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Chapter 5

THE CONTRIBUTIONS OF K. E. TSIOLKOVSKY AND OTHER NATIVE SCIENTISTS TO THE TECHNOLOGY OF ROCKET LAUNCHING*

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Five characteristic periods can be distinguished in the development of rocket launching techniques: (1) The period using the simplest launching apparatuses and devices (late 14th and early 15th centuries through the 1860s); (2) Development of mobile or "active" launchers (1820s - early 20th century); (3) Development of the theoretical prerequisites for the creation of launching systems for carrier rockets, and advances in multiple launcher designs (1900-1940s); (4) Designing of platform type launchers (1940s to the early 1960s); (5) Advent of the hardstand launching installations with launching gantries for carrier rockets and related space-launch complexes (from 1950s through the present).

The Russian and Soviet scientists and design engineers have made a substantial contribution to the art during all of these periods except for the second one. This paper is concerned with the contributions of these scientists and engineers made during the first, third and fifth periods.

THE PERIOD OF USING THE SIMPLEST LAUNCHING APPARATUSES AND DEVICES

The first stage of rocket development can be traced to the Gottingen manuscript (c.1405), which provides the first reliable evidence on a rocket firing and take off frame [18; 4, pp. 6-7, 14]. An order from the fortress at Brest to the Petersburg Arsenal in 1732 provides the first evidence of use of rockets and launching apparatuses in Russia [I7]. However, native experts possessed the knowledge of rocketry and employed rockets in the current territory of the Soviet Union by the beginning of the 16th century [5]. In the early 18th century, information on captured foreign take off frames can be found in Russian publications [22].

Russian knowledge of rocket launching techniques was very similar to other countries. It is worth noting that the apparatuses and techniques used in Russia in

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the 17th century for firing fireworks and flare rockets were practically the same as those utilized in other countries at that time.

The military application of rockets substantially advanced in Russia and throughout Europe in the early 19th century. In 1810, the Science Committee's Artillery Section studied the use of military rockets. In 1813, the committee issued a brief Manual to the Russian Army on the fabrication and employment of military rockets and take-off frames [6, p.94]. It is argued that the Russians were the first to deploy military rockets in the 19th century during the siege of Danzig [6, p.108]. However, these claims do not establish whether these were Russian made or foreign rockets.

From the beginning of the 19th century, the problems associated with rocket launching were studied closely in Russia. Russian engineers correctly concluded that for a rocket to be an efficient weapon depended on perfecting the rocket. Among the first Russian engineers that studied military rocket technique were I. Kartmazov, who manufactured two types of rockets in 1814, and A. D. Zasyadko, who tested several calibers of rockets from 1815 to 1817.

The Russian engineer K. A. Shilder made a most significant contribution to the advance of rocket launching technique. Shilder was the first to suggest launching rockets from a submerged submarine and successfully launched underwater rockets in 1834 [I6, p. 197].

In the later part of the 19th century, K. I. Konstantinov, F. V. Pestich, N. N. Bogoslovsky, A. Lazarev *et al.* designed a number of successful rocket firing apparatuses. They developed field, mountain and naval mounts for firing military rockets of various calibers, as well as signal rocket projectors, which were state of the art at the time.

DEVELOPMENT OF THEORETICAL PREREQUISITES FOR THE CREATION OF THE LAUNCHING SYSTEMS FOR CARRIER ROCKETS AND ADVANCES IN MULTIPLE LAUNCHERS

K. E. Tsiolkovsky's publication, "Exploration of the Extraterrestrial Space with Reactive Apparatuses," in 1903 shaped the theory of launch systems and multiple launchers. The paper addressed the feasibility of space travel with the aid of liquid propellant rockets. Tsiolkovsky also dealt with the difficulties of launching technique; maintaining a spaceship's acceleration within specified limits; the inadmissibility of a marked increase in the velocity of flight in the lower atmosphere and possible flight paths [8, pp. 51-52. 7I]. This enabled one to assume that Tsiolkovsky contemplated the possibility of launching a space rocket. Tsiolkovsky elaborated on these concepts in a paper in 1911-1912, and he detailed the advantages of launching rockets from the equator and high mountains because of the diurnal rotation of the Earth [9, No. 2, pp.2-3]. The solutions formulated by Tsiolkovsky's scientific approach addressed the difficulties of space flight for the first time. A number of his recommendations have become standard practice. For this reason we can assume that the scientific substantiation of a space rocket launching technique first started with Tsiolkovsky's papers. Thus, one can see that Tsiolkovsky's early papers focused

on the problems associated with rocket launching. This fact enables one to consider Tsiolkovsky as one of the founders of the techniques required to launch space rockets.

A. G. Polevoy's 1913 design of take-off settings should be considered part of the Russian contribution to the advance of space rocket launching techniques. Polevoy's design placed a space rocket into a container which provided protection during launch. The rocket was boosted to the required velocity with the aid of an electric projector. The space rocket was then jettisoned from the container to continue its space voyage [10].

In addition to K. E. Tsiolkovsky and A. G. Polevoy's accomplishments, A. F. Zander and Yu. V. Kondratyuk made considerable contributions to rocket launching methods. In 1924, A. F. Zander proposed utilizing an airplane as a launch platform to carry the rocket into the upper atmosphere. Zander even designed such a platform [20].

