Chapter 20

REST-OF-WORLD (ROW) SPACE LAUNCH

Missiles and space have a long and related history. All the early space boosters, both U.S. and Russian, were developed from ballistic missile programs. Today, many other nations are using their missile and rocket technology to develop a space launch capability.

COMMONWEALTH AND INDEPENDENT STATES (CIS) RUSSIAN / UKRAINE / KAZAKH SPACE LAUNCH SYSTEMS

Space Launch Facilities

The breakup of the former Soviet Union (FSU) into independent states has fragmented and divided the Russian space support infrastructure. This has resulted in planning and scheduling difficulties for Russia, the main inheritor of the remains of the former Soviet space program. Ukraine has the most extensive space capability after Russia but with no space launch facility, followed by Kazakhstan with a major space launch facility but little industrial base. Other newly independent countries have some limited manufacturing capability related to the space industry. Russia's spaceports are now located in two different countries. The program's oldest and biggest spaceport, and the only site currently able to do manned launches is Baikonur Cosmodrome or Tyuratam in Kazakhstan. Within Russia, there are three spaceports. There are two from the former Soviet space program: Plesetsk Cosmodrome and Kapustin Yar Space and Missile Test Facility, and the new Russian spaceport in Siberia, Svobodny Cosmodrome. The Russian's have also developed and marketed a space booster based on a Submarine Launched Ballistic Missile (SLBM) which has launched a satellite into orbit from the Barents Sea. Counting this undersea space launch platform, Russia can use five different launch locations.

Tyuratam (TT)/Baikonur Cosmodrome

In the 1950s, the Soviet Union announced that space launch operations were being conducted from the Baikonur Cosmodrome. Some concluded that this facility was near the city of Baikonur, Kazakhstan. In truth, the launch facilities are 400 Km to the southwest, near the railhead at Tyuratam (45.9ºN, 63.3ºE). The Soviets built the city of Leninsk near the facility to provide apartments, schools and administrative support to the tens of thousands of workers at the launch facility. Sputnik, the first man-made satellite, was launched from TT in October 1957. This site has been the location of all manned and geostationary orbit Soviet and CIS launches as well as most lunar, planetary launches. Additionally, it is the only facility that supports launches of the Proton (SL-12 and SL-13), the Zenit (SL-16) and the Energia (SL-17). The climate is hot in the summer and suffers violent snowstorms and -40ºC temperatures in the winter. A unique feature of the Russian/CIS space program is its ability to launch in extremely harsh climates. Since the demise of the Soviet Union, Kazakhstan has claimed ownership of the facility. However, most of the skilled workers and the military forces protecting the site are Russian. To use the facilities at Tyruatam, Russia must pay rent to Kazakhstan.

Kapustin Yar (KY)

Kapustin Yar Space and Missile Test Center (48.4°N, 45.8°E) is located on the banks of the Volga River, about 120 Km east of Volgograd and less than 48 Km west of Kazakhstan. In 1947, this site was selected as the location for the development of the Soviet rocket and space program. Numerous German V-2 rocket launches were made from here during testing and development. The first Soviet-built rocket systems, the R-1 and R-2, were launched from here in 1948 and 1949. In the past, this facility was the site of numerous sounding rockets and small orbital payload launches using the SL-8/Kosmos. There were no space launches from Kapustin Yar from 1987 until April 1999 when a commercial launch was performed for a German satellite. Kapustin Yar's proximity to Kazakhstan now precludes eastward launches without prior approval of that government.

Plesetsk (PK) Cosmodrome

Plesetsk Cosmodrome (63.8°N, 40.7°E) is about 640 Km northeast of St. Petersburg. PK is situated in a heavily wooded area close to the Arctic Circle. It is near the town of Plesetsk on the railway line from Moscow to Archangelsk. Although used for civilian communications, meteorological and international launches; most launches from PK have military roles. The site may be considered as the Russian equivalent of Vandenberg AFB. Orbital inclinations attained from PK range from 63° to 83°. Historically, it is the port of debarkation for over 1,300 launches, or more than one third of all orbital or planetary missions from all launch sites world-wide. It typically is used to deliver most (if not all) Russian polar orbiting sensor payloads and many Molniya orbit payloads. The high inclination of the Molniya communications satellites is a natural result of an eastward launch from PK. Because the launch site is on Russian soil and the flight profile does not pass over any other countries during the boost phase, the requirement for coordination with other countries is minimal. There are launch pads for the SL-4, SL-6, SL-8, SL-14 and the SL-19 space launch vehicles. Additionally, launches of the SL-3 and SL-11 could also be conducted, if necessary. The extreme northern latitude of PK has provided the Russians with valuable experience in cold weather launch operations.

