Quest™

The Magazine of Spaceflight

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Front Cover: After spending 180 days aboard Russia's Mir space station, Shannon Lucid greets the astronaut who replaced her as cosmonaut researcher during her first reunion with astronaut John Blaha near the docking tunnel that connected Mir to Atlantis on Flight Day 4, September 19, 1996 during STS-79. This historic meeting marked the first astronaut change-over of crewmembers on Mir. NASA Photo S79E-5095. **Back Cover:** When the Space Shuttle Advanced Solid Rocket Motor (ASRM) Program was alive and well, NASA needed a new type of vehicle to move the larger diameter case segments at the ASRM manufacturing site in Yellow Creek, Mississippi. Shown here is one of two Kneel-Down Transporters built for this purpose which had arrived by barge On December 7, 1992 at NASA's Kennedy Space Center from KAMAG Transportation Company in Germany. After the ASRM cancellation, the fate of these two vehicles is not known. NASA Photo KSC-92PC-2508.

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"There It Is!"

An Account of the First Dogs-In-Space Program

by Asif Siddiqi

Layka, the dog launched on board the second Sputnik in 1957 inherited the honor of being the first living being to enter orbit around the Earth. However, long before that momentous occasion, the Soviet Union had been experimenting with launching dogs on vertical trajectories above the atmosphere. A little known project, originating in the late 1940s, culminated in 1951 with an equally significant event: the first time that living beings had been launched into space and recovered successfully. Forgotten amid the rush of the spectacular Soviet and American space missions of the late 1950s and 1960s, this short-lived effort has been relegated to a footnote in space history. With hindsight, it is clear that these early efforts were progenitors and path-breakers to the ultimate successes of the Soviet manned space program in the 1960s.

The Soviet long-range ballistic missile program began in earnest in 1946 at the Scientific Research Institute No. 88 (NII-88) located at Kaliningrad near Moscow. It was here that in the Department No. 3 of the Special Design Bureau, Chief Designer Sergey P. Korolev initiated work on a series of ballistic missiles, all earmarked for use by the Soviet Artillery. While the overriding motivation for the new Soviet ballistic missile program was obviously military, over the years a small but vigorous scientific element of high-altitude rocketry research began to emerge. Primarily due to the efforts of nuclear physicist Sergey N. Vernov, the Deputy Director of the Scientific Research Institute for Nuclear Physics (NII YaF), the work of a wartime body named the Commission for the Study of the Stratosphere had been revived. Vernov was interested in using Korolev's new missiles for scientific investigations of the upper atmosphere, and his lobbying led to discussions at the Academy of Sciences level on the need for a new scientific body to oversee such launches. In late 1949, Academy President Sergey I. Vavilov formally approved the creation of the Commission for the Investigation of the Upper Layers of the Atmosphere, which was created on the basis of the older war-time commission. Appointed head of the new body was 55-year old Academician Anatoliy A. Blagonravov, a small arms and artillery science specialist of well repute.

