Dnepr

Outlook

- Production ended in 2015
- Limited shelf-life of SS-18 missile, increasing competition, and conflict between Russia and Ukraine forced an end to the program
- Two Dnepr launches took place in both 2013 and 2014, but only one occurred in 2015

Orientation

Description. The Dnepr was a converted R-36M2 (SS-18) ICBM that was used as a launch vehicle to lift small/medium spacecraft to low-Earth orbit (LEO).

Sponsor. The Kosmotras International Space Company, a consortium of the Russian and Ukrainian governments and businesses in Russia and Ukraine, sponsors the Dnepr program. Thiokol Technologies provides marketing outside Russia and Ukraine.

Status. The Dnepr-1 performed 21 successful launches following its introduction in 1999, with only one failure.

Total Produced. There are approximately 135 R-36M2 (SS-18) missiles.

Application. The Dnepr-1 was able to carry one large satellite or a cluster of smaller satellites weighing up to 4 tons into low-Earth orbit.

Price Range. Dnepr rockets were selling for as low as $8 million to $11 million at one time. However, near the end of the program, costs rose to between $30 million and $35 million.

Contractors

Prime

ISC Kosmotras	http://www.kosmotras.ru, PO Box 7, Moscow 123033, Russian Federation, Tel: + 7 095 745 7258, Fax: + 7 095 956 1659, Email: andreev@kosmotras.ru, Prime
Rosobshchemash Corp, OAO Korporatsiya Rosobshchemash	7 South Makeyeva St, Moscow 123100, Russian Federation, RDT+E (SS-18 Deactivations for Dnepr Conversion)
Yuzhnoye Machine Building Plant, NPO Yuzhnoye, KB Yuzhnoye, Yuzhmash	http://www.yuzhmash.com, 1 Krivorozhskaya St, Dniepropetrovsk 49008, Ukraine, Tel: + 380 562 34 39 04, Fax: + 380 562 34 43 79, Email: market@yuzhmash.com, RDT+E (Dnepr Integration and Engineering)

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Subcontractor

Hartron Corp	http://www.hartron.com.ua, 1 Akademika Proskury St, PO Box 9971, Kharkiv 61070, Ukraine, Tel: + 380 57 760 31 80, Fax: + 380 75 315 11 00, Email: teh@cit.kharkov.ua (Dnepr Guidance and Control Systems)

Contractors are invited to submit updated information to Editor, International Contractors, Forecast International, 22 Commerce Road, Newtown, CT 06470, USA; rich.pettibone@forecast1.com

Technical Data

Design Features. The Dnepr launch vehicle had two unmodified SS-18 primary stages arranged in sequence, and one small post-boost third stage with a modified control system memory unit. All stages were powered by storable N2O4 and unsymmetrical dimethyl hydrazine propellants. Dnepr's safety system allowed mission control to abort the mission in the first and second stages. Dnepr-1 LV was based on the SS-18 liquid-fueled ICBM and had a three-stage in-line configuration. Dnepr had a standard high-precision, computer-controlled inertial guidance system. Modifications were made to the SS-18's software, electrical connections to the spacecraft, and ground test and launch equipment. Prelaunch preparations and flight commands were also changed. The rocket was steam-ejected from a launch canister using standard launch sequence. The LV first-stage propulsion unit was ignited upon the rocket's exit from the launch canister.

	Metric	U.S.
Dimensions		
Stage 1 length	22.3 m	73.3 ft
Stage 2 length	5.7 m	18.7 ft
R-36M2 Stage 3 length	1 m	3.3 ft
Stage 1 diameter	3.0 m	9.8 ft
Stage 2 diameter	3.0 m	9.8 ft
R-36M2 Stage 3 diameter	3.0 m	9.8 ft
Weights		
Gross mass		
Stage 1	210.8 tonnes	464,700 lb
Stage 2	49.3 tonnes	108,700 lb
R-36M2 Stage 3 diameter	8.2 tonnes	18,000 lb
Propulsion		
Stage 1	4	Thrust chambers
Stage 2	1 + 4	Verniers
Stage 3	1	Engine with multiple verniers
Propellant		N2O4/UDMH

Variants/Upgrades

Dnepr-M. The rocket had the capability to launch payloads into higher LEO altitudes.

Self-Contained Booster Stage-1 (SBS-1). The SBS-1 was equipped with both solid- and liquid-fueled motors and is designed for near-equatorial LEO insertions and missions to Mars, the moon, and Lagrangian points. Payload capabilities include 300 kilograms to geosynchronous Earth orbit (GEO), 650 kilograms to highly elliptical orbit (HEO) with a 70,000-kilometer apogee, 250 kilograms to Martian orbit, or 400 kilograms to lunar orbit. Development was reportedly completed in 2006.

SBS-2. The SBS-2 was equipped with a solid fuel booster for escape trajectories to the moon and Mars and for HEO and Lagrangian point missions. Payload capabilities include 700 kilograms to HEO with a 40,000-kilometer apogee and up to 750 kilograms into lunar escape trajectories.

