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The Soviet Heavy-Lift Launch Vehicle (U)

A Research Paper

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The Soviet Heavy-Lift Launch Vehicle (S)

Summary

Information available through 1 February 1984 was used in this report. (U)

A new Soviet heavy-lift space launch vehicle, under development by the V.P. Glushko space systems design bureau since the mid-1970s, is nearing first flight at Tyuratam Missile and Space Test Center. A fully assembled prototype of this launch vehicle was seen for the first time [redacted] at Tyuratam, where it was undergoing compatibility checkout with launch pad facilities. The Intelligence Community estimates that the heavy-lift vehicle is capable of orbiting payloads weighing up to 100 metric tons, such as the Soviet space shuttle orbiter and large space station modules. Future variants of the booster may be able to orbit up to 150 metric tons. The first launch of the heavy-lift vehicle (probably without the shuttle orbiter) may occur in mid-1985. Initial launch operations with a shuttle orbiter are not expected before late 1985. 25X1

The basic heavy-lift vehicle consists of a large core booster and four strap-on, thrust-augmentation boosters. The 59-meter-long, [redacted] core booster has at least two and possibly three main propulsion engines and will use liquid oxygen and liquid hydrogen, a high-energy propellant combination. The 41-meter-long, [redacted] strap-on boosters, which are mounted offset to one side of the core booster, will use liquid oxygen and probably a hydrocarbon-based fuel such as kerosene. Large payloads, such as the shuttle orbiter, and possibly payloads with attached upper stages, will be mounted to the side of the core booster. Future variants of the heavy-lift vehicle may have differing numbers of strap-on boosters, use high-energy-propellant upper stages, and be capable of accommodating either side- or top-mounted payloads. 25X1 25X1 25X1

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Introduction

A new Soviet two-stage, heavy-lift launch vehicle (HLLV) is under development which is the successor to the large SL-X-15 (formerly the TT-5) booster. The SL-X-15 was to have been used in the Soviet manned lunar landing program, but after three successive launch failures from Tyuratam Missile and Space Test Center between 1969 and 1972, the SL-X-15 program was cancelled in early 1974. [redacted] since at least 1976 a new three-stage space launch vehicle has been under development by the V.P. Glushko space systems design bureau.[1] This booster, which we believe is the new HLLV, was described as being smaller than the SL-X-15 and employing liquid oxygen (LOX) and liquid hydrogen (LH), a high-energy propellant combination. (S [redacted])

A fully assembled prototype HLLV was first seen in October 1983 at Space Launch Site W, one of three HLLV launch sites under construction or modification at Tyuratam. Based on movements of ground support equipment, the HLLV (temporarily designated the SL-W by the Intelligence Community) was transported [redacted] from its assembly and checkout building to the launch site. There it was erected for the initial series of launch pad compatibility checkout tests. [redacted], a probable LOX-loading umbilical was observed in the extended position from a pad service structure to the vehicle. No propellant loading activity was identified, however. The HLLV was returned to the assembly and checkout building on [redacted] (S [redacted])

The Intelligence Community estimates that the payload-lift capability to low earth orbit for the HLLV and potential variants of the HLLV will probably range from 100 to 150 metric tons. The version of the HLLV observed in October 1983 will be used for launching large orbital payloads weighing up to 100 metric tons, such as the Soviet shuttle orbiter and space station modules. Potential upgrades to the HLLV, such as the use of additional stages or strap-on boosters, may enable the orbiting of payloads weighing up to 150 metric tons. The first launch of the HLLV (probably without the shuttle orbiter) is expected no earlier than mid-1985. Initial launch operations with a shuttle orbiter are expected to begin no earlier than late 1985.[2] (S [redacted])

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HLLV Components

The basic HLLV consists of a core booster and four strap-on, thrust-augmentation boosters (figure 1). We believe that the core booster will use LOX and LH and that the strap-on boosters will use LOX and probably a hydrocarbon-based fuel such as kerosene. (S [redacted]) 25X1 25X1

[1] Although the new HLLV under development has two stages, [redacted] referred to a future variant of this HLLV employing an additional stage(s). (S [redacted])

[2] For additional information on HLLV facilities at Tyuratam and the Soviet shuttle orbiter, see IA 84-10017, *Soviet Heavy-Lift Launch Vehicle and Space Shuttle Orbiter Facilities, Tyuratam Missile and Space Test Center*, March 1984 (Secre[redacted] and IA 83-10077, *Analysis of the Sovet Space Shuttle Orbiter*, August 1983 (Secret [redacted]

