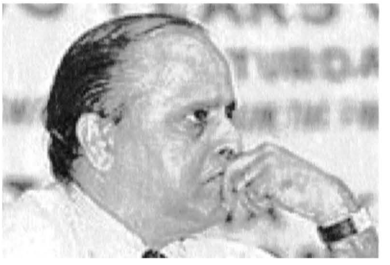

Figure 18–2: Left, Vikram Sarabhai; Right, K. Kasturirangan.

Gandhi had determined the goal-oriented course of this program as follows:

> Effective development of space science and technology and their application in the service of mankind's well-being has been considerably hampered by the poor industrial development of the country. The government aspires to use space to address our basic needs based on an independent capacity. This should determine the major aspects of our space program.

Figure 18–3: The Prime Minister of India, I. Gandhi, among cosmonauts and scientists from Star City.

Any space program, by virtue of its very nature, is a formidable challenge:

> Developing satellites, designing their payloads and operating launch vehicles are all difficult tasks. So is establishing facilities for testing on the ground, or operating satellites once they are in orbit. If you look at it that way, every space event is fraught with tension and is a challenge.
>
> (K. Kasturirangan).

India always enjoyed a high level of development in the natural sciences, allowing it to create its first satellite. India's approach in developing and executing its space program is well reflected in the recommendations resulting from a seminar in Ahmedabad, held in August 1972:

> If we look at the common densities of space sciences in the world or even to compare activities in the field of space sciences in India to other—probably more classical spheres such as, for example, chemistry—it is possible to see that these densities are still not too great. But true benefits from the use of advanced technology can be obtained only if this technology is closely connected with science. . . Space sciences and astronomy are not new to Indian culture, but we should use them to address modern requirements by means of concrete action. The Indian scientists should have an opportunity to experiment in space. . . . In space areas where it is important to keep abreast of the latest achievements and to develop in step with the times giving us the opportunity to be among the advanced countries in the world in this area. [2]

Figure 18–4: Professor V. M. Kovtunenko, main designer of space vehicles in DB Yu and Soviet director of the India–Soviet project.

Important stages of the Indian space program included the creation of India's own satellite, the schooling of experts in the field of space technology, and the establishment of a manufacturing base. In order to tackle these problems the Indian government called on the Soviet Union for assistance.

The USSR: Dnepropetrovsk in the 1960s: V. Kovtunenko and International Space Cooperation

As a result of his involvement in space research related to Earth, Sun and galaxy, V. Kovtunenko understood that this type of problem could not be tackled by one Design Bureau (DB) or even one country alone. The solution of problems facing mankind as a whole required the global study of phenomena and complex methods of research. V. Kovtunenko was one of the first to understand that to achieve these goals, it was necessary to harness scientific efforts by all the countries. Space should not divide people, but unite them. The same conclusion was reached by the USSR Academy of Sciences. Hence, on 15 April 1965, the Soviet government made an historic decision "about cooperation of the USSR and the socialist countries in the field of research and use of space for peaceful purposes." The practical realization of this policy was assigned to the USSR Academy of Sciences and various ministries. Based on their recommendations, an international cooperation framework titled "Interkosmos" was established in 1967, with Academician B. Petrov as chairman and Prof. V. Kovtunenko as director-general. Within this framework, the Soviet government ordered the manufacture and launch of six satellites based on the unified Dnepropetrovsk Sputnik (DS) satellite platform, DS-U1, DS-U2, and DS-U3. These satellites were used to study microwave radiation from the Sun and other solar phenomena, corpuscular radiation in near-Earth space, the Earth's ionosphere. The scientific equipment was provided by different countries participating in the joint projects.

On 14 October 1969, a 11K63 "Kosmos" space booster was launched from the Kapustin Yar cosmodrome putting into orbit the first "Interkosmos" DS-U3-1K satellite in the presence of scientists from nine countries. The device was officially named "Interkosmos-1" and was followed by 24 more satellites, 22 of which were developed by DB Yu. Among the partners in this program were France (*Oreol/Aureole* series in 1971, 1973, and 1981 under project *Arkad/Arcade*) and Sweden. In due course, the Indian satellites *Aryabhatta* (1975), *Bhaskara-1* (1979), and *Bhaskara-2* (1981) appeared on the list.

It is important to point out that such international cooperation from a highly secret organization such as DB Yuzhnoye in the closed city of Dnepropetrovsk was very difficult. All contacts with foreign scientists passed "under a roof," the Academy of Sciences or Dnepropetrovsk University. Any trip abroad had to be sanctioned and controlled by the special services. Professor V. Kovtunenko was Chief Designer and was the main designer of satellites at DB Yu. But as DB Yu was top secret in those days, V. Kovtunenko was presented as a professor of Dnepropetrovsk University, where he doubled as head of the faculty of aerodynamics. Professor Kovtunenko's outstanding service to humanity consisted of the fact that he was the first to open a breach in the iron curtain, the first who raised the question about the globalization of space research, and the first to put this idea into practice.

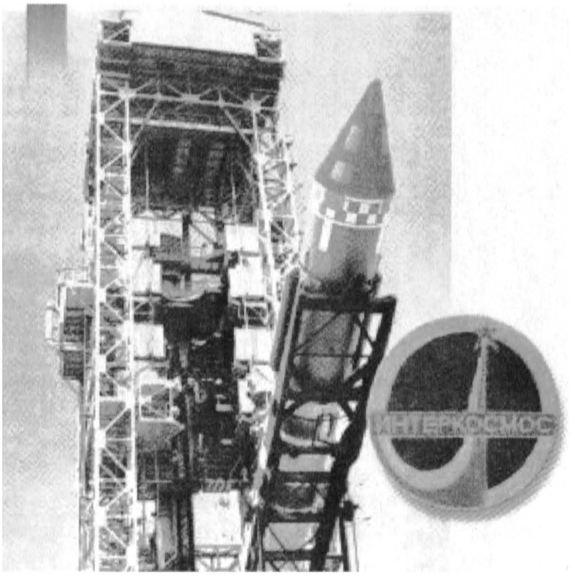

Figure 18–5: The "Interkosmos" space booster.