Svobodny Cosmodrome

When the breakup of the Soviet Union left Russia's largest spaceport of Tyuratum in Kazakhstan, experts concluded that Russia needed another spaceport. Svobodny Cosmodrome (51.2°N, 128.0°E) was selected in 1993 to fill this role. It is the site of a former ICBM base along the Trans-Siberian railway. Plans call for Svobodny to incrementally come on line as a spaceport. At first, the existing facilities of the former ICBM base will be used to launch Rokot and START-series vehicles. In later stages, launch facilities will be built to support the heavy Angara launch vehicle. Svobodny became Russia's fourth spaceport with the launch of a START-1 on 4 March 1997. A second START-1 was launched in December 1997 and a third in late 2000.

Barents Sea Launch Area

With the development of a space booster from an SLBM, the Russian's have demonstrated the potential ability to launch a small satellite from almost anywhere in the world. All Russian tests and its first commercial satellite from a submarine have all taken place from near Russian home waters in the Barents Sea located north of the Kola Peninsula, the homeport of Russia's ballistic missile submarine fleet. This first underwater launch of a satellite placed a German university built scientific satellite into a polar, low earth orbit.

Russian Space Launch Vehicles

The FSU developed an impressive array of SLVs, mostly derived from Intercontinental Ballistic Missiles (ICBMs). On more than one occasion, Russia has demonstrated the ability to conduct multiple launches within a short period of time. The SLV names such as Proton used in this chapter are Russian. The "SL-#" designation is assigned by DOD. The letter-number designation, such as “A-1”, was developed by Dr. Charles Sheldon, U.S. Congressional Research Service, to differentiate between launch vehicle families and their variants. This system is no longer used but is still found in some publications. Since the break-up of the Soviet Union, many FSU countries and companies have been marketing former Soviet booster for international and commercial space lift. This trend has lead to the increased use of the Russian names for these boosters in press releases and news reports. **Table 20-1** at the end of this SLV section is a matrix providing a list of all three types of names.

Soyuz Series (A-Class, Soyuz, Molniya)

The Soyuz class of launch vehicles is based on the original Soviet ICBM, the SS-6 Sapwood (**Fig. 20-1**), which was first tested as a missile on 2 August 1957. Its first use as a space vehicle was only two months later, suggesting concurrent development as an ICBM and SLV. This ICBM has provided, in various forms, the initial stages of a whole family of SLVs including the operational Vostok, Soyuz and Molniya SLVs.

Fig. 20-1. SS-6

The original version, the A vehicle (or SL-1/2) is classified as a one and one-half stage vehicle. It consists of a central core with four strap-on boosters. The Russians classified this as a two-stage assembly, but since the engines of the strap-ons and the central sustainer ignite simultaneously at lift off, this parallel staging arrangement is generally regarded as a one and one-half-stage vehicle. This vehicle launched the first three Sputnik satellites in 1957 and 1958. The third and largest Sputnik had a mass of 1327 Kg and was delivered to a 122 by 1016 nm orbit. All three A launches were conducted from TT.

To satisfy the need to launch bigger payloads, the Vostok (A-1/SL-3) (**Fig. 20-2**) was introduced in 1959.

With an SS-6 first stage, the Vostok has a second stage attached by a trellis-like structure. The initial version of the A-1 vehicle was used to launch the Luna moon payload. The payload fairing was then enlarged to launch the manned Vostok as well as the first-generation recoverable Kosmos satellites. With a larger and more sophisticated payload fairing used on the Vostok, the overall length of the booster increased to 38m from about 34m. Initially the Vostok was launched from TT and later from PK. PK no longer launches the Vostok, although the capability still exists. There have been about 150 successful Vostok launches.

Fig. 20-2. SL-3 Vostok

The Soyuz (A-2/SL-4) premiered in 1963, with the development of a more powerful core second stage. This SLV has been the workhorse of the Soviet rocket program (**Fig. 20-3**). Since 1964, all Soviet manned missions have relied on the SL-4. However, the largest program it supports is military and civilian photographic reconnaissance flights. It is used today to launch the Soyuz, Progress

Fig. 20-3. SL-4 Soyuz

and Biosats, as well as Kosmos observation satellites. It also launched the Voskhod manned vehicles. Over 900 Soyuz have been flown successfully from TT and PK. Normally launched 40-50 times a year, the Soyuz is by far the most launched SLV in the world.

During the 1960s, the Molniya SLV (A-2-e/SL-6) supported all Soviet planetary missions and most lunar flights, such as Luna, Zond and Venera payloads. It differs from Soyuz mainly with the addition of a core third stage. Today, this SLV supports Molniya communications satellite and Kosmos early warning satellite programs, which require highly elliptical, semi-synchronous orbits. The Molniya rocket was initially flown out of TT but is now flown from PK.