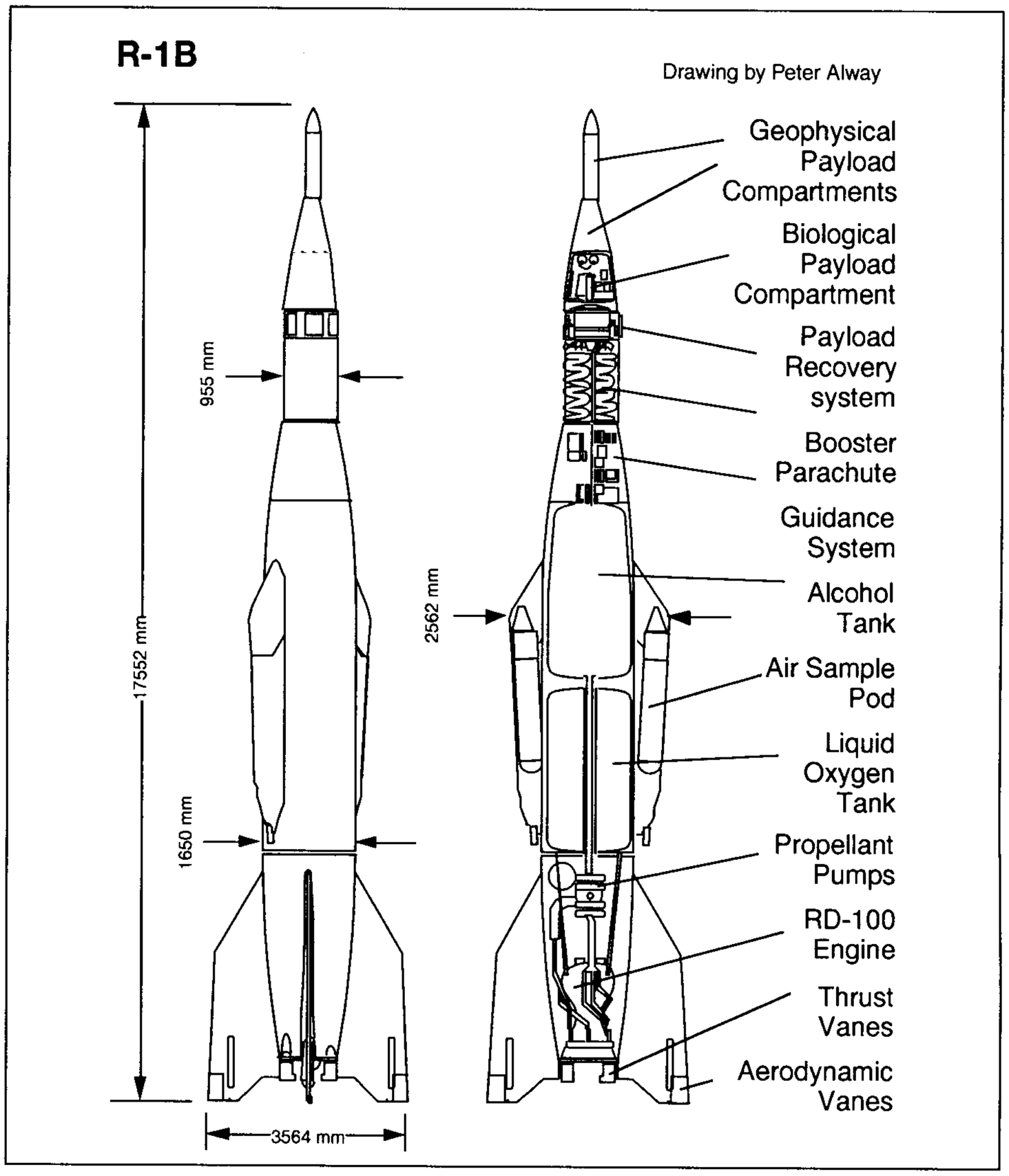
In the late 1940s, the only serious route for upper atmospheric investigation was by means of the R-1 missile, the first Soviet long-range ballistic rocket. Little more than a copy of the famous German A-4 (or V-2) missile, the R-1 was the very first and modest step in Korolev's future plans to explore space. The 14.65 meter long vehicle consisted of four primary elements: the tail assembly, the propellant compartment, an equipment section, and the warhead. Maximum body diameter was 1.65 meters. The lower part of the propellant section incorporated an oxidizer container which carried approximately five tons of liquid oxygen. An insulated feed line was routed from the top tank for four tons of ethyl alcohol. Both the containers were self-supporting, separate from the outer shell of the missile, and covered by heat insulation made of glass wool. The 25 ton thrust RD-100 engine was installed at the base of the rocket with a large turbopump assembly. The equipment section was situated on top of the propellant tanks and contained the guidance system with control and gyroscopic instruments. During flight the system would control the air rudder at the rear of four large fins at the base of the rocket via servomotors. The explosive warhead was inserted in the nose cone which itself was attached to the main body of the missile. The total mass of the rocket was about 13.5 tons, approximately 9.2 tons of which was propellant. The maximum flight range was about 300 kilometers, slightly higher than the A-4. Although work on producing a Soviet copy of the A-4 had begun as early as 1946, the R-1 ballistic missile effort was formally approved by the USSR Council of Ministers two years later, on 14 April 1948. The R-1 went through an extensive testing program between 1948 and 1950 in at least three separate trials. The missile was formally declared operational by an order dated 28 November 1950 becoming the very first long-range ballistic missile in the Soviet armed forces.

