Cyclone

Outlook

- During development, Cyclone program was repeatedly delayed due to budget, technology, relationship issues
- Conflict between Ukraine and Russia caused further strain on program
- Brazil finally pulled out of Cyclone program citing questions about cost and future market success
- Without Brazilian participation, there will be no Cyclone-4 production

Orientation

Description. Cyclone (also Tsyklon or Tsiklon) is a family of two- and three-stage Ukrainian expendable launch vehicles that can launch up to 9,923 pounds of payload to 500-kilometer low-Earth orbit.

Sponsor. Sponsored by the manufacturer.

Status. Continued development of Cyclone-4 unlikely after Brazil ended participation in development program. No further production is planned of the Cyclone-2, Cyclone-3, and R-36-O (from which the Cyclone-2 is derived) vehicles.

Total Produced. Approximately 231.

Application. Cyclone rockets are used to place military and civilian payloads into low-Earth orbits.

Price Range. Cyclone-2 launches cost about $20 million, and Cyclone-3 launches from $25-30 million. Cyclone-2K launches cost about $8,000 per kilogram of payload. Cyclone-4 was expected to cost around $40 million per launch.

Contractors

Prime

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, Prime
Puskovie Uslugi	Beryozovaya Alleya 10/1, Moscow, 127276 Russian Federation, Tel: + 7 095 402 6184, Fax: + 7 095 402 8229, Email: office@pu-lsp.ru, Launch Contractor

Cyclone

Subcontractor

NPO Energomash	http://www.energomash.ru/eng, Bldg 5, 14 Butikovsky Ln, Moscow, 119034 Russian Federation, Tel: + 7 095 792 3954, Fax: + 7 095 792 3934, Email: corp@energomash.ru (First & Second Stage Engine)

Comprehensive information on Contractors can be found in Forecast International's "International Contractors" series. For a detailed description, go to www.forecastinternational.com (see Products & Services; Companies, Contractors, Force Structures & Budgets) or call + 1 (203) 426-0800.

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 Cyclone expendable launch vehicle was historically available in two versions: the two-stage Cyclone-2 (U.S. Department of Defense designation SL-11, and Sheldon designation F-1) and the three-stage Cyclone-3 (SL-14/F-2).

Two liquid-fueled engines, both burning nitrogen tetroxide (N_2O_4) and unsymmetrical dimethylhydrazine (UDMH), powered the Cyclone-2. Six thrust chambers and four vernier rockets provided first-stage thrust, while the second stage used two chambers for thrust and four verniers to provide steering. The Cyclone-2 was also offered with an optional N_2O_4/UDMH-propellant apogee kick stage (AKS), which was capable of conducting up to 14 restarts.

Cyclone-2 launches took place from Pad 20 at the Baikonur Cosmodrome in Kazakhstan. Payloads originating from there can be deployed to 51°, 65° and 97° orbits.

The Cyclone-3's first and second stages are identical to the Cyclone-2's, but the -3 features a multistart third stage, which also burns N_2O_4 and UDMH. The Cyclone-3 can boost several spacecraft into orbit simultaneously and has carried as many as six small satellites into low-Earth orbit (LEO).

Cyclone-3s blast off from one of two pads at the Plesetsk Cosmodrome near the Arctic Circle. Plesetsk is used for placing payloads in equatorial inclinations of 63°, 73.5° and 82.5°. Inclinations from either Baikonur or Plesetsk are constrained by the need to jettison spent stages over special impact zones.

In typical Ukrainian and Russian fashion, Cyclone rockets are assembled, mated with the spacecraft, and transported to the pad in a horizontal position. Access to the satellite is limited once the vehicle is placed vertically on the launch pad. Cyclone launches are highly automated, requiring few ground personnel, and turnaround times between launches can be as short as one day.

Cyclone-4 was being developed and produced by Ukrainian firms Yuzhny Machine Building Plant and Yuzhnoye Design Bureau with assistance from the Brazilian Space Agency (AEB) and other, unnamed Brazilian partners. The Cyclone-4 is an enhanced variant of the Cyclone-3, with an advanced control system and an uprated third-stage booster providing 30 percent more fuel capacity and in-flight restart capability. It has a new RD-861K third-stage engine, and can carry 1,700 kilograms of payload to geostationary orbit (35,790 km) and 4,500 kilograms to low-Earth orbit (500 km). Cyclone-4 was to launch from Brazil's equatorial Alcantara launch site.

The Cyclone-2K variant was said to be in production for launch by the end of 2004, but a more accurate term would be "conversion," as it appears that about seven mothballed Cyclone-2s will be converted to the 2K variant for future use. The plan for the conversions was released in 2005.

