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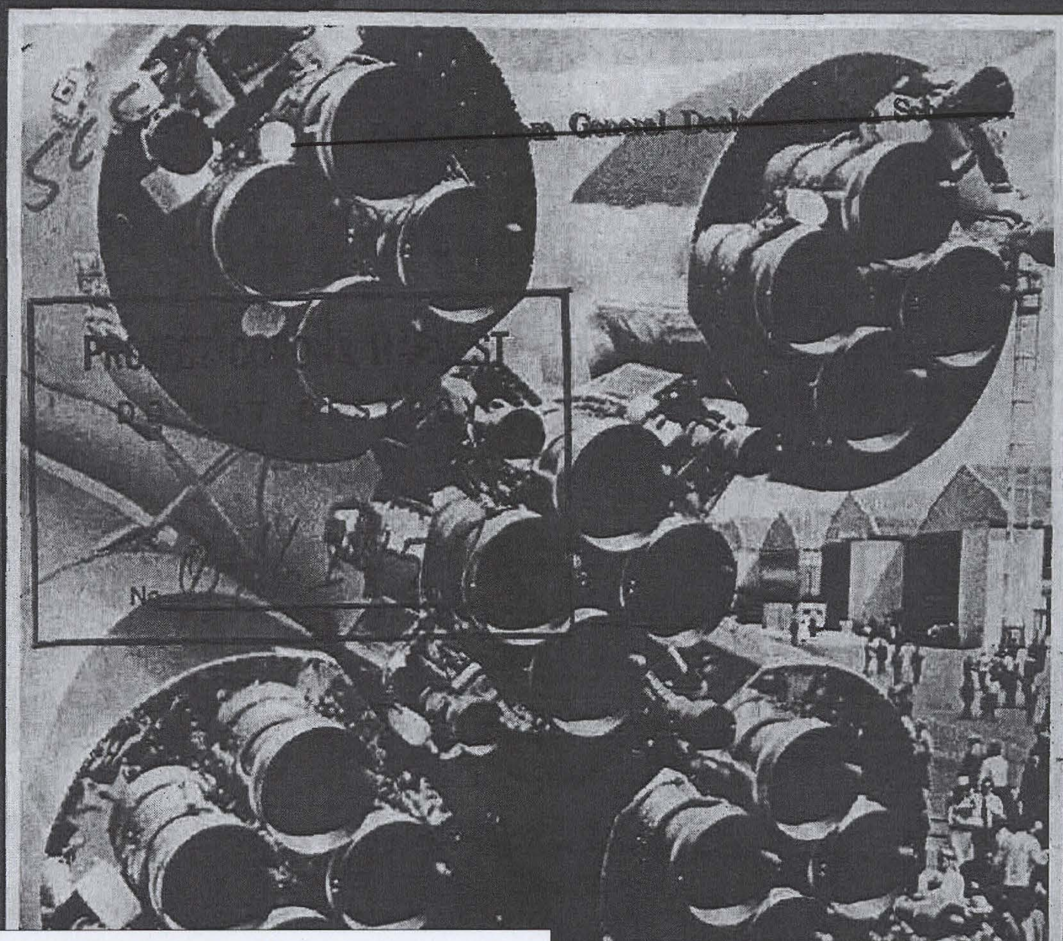

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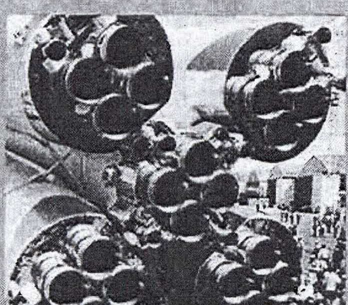

BOOSTER nozzles on Soviet SL-3 launch vehicle. For details, see article beginning on page 8. [U]

FOREWORD

MISSION: The mission of the monthly *Defense Intelligence Digest* is to provide all components of the Department of Defense and other United States agencies with timely intelligence of wide professional interest on significant developments and trends in the military capabilities and vulnerabilities of foreign nations. Emphasis is placed primarily on nations and forces within the Communist World.