The first scientific version of the R-1, the R-1A, was launched twice in May 1949. Despite some major instrumentation failures, these launches did allow Korolev and his engineers to gain valuable experience in the creation and integration of delicate instrumentation for purely scientific purposes. These launches spurred the Chief Designer to begin concrete planning for more ambitious scientific launches, ones involving live animals. Original ideas for such launches had been tabled by Korolev even earlier, in 1948, when he began to conceptualize the launch of humans on vertical trajectories into space. Inspired by U.S. programs using A-4 and Aerobee missiles for launching animals into space, Korolev mentioned his plans for human spaceflight to famous aviation designer Andrey N. Tupolev during a conversation in late 1948. In response, Tupolev gave Korolev the name of Vladimir A. Yazdovskiy, a young physician in the employ of the Air Force's Institute of Aviation Medicine (IAM) in Moscow. The 35-year old Lt.-Col. Yazdovskiy had graduated from the Tashkent Medical Institute before spending the war as an Army physician. Moving to aviation medicine after 1945, Yazdovskiy evidently made quite a name for himself as a bright and resourceful researcher. In January 1949, Korolev telephoned Yazdovskiy, introducing himself as a builder of "special equipment" (it was illegal to make references to military weapons such as missiles over the phone), and arranged a meeting at the Petrovsko-Razumovskiy Park near the IAM. Korolev was direct with the young physician, informing him that "Andrey

The above photo shows Korolev with a dog recently returned from a vertical space flight in July 1954. At the time Korolev was experimenting with the uprated R-1D model, which was launched three times in June and July of 1954, each with two dogs on board. This photo was presumably taken at Kapustin Yar. Korolev was 47 years old at the time.

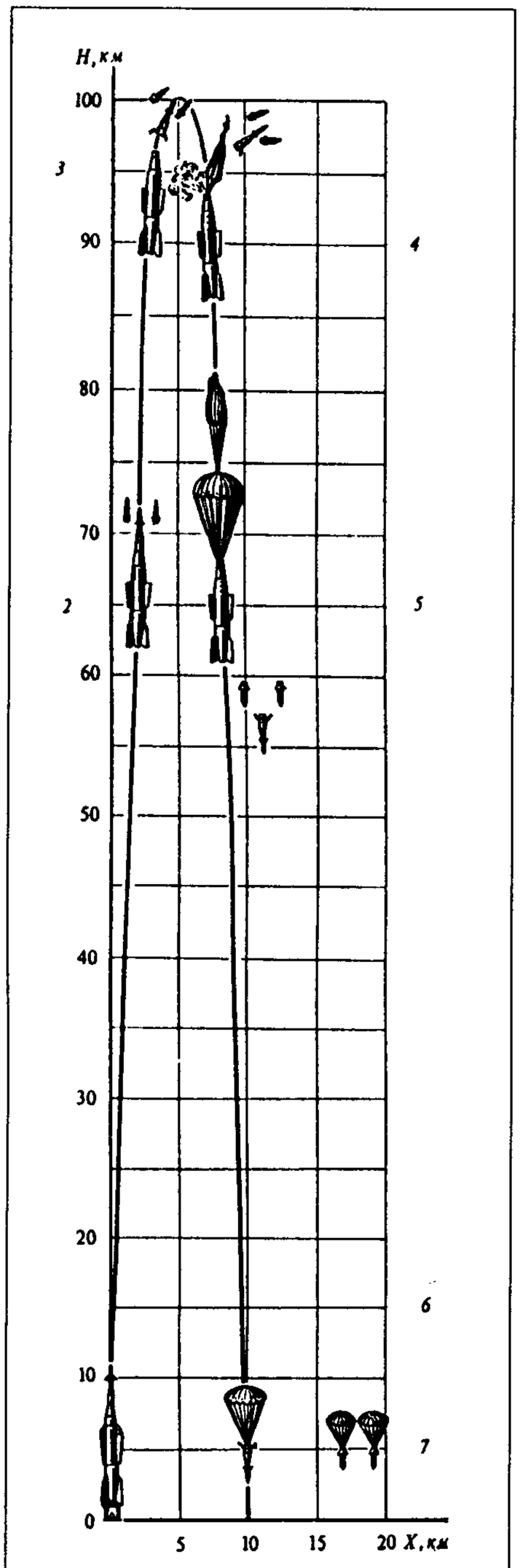
Nikolayevich [Tupolev] suggested I contact you about leading a biomedical program in preparation for future flights of spaceships. I would like you to lead this effort, since I don't know what is being done in this area nowadays and what has already been done..." Yazdovskiy was resistant at first, but Korolev would not hear no for an answer: "Oh, come on now Volodya...What's in it for you in all that aviation medicine business? What I am offering you is far more challenging." Hearing that Yazdovskiy had never seen a launch of a rocket, Korolev replied, "Well, then, if you've seen it once, it will stay with you for the rest of your life." Within a few days, Korolev personally arranged with the USSR Minister of Defense Aleksandr M. Vasiliyevskiy to have Yazdovskiy's current work transferred to others, and the physician was given a mandate to begin dedicated biomedical studies in preparation for putting a human into space at an unspecified time in the future. The short-term goals were to use small animals as testbeds for gathering medical data on the effects of rocket flight on living organisms.