SBS-3. The SBS-3 was equipped with a liquid fuel stage to serve medium-Earth orbit (MEO) and HEO missions. SBS-3 was also capable of inserting a 1,750-kilogram payload into an 800-kilometer sun-synchronous orbit.

A Converted SS-18 Dnepr Launch Vehicle

Source: Roscosmos

Program Review

Background. The Dnepr launch vehicle was a decommissioned SS-18 (R-36M2) ICBM with modifications that allow it to launch payloads into low-Earth orbit. Russia stopped production of SS-18 ICBMs in 1992 while START I negotiations were taking place.

START I called for a reduction of nuclear arsenals to approximately 3,500 warheads by 2003. Russia negotiated a 2007 deadline within the START II treaty, giving the country an additional four years to make a profit from the ballistic missiles.

Russia and Ukraine Join for Dnepr

The Russian Space Agency and the National Space Agency of Ukraine formed a joint venture company, Kosmotras, in 1997. Shareholders of the company include Rosobshchemash, Yuzhnoye Design Bureau, and TsNIImash.

Kosmotras conducted a test flight of Dnepr in 1998 to demonstrate its performance to potential customers. One year later, Dnepr successfully placed an experimental mini-satellite, UoSat-12, into orbit. Surrey Satellite Technologies Ltd (SSTL) of the U.K. developed the satellite.

Dnepr Performs Second Launch. A Dnepr launch vehicle carrying six spacecraft was successfully launched from the Plesetsk Cosmodrome in September 2000. The spacecraft included UoSat-12, UniSat-1, SaudiSat-1A and -1B, Tiungsat-1, and MegSat-1.

The satellites were placed in a circular 650-kilometer orbit at a 65° inclination.

TerraSar-X Contract. ISC Kosmotras and Astrium GmbH (now Airbus Defence and Space) signed a contract in October 2002 for launch of the TerraSar-X

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scientific and commercial spacecraft, which took place in June 2007 from the Baikonur Cosmodrome. TerraSar-X orbits in a 514.8-kilometer sun-synchronous orbit and carries an X-band synthetic aperture radar (SAR).

One Launch, Six Payloads

The third launch of a Dnepr rocket lofted six spacecraft from Baikonur Cosmodrome in December 2002. The following spacecraft were injected into a 650-kilometer circular orbit: UniSat-2 (University of Rome, Italy), Rubin-2 (OHB-System, Germany), SaudiSat-1C (Space Research Institute, Saudi Arabia), LatinSat-A and LatinSat-B (SpaceQuest, USA), and a dummy of the future Trailblazer Lunar SC (TransOrbital, USA).

Kosmotras had Ukraine manufacture the Trailblazer dummy payload to work out the high-energy orbital injection technology for large spacecraft, using an additional propulsion unit on Dnepr.

Bigelow Contract. In May 2004 at the Berlin Air Show, U.S. company Bigelow Aerospace signed a contract for six launches on Dnepr launch vehicles. The first launch under the contract took place in 2006, followed by the second in 2007. Bigelow's four remaining options were expected to be exercised by 2009, but have not been utilized yet. Bigelow Aerospace, a producer of inflatable orbital modules, is based in Las Vegas, Nevada.

Fourth Dnepr Launch. In June 2004, the fourth Dnepr was launched, from the Baikonur Cosmodrome. The launch vehicle orbited eight spacecraft: Demeter (CNES); SaudiComsat-1, SaudiComsat-2, and SaudiSat-2 (Space Research Institute, Saudi Arabia); LatinSat-C, LatinSat-D, and AMSat-Echo (SpaceQuest, USA); and UniSat-3 (La Sapienza University, Rome, Italy).

Fifth Dnepr Launches Two Japanese Payloads

Two Japanese satellites successfully made it to orbit on August 24, 2005, following a perfect Dnepr launch. The Optical Inter-orbit Communications Engineering Test Satellite (OICETS) and the Innovative Technology Demonstration Experiment Satellite (INDEX) were launched at 6:10 a.m. (Japan Standard Time) from the Baikonur Cosmodrome in the Republic of Kazakhstan. The Japan Aerospace Exploration Agency (JAXA) confirmed that the OICETS and INDEX had successfully separated and been injected into their scheduled orbits.

Additional Dnepr Launches

A Dnepr rocket successfully launched five remote sensing satellites for a German company in August 2008 from the Baikonur Cosmodrome. It placed the five RapidEye spacecraft in sun-synchronous orbits. The spacecraft, built for prime contractor MacDonald, Dettwiler and Associates (MDA) by Surrey Satellite Technology Ltd (SSTL), each weigh about 150 kilograms and carry cameras designed to provide medium-resolution imagery of the Earth. The spacecraft will be used by their owner, German company RapidEye AG, for a variety of commercial agricultural and land information products.

A Dnepr rocket successfully launched a long-delayed remote sensing satellite for Thailand in October 2008 from the Yasny launch site in southern Russia. The satellite eventually maneuvered into an 822-kilometer sun-synchronous orbit. It provides medium-resolution imagery for Earth science and disaster monitoring applications.