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Joseph F. Carroll

JOSEPH F. CARROLL
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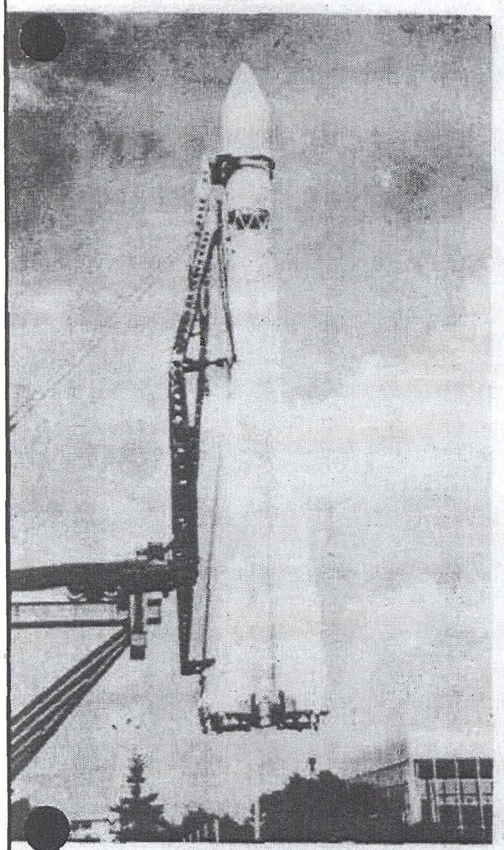

THE SL-3 LAUNCH VEHICLE: A MAJOR SOVIET ACHIEVEMENT

SOVIET displays of the Vostok launch vehicle at the Paris Air Show and at the new permanent space exhibit in Moscow were the first open showings of the workhorse of the Soviet space program. This vehicle, designated SL-3 by the West, has been used in more than 160 space launches with a reliability factor based on launch successes of better than 90 percent. It was used extensively in the direct-ascent lunar program and since that program ended in 1960, the SL-3 has been used in numerous other space activities. For example, it has been used principally to launch 10,000-pound-class recoverable earth satellite vehicles (ESV), including the manned Vostoks, Electron series, and meteorological satellites.

In addition, many different vehicle configurations evolved from the basic unit. In 1960 a new upper stage called Venik was introduced. It was first used with an "interplanetary" fourth stage to launch the early Soviet Venus and Mars probes. This four-stage launch system is designated SL-6. From 1963, the three-stage SL-4 launch system, with Venik as the third stage, has been used for near-earth orbit payloads in the 15,000-pound class, including the Voskhod series. The SS-6 booster-sustainer combination also has been used in two spacecraft propulsion flight test programs. The system that launched Cosmos 102 and 125 is known as the SL-5 and that which launched the Polyots is designated SL-10.

All of these systems evolved from the SL-3, which was designed and developed in the mid-1950's under the engineering genius of the late Sergei L. Korolev (1906-1966). And the SL-3 system was built around the booster-sustainer combination derived from the SS-6, the first "heavy payload" Soviet ICBM.

The SL-3 and its close relation to other Soviet launch vehicles represent a major technical achievement. The Soviets created, in the mid-1950's, a booster-sustainer combination in the million-pound thrust class, of refined aerodynamic design, and powered by reliable and efficient multichamber rocket engines that owed little to Western concepts and less to the German legacy from World War II. This achievement illustrates the high priorities assigned to missiles and space power and also the significant advances in Soviet technology.

Aerodynamic design

One of the more striking features of the Vostok display vehicle is its overall shape, which is flared and presents several aerodynamic advantages. The gradual increasing diameter from the top of the sustainer to the vehicle base, minimizes wave drag. Also the multitude of engine nozzles means that the exhaust plume is emitted from the entire vehicle base. This design and the configuration virtually eliminate base drag. The simple and robu open-truss interstage allows smooth uninterrupted boundary layer flow while permitting clean flyaway staging. Although too small to provide effective trajectory control, the movable aerodynamic fins significantly aid vehicle stability in the 20,000- to 30,000-foot altitude region of the atmosphere where high wind-shear forces may be encountered as the vehicle experiences maximum dynamic pressure. The greater structural rigidity and reduced height of the parallel booster-sustainer configuration, as compared with a tandem tank design, eases the distribution of end and bending loads.