The Director of the IAM, Maj.-Gen. Aleksey V. Pokrovskiy initially assigned a small group of physicians to work under Yazdovskiy including Boris G. Buylov, Vitaliy I. Popov, and Aleksandr D. Seryapin. At the time, the literature in the Soviet Union on space medicine was almost nonexistent. Thus, the group began their efforts by studying in detail translations of American texts on the subject and identifying the major areas of focus. In designing a payload module for a small animal to fly on board a modified R-1 missile, Yazdovskiy narrowed down three factors which would play an important role. These were: (1) the environment of vacuum, radiation, extreme temperatures, and meteorites in near-Earth space; (2) the presence of parameters such as vibration, noise, and weightlessness during dynamic flight; and (3) the issues associated with the confinement of organisms in a very small space. In studying these factors, the group also addressed the question of what type of animal to use on the launches. The candidates most appropriate for medical use were initially narrowed down to apes and dogs, but by late 1950, the group began to lean more toward the use of the latter. Apes were considered to be more difficult to dress and were more likely to get colds and other diseases. Furthermore, since they were more excitable than dogs, it was believed that they might, for example, bite off important sensors from their bodies. The decision to use dogs was formally approved at a meeting of important scientists and physicians at a special session organized by the Academy of



Medical Sciences and the Academy of Sciences in December 1950. Academician Blagonravov, as Chairman of the Commission for the Investigation of the Upper Layers of the Atmosphere was a natural choice to head a subcommission to oversee the launches, and his nomination was approved at the meeting. Several famous Soviet biomedicine specialists, such as Vladimir N. Chernigovskiy, Vasiliy V. Parin, and Norair M. Sisakyan were also inducted as advisors to the commission, emphasizing the importance with which the scientific community viewed the program.

The selection of dogs as test subjects commenced a search to establish criteria for particular types of dogs. Starting with the rationale that the choice had to be satisfactory to both the rocketeers and the biologists, Yazdovskiy's group had to negotiate a number of major obstacles. At the outset it was agreed that at least two dogs would have to be launched in a common container on each flight since the reaction of one animal would not provide objective results, given the conditions on a particular launch and the peculiarities of the dog. With the constraint of only 0.28 cubic meters of volume, the dogs had to be relatively small and light, somewhere between six and seven kilograms. Experts in dog behavior were consulted and it was ascertained that for the most part, small dogs were not compatible with each other, further narrowing the field. The subjects also had to have a high level of resistance and be easily trainable. Additionally, the dogs had to have a white or brightly colored coat since the plan was to film the behavior of the animals during flight using a system of mirrors in the poor lighting conditions inside the capsule. Finally, only female dogs were to be considered, since the special anti-gravity suit and sanitation equipment would pose complex problems in the case of males. The requirements were so stringent that at one point one of the 'dog catchers' in exasperation told one of the physicians, "Perhaps you'd like them to also have blue eyes and howl in C major?" Such aspects as the posture of the dogs in flight were also carefully planned out prior to launch. Yazdovskiy's team used pairs of dogs in a special centrifuge with self-contained life-support systems to ascertain that a vertical posture would probably kill the animals due to the high rates of acceleration



R-1B flight profile. Source: "Tvorcheskoye naslediye akademika Sergeya Pavlovicha Koroleva: izbrannyye trudy dokumenty" (Nauka: Moscow, 1980), 350.

in the initial stages of flight. Equipment for monitoring the physiological behavior of the dogs was culled from a variety of sources including a local military college and the Krasnogorsk Mechanical Optical Plant which manufactured a camera capable of holding 120-300 meters of film.