The USSR and India in 1971: The Beginning of Cooperation: B. N. Petrov, V. M. Kovtunenko, Agreement between the Academy of Sciences and ISRO

The enterprises to be involved—including the two leading executors, DB Yu and the Experimental Design Bureau (SDB) of the Moscow Power Engineering Institute (MEI), were listed in the state agreement between the USSR and India on space cooperation.

First on the list of cooperative ventures was the launching of the Indian satellite. The parent organizations were the Indian Space Research Organisation (ISRO) and DB Yuzhnoye in Dnepropetrovsk. The agreement providing for advisory and technical assistance for the creation of the Indian scientific satellite and its launching by Soviet carrier rocket from Soviet territory was signed on 10 May 1972 between the USSR Academy of Sciences and the Department of Space Research of the government of India.

The project was jointly coordinated by the "Interkosmos" Council (chaired by Academician B. N. Petrov) and ISRO (chaired by Professor Dhawan Satish, the great Indian scientist who headed ISRO between 1972 and 1982).

Figure 18–6: Soviet scientists visiting artist S. Roerich.

The project was jointly coordinated by the "Interkosmos" Council (chaired by Academician B. N. Petrov) and ISRO (chaired by Professor Dhawan Satish, the great Indian scientist who headed ISRO between 1972 and 1982).

Figure 18–7: General designer V. Yangel of DB Yu and K. Mennon, India's ambassador to the Soviet Union.

Figure 18–8: B. Petrov and V. Kovtunenko among the Indian experts.

The text of the agreement went as follows:

Guided by the contract about the world, friendship and cooperation between the USSR and the Republic and India, having as an objective the promotion and development of cooperation between the two countries in the field of research and the use of space for peaceful purposes, the Academy of Sciences of the USSR and the Indian Space Research Organisation (ISRO) of the Government of India, as a result of preliminary discussions between experts from both sides have agreed the following:

The Academy of Sciences of the USSR and ISRO will carry out the launching of a scientific satellite designed and manufactured in India no later than 1974. The launching will be carried out by Soviet rocket from the territory of the USSR.

. . . To carry out this joint project

ISRO:

- will submit the design of the satellite, subject to joint discussion and approval by experts from both sides, by 1972;

- will undertake the necessary steps to manufacture the satellite according to the agreed-upon design within the established time-frame;
- will ensure the delivery of the satellite, the necessary auxiliary systems, and the engineering specifications to Moscow.

The Academy of Sciences of the USSR:

- will provide and launch the Soviet carrier-rocket and will render all necessary advisory and technical assistance to carry out the joint project;
- will insert the satellite into the planned orbit within the established time-frame;
- will provide for the participation of the Indian experts in preparing the satellite before launching from the Soviet cosmodrome;
- will provide for the delivery of the satellite and necessary auxiliary systems from Moscow to the proper facilities on the cosmodrome;

No exchange of financial assets to carry out the specified project is provided for. Each side covers the expenses related to performance and obligations.

For decision-making on specific technical questions it is considered expedient to set up a mixed working group the structure of which will be determined as agreed.

Figure 18–9: Professor V. Kovtunenko and A. F. Bogomolov (SDB of MEI).

Participants

The practical execution of the agreement was assigned to DB Yu as the developer of the rocket-carrier and of the small satellites of the Kosmos and Interkosmos series.

Appointed on the Soviet side were:

- Project Director: Professor V. M. Kovtunenko
- Deputy Director: A. M. Popel

Appointed on the Indian side were:

- Project Director: Professor U. Rao
- Deputy Director: Dr. K. Kasturirangan.

Contributions of Yuzhnoye Design Bureau to the First Indian Satellite

The Yuzhnoye Design Bureau provided all necessary assistance, in particular in choosing the basic design of the satellite, in thermal calculations, in estimating the dynamic characteristics based on its experience in designing space vehicles gained since 1960. DB Yu experts carried out the design and electrical integration with the booster rocket, took part in experimental ground testing, in preparing the operational documentation, in preparations at the cosmodrome and during the initial phase of management of the space vehicle in orbit from the Bear Lakes Control Center in the Moscow suburbs. DB Yu equipped the satellite with a complete gas jet propulsion system for spin-stabilization, solar and chemical batteries, the onboard tape recorder for registration of the scientific findings and other equipment including thermal protection.

Space Universities of India—Dnepropetrovsk—Moscow, 1972–1975

In his book featuring interviews with the two project directors—U. R. Rao and V. M. Kovtunenko—Journalist V. Gubarev provided important insights into the teamwork involved in the creation of the first Indian satellite [12].

The cooperation between the Indian experts (some 200 people with an average age of 25) and Soviet scientists covered various grounds. For example, the complex of scientific instruments to study the upper layers of the atmosphere was jointly planned. However, joint work with the Indian colleagues had a much wider range. A new approach to meteorology, bringing together separate branches of science, was pioneered at this time. The project made it necessary to solve complex problems. In addition, the Indian experts not only had to learn the technique of performing experiments in space but also had to master the technology to create a satellite from scratch.

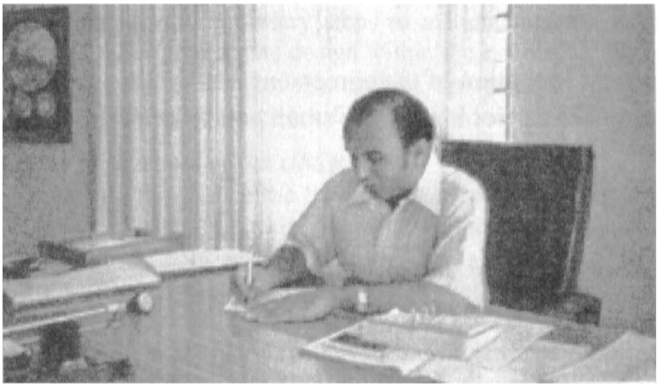

Figure 18–10: Professor U. Rao, Indian director of the India–Soviet project.