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Core Booster

The HLLV core booster, about 59 meters long and [redacted] has at least two and possibly three LOX/LH propulsion engines. The core booster serves as the structural backbone of the HLLV configuration, in that the strap-on boosters and payloads are mounted to it for launch. The core consists of two major components which are manufactured at Kuybyshev Aerospace Plant 1. The smaller of the two components [redacted] consists of the core nosecone/LOX tank and the intertank structure. The larger of the two components, the LH tank, is about [redacted] (figure 2).[3] (S [redacted]

[3] [redacted] hemispherical-cylindrical aerodynamic cover is attached to the intertank section of the smaller component for transport, increasing the overall length of the component [redacted] An 11-meter-long ogival aerodynamic cover also is attached to one end of the LH tank for transport, increasing the overall length of this component to [redacted]

The [redacted] ogival nosecone is used for the core booster LOX tankage. Although the exact size and configuration of the LOX tank is not known, [redacted]. The domed-cylindrical tank section was [redacted] and had an approximate volume of 292,000 liters (figure 3). Based on the LOX-to-LH propellant mixture and volume ratios used on US boosters, and on the known size of the core's LH tank, the complete LOX tank will have a volume of at least 500,000 liters.[4] (S [redacted]

The bottom of the LOX tank is attached to the intertank section, which is the structural connection used to join the LOX and LH tanks of the core booster together. [redacted]. Hard points are located around the circumference of the intertank, several of which are used as attachment points for the strap-on boosters. (S [redacted]

The LH tank is cylindrical with domed endcaps and has an approximate volume of 1.5 million liters. An LH tank without its aerodynamic transport cover was imaged in late 1980 and early 1981 at Ramenskoye Flight Test Center (figure 3). (S [redacted]

At some point during core processing, the LOX/LH engines, which comprise the core booster's propulsion system, are attached to the base of the LH tank. Each engine assembly [redacted] (figure 4). The presence of engine pod structures suggests that the engines may be reusable and that each pod may be detachable and house a recovery system for the return of its engine after completion of the boost phase. (S [redacted]

The first fully assembled core booster [redacted] outside its assembly and checkout building at Tyuratam. The core was then transferred to one of two high-bay areas in the building for integration with its strap-on boosters. (S [redacted]

[4] LOX-to-LH propellant mixture and volume ratios commonly employed on US space booster systems are 5: or 6:1 and 1:3, respectively. (U)

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Strap-On Booster

The HLLV strap-on, thrust-augmentation boosters are assembled at Dnepropetrovsk Missile Development Production Center. Each strap-on booster is about 41 meters long [redacted] and is derived from the [redacted] first stage of the SL-Y, a medium-lift space launch vehicle also under development at Tyuratam (figure 5). The additional length of the strap-on booster is for an asymmetric nosecone which is attached to the intertank of the core booster. The nosecone could house a recovery parachute system if the strap-on is to be reused. Because the strap-on booster is derived from the SL-Y first stage, it will probably use the same propellants and quantity of propellants as the SL-Y's first stage. Analysis of on-pad propellant tanking tests indicates that the SL-Y first stage has a LOX tank and probably a kerosene tank. The LOX tank, located beneath the strap-on's nosecone, [redacted] The kerosene tank is [redacted] positioned beneath the LOX tank.[5] Based on these dimensions, the quantities of LOX and kerosene required for tanking each HLLV strap-on booster (before losses due to venting, overflow, etc.) are approximately 206,000 liters and 106,000 liters, respectively. The propellant volume ratio (volume oxidizer to volume fuel) of the strap-on is about 1.9 : 1. (S [redacted]

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Analysis of the SL-Y first-stage engine section, which [redacted] located beneath the kerosene tankage, suggests that the propulsion system will use a single exhaust nozzle. A [redacted] ring appears to encircle the end of this nozzle and apparently is connected to four possible actuators on the booster. If so, the ring may be gimballed or pivoted by these actuators into the exhaust flow from the nozzle in order to provide thrust vector control for the booster during launch. (S [redacted]

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HLLV Configuration

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The prototype HLLV observed at Launch Site W in October 1983 had an overall length of about 60 meters [redacted]. The vehicle consisted of the core booster and four attached strap-on boosters, two per side. While no payload was present on the prototype, the basic HLLV is intended to carry payloads which will be mounted to the side of the core booster. (S [redacted]