At Korolev's department at the NII-88, work on the design of a modified R-1 missile and a special container to carry the small animals had formally begun on 30 December 1949 as part of a coordinated project to develop different variants of the rocket for scientific purposes. In particular, two scientific variants of the R-1 emerged as a result of these studies, the biomedical R-1B and the geophysical R-1V. The chief of the planning sector at Korolev's section, Konstantin D. Bushuyev, was appointed to lead the team which would design the former, slated to be the first Soviet missile to carry live animals. The design of both the R-1B and its payload evolved over 1950 and 1951, with significant interaction between Yazdovskiy's group at the IAM. Both visually and technically, the R-1B rocket was markedly different from its predecessor, the geophysical R-1A missile. It, in fact, incorporated many of the mechanisms developed for the R-2 ballistic missile and had a much more sleek appearance than the R-1A. The missile was 17.55 meters in length with a base diameter of 2.56 meters, dimensions significantly exceeding the R-1A. Total lift-off mass was expected to be 14.32 tons. The total mass of the experimental payload of the vehicle was set at 1,160 kilograms of which 590 kilograms was to be the actual container carrying the dogs. Seven major objectives of the R-1B and R-1V program were included in documentation: (1) the study of the composition primary cosmic radiation and its interaction with matter; (2) research into the physical and chemical characteristics of air; (3) research into the spectral composition of solar radiation; (4) verification of the absorption capabilities of ozone; (5) verification of the life functions of living organisms at very high altitudes and the increased loads associated with the ascent of the rocket and the possibility of rescue after ascent; (6) aerodynamic research associated with the high velocities and high altitudes of flight; (7) experimental verification of the possibility of rescuing the rocket with the aid of parachutes with the goal of repeated use of the rocket for experimental launches.

A significant amount of work at Korolev's department was expended on designing a container which could be safely recovered. The original nose cone separation mechanism from the R-1A was modified, and the reliability of the parachute system was raised during pre-flight tests. Auxiliary air brakes were introduced to decrease the rate of descent prior to the opening of the parachute, primarily to reduce deployment shock. The R-1B also incorporated an improved telemetry system for the transmission of the basic parameters of the life signs of the dogs. In order to save payload mass, the film of the animals in flight was to be stored in the onboard camera and recovered along with the main container. An improved orientation and stabilization system was also installed on the payload, which would allow uninterrupted transmissions to the ground. The life-support systems for the dogs consisted of 150 atmosphere oxygen cylinders, an injector, silica gel dessicators, and chemical calciferous absorbent material for removing carbon dioxide. The injector was used to provide compressed air, which was enriched with oxygen, while carbon dioxide and moisture were to be removed via closed cycle process. The end result of the R-1B design program in 1951 was the development of a standard nose cone payload section which could be used in a variety of configurations for different requirements. In addition to the main payload container, two 85 kilogram scientific modules were also to be attached longitudinally to the sides of the main body of the missile, each designed by the Geophysical Institute of the USSR Academy of Sciences, and containing a number of instruments for studying the upper atmosphere.

In the mid-summer of 1951, the State Commission headed by Blagonravov, representatives from the IAM including Yazdovskiy, and engineers from the Experimental Design Bureau No. 1 (OKB-1) led by Korolev converged at the famous Kapustin Yar site 90 kilometers southeast of the town of Volgograd. A total of nine dogs were selected to form the core pool including Albina (Russian for White), Bobik, Dezik, Kozyavka (Gnat), Lisa, Malyshka (Little One), Smelaya (Bold), and Tsygan (Gypsy). Prior to putting dogs on the rocket, the State Commission conducted at least two preliminary test launches of the R-1B missile. The first article lifted off on 22 July 1951 and the second occurred a week later on 29 July. The latter had the distinction of being the very first biomedical space launch in Soviet history. A Soviet space historian later wrote that the missile carried "experimental animals on board, as a result of which was received valuable telemetric data on the behavior of the organism in rocket flight." It appears that although dogs were not carried on the rocket, there were smaller animals such as mice, rats or rabbits. Additionally, it is not clear if the animals were recovered or not, although given hindsight, it appears they were not.

