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Front Cover: **One of the clearest days for a Shuttle launch was on 4 April 1997 when STS-83 was reportedly seen as far south as Miami over 200 miles away. The boosters were observed tumbling over the horizon minutes after separation. See pp.344-349 for mission reports on STS-83 and its reflight STS-94.** PETER GUALTIERI

Before Sputnik: Early Satellite Studies in The Soviet Union 1947-1957

BY ASIF A. SIDDIQI
Philadelphia, USA

Introduction

The launch of the world's first artificial satellite, Sputnik, in 1957 was a watershed event in the history of humankind. From seemingly out of nowhere, the Soviet Union had achieved a technological breakthrough of tremendous proportions, one that visibly eclipsed the efforts of its chief rival, the United States.

One after another, the Soviets accomplished an unprecedented series of spectacular space missions in the ensuing years, all of which served to highlight the apparent technological gap between the two superpowers. In the eyes of the Soviet press, their space achievements were also metaphors for the differences in social, political and economic systems governing the countries.

Clearly, one of the reasons that Sputnik was such a surprise was due to its unexpected nature. The Soviet Union was a nation of secrets and what was known about it by the general public was essentially what was allowed to be known. While there was occasional talk of artificial satellites and space exploration, it was of a very general nature, quite the reverse of the situation in the United States. Although national security satellite programmes such as CORONA were kept hidden, there were an abundance of plans, proposals, reports and articles on 'civilian' satellites and boosters well before the launch of Sputnik.

Sputnik, obviously, did not come out of 'nowhere.' In fact in the last few years, much information has been declassified which suggests that there was a rich history of research on artificial satellites in the 1950s which eventually led to proposals for several highly complex satellites by 1957, some for scientific purposes, and others for military reconnaissance.

The basis for all this work was a remarkably detailed report completed in 1954 which was finally declassified after 37 years. This report itself was the result of several years of intensive work at a number of different institutions on both satellite launch vehicles and their payloads. In particular, the report could not have emerged without the efforts of two of the most important men in the history of the Soviet space programme, Sergey Pavlovich Korolev and Mikhail Klavdiyevich Tikhonravov.

Part 1

Korolev and Tikhonravov

Sergey Korolev, the younger of the two had become absorbed in dreams of space exploration during his short tenure as a charter member and eventually leader of the Group for the Investigation of Reactive Engines and Reactive Flight (GIRD) in the early 1930s [1]. It was at GIRD that the second individual, Mikhail Tikhonravov designed the very first Soviet liquid-propellant rocket, the '09.'

By late 1933, this section of the amateur GIRD had been dissolved and subsumed under a larger state-controlled organisation named the Reactive Propulsion Scientific Research Institute (RNII) which through the 1930s focused on research on winged rockets, solid-propellant missiles, and the development of liquid propellant engines [2].

The significant work at the RNII (later called the NII-3) was dramatically interrupted in 1937-38 by a number of arrests and executions during the so-called Great Purges. While Korolev served a long prison term, Tikhonravov remained behind at a reorganised NII-3 through World War II. Their paths met up again at the end of the war when Korolev was appointed the Chief Designer of Department 3 of the Specialised Design Bureau at the Scientific Research Institute No. 88 (NII-88) [3].

The NII-88 (pronounced 'nee-88') was established at the time to serve as the leading engineering organisation in Soviet industry to develop long-range missiles, and Korolev, having paid a terrible price during the Purges found himself as the technical head of that effort.

During the following decade, his department, which eventually became an independent organisation, the Experimental Design Bureau No. 1 (OKB-1), focused efforts on a series of ballistic missiles such as the R-1, the R-2, the R-3, the R-5 and finally the intercontinental R-7. Since the primary thematic thrust of Korolev's group was military missiles, there was negligible work on purely scientific projects which had no military utility. Dedicated wholly to the grand ideals of space exploration, Korolev made a few spurious efforts to interest the leadership in artificial satellites in the late 1940s, but none of these ever proved to have any results until he combined his lobbying with Tikhonravov's independent work.