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[5] The size and location of the propellant tankage is based on the identification of icing on specific sections of the SL-Y airframe during tanking tests at Tyuratam in September and November 1983. The sections with ice probably are used for housing LOX tankage. Those sections without ice (except for the payload shroud) probably are used for housing kerosene tankage. (S [redacted]

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[redacted]

The four strap-on boosters are mounted to the core booster in an arrangement in which the strap-on positioning is offset toward one side of the core. The angular displacement of the two opposing pairs of strap-on boosters is about [redacted] respectively (figure 6).[6] The offset positioning of the HLLV strap-ons is designed to accommodate the attachment of large payloads, such as the shuttle orbiter, on the opposite side of the core and to counter the center-of-gravity shift caused by the weight of such payloads. (S [redacted]

[6]Angular displacement is defined geometrically as the angle between the intersection of a reference plane with another plane. As seen in the top view of the HLLV, the reference plane is located equidistant between the opposing pairs of strap-on boosters and passes through the center of the core booster. The other plane bisects the strap-on booster and terminates at the center of the core booster. (S [redacted]

Each strap-on booster is attached to the core booster at a minimum of two points. The top of each strap-on's nosecone is attached near the center of the intertank section, and the lower portion of each strap-on is attached to the LH tank's base. At least two probable circumferential stiffener rings are present near the base of each strap-on booster and may include the lower core booster mounting points. Furthermore, the HLLV core booster apparently is physically supported by the strap-ons while on pad since no structures for core booster support have been identified. (S [redacted]

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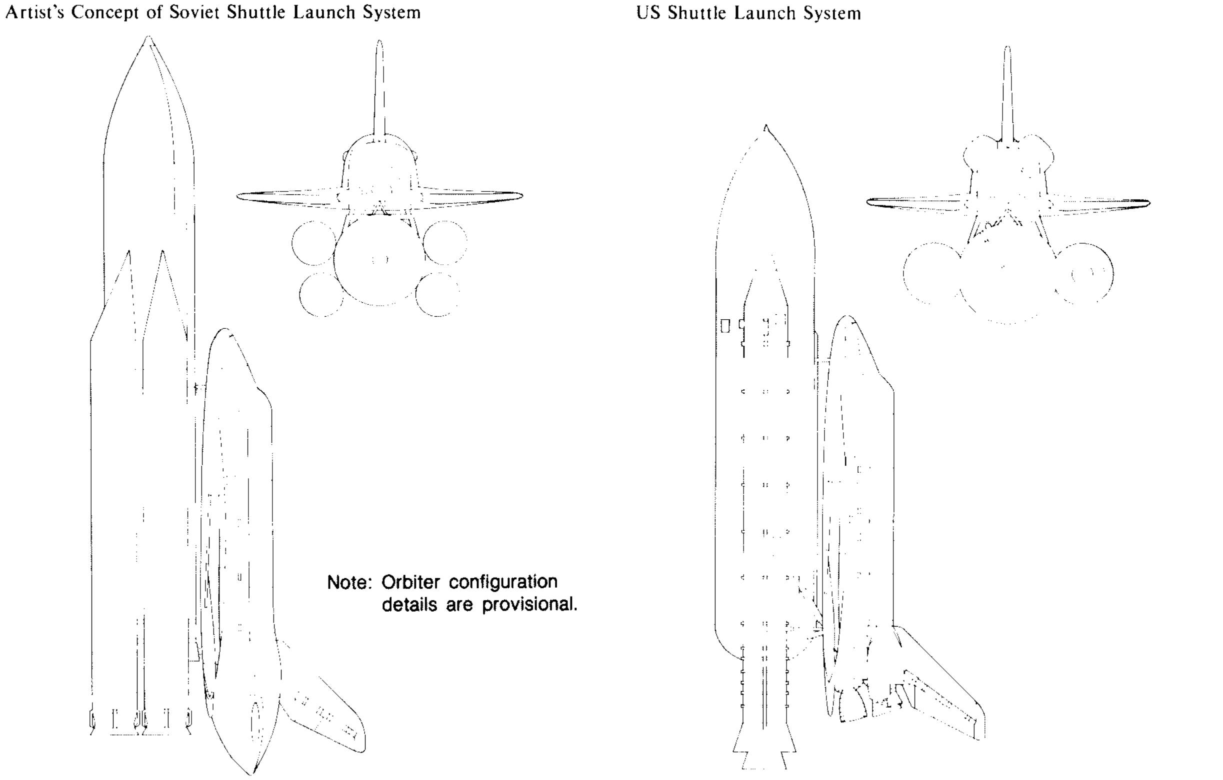
Propellant loading of the strap-on boosters may, in part, be conducted through the core booster. Only one propellant-loading umbilical has been identified at site W for supplying LOX to the HLLV. This umbilical mates with a probable receptacle or fixture on the exterior of the core's intertank section and is probably used for tanking LOX onto the core booster. Hypothetically, because no umbilicals are evident for loading LOX onto the strap-ons, LOX from the single umbilical also may be distributed to the strap-ons by means of a possible intertank piping system. Conceivably, LOX lines could run from the intertank into each strap-on booster through its attachment point at the intertank. The kerosene-type fuel for the strap-ons probably will be loaded through individual fixtures on the launch pad's HLLV support pedestal into each booster's kerosene tank. (S [redacted]