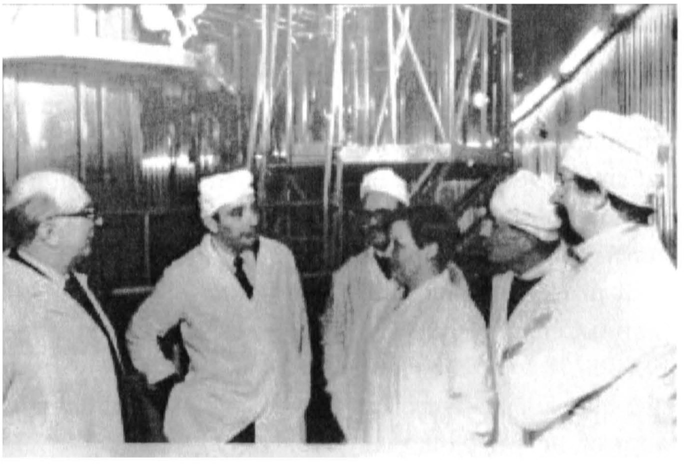

Figure 18–11: V. M. Kovtunenko in an assembly test complex with Indian experts.

Figure 18–12: Indian experts becoming acquainted with the space vehicle.

In the opinion of Professor V. M. Kovtunenko, the initiator of all the work and the director of the satellite project, all the Indian experts had been perfectly prepared. They knew every system very well but could not yet think in terms of the satellite as an integrated complex. Therefore, teamwork was planned in order for the Indian colleagues to gain knowledge of all the intricacies involved. The working atmosphere was not one of "educational occupation" but was useful for the Indian and Soviet scientists alike. There was a mutual enrichment of ideas. In the interview published by V. Gubarev, V. M. Kovtunenko formulated the executed work as follows:

> Three years ago, I did not appreciate the difficulties we would face. It was supposed that Thumba would become the center where the satellite would be created. I flew there. But what I saw was handicraft-style manufacturing. It was impossible to start on that basis. I consulted with the Indian colleagues, arguing that it was necessary to choose a city with a well-established advanced aviation industry. Space technology grows from aviation, inheriting its experience in the field of design and manufacture. During my following trip to India I already landed in Bangalore. The first proposal was to make a small satellite. The longer we worked, the heavier and more complex the satellite became. The proposal was then to start with one scientific experiment first, then the second. . . The elementary satellite turned into a complex whole.
>
> We saw it as our main task to transfer to our Indian friends our experience in designing a complex space vehicle. For this purpose, mixed groups were created.
>
> To tell the truth, during the initial stage, I did not see "the Indian brigade" as a single group. But we gradually got to know our friends better. As they gained more experience, our Indian colleagues became more confident of themselves. The more you find out, the more ideas pop up. Some participants in the project constantly proffered improvements, new variants of this or that unit.
>
> It was necessary to combat "individualism." It happened that one expert altered a unit and did not care how his colleagues would cope with the change. So nothing was obtained with such a new variant. The skill to see the entire complex, to analyze the mutual influence of one system on another is part of an integrated design method. That was the main thing we were able to teach the Indian experts. [2]

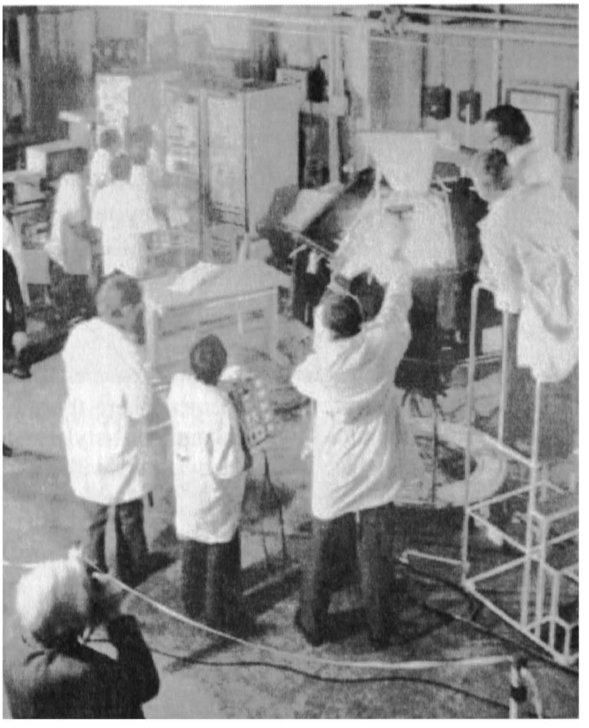

Figure 18–13: Checkout of the "Interkosmos" satellite in an assembly-test complex at Kapustin Yar.

Indira Gandhi proposed to name the first satellite *Aryabhatta*, which is the name of a great ancient mathematician, a "Copernicus of the East" and a symbol of will, courage, mind, and knowledge through the ages. At the age of 23, Aryabhatta was already recognized as the wisest among men of science. He was worshipped and everyone was proud of him.

> The first artificial satellite represented a step towards the future for India. The Aryabhatta satellite finally became the embodiment of a cherished dream and hope, a major event in the history of India. [2]

Aryabhatta represented a stage in the development of science in India. The first Indian sputnik resulted from three years of joint work, with the perspective of further cooperation in the future. The birth of a group of people capable of creating an artificial Earth satellite instilled optimism to continue along this road.

