The Launch Vehicle Landscape: New and Existing Entrants Serving the SmallSat Market

Kirk Pysher, Tom Carroll, Jim Kramer, John Palmé
International Launch Services
1875 Explorer Street, Suite 700, Reston, VA 20190; (571) 633-7429
k.pysher@ilslaunch.com

ABSTRACT

With the influx of small satellites in recent years, a host of launchers are vying to address demand—from new entrants to mainstay launch services providers—and operators are looking for cost effective access to space. Ride sharing or launching multiple satellites on one launcher is one of the ways this can be achieved. There are complications to this option however, including manifest availability, schedule assurance and deployment to the necessary orbital location. In some instances, a dedicated launch makes more sense; performance isn’t sacrificed and costly adjustments to the satellite propulsion systems are not necessary.

Competition among the many launchers in the small satellite market is fierce and a key question remains: does the supply of launchers exceed the actual demand and number of small satellites being manufactured? At this time there are dozens of potential competitors lining up to serve this market when only a few short years ago, these vehicles were in very short supply.

Khrunichev State Research Production Space Center (Khrunichev), of Moscow, which reached its 100 year anniversary in the space industry this past April, has addressed the need for cost effective access to space with a new vehicle—the Angara 1.2. This new vehicle will address the full range of mass classes to all types of orbits with lift capability of up to 3 MT to Low Earth Orbit (LEO).

The Angara 1.2 vehicle will be available to support a commercial launch from the Plesetsk Cosmodrome, located in Northern Russia, in 2019. Following that initial launch opportunity, there are plans for up to two commercial Angara 1.2 missions per year starting in 2020 under the auspices of International Launch Services (ILS), a U.S. company located in Reston, Virginia, a subsidiary of Khrunichev. ILS is a launch services provider with the exclusive rights to market the Angara and Proton vehicles, built by Khrunichev, to the commercial marketplace.

ANGARA TEST FLIGHTS AND USE OF FIRST STAGE WITH KOREAN SPACE LAUNCH VEHICLE (KSLV) LAUNCHES:

A variant of the Angara Universal Rocket Module (URM) system, built by Khrunichev, was flight demonstrated successfully as the first stage of KSLV (Korean Space Launch Vehicle) during its first three missions in 2009, 2010 and 2013 from the Naro Space Center in South Korea. Two test flights of the Angara vehicle were conducted 2014 from the Plesetsk Cosmodrome.

Angara 1.2 ML Flight

The first Angara flight, The Angara-1.2ML (Maiden Launch) integrated launch vehicle (ILV) was successfully launched by the Russian Ministry of Defense from the State Testing Cosmodrome (Plesetsk Cosmodrome) in the Archangelsk Region of Northern Russia on July 9, 2014. The light-lift Angara-1.2ML with a mock payload on board lifted off from the Angara multi-purpose launch pad at 4:00 pm Moscow time (12:00 GMT, 8:00 am ET).
The ILV mission proceeded over the Russian territory along a ballistic trajectory in accordance with the planned timeline. Following the liftoff and the subsequent separation of Stage 1, the payload fairing was jettisoned during the Stage 2 powered flight. Stage 1 and the fairing were released into a planned targeted area in the southern part of the Barents Sea. After 21 minutes and 28 seconds, Stage 2 and the firmly attached mass/dimensional payload simulator reached the planned targeted area of the Kura Range on the Kamchatka peninsula, 5,700 km from the launch site.

The Angara-1.2ML ILV comprised two stages that are based on Common Core Boosters (URM-1 and URM-2), a payload mockup with a mass of 1.43MT, and a payload fairing. The propulsion system runs on ecologically clean components of oxygen and kerosene. The lift-off mass of Angara-1.2ML ILV was approximately 171 Metric Tons.

The flight test of the newest the heavy-lift Angara A5.1L launch vehicle was successfully conducted on December 23, 2014 from the Plesetsk Cosmodrome.

The purpose of the test flight was to carry out comprehensive verification and demonstration of the Angara A5.1L launch vehicle readiness to loft geostationary spacecraft.

**Angara A5.1 L Flight**

The Angara A5.1L integrated launch vehicle consisted of the 3-stage Angara A5.1L launch vehicle based on the Universal Rocket Modules (URM) and the Ascent Unit. The Ascent Unit includes the mass/size mockup of the satellite (simulated payload) stacked on the Breeze M upper stage under the payload fairing. The launch vehicle is powered by the engines utilizing environmental friendly propellants – oxygen and kerosene. The lift-off mass of the Angara A5.1L integrated launch vehicle is approximately 768 metric tons (MT), the mass of the payload is 2.04 MT.