Payloads which will be launched by the basic HLLV will be attached to the side of the core booster. These payloads will be side-mounted in a manner similar to that of the US shuttle orbiter on its launch system (figure 7). The positioning of the strap-on boosters toward one side of the core booster has made a large, relatively unrestricted area available on the opposite side of the core for payload attachment. The attachment of large payloads on the side of the core booster probably will require special fittings or structural provisions on the core for mounting such payloads. Two structural features on the core have been identified which may serve such a purpose (figure 1). The possible attachment structures are located on the side and base of the core booster's LH tank and appear similar to the orbiter mounting structures on the US shuttle system's external tank. (S [redacted] 25X1

Figure 7
Soviet and US Launch Vehicles with Side-Mounted Orbiter Payload

Artist's Concept of Soviet Shuttle Launch System

US Shuttle Launch System



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HLLV Transport

The major components of the HLLV's core booster and the strap-on boosters are shipped assembled from their manufacturing plants to Tyuratam to maximize factory control over component quality and reduce processing time after delivery. The two major components comprising the core booster are outfitted with aerodynamic covers and are individually air-transported atop modified Bison aircraft from Kuybyshev to Tyuratam (figure 8). Upon arrival at Tyuratam, the components are transported by dolly from the airfield to the HLLV assembly and checkout building for aerodynamic cover removal and receipt and inspection activities. The components are then mated to form the propellant tankage of the core booster. Each HLLV strap-on booster is shipped by flatbed rail train from Dnepropetrovsk to Tyuratam (figure 8). The strap-ons are offloaded in the HLLV asembly and checkout building in preparation for core booster attachment. Once assembled and checked out, the core and strap-on boosters are integrated in the horizontal position to form the HLLV. (S [redacted]

After HLLV integration has been completed, the HLLV is mounted on a transporter/erector (TE) for horizontal transport from the assembly and checkout building to another building for payload mating. Finally, the HLLV arrives at the launch pad where it and the attached payload are erected into place.[7] Transportation and erection is accomplished by one of two TEs formerly used for the SL-X-15 booster and later reconfigured for the HLLV. The TEs, each of which consists of a rectangular, steel-framework chassis with two hydraulic erecting arms, are normally parked outside the HLLV assembly and checkout building. Each TE is about 55 meters long, 24 meters wide, 19 meters high and travels on a 20-meter-gauge rail network (figure 9). A total of four locomotives, two per TE side, are used for moving the TE between locations on the rail network. (S [redacted]

[7]The October 1983 series of compatibility checkout tests between the prototype HLLV and the launch pad did not involve a payload; therefore, the HLLV was transported directly to the launch pad. (S [redacted]

The HLLV is supported on the TE by a curved support cradle and two bracketlike, rectangular support structures. The cradle is a permanent structure located near the front of the TE that mates with the intertank for support of the forward portion of the HLLV. The rectangular structures are positioned around the lower portion of the HLLV and are supported by the rear of the TE during transport and erection. These structures apparently provide HLLV support both during transport and after erection on pad, since they remain attached to the strap-on boosters once the HLLV is mounted on the pad's launch vehicle support pedestal (figure 9). (S [redacted]

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HLLV Variants

Variants of the basic HLLV may be developed which will use differing numbers of strap-on boosters, high-energy-propellant upper stages, and be capable of launching either side- or top-mounted payloads. Although up to eight strap-on boosters could be accommodated around the core, it is unlikely such an HLLV variant will be developed because of limitations at the launch facilities. Based on launch pad configurations, the HLLVs launched from site W apparently will be limited to four strap-on boosters. Those launched from the other two HLLV launch sites, J1 and J2, will have at least four and possibly six strap-ons, depending on the final pad configuration, the capabilities of the TE, and the mounting position for the payload. (S [redacted]

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