The 2K is a standard two-stage Cyclone with a third-stage boost engine that was used on the SS-24 Satan ballistic missile. Cyclone-2K is said to lift 1,800 kilograms (3,960 lb) of payload into an 800-kilometer (500-mi) sun-synchronous orbit, at a cost of $8,000 per kilogram. Russia's Puskovie Uslugi manages the Cyclone-2K program.

	Metric	U.S.
Dimensions		
First Stage Length	18.7 m	61.5 ft
Second Stage Length	10.1 m	33.1 ft
Third Stage Length (Cyclone-3)	2.8 m	9.0 ft
First and Second Stage Diameter	3 m	9.8 ft
Third Stage Diameter (Cyclone-3)	2.2 m	7 ft

Cyclone

	Metric	U.S.
Weights		
Cyclone-2 Gross Mass	180,000 kg	396,800 lb
Cyclone-3 Gross Mass	184,600 kg	406,970 lb
Performance		
Cyclone-2 to 200 km, 51°	3,350 kg	7,385 lb
Cyclone-2 to 200 km, 65°	2,820 kg	6,217 lb
Cyclone-2/AKS to 407 km, 51.6°	2,850 kg	6,283 lb
Cyclone-2/AKS to 800 km, 98.6°	2,100 kg	4,630 lb
Cyclone-2K to 800 km SSO	1,800 kg	3,960 lb
Cyclone-3 to 200 km LEO	4,100 kg	9,041 lb
Cyclone-3 to GEO	600 kg	1,323 lb
Cyclone-4 to GEO	1,700 kg	3,749 lb
Cyclone-4 to 500 km LEO	4,500 kg	9,923 lb

Propulsion	Stage 1	Stage 2	Stage 3
Cyclone-2/2A	RD-251 (= 3 RD-250) + 4 RD-68M	RD-252 + 4 RD-69M	n/a
Cyclone-2K	RD-251 (= 3 RD-250) + 4 RD-68M	RD-252 + 4 RD-69M	APM-600
Cyclone-3	RD-261 (= 3 RD-260) + 4 RD-68M	RD-262 + 4 RD-69M	S5M/RD-861
Cyclone-4	RD-261 (= 3 RD-260) + 4 RD-68M	RD-262 + 4 RD-69M	RD-861K

n/a = not applicable

Variants/Upgrades

Cyclone-2 (F-1/SL-11). Two-stage vehicle available with optional AKS.

Cyclone-3 (F-2/SL-14). Three-stage vehicle with restartable upper stage.

Cyclone-2K. Three-stage vehicle using APM-600 upper stage.

Cyclone-4. An upgraded Cyclone-3 featuring greater fuel and payload capacity, a new RD-861K third-stage engine, and more accurate control.

Program Review

Background. Derived from the SS-9 (NATO code-name Scarp) ICBM, the Cyclone-2 first appeared in 1966 as the F-1-r/SL-10 and was followed a year later by the F-1/SL-11. Cyclone-2 boosters were used primarily for military payloads, including the Fractional Orbit Bombardment System (FOBS) and satellite interceptor.

The Cyclone-3 entered the scene in 1977 and took over payloads previously launched on the smaller Cosmos and larger Vostok vehicles. Payloads launched into space using this vehicle have included communications, meteorology, remote sensing, science, geodesy, electronic intelligence, and small military spacecraft.

Although the Cyclone-3 has been commercially available since 1987, it was not until 1993 that it performed a commercial mission, carrying a small Italian Temisat data relay experiment satellite into LEO. A year later, a Cyclone-3 boosted the German Tubsat spacecraft. Both payloads flew piggyback with Russian spacecraft.

Cyclone rockets historically competed against the Ukrainian Zenit family of launchers for Western satellite launches. Ultimately, the Zenit (-3 variant) was selected as the basis for the Boeing Sea Launch program, which lofts payloads from a unique, ship-based platform in the Pacific Ocean.

With the collapse of the Soviet Union, the Ukrainian manufacturer ended up in a different country, most inconvenient for a launcher used for national security payloads. Existing stocks of the vehicle were used, but no new ones were built. In 1998, the launch team at Baikonur was dissolved, and only four launch vehicles remained in reserve storage.