In July 2009, a Dnepr launch vehicle lifted off with six small satellites from the Baikonur Cosmodrome. Two of the satellites, DMC 2 and Deimos 1, joined the international Disaster Monitoring Constellation. The payload also included DubaiSat-1, an optical imaging satellite operated by a UAE company; two U.S.-owned communications satellites; and an experimental Spanish satellite, Nanosat 1B.

In April 2010, ESA's CryoSat-2 was launched on board a Dnepr from Baikonur Cosmodrome. CryoSat-2 was designed to observe Earth's polar regions for three years. During that time, the satellite was to determine how quickly ice was melting in the polar regions, and how that would affect the Earth's climate and sea levels.

In June 2010, five more satellites were launched on board two Dnepr rockets. A mission on June 15 launched the French Picard satellite; the Swedish Prisma system, which consists of two satellites; and the Ukrainian BPA-1 satellite. On June 22, the German TanDEM-X (a sister spacecraft to the TerraSar-X launched in 2007) was launched.

On August 17, 2011, a Dnepr rocket carried seven satellites into orbit: the Sich-2, NigeriaSat-2, NigeriaSat-X, RASAT, EDUSAT, Aprizesat-5, and Aprizesat-6.

The next Dnepr launches took place in 2013. An August 2 launch carried South Korea's KOMPSAT-5 into orbit, while a November 21 launch carried 31 CubeSats and the UAE's DubaiSat-2.

Two Dneprs lifted off in 2014. The first launch, on June 19, carried 37 small satellites, including 11 Doves for Planet Labs. A second flight carried five small satellites into orbit on November 6.

A Dnepr carried KOMPSAT-3A into orbit on March 26, 2015.

Funding

Kosmotras and its shareholders provide funding for the Dnepr program.

Timetable

Month	Year	Major Development
	1997	Kosmotras formed
Apr	1999	Dnepr places UoSat-12 into orbit
Sep	2000	Dnepr places five spacecraft into 650-kilometer circular orbit
Dec	2002	Dnepr places UniSat-2, Rubin-2, SaudiSat-1C, LatinSat-A, LatinSat-B, and dummy Trailblazer Lunar SC payload into orbit
Jun	2004	Dnepr launches Demeter, SaudiSat-2, AMSat-Echo, LatinSat-C/-D, SaudiComsat-1/-2, and UniSat-3
Aug	2005	Dnepr launches OICETS and INDEX
Jul	2006	Failed launch of a dozen CubeSats
		Genesis-I launched; first of six launches contracted for Bigelow Aerospace
Apr	2007	Dnepr launches EgyptSat-1, SaudiSat-3, SaudiComsat-3 to -7, AKS-1 and -2, Cal Poly PicoSat Project 3 and 4, CAPE 1, Libertad 1m, AeroCube 2, CubeSat TestBed 1, and MAST
Jun	2007	Dnepr launches TerraSar-X
		Dnepr launches Genesis-2
Aug	2008	Dnepr launches RapidEye spacecraft
Oct	2008	Dnepr launches Theos spacecraft
Jul	2009	Dnepr launches six small satellites
Apr	2010	Dnepr launches CryoSat-2
Jun	2010	Dnepr launches Picard, Prisma, and BPA-1 missions
		Dnepr launches TanDEM-X
Aug	2011	Dnepr launches with seven payloads
Aug	2013	Dnepr launches KOMPSAT-5
Nov	2013	Dnepr launches DubaiSat-2 and 31 CubeSats
Jun	2014	Dnepr launches 37 small satellites
Nov	2014	Dnepr launches five small satellites
Mar	2015	Dnepr launches KOMPSAT-3A

Forecast Rationale

The Dnepr's low price, reliable launch record, and ability to launch multiple payloads made it appealing to customers who needed light- and medium-weight launch services. Manufacturing the Dnepr out of refurbished ICBMs saved on costs, and the launch vehicle successfully placed payloads into orbit 20 out of 21 times.

Despite the strengths of the Dnepr, a number of issues limited launch rates and eventually forced the end of the program. The Dnepr launch vehicles were based on Soviet-era SS-18 ICBMs, and, as these missiles aged, they were no longer able to launch satellites into orbit. It was too expensive to upgrade the vehicles to continue commercial launches once they reached the end of their lifespans.

In addition, the Dnepr faced intense competition in the lightweight launch market. New launch vehicles, such as the Vega in Europe and India's PSLV, competed for contracts with the Dnepr. In the U.S., entrepreneurial firms have been developing a number of lightweight launch vehicles. Also, the Dnepr – once an extremely cheap launch vehicle – had risen in cost to between $30 million and $35 million per launch, putting its price closer to that of its rivals.

The biggest factor that led to the end of Dnepr production was the conflict between Russia and Ukraine. The launch vehicle was a joint project between contractors in the two countries. With the conflict ongoing, the Ukrainian space industry suffered while Russia's government no longer used the Dnepr. In

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addition, Russia denied components (as well as the Yasny launch site) to Kosmotras, leaving it unable to produce and launch the Dnepr.

At this time, any further production and launches of the Dnepr are highly unlikely. The launch vehicle flew twice in both 2013 and 2014. However, only one Dnepr lifted off in 2015 – the last to be launched. With the Russian government pulling out of the program and Ukrainian industry unable to support the program, production has ended.

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