Research on Launch Vehicles

Concrete research work on satellites and piloted space ships was undertaken not at Korolev's NII-88, but in an unrelated organisation, the Scientific Research Institute No. 4 (NII-4), which itself was under the jurisdiction of the newly-formed USSR Academy of Artillery Sciences. Tikhonravov had been transferred to the institute in late 1946 as part of an organisational restructuring after a failed attempt to propose a project to loft humans on 'vertical' trajectories on modified German A-4 missiles [4].

After the demise of that effort, Tikhonravov was moved to the 1st Sector at the NII-4 as one of the institute's Deputy Directors. The mandate for the NII-4 was completely military: it was established in June 1946 to investigate and ascertain "the development of methods of testing, acceptance, storage and combat application of missile weaponry" [5].

Known secretly as the "unit 25840," and located at Bolshevo near Moscow, the first Director of the institute was Lt.-Gen. Aleksey I. Nesterenko, one of the many veterans of the war-time Katyusha rocket operations who inherited major positions in the ballistic mis-

sile programme following the end of the war. The military were, however, not averse to exploring exotic applications of missiles. In fact, Tikhonravov's move to a new sector of the NII-4 in 1947 precipitated a major first for the Soviet rocketry programme: serious investigations into the possibility of designing very powerful ballistic missiles which could be used to potentially launch artificial satellites.

In the same year he established a small group under Pavel I. Ivanov at the institute to conduct research on the development of multi-stage rockets [6]. Although not specifically stated as such, the rationale for conducting the study, at least on Tikhonravov's part, was to develop a satellite launch vehicle in the near future using available Soviet technology.

The responsibility for exploring the details of various possible configurations of multi-stage long-range ballistic missiles was assigned to Vladimir A. Shtokolov and Igor M. Yatsunskiy, two young engineers in Tikhonravov's employ. Thus, in December 1947, a preliminary report was produced by the group which included analyses of several different variants of so-called 'composite' missiles, in which stages would be discarded following depletion of propellant, lightening the overall mass of the booster and consequently increasing velocity [7]. Two specific types were examined: clusters with stages attached in parallel, and tandems with stages connected serially [8].

In the following months, Shtokolov and Yatsunskiy carried out hundreds of calculations which began to show the advantages of the cluster scheme, which by this time was given the name 'packets' by Tikhonravov. In their work, the two engineers examined a broad range of topics, including the means to link up the various rockets in parallel, possible ways to separate the strap-ons, and also the ballistics of the active part of the trajectory. In their formal documentation, no mention was made of a satellite launch vehicle, although the work was clearly aimed at achieving orbital velocity.

Tikhonravov's engineers were, in fact, not the only individuals at the NII-4 involved in space-related themes. Institute Deputy Director for science Maj.-Gen. Yakov B. Shor was at the same time focusing on work on a traditional successively-staged missile, while institute Director Maj.-Gen. Nesterenko, Nikolay G. Chernyshov, and others were also participants in "discussions" on space themes [9].

In early 1948, despite the fact that the results of the study on packets were still somewhat preliminary, Tikhonravov orally presented a summary of the investigations to the Scientific and Technical Council of the institute [10]. Reception was divided on his proposal for a missile capable of reaching the upper reaches of the atmosphere while travelling at four times the speed of any current missile. This resistance did not deter Tikhonravov and he decided to present a formal paper, now titled "Paths to Accomplishing Great Ranges by Firing Missiles," at the annual meeting of the Academy of Artillery Sciences, the overseeing authority over the NII-4.

Despite Nesterenko's apparent support, Academy President Anatoliy A. Blagonravov was not easily convinced of the propitiousness of allowing presentation of the paper. Fully aware of Tikhonravov's ideas of a satellite launch vehicle, Blagonravov told Tikhonravov that, "The topic is interesting. But we cannot include your report. Nobody would understand why...They would accuse us of getting involved in things we do not need to get involved in..." [11]. Tikhonravov was not easily discouraged and argued convincingly for the presentation at a follow-up meeting with Blagonravov the very next day. This time the Academy President agreed to the request, warning Tikhonravov that, "Be prepared - we will blush together" [12].