Launch operations were conducted by the teams from the Russian Aerospace Defence Forces and Russian space industry. All processing, lift-off and flight of the vehicle were reported to be nominal.

The launch was performed along the flight trajectory with inclination of 63.2 degrees. Separation of the Orbital Unit (including the Breeze M upper stage and the dummy satellite) from the 3rd stage of the launch vehicle was nominal. Further injection of the Orbital Unit into the target geostationary orbit was accomplished by the means of the Breeze M propulsion system. The Orbital Unit achieved the target orbit at the expected time, approximately 9 hours following the launch vehicle lift-off.

Per the mission design, there was no separation of the payload from the upper stage occurred. Upon reaching the target orbit, the Breeze M upper stage completed two maneuvers into the graveyard orbit.

**Angara and the Korea Space Launch Vehicle (KSLV) Program**

Based on an inter-governmental agreement with Russia and South Korea on space cooperation, it was agreed to jointly develop and build a space booster complex for South Korea based on the small-lift KSLV-1 launch vehicle. The KSLV-I contract was signed in October 2004. The first stage of KSLV-I was developed and fabricated in Russia while the second stage and payload were designed and built in S. Korea.

Under the contract, Khrunichev designed and fabricated Stage 1 for KSLV-1, while Stage 2 was designed and manufactured in South Korea.

Stage 1 of the KSLV is a variant of the Angara URM system. The Korea Aerospace Research Institute (KARI) is the Customer in KSLV project. The Naro
Space Center supports all launches for the KSLV program.

KSLV-1 is capable of launching 100 kg payload into low elliptical orbits with an altitude of 300 km in perigee and 1500 km in apogee. The launch vehicle is 33 meters long and 2.9 meters in diameter, and its overall mass is 140 MT.

On June 19, 2009, the prototype of the Stage 1 manufactured by Khruvichev was delivered from Russia to South Korea aboard an Antonov transport plane operated by Polet Airliner. The first launch of the KSLV-1 took place in 2009. The KSLV booster (also known as Naro-1 LV), carrying the S. Korea's STSAT-2 satellite, was launched from the Naro Space Center on August 25. The first stage of KSLV-1, developed and fabricated by the Russia's Khruvichev Space Center performed nominally.

On April 4, 2010, the first stage for Naro-2, developed and fabricated by Khruvichev, was delivered from Russia to South Korea aboard transport plane operated by Russia’s Polyot carrier. South Korean KSLV-1 (The first Korean Space Launch Vehicle.), a space rocket known as Naro-Two, was launched at 5:01 p.m. local time from the Naro National Space Center on June 10, 2010. The first stage of the KSLV vehicle performed nominally during this mission.

A successful launch of KSLV-1 took place in 2013. KSLV-1 carrying a South Korean research spacecraft, the STSAT-2C lifted off from the Naro Space Center at 11 a.m. Moscow Time on January 30, 2013. The satellite was put into designated elliptical orbit at 11:09 a.m. Moscow Time.

ANGARA 1.2 SUN-SYNCHRONOUS PERFORMANCE FROM PLESETSK COSMODROME

THE ANGARA 1.2 SERVICE MODULE

The service module for the Angara 1.2 engine is designed to generate velocity impulses to inject the spacecraft into its target orbit. It is also designed to support the required attitude during the coast phase of the mission while on transfer orbit and for spacecraft separation. The service module can generate velocity impulses for a de-orbiting maneuver from the spacecraft target orbit and uses 600 kg MON+MMH propellants.

THE ANGARA 1.2 PAYLOAD FAIRING

- The payload fairing is 2.9 m in diameter
- It has a clamshell design connected by mechanical pyro locks
- It is installed on the upper ring of Stage 2
- The payload fairing shell is 3-layered with a honeycomb filling compound
SUMMARY: ANGARA 1.2 AND COMPETITION IN THE LEO MARKET

The marketplace for Angara 1.2 in the small to medium class market is highly competitive marketplace with five primary and three secondary participants. It is anticipated that there will be a large number of potential new entrants over the next ten years. However, these are expected to be primarily lower performance vehicles targeting the small satellite marketplace. The performance capability and price per kilogram of spacecraft for Angara 1.2 is currently very competitive with three main markets for this vehicle: LEO satellites, making up about 20 percent of the marketplace, multi-satellite constellations and satellites that are aggregated.

Acknowledgments

Khrunichev State Research and Production Center (KhSC)

References


ANGARA 1.2 LEO PERFORMANCE

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<th>Orbit Parameters</th>
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