The Soyuz SLVs have dominated the Russian space program, having performed about 60% of the all launches. Since 1957, A-class boosters have placed more than 1,300 payloads into earth orbit.

The most recent versions of the Soyuz family are the SL-22, Soyuz/Ikar **(Fig. 20-4)** and the SL-26, Soyuz/Fregat. These boosters were modified from the original Soyuz by the addition of a new upper stage, either the Ikar or the Fregat. Both boosters are a commercial venture between France and Russia to perform commercial launches with versions of the SL-4 Soyuz. Depending on the satellite payload requirements, different upper stages may be used or special purpose built.

Fig. 20-4. SL-22 - Soyuz-Ikar

Launch Processing. Three or four weeks before the launch, the components of the A-class SLV are delivered to the Space Vehicle Assembly Building (MIK) assembly complex in up to seven parts (4 strap-on boosters, first, second and third stages). In a few days, the separate parts are horizontally mated. After a successful integration test, the entire SLV, with its payload, is carried on a rail transporter-erector car to the launch pad, then tilted up to sit on a stand over a huge flame deflector pit.

The payload or satellite is also delivered to the launch facility by rail. The prospective satellite first goes to the MIK for initial pre-launch check-out. It is then carried by a special transport to the fueling facilities several kilometers from the launch site. Once fully fueled, the spacecraft is transported back to the MIK for horizontal mating with the SLV and final pre-pad checkout.

The launch structure for the vehicle employs four releasable support beams which accept the weight of the SLV. The SLV is suspended over the gas deflecting trough with its tail portion 7m below the level of the platform.

After ignition, the four support beams are initially held in place by the weight of the booster. Counterweights cause these four beams to fall back and allow the climbing SLV to clear the structure.

The A-class SLVs are normally brought to the pad less than 48 hours before liftoff. They are capable of launching in severe weather conditions including dense fog, wind, rain and snow.

Flight Sequence. The following table shows the sequence of a Soyuz Manned LEO Mission Launch:

MIN:SEC	
0:00	Lift Off
1:58	Strap-on boosters separate
2:40	Escape system jettison command
5:00	1st stage separation
	2nd stage ignition
9:00	2nd stage shutdown
9:43	Spacecraft orbital injection

Kosmos Series (C-Class SLVs, Kosmos)

The Kosmos (C-1/SL-8) (**Fig. 20-5**) was first launched in 1964. It is a two-stage, storable propellant SLV with the capability to place 1350 Kg into low-earth orbit (LEO). This bridged the payload gap between the older SL-7 (B-1) booster, which was capable of placing 600 Kg into LEO and the A-class boosters capable of placing 4730 Kg to LEO. As with earlier SLVs, a missile, in this case the SS-5 Skean, was used as the first stage.

Kosmos' first use launched the triple payload of Kosmos 38, 39 and 40 out of TT. Launching multiple small payloads with a single Kosmos has remained a common mission. Initially launched from TT, PK has been the launch site since 1966. Today, nearly all Kosmos launches are conducted at PK, although a few were conducted from KY. Kosmos is the first and only SLV to date that has been launched from three operational launch sites.

Fig. 20-5. SL-8 Kosmos

In 1983 and 1984, Kosmos launched four BOR-4 lifting bodies under the names Kosmos 1374, 1445, 1517 and 1614. These sub-scale space plane missions were conducted for the Buran space shuttle program to test heat resistant reentry materials and gather additional transonic aerodynamic data. The four space missions were successful, culminating in recoveries in the Indian Ocean or the Black Sea.

Today, Kosmos has replaced the B-1 SLV. Its annual flight rate has dropped to pre-1970 levels and many of its payloads have been transferred to the more capable and more modern Tsyklon booster. Primary payloads are low-altitude navigation satellites and store/ dump communications satellites.

Launch Processing. Launch processing is the same as A-class SLVs, with payload check-out and fueling done prior to mating horizontally with the SLV and being moved to the pad for launch. However, different launch sites and pad structures are used.

Proton Series (D-Class, Proton)

Until the 1987 launch of the Energia, for over 20 years, the Proton was the largest operational booster. However, not until the launch of the two Vega probes to Halley's comet in December 1984 did the world receive its first complete view of the Proton SLV.

Additional data has since been made available as a result of Glasnost and the Russian/CIS effort to compete in the commercial world market.

There are three variants of the Proton; a two, three or four stage SLV. The first three stages of the Proton were designed in the early 1960's by the design bureau headed by V.H. Chelomey. It was the first Soviet SLV design not based on an existing ballistic missile.