Vehicle structure

The SL-3 appears to be an expensive vehicle to build; however, the cost of the complex tooling required to fabricate the tapered sections could be offset to some extent by the savings in rough machining and loose tolerances permitted in noncritical areas. The fabrication techniques observed are fully consistent with Soviet capabilities during the 1953–1956 time period. The "roll and weld" process is extensively used. Fastening methods include resistance spot-welding, fusion seam-welding and screw-type fasteners. There is no evidence of chemical milling. The use of spot-welding in preference to rivetting suggests a concern for weight-saving.

Basic propulsion system

The engines displayed in the SL-3 are of Soviet design and sophisticated by mid-1950 standards.

The booster-sustainer propulsion system consists of five four-chamber main engines. Each of the four boosters has two control vernier chambers while the single main thrust sustainer has four. The multichambered main engine configuration was unexpected as previous Soviet technology had suggested a single chamber unit. But the display sustained previous estimates of the thrust capability of each booster unit at about 200,000 pounds of vacuum thrust and the sustainer at about 187,000 pounds.

A notable feature of the displayed engines is the high combustion-chamber pressure claimed by the Soviets. A pressure level of 60 atmospheres (about 880 pounds per square inch) is considerably higher than would be expected for a mid-1950's design. However, this figure probably is the design pressure and the actual operating pressure is lower.

The claimed 20:1 expansion ratio probably is a compromise to allow engine commonalty, since the ratio would not be optimum for either the boosters or the sustainer.

The turbopump, gas generator, and other propellant feed arrangements are fairly conventional in design and arrangement. The injector plate is a particularly neat and efficient design. Propellants are pre-mixed in concentric rings of tubes just before injection into the flame front. Each tube is surrounded by four small holes for injection of additional fuel, the tubes in the two outer rings are blanked off to pro-

SOVIET LAUNCH VEHICLES

Designators	*Systems*
SL-1	Launch system for Sputniks 1 and 2
SL-2	Launch system for Sputnik 3, probably the SS-6 booster
SL-3	SS-6 booster/Lunik 3d stage
SL-4	SS-6 booster/Venik 3d stage
SL-5	SS-6 booster/Lunik 3d stage/restartable injection stage integral with payload (first observed as Cosmos 102 and 125)
SL-6	SS-6 booster/Venik 3d stage/parking orbit ejection 4th stage
SL-7	SS-4 booster/2d stage
SL-8	SS-5 booster/restartable 2d stage
SL-9	Two-stage booster first used to launch Proton payload
SL-10	SS-6 booster/restartable injection stage integral with payload (Polyot 1 and 2)
SL-11	SS-9 1st stage/SS-9 2d stage
SL-12	SL-9 1st stage/modified SL-9 2d stage/3d stage/restartable 4th stage