On 14 July 1948 Tikhonravov read his report at the Academy in the presence of a large group of prominent dignitaries from the military [13]. Apart from Blagonravov and Nesterenko, Chief Designer Korolev was also present, on a visit from the NII-88. The audience listened to Tikhonravov's speech "with tremendous attention" as he argued persuasively that the design of rockets capable of reaching very high altitudes and velocities was technologically feasible. Not surprisingly the reaction of most of the audience was negative. One high ranking military official reportedly said, "The institute must not have much to do since they've decided to switch to the realm of fantasy!" [14].

Korolev was one of the very few who reacted positively, telling Tikhonravov after his presentation that, "We have some serious things to talk about..." [15]. For Korolev it was a small opening for his own nascent dreams of space exploration. As plans for new longer range missiles to follow the R-2 were beginning to emerge at the NII-88, Tikhonravov's bold report clearly served as a catalyst for combining the disparate efforts at the two different institutions.

The political climate, and especially the fear of the secret police in the late Stalin era no doubt also played a major role in any decision on the part of either Tikhonravov or Korolev. Given the job of creating a long-range military missiles for the Soviet armed forces, Korolev was not about to jeopardise his job and perhaps even his life by making hasty diversions into what the secret police no doubt considered a pointless endeavour.

In Tikhonravov's case, his work on packet-based long-range rockets was continued into the following year only to face near cancellation. For reasons still unclear, the leadership of the NII-4 disbanded Ivanov's subdivision in early 1949. Put into a difficult position, Tikhonravov entrusted one member of his team, Yatsunskiy to persevere with this theme [16]. The latter by this time was employed in a different sector of the institute, and work on Tikhonravov's coveted launch vehicle was consequently slowed down significantly.

Setbacks

The slowdown of work at the NII-4 on space launch vehicles did not deter the search for fruitful results. By mid-1949, Yatsunskiy finished a series of calculations determining the relative mass of a three-stage rocket optimised with the specific goal of achieving orbital velocity [17].

Upon seeing the computations, Tikhonravov requested that Yatsunskiy apply his work specifically to the missiles being developed currently at the NII-88 under Korolev, in particular the still-to-be built R-3 missile. The R-3 programme, approved in 1949, was the most ambitious ballistic missile project in the Soviet Union at the time. With a slated range of 3,000 km, its performance characteristics were intended to be at least 10 times more than those of the old R-1, itself a copy of the famous German A-4 (or V-2) rocket. A 20-volume report on the missile was issued in December 1949 following which dedicated work began at the NII-88 under Korolev's overall command [18].

To coordinate the work more efficiently, Tikhonravov invited Korolev to meet him at the NII-4 premises at Bolshevo in July of 1949. The Chief Designer was clearly impressed with Yatsunskiy's work, which foresaw the use of three R-3 missiles attached in parallel, and designated a 'packet,' by Tikhonravov [19]. Not afraid of the repercussions of promoting 'fantasies,' Korolev encouraged Tikhonravov to prepare a formal report addressing the issue of launching a satellite at the next session of the Academy of Artillery Sciences.

Boosted by Korolev's support, Tikhonravov was granted his request to re-establish a group to study packet-based space launch vehicles. The original group with A.V. Brykov, Ya.I. Koltunov, G.Yu. Maksimov, and L.N. Soldatova was set up in late 1949, augmented by G.M. Moskalenko and B.S. Razumikhin in 1950, and I.K. Bazhinov and O.V. Gurko in 1951 [20]. All were recent graduates of the N.E. Bauman Moscow Higher Technical School where special advanced engineering courses on missile design, construction, and engineering had been instituted and taught by such luminaries of the Soviet ballistic missile

programme as Korolev (1947-49), Valentin P. Glushko (1947-53), Tikhonravov (1947-52), Yuriy A. Pobedonostsev and others [21]. The lectures themselves were surprisingly interconnected with actual developments in the Soviet rocketry industry. For example, Korolev's own lectures incorporated details of the R-1, R-2 and R-3 missiles, albeit with disguised designations.