Chosen for the first actual dog flight, set for 15 August 1951 were Dezik and Tsygan. The launch was to be held during the early morning hours in order for the rocket to be illuminated by the Sun during the ascent portion. Preparations for the launch were conducted in a mood of unconcealed excitement and anxiety, and following Blagonravov's formal approval, the R-1B finally lifted off in a roar amid the dust of Kapustin

Yar carrying its two canine passengers. During their flight, the animals reached a velocity of 4,200 kilometers per hour, an altitude of 101 kilometers, and experienced four minutes of weightlessness. Approximately 188 seconds following launch, at an altitude of about 100 kilometers, the payload section separated from the main booster and went into freefall. The parachute system for the animal container deployed at an altitude of only six kilometers from the ground. Yazdovskiy had personally asked all the members of the State Commission to remain at their viewing positions until the dogs had landed, but about 20 minutes following launch, a white parachute became visible in the sky and everyone at the launch site rushed to their cars, driving off into the desert in a cloud of sand. Blagonravov's recollection of the descent of the missile is vivid:

> "There it is!" shouts one of the observers. We can discern an elongated object, descending rapidly some 4-5 km away. A flash indicates that the rocket's main body has fallen and what is left of the fuel has exploded. The thunder reaches us, but we are all looking back at the sky. "It's coming down!" someone shouts. And in fact a small spot appears in the sky. The parachute with the nose cone of the rocket is opening. Yazdovskiy rushes to a car on his way to where the nose cone is landing. He is followed by Korolev's and other cars in their wake, presenting a spectacle much along the lines of the Charge of the Light Brigade. [24]

At the landing site, the cabin hatch was hurriedly unscrewed and both dogs were found barking and wagging their tails. Although Dezik was in perfect condition, Tsygan had apparently sustained a minor injury on her belly, when the inner compartment had curved in upon impact. The dogs were the first living organisms successfully recovered after a flight into space.

This first historical launch was followed by an unevenly successful program. The second of six total launches carried Dezik on her second flight with a new dog, Lisa. Unfortunately the pressure sensor used to trigger the parachute system had been damaged by vibration and both dogs were killed upon impact on the steppes of Kapustin Yar, although the onboard data recorders were successfully salvaged. Korolev himself was apparently greatly grieved by the loss. The third launch almost didn't go off. One of the dogs chosen for the flight, Smelaya, unexpectedly ran loose the day before launch, causing great consternation among the specialists that she had met her fate at the claws of jackals who were known to roam the area. The next morning, Smelaya returned to the launch site, quite safe, and the launch went off on time. Both dogs survived and were recovered successfully. The fourth launch was another failure with two canine fatalities, although the fifth was once again successful. One of the dogs slated to fly on the sixth and final flight once again disappeared during a walk prior to launch. Yazdovskiy ordered Seryapin to search for a replacement and the latter went to the local canteen and picked up one of the dogs who were known to frequent the place, making sure that she was suitable in size and temperament. With no previous documentation, Korolev opted to give her the name ZIB, the Russian acronym for 'Substitute for Missing Dog Bobik.' With minimal training, she and another dog were successfully launched on 3 September during a completely successful mission reaching an altitude of 100 kilometers and finishing the complete program. In total, nine dogs were flown on six launches, three of them flying twice.

