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Chapter 14

The Role of S. P. Korolev as a Designer of Launchers for Sputnik and Vostok*

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Introduction

When the first Earth artificial satellite, which commenced the Space Age in the history of mankind, was launched on 4 October 1957, the world was shaken. Another surprise came on 19 April 1961, when Yuri A. Gagarin made his famous spaceflight in a Vostok craft, which was placed into orbit by a Vostok three-stage booster rocket.

Those accomplishments are evaluated as outstanding scientific and technological achievements of the Soviet Union. But, at that time, very few could see all the social, economic, political, and military consequences of those events for the further course of history.

Many people still wonder how the Soviet Union, exhausted by World War II, succeeded in surpassing the U.S.A. in launching the first satellite and the first man in space. The reasons are rather numerous, but some, to my mind, principal ones are worth being discussed. The first one is connected with the then postwar international situation of the Cold War, when the U.S.S.R. was encircled by a

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chain of foreign military bases. The U.S. and its allies could destroy essential industrial, administrative, and military strategic targets by bomber raids.

In that situation, the development of an intercontinental ballistic missile (ICBM) became of vital importance for the U.S.S.R. to balance the threat. Such a missile is known to have been built in the shortest time under the management of S. P. Korolev. It was designated as R-7, and it became the groundwork of the Soviet two-stage booster-rocket for the first satellite launching, and of the Vostok three-stage space launcher for the first manned spaceflight.

Another important incentive for the then U.S.S.R. leadership, was U.S. overconfidence, since that country underestimated our ability to develop a weapon system which could strike the continental United States (CONUS) a rather violent blow. Besides, the U.S. could not expect that, by constructing ICBMs, the U.S.S.R. would gain an advantage in near-Earth space exploration and application. On the contrary, the U.S. developed its satellite launching capabilities without proper interaction with other missile technology efforts. This is proved by the fact that the National Aeronautics and Space Administration, which became responsible for coordinating the U.S. civilian space exploration and technology programs, was organized only after the first Soviet satellite launchers.

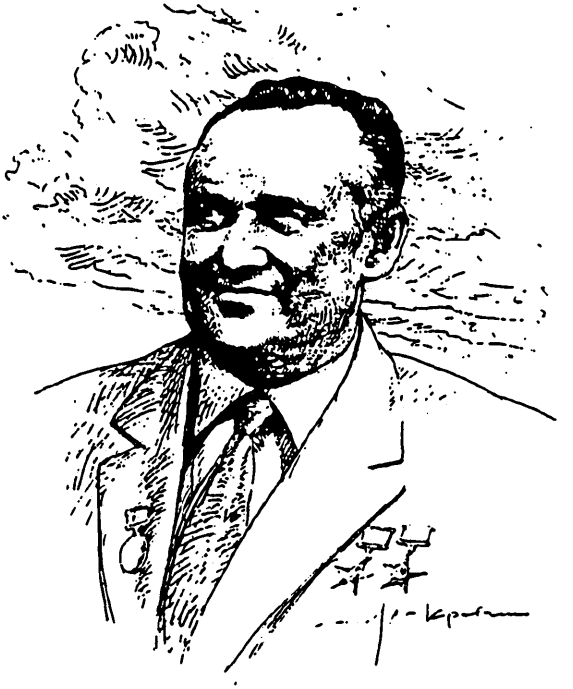

Figure 1 Sergei Pavlovitch Korolev (1906-1966), Russian spacecraft designer, who headed the Vostok and Voskhod Projects, as well as the early Zond and Kosmos series.

The R-7 ICBM Development

In the early 1950s, the U.S.S.R. commenced developing an ICBM with a payload mass of 3 tons. But, in late 1953, its performance requirements were revised, and the payload mass was increased up to the 5.6-6.0 tons that was thought sufficient to deliver a hydrogen bomb to the CONUS. That bomb had been successfully tested by that time.

Having gotten acquainted with the requirements, Korolev and his associates realized that the missile could be used to launch a 1.4 ton heavy satellite into near-Earth orbit. They started simultaneous development of the ICBM and a 968 kg heavy satellite laboratory equipped with special scientific devices for near-Earth space exploration.

Since the missile development was rather a pioneering one, it was surcharged with numerous and complex scientific and technological problems. It is obvious that the ICBM development efforts were preceded by broad theoretical and experimental studies. When new problems arose in the course of development, they were usually addressed and surmounted in a timely and parallel manner.

Korolev's design bureau, that was in charge of missile development, was also responsible for coordinating these efforts and for specifying problems and objectives to be reached. Many scientific and technological problems were solved at research institutions headed by M. V. Kheldysh, one of the most prominent Soviet scientists. He was a project scientist and took an active part in developing ICBM and spacecraft flight mechanics fundamentals.

The research results proved the feasibility of ICBM construction in the assigned span of time, and with specified performance characteristics. The most well-grounded trends of present goal achievement were also defined.

In the progress of the first ICBM development, many design and engineering achievements were attained. They were used in further efforts as a groundwork for advanced evolution of Soviet rocketry and space technology. They were as follows:

- o Development of ICBM flight mechanics fundamentals.
- o The most optimal trend definition for obtaining assigned ICBM design, energy, and aerodynamic characteristics as a basis for the construction of missiles.
- o Research on various model power plants based on liquid rocket engines with different propellants.