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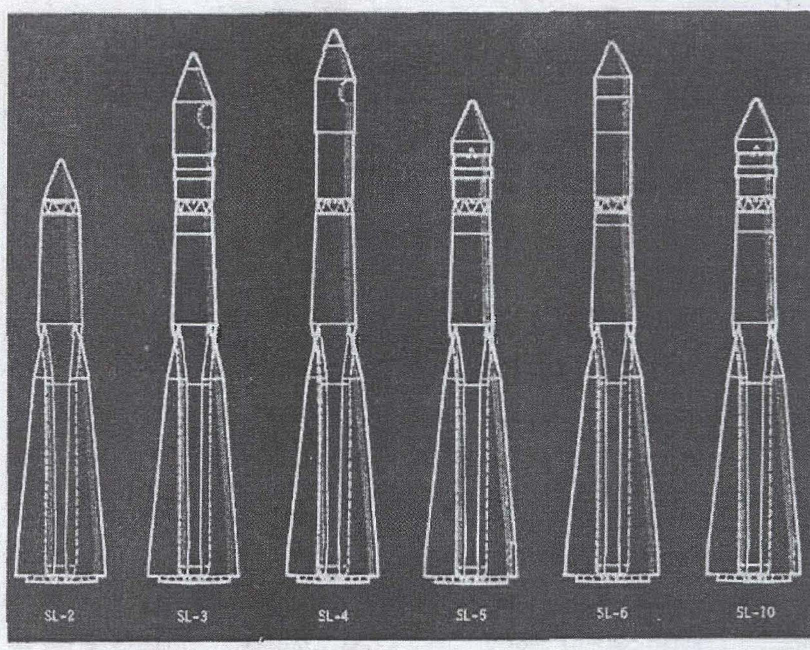
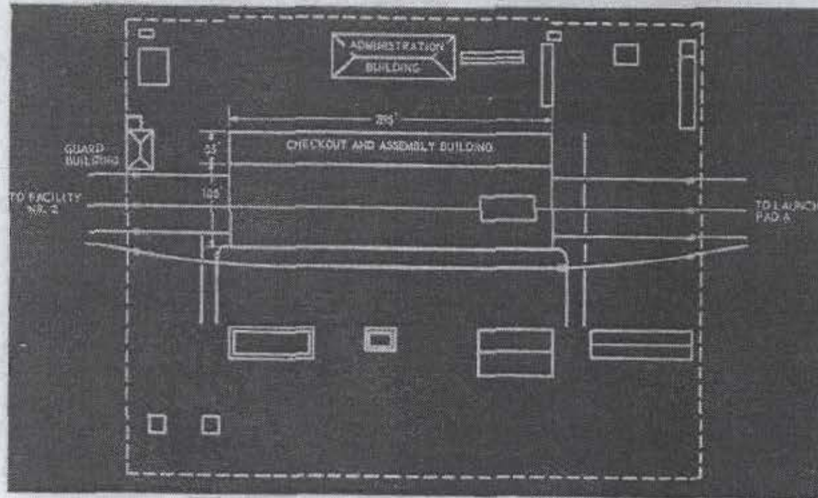


BASIC SS-6 booster-sustainer probably is used on six SL systems. ~~(S)~~



VEHICLE assembly and checkout facility, Area A, Tyuratam range. ~~(S)~~

vide a cooling fuel-rich annular zone next to the chamber walls.

The combustion chamber heads are of simple all-welded construction, light and leakproof, without external seals or heavy bolted flanges. The nozzles of all 20 chambers are regeneratively cooled with milled longitudinal cooling channels.

The propellant combination is not clear from the display. The oxidizer is liquid oxygen, but the fuel, quoted as "hydrocarbon" on the display placards, is not necessarily a kerosene. The quoted vacuum specific impulse of 314 seconds, which agrees closely with previous estimates, would be very difficult to obtain even at the high chamber pressure claimed if kerosene were used. An amine-type fuel—possibly a mixture of methylated hydrazines, which could be considered as hydrocarbon—would readily provide the performance and this fuel probably is used.

Flight profile

All SS-6 booster earth-satellite vehicles are believed to follow a similar flight path to orbit as shown on the right. In this profile a zero pitch rate occurs at booster burnout, which would tend to aid in staging. The apparent reason for incorporating a long zero lift during booster burn is to allow more time for the reduction of dynamic pressure before introducing a large angle of attack.

[redacted] however, the possibility of some radio-monitoring cannot be ruled out. [redacted]

50X1 and 3, E.O.13526

[redacted]