Despite four dog fatalities, the results of the R-1B launch program were encouraging. Data gathered on a four-channel recorder included information on fluctuations of skin temperature and pulse, and on cabin pressure and temperature. Film from the movie camera proved extremely useful in observing the behavior of the dogs in flight. In addition, before and after the missions, an ECG, x-ray of the thorax, conditional food reflexes, and data on body mass were obtained. The flights also introduced the first fully-functioning life-support system for organisms in Soviet rocketry, comprised of a seven liter globe filled with a mixture of 70% air and 30% oxygen. A soda lime cartridge was utilized to absorb exhaled carbon dioxide and a silica gel cartridge was used as a desiccant. Among non-biomedical experiments, the launch of 15 August was the first time that Soviet instruments were used to study the spectral composition of solar shortwave radiation from an altitude of 100 kilometers. For Blagonravov himself, the R-1B launches had one important result. After the second launch, when Dezik and Lisa had been killed, the Academician had decided that Tsygan, who had been Dezik's partner on the first flight, should not fly again. Instead, in early September, he took the lone dog back to Moscow and adopted her as his own. Tsygan lived to a great old age, and Blagonravov and the dog would often be seen walking the streets of Moscow, both clearly very much attached to each other.

The vertical dog flights of 1951 opened up the era of space biomedicine for the Soviet Union. At the same time, there was also a significant expansion of the use of ballistic missiles for the study of the upper atmosphere. Under Academician Blagonravov's chairmanship, the Commission for the Investigation of the Upper Atmosphere submitted a formal report in 1951 describing a full-scale program for high altitude scientific research. In addition, Yazdovskiy's group also conducted important studies on their original mandate: to design a cabin to carry a human on a vertical space flight. These efforts apparently reached at least a drawing stage by 1951; one illustration from that period shows the same R-1B rocket with a large cabin carrying a human passenger on a reclining seat. While these efforts were not funded as dedicated programs, they were important predecessors to more ambitious and concrete programs in 1955-56 for launching a Soviet citizen on a suborbital flight. But that, as they say, is another story....

The above is a modified excerpt from the author's forthcoming book on the history of the Soviet Union's piloted space programs which is to be published by the NASA History Office as part of the SP-4000 series.

Notes:

1.) Vernov was also on the staff of the P. N. Lebedev Physical Institute of the USSR Academy of Sciences (FIAN). See L. L. Layko, "11 July - 80 Years from the Birth of Soviet Scholar S. N. Vernov (1910)" (in Russian), *Iz istoii aviatsii i kosmonavtki* (1993), V. 64: 48-54.

2.) Yu. V. Biryukov, "Materials in the Biographical Chronicles of Sergey Pavlovich Korolev," in B. V. Raushenbakh, ea., *Iz istorii sovetskoy kosmonavtiki: sbornik pamyati akademika S. P. Koroleva* (Moscow Nauka, 1983), 229. Blagonravov's 'real' job at the time was as the President of the USSR Academy of Artillery Sciences which he headed between November 1946 and December 1950.

3.) Peter Stache, *Soviet Rockets*, Foreign Technology Division Translation, FTD-ID(RS)T-0619-88 (from unnamed source), Wright-Patterson Air Force Base, Ohio, November 29, 1988, 173. This is a translation of Peter Stache, *Sowietischer Raketen* (Berlin: Militarverlad der DDR, 1987); G. A. Sadovoy, "10 October--40 Years After the First Successful Launch of the First Soviet Guided Missile of Long Range R-1 (1948)" (in Russian), *Iz istorii aviatsii i kosmonavtiki* (1989), V. 59: 94-101.

4.) B. Ye. Chertok, *Rakety i lyudi* (Moscow: Mashinostroyeniye, 1994), 310; Sadovoy, 1989.

5.) The first series of 12 were launched between 17 September and 5 November 1948. The second of 20 missiles were launched between 10 September and 23 October 1949. A third series of 10 were launched in late 1949.

6.) I. D. Sergeyev, ed., *Khronika osnovnykh sobytiy istorii raketnykh voysk strategicheskogo naznacheniya* (Moscow TslPK, 1994), 34. Even after formal adoption by the armed forces, fur-

ther testing of the R-1 was continued at Kapustin Yar. Controlled winter launches in temperatures as low as -26 degrees Celsius were conducted between 29 January and 2 February 1951. A further series occurred between 13 and 27 June 1951. These launches had a 100% success rate in reaching the assigned targets.

7.) Biryukov, 1983, 228. The first of four non-scientific R-1A missiles was launched on 7 May 1949. The two with scientific payloads were launched on 24 May and 28 May respectively, after the earlier four tests.

