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Chapter 17

A Little-Known Project of a Super-Heavy Space Rocket*

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Introduction

Having realized long-endurance manned near-Earth missions on multi-seat spacecraft involving cosmonauts stepping off the ship into space, optimization of spaceships maneuvering and rendezvous and docking in orbit, cosmonautics was already able to set further tasks to introduce a lunar mission and spaceships towards planets of the solar system and outside its frontiers.

However, the most powerful vehicles at that time, the Vostok and Atlas, had insufficient performance capabilities to realize the above mentioned tasks. Thus, in the 1960s, the U.S. and U.S.S.R. commenced to design more powerful rockets.

Three rocket design bureaus in the U.S.S.R. submitted their projects on space launch vehicles of the heavy class. Yuzhnoye's project included several unique design solutions and foresaw the creation of a launch vehicle that would be able to realize tasks of both adjacent and far-out space within the next decades at low costs and maximum reliability.

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Project Purpose

Lunar mission activities were commenced in the Soviet Union in the 1960s. OKB-1, with their N-1 launch vehicle project, OKB-52 with their UR-500 and UR-700 rockets, and OKB-586 with R-56, assisted in this program. Accounts on the R-56 launch vehicle and its predecessors, RK-100 and R-46, were presented in earlier IAF papers: IAA-95-IAA.2.2.09, presented at the 46th International Astronautical Congress;[1] and IAA-98-IAA.2.1.05, presented at the 49th Congress.

The R-56 (8K68) rocket was designed originally as a military missile with a tandem stage arrangement, and it was offered as a multi-purpose space launch vehicle that could be able to ensure manned circumlunar flight, lunar-landing missions of an automatic probe having its mass about three tons. A two or three strap-on cluster configuration was capable to introduce a manned lunar landing mission.

Launch vehicle performance capability was estimated proceeding from the probable creation of a global information communications system, lunar research efforts, and deep space exploration with the help of automatic probes. This rocket system was intended for the solution of tasks that required regular LV missions. The R-56 LV had to inject spaceships to the following orbits:

- Circular polar orbit - 40 tons to 200 km altitude;
- GEO - six tons;
- Near-Moon orbit - 12 tons;
- Towards Mars and Venus – six to eight tons;
- The following criteria were taken for design estimations
  * Minimal cost;
  * Maximum reliability;
  * Creation of systems within the shortest period of time.

Much attention was given to the selection of principal configurations and structural arrangements. Through the study of various configurations, arrangements were carried out by KB Yuzhnoye in collaboration with the primary contractors and branch institutes NII-88, NITI-40, GSPI, MOD of the U.S.S.R., and the U.S.S.R. Academy of Sciences. They showed that the tandem two-stage rocket met the major requirements in full. Such a configuration was the most promising, also in view of the establishment of production facilities for the creation of more powerful vehicles including those ones using other kinds of energy sources providing interplanetary manned missions. The following configurations were examined:

1. Cluster of four boosters, 3,800 mm in diameter each (maximum permissible diameter in view of railway transportation without any traffic restrictions).
2. Cluster of seven boosters, 3,000 mm in diameter each (maximum diameter to have been mastered by production technology).
3. Tandem stage arrangement; the diameter of the body was equal to 6,500 mm proceeding from a condition to transport a totally assembled launch vehicle from the plant by waterway.

It was decided to install engines of 150 tons thrust (ground-level value) designed by OKB-456. Notwithstanding the necessity to rebuild primary production facilities and verify transportation methods using inconvenient vehicles, the study was performed in collaboration with specialized organizations, including building ones, and showed the advantage of tandem stage arrangement with all parameters. The minimal cost of tandem stages was substantiated by the following factors:

- Minimal labor intensity applied to manufacture and integration procedures;
- Use of design and technical solutions developed for the rockets R-16 and R-36;
- Introduction of a dynamic diagram, theoretically developed and approved;
- Considerably less scope or research and tests;
- Less cost of the launching complex.

Adopted solutions allowed the development of a project of a powerful multipurpose launch vehicle.

Design Features

The launch vehicle is a rocket of tandem two-stage arrangement (Figure 1). Two additional stages are installed atop the LV: an orbital stage equipped with a single-start engine, and a space stage with a restartable rocket engine. A hypergolic bi-propellant was chosen. The space stage was to use hydrazine-50.

With the purpose of decreasing weight and reducing the dimensions of the rocket, the second stage propellant tanks were combined in the form of a single propellant section.

The orbital and second stage propellant sections and engines were protected by a shield-vacuum insulation, which ensured a pre-assigned thermal environment for the propellants under effect in outer space.

The spacecraft was installed with an adapter and covered with a nose fairing. An LV self-contained control system was designed by OKB-692 and NII-944. It had to ensure the completion of a mission under conditions of any first stage engine failure and launch by any azimuth from a fixed (non-rotatable) launcher. The first stage propulsion system consisted of 12 main and four control engines swinging in a pitching plane. The second stage was equipped with a main single-chamber engine (altitude version of the first stage engine) and a four-chamber control engine. The propulsion system of the orbital stage consists of a single-chamber main engine and four-chamber control engine, both restartable under zero-g conditions.

The first/second stage separations were fulfilled by means of retro engines. The first stage oxidizer tank was pressurized with the air dynamic pressure and further additional pressurization was fulfilled following the 107s in the mission by fuel injection inside the tank. The first stage fuel, second and orbital stage tanks were pressurized with the help of special gas generators. A compressed gas bottle system was used for pressurization of space stage tanks. All the stages had a system of simultaneous propellant components discharge from the propellant tanks.