50X1 and 3, E.O.13526

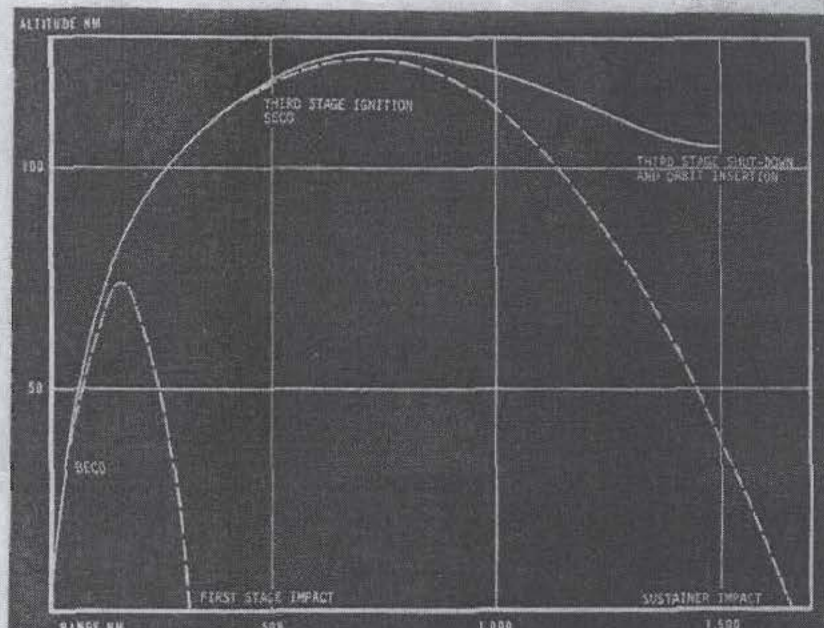
[redacted]

50X1 and 3, E.O.13526

The exact method of booster jettison is not clear. The most logical technique appears to be pivoting of the boosters about their upper attachment points followed by flyaway staging. Rotation about the lower x-type attachment could cause nozzle interference with the sustainer stage.

Launch facilities

Until March 1966, all SS-6-boosted space payloads were launched from Tyuratam. The launch of Cosmos 112 by an SL-3 during that month introduced the Plesetsk Missile and Space Complex as a space launch facility. Previously this installation was used only for ICBM flight tests. Since then the SL-4 also has been launched from Plesetsk. The use of Plesetsk considerably widens the range of orbital inclinations available to the Soviets,



SL-3 typical flight profile of boosters and earth-satellite vehicles; BECO: Booster engine cutoff; SECO: Second engine cutoff.

and inclinations up to 81 degrees have been demonstrated from this facility.

Launch operations

The assembly procedures of the SL-3 at Paris indicate that a typical launch site, such as Area A at Tyuratam, would include a large missile assembly building. This building would have three parallel drive-through rail tracks. The checked-out vehicle sections and the spacecraft are believed railed or trucked to the building from adjacent support buildings. After the two sustainer sections have been mated on rail dollies the four boosters would be swung into position by a bridge crane and mounted at their respective attachment points. The mated Lunik upper stage and spacecraft then are joined, again using rail dollies, to the open truss interstage already mounted on the sustainer. After a final overall checkout the complete launch vehicle, weighing some 40 tons, is transferred by bridge crane to a waiting rail transporter-erector. The assembly operation is estimated to take 8 to 10 hours, using a 20- to 25-man crew. When the vehicle is required for launch, a diesel-electric locomotive probably is coupled to the payload end of the transporter-erector and pushes it to the pad, engines first.