The courses from this time period were instrumental in training a new generation of young engineers who would join major design bureaux and research institutes and make important contributions to the Soviet space programme. Thus, by the time that Brykov, Koltunov, Maksimov and the others joined Tikhonravov's team in 1949-51, they had a solid training in actual and proposed Soviet ballistic missiles, providing a key connection between Korolev's work at the NII-88 and Tikhonravov's efforts at the NII-4.

The work of the original members of Tikhonravov's newly established group culminated in 1950 with the authorship of what was the very first detailed Soviet exposition on the technical prospects and requirements of launching an artificial satellite of the Earth. Entitled, "On the Possibility of Achieving First Cosmic Velocity and Creating an Artificial Satellite with the Aid of a Multi-Stage Missile Using the Current Level of Technology," the paper was formally presented by Tikhonravov at a special session of the Academy of Artillery Sciences in March 1950 [22].

Along with many important military representatives, three engineers from the NII-88 were present to hear his speech: Designer Korolev, his first deputy Vasiliy P. Mishin, and planning department chief Konstantin D. Bushuyev. In an unexpected move, near the end of his monologue Tikhonravov raised the issue of launching humans into orbit in the near future using his proposed launch vehicle [23]. Although not specifically mentioned as such, the plan envisioned a possible launch within the mid-1950s given the requisite support. The reaction to this presentation was much more negative than the earlier session in 1948. Some in the audience were outwardly hostile to Tikhonravov's ideas, others silent, while many had sarcastic reactions. There was, in fact, a running joke after the conference that Tikhonravov and a monkey, in each other's embrace would fly off to the Moon [24]. Korolev was one of the few who unconditionally and publicly supported Tikhonravov's ideas.

The March 1950 report precipitated an extremely fruitful few months for Tikhonravov's group. Each participant was given a separate assignment on the development of a space launch vehicle with the goal of authoring a detailed and comprehensive study on the issue. Various configurations of clustered and tandem missiles were studied and a special mathematical model for mass analysis was devised based on first-hand information on the R-3 missile provided by Korolev's own engineers. Moskalenko subsequently authored a text Engineering Methods of Designing Missile Dynamics as a result of this work. Every possible technical area was studied, including a report by Maksimov on the ballistic trajectories of an artificial satellite launched by the booster. Advanced studies were also conducted on inter-orbital transfers and the de-orbiting, reentry, and recovery of a satellite. In designing the launch vehicle, Tikhonravov favoured a two-stage packet of three R-3s, which calculations showed would be able to insert a fairly heavy satellite into orbit. The results of all of this work were collated in a massive work consisting of three volumes which was published in late 1950 [25].

Tikhonravov's own March 1950 paper was also published in a scientific journal in 1951. Despite the voluminous amount of fruitful work, Tikhonravov's group was once again abruptly disbanded at this time [26]. Although this second setback was temporary, the termination of the launch vehicle effort appears to have been related to a number of institutional and personal factors that clearly illustrated the tenuous support for scientific endeavours in a predominantly military industry.

Almost fifty years after the event, it is still unclear as to why Tikhonravov's group was dissolved at the time. Some imply that it had to do directly with the "absurd" ideas which Tikhonravov presented to the Academy in March 1950 [27]. Others recall that it was related to a feud between Korolev and the NII-4 over a particularly important state award which was given to the NII-4 instead of Korolev's own NII-88 [28]. Marshall Mitrofan I. Nedelin, at the time the Commander-in-Chief of the Artillery Forces was also evidently extremely wary of Blagonravov's support of Tikhonravov's unpopular ideas, once even threatening Korolev himself for his "space" dreams [29]. To complicate matters further, NII-4 Director Nesterenko himself had irked Korolev's wrath by writing a letter to the Central Committee denouncing all work on long-range ballistic missiles as without a future. Given Nesterenko's important position, the letter might have had dire consequences, had it not been for the actions of Minister of Armaments Dmitriy F. Ustinov, one of Korolev's "patrons" in the government, who apparently intercepted the document [30]. The Chief Designer nor Ustinov ever forgave Nesterenko and in fact held grudges against the General until their respective deaths. In the end Nesterenko was dismissed from his post as NII-4 Director, Blagonravov was demoted to Vice-President of the Academy of Artillery Sciences and Tikhonravov himself was demoted to a 'Scientific Consultant,' a position one of his associates recalls as being like an "honorary banishment" [31].