This group consisted mainly of young engineers who in time all became fine experts. From this group of Indian citizens a number of people emerged who would undoubtedly become heads of an independent "space" group in a short time. All this laid the foundations for a fast-paced development of space industry in India.

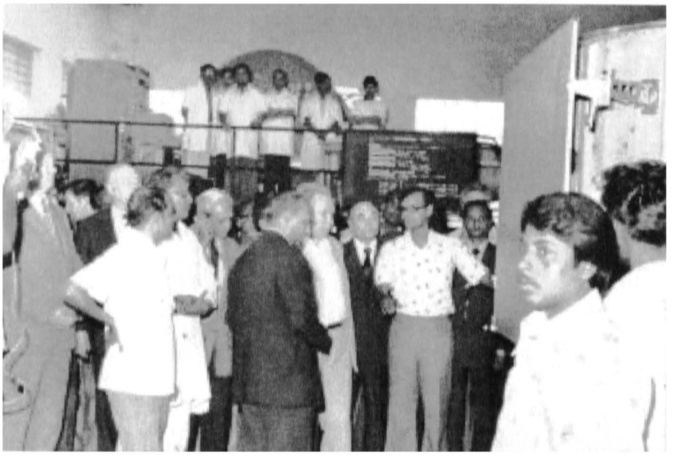

Figure 18–14: Indian experts in an assembly-test complex.

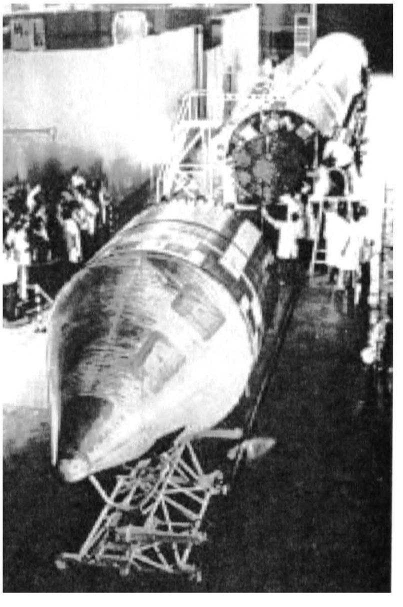

Figure 18–15: "Interkosmos" in assembly-test complex at Kapustin Yar.

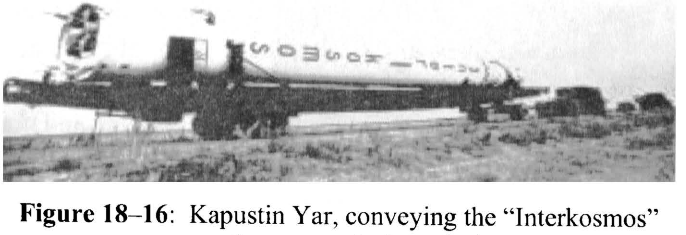

Figure 18–16: Kapustin Yar, conveying the "Interkosmos" space booster to the launch site.

Kapustin Yar Cosmodrome—Interkosmos—Aryabhata, 19 April 1975

The first Indian space satellite, *Aryabhatta*, was launched from Kapustin Yar cosmodrome on 19 April 1975 using an "Interkosmos" booster rocket.

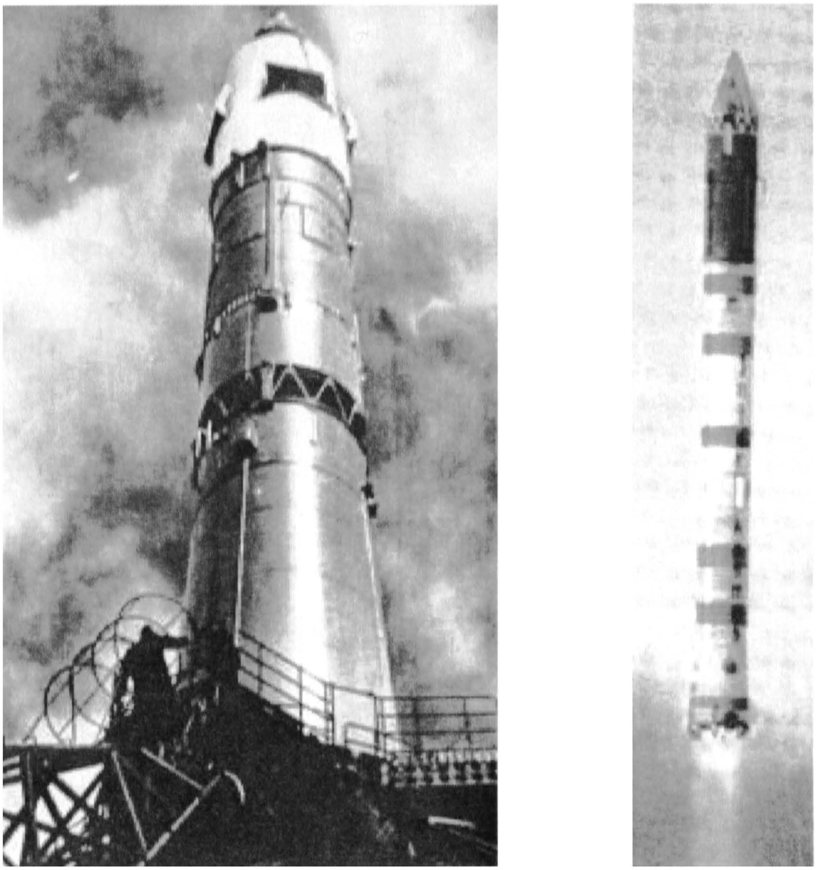

Figure 18–17: Kapustin Yar: "Interkosmos" on the launch pad and launching.