Deal for Alcantara Launches Struck

Brazil and Ukraine struck a deal in 1999 to develop and launch an uprated Cyclone-4 variant at Brazil's sorely underused Alcantara equatorial space center. Located at 2.3° S, the facility would allow Cyclone missions to inclinations between 2.2° and 100°, and would allow the Cyclone-4 to carry heavier payloads into LEO. The two

nations signed space cooperation agreements in Kiev in January 2002 for use of the Alcantara range. Under the terms, a joint-venture space research center would be built in Brazil for use by Ukrainian researchers. Ukraine would allow Brazil to gain some much-needed technical experience by developing the Cyclone-4 launchers, although any "sensitive" Ukrainian satellite technology would remain protected. The new firm included the Yuzhny Machine Building Plant and Yuzhnoye Design Bureau, but the full list of Brazilian partners was not announced.

Tragedy at Jungle Launch Site

In August 2003, over 700 experts, technicians, and Army personnel at the Alcantara launch base were working around the clock to complete the 65-foot Brazilian vertical launch system (VLS) rocket. The planning and preparations were abruptly and violently brought to an end when more than 21 Brazilian space technicians and engineers were killed and another 20 injured in a massive rocket explosion. The explosion destroyed the Brazilian VLS rocket and two satellites. The accident was a severe blow to Brazil's burgeoning space program.

It was determined that during routine prelaunch preparations, one of the Brazilian-designed VLS-1 VO3 rocket's four S-43 strap-on boosters ignited, triggering an explosion that destroyed the launch pad. News of the accident reached the Brazilian capital just as the head of the Brazilian Space Agency was holding a news conference with his Ukrainian counterpart to announce a deal to launch Ukrainian Cyclone rockets from Alcantara. Brazil's then-president, Luiz Inacio Lula da Silva, said at the time that the accident would not derail the Ukrainian deal.

Cyclone-4 Development Moves Forward

In November 2003, the governments of Brazil and Ukraine announced the completion of the formation of the new joint enterprise known as Alcantara Cyclone Space. And with that, the framework deal (finalized on the day of the Alcantara tragedy) was signed.

Under the terms of the arrangement, the two nations equally split the $105 million funding requirement for the project. The Ukraine portion included $40 million for development of the Cyclone-4, while Brazil was developing the Alcantara launch facilities and infrastructure, which had to be enlarged.

The Alcantara Cyclone Space venture was designed to cater to the needs of the space programs in Ukraine and Brazil, but both countries made it clear that they would actively market the vehicle to other countries as well. Germany and Argentina expressed interest in using the launch vehicle.

In December 2009, Brazilian President Lula and Ukrainian President Viktor Yushchenko met in Ukraine to discuss a number of economic initiatives, including the Cyclone-4 project. The two (then) presidents committed to a first launch of the Cyclone-4 by the end of 2010.

Despite the agreement, delays continued to mount for the Cyclone-4 program. Construction of the Alcantara launch site did not begin until September 2010. Political and economic problems in Ukraine due to the conflict with Russia created additional delays. Partners had problems raising enough financing to fund the program.

By April 2015, Brazil decided to stop its participation in the program. With the economy slipping in Brazil, the long delayed program has become a target for cost cutting. Petronio Noronha de Souza, the Brazilian Space Agency's director of space policy, said that there are too many questions about program cost and the potential market for the launch vehicle.

Timetable

As of April 2012, the Cyclone-2 had performed 105 launches with only two failures, for a 98.1 percent success rate. The Cyclone-3 has logged 121 missions, including eight failures, for a 93 percent success rate. The chart below lists only initial launches.

Month	Year	Major Development
Sep	1967	First Cyclone-2 launch
Jun	1977	First Cyclone-3 launch
Sep	2010	Construction begins at Alcantara launch site
Apr	2015	Brazil pulls out of Cyclone-4 project

Forecast Rationale

With Brazil pulling out of the Cyclone-4 program, production will end for the launch vehicle. Originally intended to launch in 2010, the program experienced years of delays and cost overruns. One problem was a delay in doing the necessary upgrades to the Alcantara launch site.

The most recent trouble for the program was the conflict between Russia and Ukraine, which has caused delays with the delivery of components, a lack of available finances to fund the program, and chaos within Ukraine due to intense fighting – particularly between the Ukrainian government and rebels in the east. Reports indicate that Ukraine's aerospace industry faces a crisis due to these issues.

Reports that Brazil would pull out of the program entirely began to surface in March 2015. Termination of Brazil's participation was confirmed a month later when the Brazilian Space Agency's (AEB's) director of space policy and strategic investments, Petronio Noronha de Souza, said the program had suffered from budget and technological issues, as well as problems between Brazil and Ukraine. In addition, Brazil has begun to question the commercial market for the Cyclone-4.

Without Brazil providing a launch base and financial backing, Ukraine will be unable to continue development of the launch vehicle, or conduct commercial launches. Therefore, Forecast International expects there to be no production of the Cyclone-4. Unless another major player steps in to resurrect the program, this report will be archived next year.

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