To save space objects in case of emergency on the launch pad and during the first stage powered flight, the launch vehicle was equipped with a recovery system consisting of a solid fuel motor and parachute system.

The launch vehicle's main performance characteristics are given in the table below.

Table 1

Parameter	**1st Stage**	**2nd Stage**	**Orbital Stage**	**Space Stage**
Launch Weight, Tons	1,421	259	46	15
Propellant Weight, Tons	1,000	200	30	8.7
Propulsion System Thrust, Tons	148*16	172+30	50+5.5	12
Specific Impulse (In Vacuum), Seconds	316	325	327	350
Pre-Launch Procedure, Minutes 80				

A comprehensive study showed that the R-56 LV, in view of its characteristics and performance capability, was an optimal rocket to solve the tasks of space missions within a period of up to fifteen years.

Operational Features

A vehicle completely assembled at the manufacturer's plant was transported to the launch site that included:

- Two launchers;
- A service tower (common for both launchers);
- Propellant loading and compressed gases charging systems;
- Command post;
- LV storage;
- Spacecraft processing facility;
- Administrative and service building.

The pre-launch procedure was carried out with the help of the service tower. The assigned temperature was maintained inside the tower continuously. Service platforms were mounted inside the tower and communication links ("ground to LV") went along its internal wall. Free spaces in the structure included room for the accommodation of checkout hardware. The service tower was moved from one launcher to the other by two standard gauge railways, one of which was connected with a branch-line.

The launcher was in a partially buried structure. The engine's exhaust expelled with the help of a chute gas duct. The block house with launching equipment was situated under the launcher.

The LV propellant loading was fulfilled with the help of a pump system. Filling/charging lines, control system and power supply wires/cables were run via channels which interconnected to the Command Post with launcher and propellant storage facilities.

The launch was scheduled to perform from existing launch sites at Kapustin Yar, Baikonur, and Plesetsk. Kapustin Yar had a preference in view of its easier transportation.

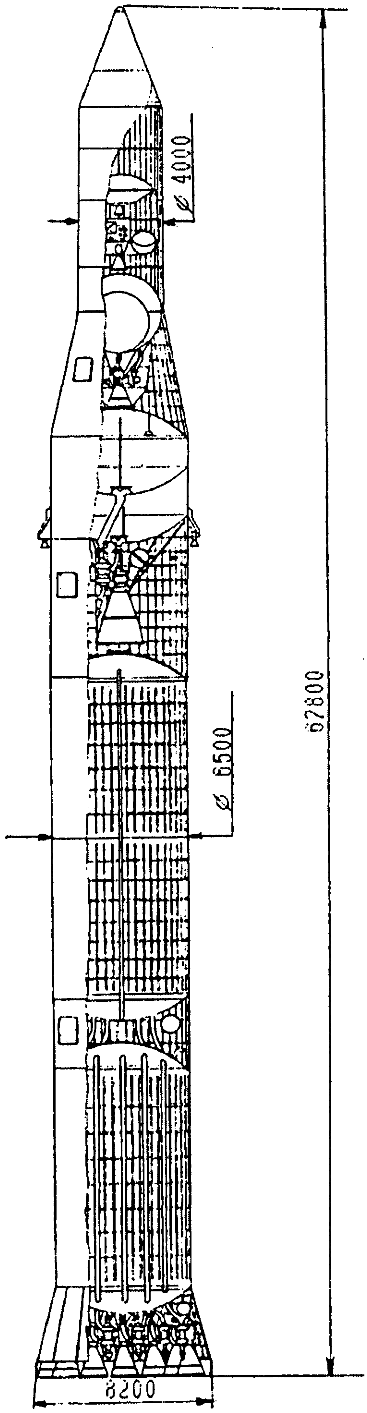

Figure 1: Drawing, super-heavy R-56 launch vehicle (Courtesy of S. N. Konyukhov).

It was supposed to deliver the launch vehicle to the launch site aboard a modified ST-600 self-propelled barge. Truck road vehicles were used for LV transportation from the manufacturer to the point of loading on the barge and from the waterway terminal to the launch site.

Transportation to Kapustin Yar was possible to be carried out via the Dnepr, Black and Azov Seas, Volga-Don channel, and the Volga. Volgograd was the final point. Then, a truck had to he used. The total route length was equal 2,030 km. (including 30 km by ground).

Transportation to Baikonur could be fulfilled by the same way until the Volga, then downstream on the Volga to the Caspian Sea and upstream the Ural until the town of Inderborsky where the LV could be re-loaded on to trucks. The total way would be 4,270 km (including 1,200 km by ground).

The route to Plesetsk (6,200 km including 100 km by ground) was similar to the above initial path, then upstream on the Volga to the Rybinsk water storage basin, upstream on the Sukhona and Severnaua Dvina until the Siya settlement, then by trucks to the launch site.

When the submitted conceptual design was studied, further development of the R-56 system was terminated because of the Government order to create the N-1 and UR-500 launch vehicles, which was issued far from economical and technical reasons.

References

[1] Konyukhov, S. N. and Pashchenko, V. A., "The History of Space Launch Vehicle Development," in Donald C. Elder and Christophe Rothmund, eds., *History of Rocketry and Astronautics*, Proceedings of the Twenty-Eighth and Twenty-Ninth History Symposia of the International Academy of Astronautics (Volume 23, *AAS History Series*) (Univelt, Inc.: San Diego, 2001), pp. 451-458 (paper IAA-95-IAA.2.2.09 originally presented at the 29th History Symposium of the IAA, Oslo, Norway, 1995).