In 1919, Yu. V. Kondratyuk studied the use of an electromagnetic gun to influence space flight [21, p. 534]. He proposed a design of some assemblies that lowered the loads exerted on a spacecraft. Throughout Kondratyuk's career, he paid considerable attention to the need to employ launching devices such as artillery [21, pp. 661-662]. He advanced the idea of two separate launch systems: one using a highly reliable rocket for launching astronauts; the other, a less complex system of lower cost and reliability to launch cargoes [1]. Kondratyuk's concept was carefully studied by engineers in the early 1950s. Kondratyuk's ideas are used to a lesser degree today in the U.S.S.R. with the advent of the cargo vehicles of the "Progress" type and the "Soyuz" man/cargo system. Despite the fact that both the "Progress" and "Soyuz" systems are liquid propellant rockets, further advances in astronautics may lead to implementation of Kondratyuk's theories.

In addition to the theoretical investigations in the 1930s, Soviet engineers successfully designed and launched several land-based, liquid-propellant, prototype rockets. The first successful Soviet launch took place in 1933. This success resulted in a certain amount of experience and expertise of value to the U.S.S.R.

During these early years, Soviet engineers directed considerable attention to the problems associated with gunpowder rockets. In 1909-1910, N. A. Sytenko designed a system of rockets and launching ramps to combat airborne targets. In 1912, I. V. Volovsky designed a truck mounted multiple launcher as well as a conceptual design for firing rockets from aircraft [2, p.174].

Soviet scientists and design engineers (I. I. Gvai, V. N. Galkovsky, A. P. Pavlenko, A. S. Popov *et al.*) at the Scientific Research Institute for Jet Propulsion between 1937 and 1941, and the Special Design Bureau at the "Compressor" Plant (V. P. Barmin, Yu. E. Endeka, V. A. Timofeev, A. N. Vasiliev, V. M. Vasiliev, A. N. Glyuske *et. al.*), between 1941-1945 made considerable contributions in the development and launching techniques required for solid propellant, unguided rockets [15]. Soviet engineers were the first to solve the complex problems associated with launch systems for naval and field applications. These designs met all of

the requirements of the missile art. Soviet success and experience in solid rockets and launch systems provided the impetus for other nations to study their potential.

CREATION OF THE CARRIER ROCKET LAUNCHING GANTRIES AND SPACE LAUNCH COMPLEXES

The development of launching gantries and fixed space launch complexes began in the mid 1950s. Soviet scientists and design engineers developed these facilities for the "Sputnik" program, the first artificial satellite.

The Soviet scientists and design engineers created these facilities for the new class of the so-called carrier rockets; in so doing, they solved a number of inter-related scientific and engineering problems. The well known Vostok carrier rocket featured substantial improvements in its structure and design. This rocket was a considerable advance in the practice of the world's rocketry. Launching these new rockets created new difficulties in the launch process. The difficulties associated with launching a rocket with the several ton mass of the Vostok carrier rockets had not been solved [3]. The Vostok configuration added problems to the launch. The first stage liquid propellant motors were equipped with support members that rested on the launch support table. Another problem that had to be overcome was that the Vostok did not have an "even" diameter like the rockets that preceded it. Because of this feature, the Vostok had no support members at the top to adequately support the rocket on a platform launcher, thus eliminating all previous experience employing a table launcher.

Because of the Vostok's new configuration, Soviet design engineers found themselves facing problems in designing a new launch platform. To launch a carrier rocket of such a configuration, engineers had to design a platform that carried the mass of the Vostok without detriment to the flight performance of the rocket. It should be noted here, as mentioned previously [14], by the early 1950s there were several recommended methods to pump the liquid propellants into rockets. However, these recommendations were of a general nature and also failed to be of specific assistance in developing the launch techniques required for the Vostok system.

Analysis of the possible launch arrangements for the Vostok carrier rocket made in the 1950s demonstrated that the optimum setup must account for launching the rocket in the vertical plain utilizing a field launcher. Engineers had to design a reliable and uncomplicated launch facility and system that would hold the rocket in the vertical position and would not inhibit the take-off motion of the rocket. Several design solutions followed. The system adopted suspended the rocket from its reinforcement assemblies at the central unit with the aid of four retractable load-bearing support girders. Many years of successful operation have proven the logic of this solution. The launch system for the Vostok carrier rocket was an appreciable contribution to the development of astronautics.

Another important achievement by the Soviet engineers was the development and practical realization in 1957 of the launch preparation procedures for the Vostok carrier rocket. Proceeding from the expertise already gained in the field of rocket launching, Soviet scientists and design engineers suggested optimum (in

terms of time) launch preparation procedures for the Vostok carrier rocket. These procedures included a check of the individual stages of the rocket and assembling them in a stack to form an integral whole—these steps carried out within a special purpose assembly room (MCR). Next, the rocket was transported in a horizontal position from the MCR to the launch pad, and, finally, the carrier rocket was erected in the vertical position on the pad with the vehicle checked and fueled.

Successful employment of these launch preparation procedures for the Vostok carrier rocket over several decades in the U.S.S.R. has demonstrated that this technique completely satisfied the requirements imposed for launch on the part of the space scientists and engineers.

In the design of the launch facilities for the carrier rockets such as Vostok, Soyuz, Molnya, Proton and Cosmos, Soviet scientists and engineers were the first to solve several unique engineering problems in the field of rocket launching technique: accurately filling the launch vehicle with large amounts of propellants and compressed gases; ease of transportation and erection of the rockets in the vertical position; safely deflecting the high velocity and high temperature gas jet; the ease of escape by gantry tower operators in case of emergency; and the establishment of launch "windows" [12, p. 404].

Space launch complexes such as Baikonur, Kapustin Yar and Plessetsk have successfully operated for many years in the U.S.S.R. These complexes have, in large measure, accounted the the progress made in the Soviet Union in mastering outer space [3, pp. 65-71; 13, pp. 38-41]. No doubt further developments in astronautics will be marked by new achievements of Soviet scientists and engineers in solving the complex problems associated with space rocket launching techniques.

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