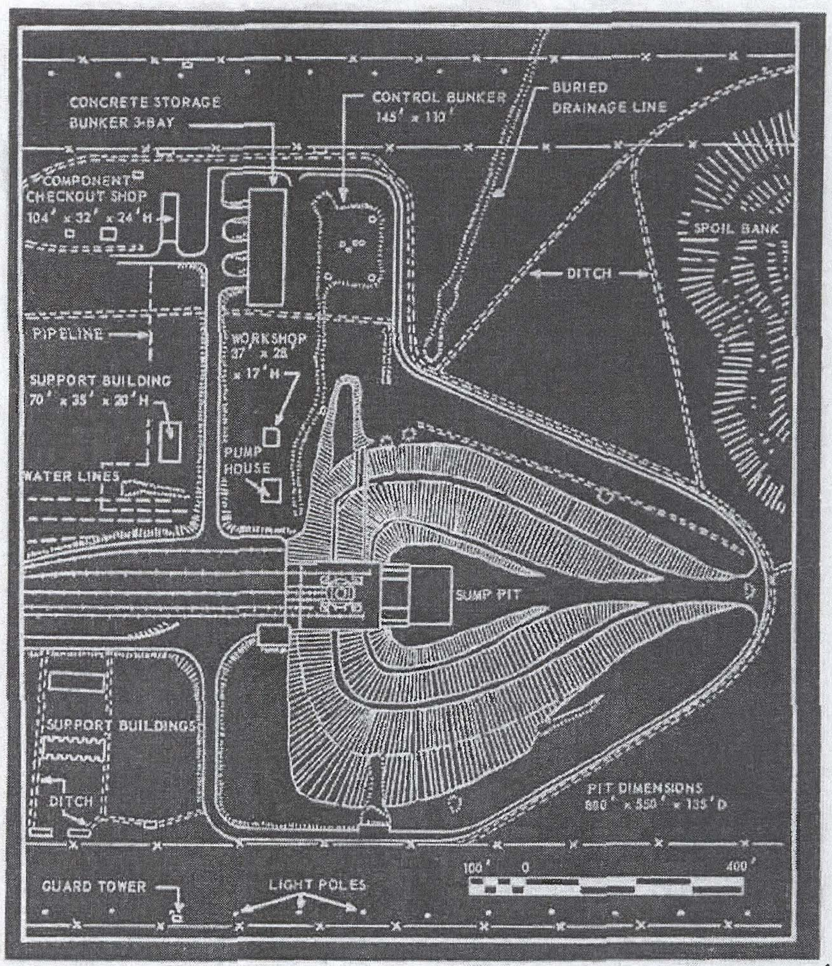
The layout of the launch pad at Area A as it appeared in the late 1950's is shown on the right. The pad deck, supported on four massive columns, stands 135 feet above the bottom of the sump pit. A rail track from the missile assembly building terminates at the 50-foot diameter hole in the pad center. The loaded transporter-erector is pushed along this track to the rim of the hole. The payload end of the transporter-erector is then anchored to the pad approach way by two pairs of swingdown tension bars, and two hydraulic buffers at the pivot end are swung down onto projections in the pad hole. The self-contained diesel-hydraulic unit at the payload end of the transporter-erector is then started and pressure is applied, first to the hydraulic buffers to brace the pivot end of the transporter-erector, and then to the twin main erection jacks. As the strongback carrying the launch vehicle pivots to the vertical, the overhang enters the pad hole. The launch vehicle finally comes to rest vertically on a stand structure some 21 feet below the pad deck, supported by a single strongpoint on each booster and four strongpoints on the sustainer. When the weight of the vehicle has been transferred to the stand it is disconnected from the strongback, the transporter-erector anchors are released and stowed, and the transporter-erector is moved backwards until the strongback can be lowered to clear both the vehicle and the pad hole. The transporter-erector is then towed away. The complete erection operation is controlled from a cab on the transporter-erector.

The rail carriage is used throughout the assembly-erection-launch sequence. The largely self-contained transporter-erector, which betrays its ICBM ancestry, weighs about 70 tons. Its total loaded weight, including complete launch vehicle, is about 110 tons. The use of the engine compartment overhang to offload both the strongback pivots and the erection jacks considerably reduces the weight and power requirements of the erection machinery.

Soviet on-pad time is believed to be very short. Unmanned SL-3 payloads probably can be launched within 24 hours of erection, and manned payloads are believed to take not more than a few days.

Fitting testament

The SL-3 is truly a fitting testament to the engineering genius of Soviet Rocket Designer Korolev. As the head of the Central Design Bureau for "Intercontinental Rockets and Space Boosters," he directed all major Soviet launch-vehicle programs. His official epitaph credited him with launching the Sputniks, Cosmos satellites, and interplanetary probes, as well as the manned Vostoks and Voskhods. He must have been justly proud of the SL-3 creation. [END]



LAYOUT of R&D launch site, Area A, Tyuratam, as it was in late 1950's. ~~[S]~~