- o Research definition and development of design and construction procedures in connection with liquid propellant heavy lift rocket flight and attitude control at a powered phase.
- o Theoretical and experimental studies in hypersonic aerogasdynamics, heat and mass transfer, thermal physics and materials in connection with developing ICBM warheads and spacecraft reentry capsules.
- o Methodology elaboration for large rocket complexes, with amendment through ground and flight tests to attain designed performance characteristics.
- o Construction of experimental bases, test-beds, launch ranges, and flight control and tracking facilities.

When the R-7 ICBM tests became successful, it became clear that some equipment for the heavy satellite would not be delivered in time. Besides, the U.S. was well into a widely publicized Vanguard program, designed to launch a near-Earth satellite during the International Geophysical Year. At that time, Korolev suggested launching an elementary satellite (Proateishyi Sputnik, or PS) in the course of that missile flight test. The idea was endorsed.

The first R-7 ICBM test launch took place on 6 May 1957, and the fourth one was performed on 22 August 1957, the latter being an entirely successful flight test. It is well known that the 83.6 kg Sputnik was launched on 4 October 1957. It was designated as PS-1. The launch was the fifth R-7 test flight. The space race began. The U.S.S.R. launched the second satellite on 3 November 1957, its mass being 508.3 kg. It was designated as PS-2 and carried a dog aboard. Then, at last, the above-mentioned heavy satellite-laboratory was put into orbit on 15 May 1958. The U.S. answer was a launch of its satellite by an advanced Jupiter-C rocket in January 1958.

Vostok Space Launcher Development

The upper limits of the lifting capacity of the R-7 ICBM two-stage launcher to near-Earth orbit were reached with the launching of the third Soviet satellite. By that time, an outer space exploration and application program had been worked out. It was aimed at an expeditious increase of orbital assets and their launch mass. Under Korolev's management, a three-stage space launcher was developed. It was based on the R-7 ICBM and fitted with a new "E"-rocket section for the third stage. Later on, the launcher was called 'Vostok,' since it put a Vostok manned spacecraft into orbit on 12 April 1961.

A team, headed by Korolev and Cosberg, expeditiously designed and constructed a new liquid oxygen-kerosene engine for that section. It was an opencycle rocket motor with turbine exhausted gas expulsion. It was designated as RO-7. Its thrust was 50 kN, its specific impulse 3,160 m/sec: it had a mass-to-thrust ratio of 0.02 kgm/kgf. It was the first national engine of that type. It started up in flight at so-called hot separation of the third stage with the "E"-rocket section and the R-7 ICBM central section. The engine pump turbine was driven by a gas generator which used the main propellant components. The "E"-section oxidizer tank was pressurized with gaseous oxygen fed from a separate pressurization generator. The full tank was pressurized with turbine exhausted cooled gas from a separate gas generator.

A special system of gas distributing valves, gas feeders and steering jet nozzles, operating on turbine exhausted gas, was used, for the first time, to control the third stage flight. The controls design enabled the engine specific impulse in vacuum to be increased. The combustion chamber and turbopump unit arrangement was also unique. The latter was installed near the nozzle throat. Such a positioning enabled the engine and "E"-section mass and dimensions to be reduced.

In the process of engine development, theoretical and methodological background was worked out, and experimental assets were constructed for altitude tests of liquid propellant engines and controls of upper stages that burned in high vacuum. To install an "E"-rocket section, a spacecraft, and a nose fairing on the R-7 ICBM central body, it was necessary to reinforce its upper part. To deflect the exhausted plume of the "E"-section engine at its start-up, a special shield and an interstage truss section were fixed to the central body upper tank.

To improve reliability in performing a spacecraft orbit injection by means of the Vostok space launcher, it was necessary to introduce some advances. For instance, because of the third stage with the "E"-section installation on the R-7 central body, the ground launch complex was significantly modified. Several additional systems were developed and brought in to make ground prelaunch operations, countdown, and launch of the Vostok manned spacecraft smooth.

The Vostok space launcher enabled a near-Earth orbit payload to be increased from 1.4 to 4.7 tons, and a 0.3 ton unmanned space probe to be propelled to the Moon at the planet escape (or parabolic) velocity. The achievements are thought to be a qualitative leap in rocketry and space technology. They paved the way for the launching of successive manned spacecraft and lunar probes. It is worth noting that, before Gagarin's first space flight, the Vostok space launcher was used to put heavy unmanned near-Earth satellites in orbit, and to deliver automatic probes to the Moon.

Conclusion

The prominent scientific discoveries made by K. E. Tsiolkovski, R. H. Goddard, H. Oberth, and other space science and technology pioneers were important. Unfortunately, those ideas in rocketry were used to construct destructive weapons, which were employed in late World War II for the first time. In the post-war period, many new missile systems were developed, the R-7 included. They were thought to ensure military parity and peaceful coexistence. It is to Korolev's credit, that he used a combat rocket to develop Sputnik and Vostok space launchers.

Modern rocketry, space technology, and astronautical achievements cleared the way for their application to solve numerous problems facing our generation on energetics, resources, ecology, food supply and other spheres. To do so, they should be exclusively used for the cause of peace and progress. It is high time for all of the world's scientific community to appeal to mankind for the peaceful application of rocketry and space technology.

Figure 2 Yuri A. Gagarin (1934-1968).