Aryabhatta's structural mass was 358 kg. It had the following dimensions: height: 1,200 mm; diameter: 1,600 mm; and the following orbital parameters: apogee 619 km; perigee 563 km; and orbital inclination: 50.7°. The satellite carried a complex of scientific instruments for research in the field of X-ray astronomy, for detecting neutrino and Y-radiation from the Sun and for measuring streams of particles and radiation in the ionosphere. The satellite carried a small plaque with the inscription: "The first scientific satellite of India. Soviet–Indian cooperation."

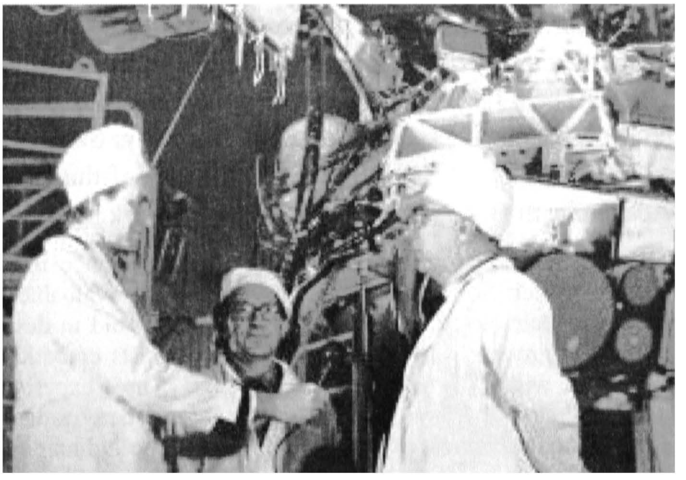

Figure 18–18: V. Kovtunenko and R. Sagdeev in assembly shop for space vehicles.

Figure 18–19: Launch of the satellite, *Aryabhatta,* by Interkosmos—B. Petrov (above) and V. Kovtunenko and U. Rao (below) [2].

All preparatory work necessary for a timely launch was accomplished within the planned time frame, thanks to the dedicated work of Soviet and Indian colleagues. On 18 April 1975, Academician B. N. Petrov and Professor S. Dhawan signed the decision to launch the satellite on 10:30 a.m. the next day.

Here is how chairman of the Interkosmos Council of the USSR Academy of Sciences, Academician B. N. Petrov summed up the work:

> In a short time, the Indian experts overcame a great distance in science. With the help of their Soviet colleagues, they acquired invaluable experience in both the technology needed to create a satellite and in developing the scientific and ground equipment. The Indian scientists embarked upon the road to space with their own scientific program. Three experiments in the program, the study of the sun, the ionosphere and x-ray radiation are problems of particular interest to modern science. . . The Indian colleagues were characterized by their wide-ranging view of space research. They enlisted psychologists, teachers, cinematographic artists. . . The first satellite has become a symbol of friendship and cooperation between two great peoples—Soviet and Indian. Aryabhatta has become a bridge in space connecting science and scientific experts from India and the USSR. [2]

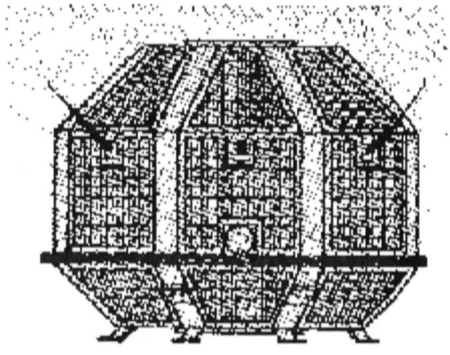

Figure 18–20: Indian sputnik *Aryabhatta.*

Kapustin Yar Cosmodrome—Interkosmos—Bhaskara-1 and -2 (1979–1981)

Indian–Soviet cooperation continued unabated after the successful launch of *Aryabhatta.* On 22 April 1975, the USSR Academy of Sciences and ISRO signed another agreement, providing for the creation and launch of a new experimental satellite for remote sensing of Earth and the detection of natural resources in India.

Subsequent teamwork between Soviet and Indian experts resulted in the successful launch, on 7 June 1979, of a second satellite, named *Bhaskara-1*, again by 11K65M "Interkosmos" carrier rocket. This satellite was named in honor of the 12th century Indian astronomer and mathematician Bhaskara. The design of the *Aryabhatta* satellite and its basic systems served as the basis of the new *Bhaskara-1* spacecraft. This satellite had a mass of 442 kg, with the following orbital parameters: apogee: 541 km; perigee: 519 km; and orbital inclination: 50.7°. The satellite was spin-stabilized perpendicular to the orbital plane.

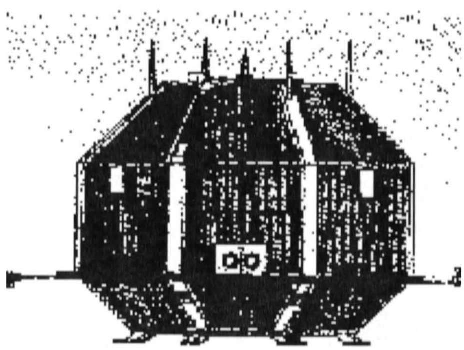

Figure 18–21: Indian sputnik *Bhaskara.*

This sputnik had a two-channel television system, a three-band millimeter-range radiometer, an X-ray spectrometer, a system to collect and transfer information to and from independent stations in remote areas, experimental solar batteries, thermo-coated panels, and heat pipes.

In accordance with an 11 June 1979 agreement between the USSR Academy of Sciences and ISRO a third Indian sputnik, the advanced *Bhaskara-2* satellite was launched from the territory of the USSR on 20 November 1981, again by means of a 11K65M "Interkosmos" carrier rocket. This satellite had the following orbital parameters: apogee: 557 km; perigee: 541 km; and orbital inclination: 50.7°. While preserving the design and scientific equipment of its predecessor, it was equipped with an additional third microwave radiometer for measuring the composition of water vapor in the Earth atmosphere. The joint development and successful launch of the first Indian satellites, *Aryabhatta*, *Bhaskara-1*, and *Bhaskara-2* was possible thanks to the development of what was to become the Indian national space program.