8.) Yu. Mozzhorin et al., eds., *Dorogi v kosmos: II* (Moscow. MAI, 1992), 119-120. The first U.S. program for launching animals into space also used A-4 missiles. Between 11 June 1948 and 31 August 1950, five A-4s (three of them stretched) were launched from White Sands in New Mexico as part of the *Albert* and *Blossom Albert* programs. All except one carried monkeys. Despite reaching a highest altitude of 136.5 kilometers on the last launch, none of the animals were recovered alive. A second program involved Aerobee RTV A-1 missiles, three of which were launched between 18 April 1951 and 21 May 1952. The second flight on 20 September 1951 with a monkey and 11 mice was the first U.S. mission involving the successful recovery of animals after a high altitude (70.8 kilometers) flight.

9.) Mozzhorin et al., 1992, 120.

10.) Mozzhorin et al., 1992, 122-124.

11.) Yaroslav Golovanov, *Korolev: fakty I mify* (Moscow. Nauka, 1994), 545-546; Stache, 1988, 212.

12.) Stache, 1988, 212-213. Evgeny Riabchikov, *Russians in Space* (Garden City, NY: Doubleday & Company, Inc., 1971), 140.

13.) Mozzhorin et al., *Dorogi v kosmos: II*, 1992, 126-127.

14.) Biryukov, 1983, 229.

15.) M. V. Keldysh, ea., *Tvorcheskoye naslediye Akademika Sergeya Pavlovicha Koroleva: izbrannyye trudy i dokumenty* (Moscow: Nauka, 1980), 536.

16.) Keldysh, 1980, 536.

17.) Mozzhorin et al., *Dorogi v kosmos: II*, 1992, 126; Stache, 1988, 213.

18.) Stache, 1988, 213.

19.) The Kapustin Yar site was officially known as the State Central Range No. 4 (GTsP-4) and was selected for Soviet ballistic missile launches on 23 June 1947. The range covered a 96 X 72 kilometer stretch of barren and inhospitable area of desert.

20.) Riabchikov, 1971, 141.

21.) Biryukov, 1983, 230-231.

22.) Biryukov, 1983, 231.

23.) The date is from Biryukov, 1983, 231. There is still some confusion regarding the date of the first dog launch. Most unofficial sources and oral histories state that the first launch of dogs occurred on 22 June 1951. For example see Golovanov, 1994, 546. See also V. P. Mishin, "And the Flight Continues" (in Russian) in M. I. Gerasimova and A. G. Ivanov, *Zvezdnyy put* (Moscow Politicheskoy literatury, 1986), 307. Since the Biryukov source is purported to be based on archival sources at the OKB-1, it has been used instead of other oral histories.

24.) K. V. Frolov, A. A. Parkhomenko, and M. K. Usokov, *Anatoli Arkadyevich Blagonravov: Outstanding Soviet Scientists* (Moscow: Mir Publishers, 1986), 144-145.

25.) Frolov, Parkhomenko, and Usokov, 1986, 145; *Mozzhorin et al., Dorogi v kosmos: II*, 1992, 127.

26.) Golovanov, 1994, 547.

27.) Mozzhorin et al., *Dorogi v kosmos: II*, 1992, 128-129.

28.) Mozzhorin et al., Dorogi v kosmos: II, 1992, 129.

29.) George Wukelic, ed., *Handbook of Soviet Space-Science Research* (New York: Gordon and Breach Science Publishers, 1968), 16-17, 19-20.

30.) G. S. Ivanov-Kholodoyy and L A. Vedeshin, "First Rocket Experiments for Research on Solar Short-wave Radiation," in Frederick I. Ordway III, ed., *History of Rocketry and Astronautics, Vol. 9* (San Diego: American Astronautical Society, 1989), 191.

31.) Golovanov, 1994, 547; Stache, 1988, 116.

32.) Christian Lardier, *L'Astronautique Sovietique* (Paris: Armand Colin, 1992), 244.

CLASSIFIED ADS

SEEKING INFORMATION on Apollo Proposals. CSM: North American, Convair, GE, Martin, McDonnell 1961. LEM: Lockheed, Boeing, Northrup, LTV, Grumman, Douglas, Convair, Republic, Martin 1962. Paul Carsola, San Diego Aerospace Museum Library, 2001 Pan American Plaza, San Diego, CA 92101.

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