Tikhonravov continued to work on space themes, although he no longer had an institutional forum to pursue them at higher levels. Thus, in the ensuing two years, although substantial work was carried out, the impetus which had driven the group in 1949-50 was lost due to the institutional changes. The early efforts of the group did, however, serve as an extremely important base from which Korolev's NII-88 in cooperation with other institutes began to embark on concrete work on the creation of an intercontinental ballistic missile capable of reaching orbital velocity.

In a curious departure from the pervasive security regarding high technology efforts, an article authored by Tikhonravov titled "Flight to the Moon" was published in the newspaper Pionerskaya pravda in October 1951 [32]. Prominently mentioning the works of Tsiolkovskiy, Tikhonravov adeptly describes a two-man interplanetary spaceship of the future and the industrial and technological processes required to create it. He ends the short article, written for young readers, with a clear forecast of the future, "We do not have long to wait. We can assume that the bold dream of [Tsiolkovskiy] will be realised within the next 10 to 15 years. All of you will become witnesses to this, and some of you may even be participants in as yet unprecedented journeys" [33].

In perhaps the very first reportage of Soviet space plans in the West, Tikhonravov's article appears to have caused quite a stir. It was the subject of a prominent write-up in The New York Times two days after the original publication, which explained that, "Dr. Tikhonravov left no doubt that Soviet scientific development in the field of jet propulsion and rockets was advancing rapidly. He suggested that this science in the Soviet Union had reached the level at least equalling if not exceeding that in Western countries" [34]. It was a rare peek into the shrouded world of Soviet rocketry. Although there was obviously no mention of the NII-4, the fact that Tikhonravov was allowed to write under his own name on a potentially sensitive topic indicates that the censors viewed the article as of no importance or relevance to the national security.

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Sputnik on Stamps

As was the case with Gagarin and Vostok 1 in 1961, Soviet bloc countries were quick to celebrate the launch of Sputnik in October 1957 by issuing postage stamps very smartly - a cheap and very successful way of making a political point internationally.

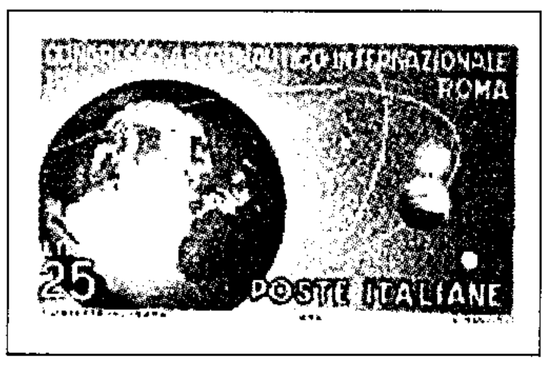
BY HARVEY DUNCAN
Falkirk, UK

ALTHOUGH THERE WERE no detailed images of Sputnik 1 on the first issues, this was not for reasons of secrecy as was to be the case with Vostok, because a Russian official gave details of what it looked like the day after the launch at an International Geophysical Year meeting in Washington.

Curiously, it was an Italian stamp (issued on 22.9.56) to mark the International Astronautics Conference in Rome that first showed the trajectory of a satellite round the Earth. Presumably this was meant to depict an American one as the West had little idea that the Russians had the capability to launch in the way they did.

Russia's first issue to mark Sputnik came on 5 November 1957, followed by Rumania (four stamps and two labels) on the 6th and East Germany on the 7th. Further Russian issues (overprinting a Tsiolkovsky commemorative, and a re-issue of the 5 November stamp in a different colour/shade of blue) occurred before the end of the year.

To date there are now over eighty stamps showing Sputnik 1 - a small thematic collection on its own!



Italy (1956).

First Russian stamp (5 November 1957).

Later re-issued in a new colour (28 December 1957).

One of two triptychs of stamps and label issued by Rumania on 6 November 1957 (shown 75% of actual size).

* * *

The assistance of Jeff Dugdale of The Astro Space Stamp Society is gratefully acknowledged.

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Part 2 of this two-part article will appear in a subsequent issue.