The public and governmental circles of India highly appreciated the help from the Soviet side, particularly that of the Yuzhnoye team of scientists. DB Yu researchers V. M. Kovtunenko, A. M. Popel, E. I. Uvarov, V. I. Dranovsky, V. S. Gladilin, A. P. Churayev, V. S. Varyvdin, Y. N. Vovk, I. N. Lysenko, N. A. Shmatok, Yu. V. Petrov, and others were most actively involved in this development work. The great technological skills and organizing abilities of the Bangalore Space Research center workers U. Rao, K. Kasturirangan, Kosta, Ashiya, Thomas, Mourty, Saha, Kalla, and many others greatly contributed to these positive results.

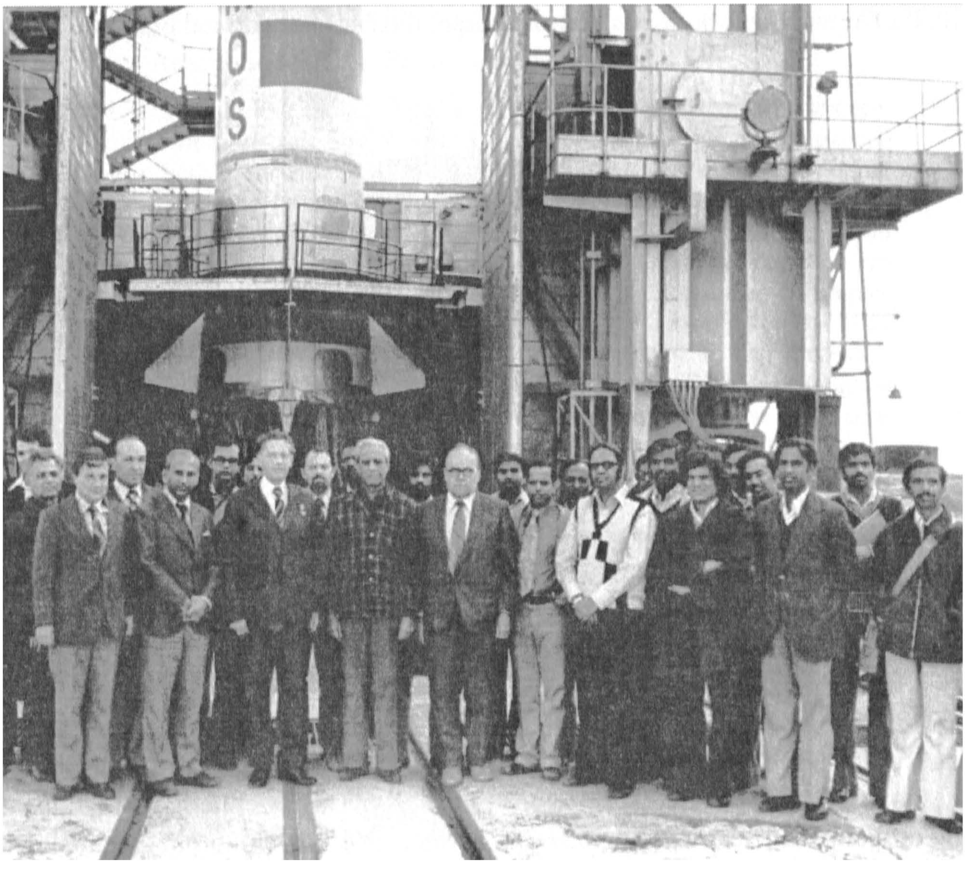

Figure 18–22: Heroes of India, in whose hands was the space future of India. Before the "Interkosmos" launch: from left to right—third A.M. Popel, fourth U. Rao, sixth B. Petrov, eighth Satish Dhawan, ninth Radjan, tenth S. Novikov, twelfth K. Kasturirangan.

Bangalore, India—Three Early Challenges

The dream of the outstanding Indian scientist Vikram Sarabhai to create indigenous Indian satellites has been realized. ISRO chairman Dr. K. Kasturirangan, who succeeded Vikram Sarabhai, enumerated 10 challenges faced by the Indian space program. We would like to mention three of them, related to the period of cooperation with V. Kovtunenko, 35 years ago:

1. Space without Vikram Sarabhai. ISRO was established in November 1969 under the Department of Atomic Energy. Dr. Sarabhai, chairman of the Atomic Energy Commission, personally planned and implemented all the early parts of the space program, like developing rockets and satellites, demonstrating space applications and science. When he died suddenly in 1971, the others in the program, most of whom had been hand-picked by him, were left trying to make his dreams and vision come true. This was a great challenge, but it was done over the next three decades.

2. Designing Aryabhatta. Developing *Aryabhatta*, the very first Indian satellite, from scratch with absolutely no infrastructure, was one of the toughest things that Indian space scientists have ever done. New scientists were hired, trained, facilities built up, all in a very short time, and *Aryabhatta* was launched in April 1975 on the "Interkosmos" rocket of the then-USSR.

3. Making Bhaskhara beam television pictures. *Bhaskhara-1*, an experimental remote sensing satellite, was launched in June 1979 with a television camera onboard. However, a high-voltage terminal employed in the instrument arced, due to suspected outgassing (evaporation of certain compounds in high vacuum), and it looked as if the camera would never be usable. But space scientists decided to wait for eight to nine months for the gases to dissipate, and the camera was finally switched on in 1980 . . . and it worked. The challenge here was in taking decisions about the environment inside a satellite in orbit 350 km above Earth.

In conclusion, speaking about the inherent ability of Indian scientists to think globally, strategically, and to make scientific forecasts, we would like to mention the recent publication of Dr. Kusturirangan's report to the UN Commission on the "Potential of Space Technology to Serve Humankind in the Coming 50 Years," which has become a fine reference point for all experts on space and rocket technology.

Figure 18–23: Soviet and Indian cosmonauts prepared for joint flight.

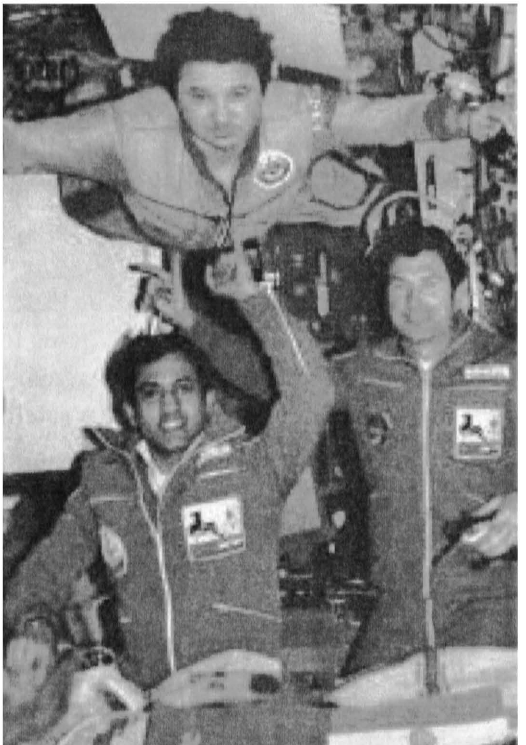

Figure 18–24: Soviet and Indian cosmonauts
in orbit on joint flight.

Epilogue: End of the Soviet–Indian Space Cooperation—Beginning of the Indian Space Era

Only 35 years have passed since the beginning of joint Soviet–Indian design studies in the space area. In a very short time India not only mastered the launching of satellites but in addition, in 1984 the first Indian cosmonaut, R. Sharma, visited the orbital space station *Salyut-7*.

Years of intensive joint work by scientists and experts on the first satellites and more years of studies enabled India to create its own launch vehicles and spacecraft. Indian scientists correctly defined the areas of space science and technology which to pursue. The next two decades saw India on an independent road on the conquest of space.

Figure 18–25: Soviet and Indian cosmonauts at Krasnaya Square—End of space cooperation between the USSR and India.

Today, India holds the fifth position in the world in terms of the financing of space research, on a par with Russia. India has launched several dozens of spacecraft independently. Paramount in India's space plans has been the aspiration to develop a completely independent program, with all spacecraft not only being manufactured but also launched from Indian territory. A key element in realizing this priority has been the geosynchronous satellite launch vehicle (GSLV). Most of the rocket's systems, including the missile body, various types of rocket engines, and the electronic equipment, have been constructed by Indian companies.

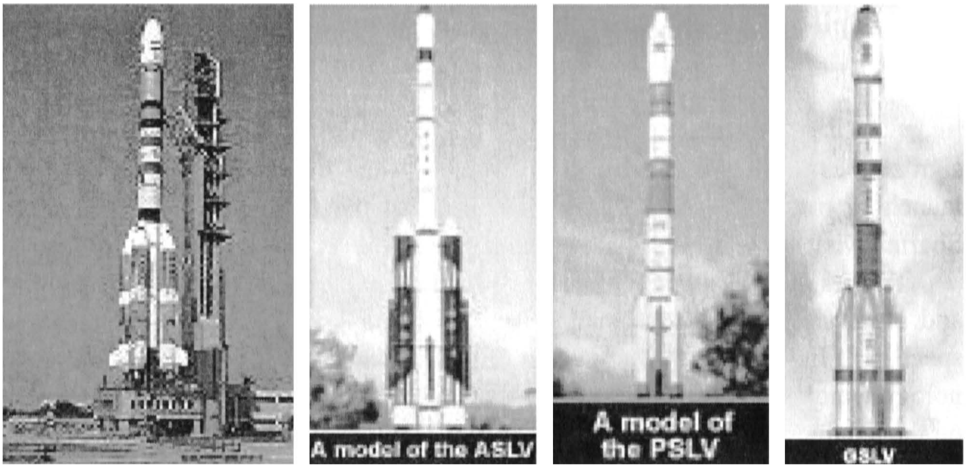

Figure 18–26: India's space launch vehicles.

Several universities and scientific institutes actively participated in the research and development of launch vehicles, and some 150 industrial organizations took part in manufacturing and testing rocket equipment. On 10 January 2007, a polar satellite launch vehicle (PSLV)-C7 rocket was launched from the Satish Dhawan space center in Sriharikota and put into orbit no less than four satellites, including an Indonesia and Argentine one. The payload also included a 650 kg Earth resources satellite (*Cartosat-2*) developed by ISRO, to perform an optical survey of the Earth surface. In addition, the rocket carried the 550 kg Space Capsule Recovery Experiment (SRE)-1 payload recovery experiment into a circular polar 635 km orbit. This capsule, intended to demonstrate microgravity experiments, successfully returned to Earth after 12 days. In the next 25 years, India plans to develop a reusable vehicle equipped with an air-breathing engine for use in the lower levels of the atmosphere. The most powerful version of the GSLV, Mark III, capable of launching a 4-ton to 5-ton payload into geosynchronous transfer orbit (GTO), is planned for 2012. In addition, India is planning to put the *Somayana* (renamed *Chandrayaan*) space probe into lunar orbit. All this clearly illustrates that the Indian pupils not only caught up with their Soviet teachers but even surpassed them in terms of the quantity of space research in a very short time. The belief of the Indian scientists that the first small step in space, the launching of *Aryabhatta*, would lead to even bigger leaps in the study of space turned out to be completely justified.

Ukraine, 2006: The Indian President Visits DB Yuzhnoye—Prologue of Space Cooperation between Ukraine and India

On 3 June 2005, Indian President A. P. G. Abdul Kalam visited Pivdenne Design Bureau (Ukrainian for DB Yuzhnoye) and Pivdenmash (Yuzhmash).

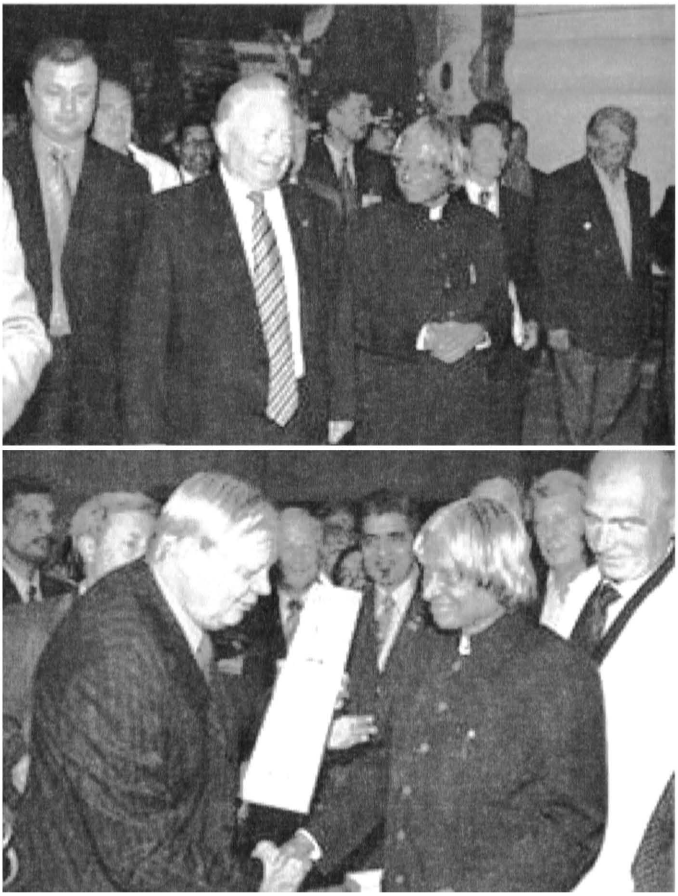

Figure 18–27: A. P. G. Abdul Kalam, President of India, in Pivdenne Design Office (above) and Yu. Alekseev, General Director of Pivdenmash (and future General Director of Ukraine's national space agency), presents a memento to President Kalam (below).

The Chief Designer of the Pivdenne Design Bureau informed the President and the accompanying dignitaries about the opportunities offered by the "Cyclone-2," "Cyclone-3," "Dnepr," and "Zenit" carrier rockets and various spacecraft, and outlined possible areas of cooperation. The Indian delegation visited several "Pivdenmash" shops and familiarized themselves with the manufacture of the "Tsyklon" ("Cyclone") and "Zenit" carriers. General Director of Pivdenmash Yu S. Alexeyev showed the President of India and his company new missile prototypes. At a subsequent meeting, the Ukrainian and Indian experts considered opportunities and areas of cooperation. In the final report, the mutual desire to develop scientific and technical cooperation in the field of space and rocket technology was outlined.

It may be hoped that this visit will give a push to Ukrainian–Indian space cooperation similar to the one taking place 35 years ago.

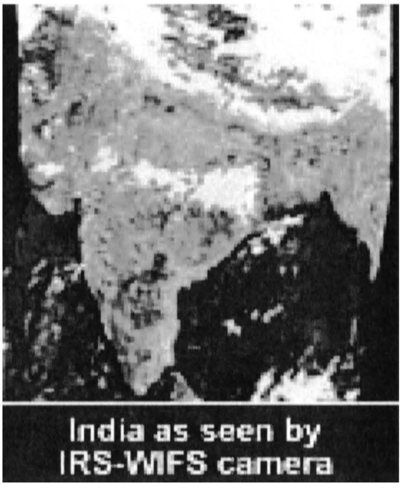

Figure 18–28: India as seen by the IRS-WIFS camera.

Editorial Acknowledgment

Each paper published in the Proceedings of the IAA History Symposia is undergoing an editing process in three steps and at the end the author gives the approval of the edited version of his/her paper. The editing of this paper of Prof. Prisniakov was only completed after his death in 2009 and thus could not be reviewed by the author himself. Thus the Editorial Board of the IAA History Symposia Proceedings had this paper reviewed by an additional historian scholar, Philippe Cosyn, to provide the best of technical and idiomatic correctness.

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[11] A. M. Kadakin, "Rossiya–India: Space Cooperation," *Aerokosmicheskiy Courrier*, N6 (2003). (see *The Diplomatic Bulletin* (February 2004)

[12] One of the authors of this report worked together with V. M. Kovtunenko during the latter's 10 years as a part-time worker at Dnepropetrovsk University. During that time, the faculty of aerodynamics, headed by V. M. Kovtunenko, was constructing the most powerful wind tunnel, while the faculty of rocket engines was building engine stands. During the Soviet era, such undertakings were hampered by extreme organizational difficulties, and we had to solve together many questions not necessarily of a scientific nature. Therefore it was decided to join hands. (Here it is necessary to tell that V. M. Kovtunenko was paying very great attention to his university work, unlike many other part-time workers. He understood that the experimental work at the university was also the work on which DB Yu was based.) When the faculties moved to the as-yet unfinished laboratory, one of the authors was in close touch with Vyacheslav Mikhailovich a lot of time. This acquaintance supported Kovtunenko through and through. It so happened that when there were some problems on the flight to Bangalore, where the 39th Congress of the IAF was taking place, V. M. Kovtunenko was given a separate plane. Hence, the author who was a member of the Soviet delegation had the opportunity to spend many hours with Vyacheslav Mikhailovich and learned a great deal about his cooperation with the Indian experts. The information he provided closely coincides with the interview given by V. M. Kovtunenko to V. S. Gubarev and published in reference 2.