The original version of the Proton is known in the west as the D or SL-9 SLV (**Fig. 20-6**). It consists of two stages; the first with a cluster of six engines and the second with a cluster of four. No longer in use, the original D SLV was only used four times in 1965 and 1966 to launch Proton 1 through 4 satellites, thus naming the booster. The payloads were 12,000 Kg; well below what the SLV was capable of placing into orbit.

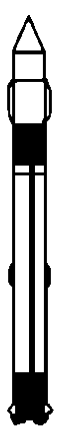

Fig. 20-6. SL-9 Proton

The next two versions of the Proton, still in operation today, are the D-1 (SL-13) and the D-1-e (SL-12) (Fig. 20-7). The D-1 consists of the D's first two stages plus a new third stage. This SLV, first flown in 1968, has flown LEO payloads including all of the Soviet space stations from Salyut 1 in 1971 to the Mir in 1986.

The D-1-e consists of the D-1's three stages plus a fourth stage for orbit transfer or escape. This SLV, first flown in 1967, has flown geosynchronous communication satellites like the Ekran, Raduga and Gorizont, and interplanetary satellites like the Zond and Luna missions to the Moon, Venera to Venus, Vega to Haley's comet and Mars and Phobos to Mars. Nearly 90% of Proton launches used the D-1-e variant.

Fig. 20-7. SL-12 Proton

In December 1968, before the Apollo 8 mission, the Soviets scheduled a Zond mission on a Proton to carry Aleksei Leonov and Oleg Makarov around the moon and back to earth. That mission was scrubbed when an unmanned Zond 6 suffered cabin decompression the month before. There are no current plans to man-rate the Proton for cosmonauts. All Proton launches are conducted from TT.

Flight rate of the Proton **(Fig. 20-7)** steadily grew from an initial six launches in 1970 to a peak of 14 in 2000. The Proton SLV was considered operational in 1970 despite failing on seven out of nine missions in 1969. Between 1983 and 1986, the Proton had its longest string of consecutive launch successes, totaling

43. Recently, about 10% of all CIS launches are Proton launches.

The Proton SLV can deliver 20,000 Kg to LEO, 5,700 Kg to lunar transfer trajectories, 5500 Kg to geo-transfer orbit and 2,800 Kg to sun-synchronous polar orbits.

The newest version of the Proton is the SL-25. This booster has a new upper stage, the Breeze. This new stage allows for improved performance placing satellite in orbit.

Launch Processing. The special, technical and launching complexes for the Proton SLV are at the Baikonur Cosmodrome or TT. The technical complex is equipped with railroad spurs and engineering service lines that are used to transport the SLV and its payload through-out the complex.

Fig. 20-8 Proton

The main building of the technical complex is the integration and testing facility. Assembly and integration of the Proton booster stages **(Fig. 20-8)** are carried out in the horizontal position. Special jigs and assembly mating trolleys are used to accomplish these functions. The jig, used for the SLVs first stage assembly, is the most important.

The central block of the launch vehicle is fixed horizontally on the jig and can be rotated around the x-axis. One of the first stage lateral strap-on blocks is brought under the bottom of the central block by the assembly-integration trolley and is attached to the core vehicle. Next the trolley is removed, and the central core is rotated to the desired angle and the next of six lateral strap-ons is attached.

As soon as the central core and strap-ons are assembled into a single unit, they are removed from the jig by a bridge crane to the assembly integration erector trolley. Here the various units are mated to the next stage, after which the integration test of the assembled launch vehicle is carried out. Up to three Proton SLVs can be assembled in this facility in about 21 days and the assembly building can accommodate as many as six boosters at one time.

Once the spacecraft and the fourth stage are assembled and encapsulated in the satellite preparation building, (**Fig. 20-9**) they are transported to the Proton SLV horizontal assembly building located 6.5 Km from the Sputnik/Soyuz satellite technical zone.

Fig. 20-9. Satellite encapsulation

There the satellite is installed on the launch vehicle under the nose fairing and rolled out horizontally to be erected on the pad into a vertical position. Satellite thermal control is provided by an air conditioning system feeding air under the nose fairing.

There are two Proton launch complexes. Each complex consists of two launch pads located 600 meters apart.

The SLV is not suspended on the launcher system like the Soyuz SLV. It is erected directly on the supporting fixtures on the launch pad (**Fig. 20-10**). It takes four hours to erect and install the Proton on the pad. Normally the launch happens three to four days after installation on the pad. If a scrub were to occur, it would require 12 hours to de-fuel the booster and lower it to a horizontal position for the roll back to the assembly building.

Fig. 20-10. SL-12 Lift to launch pad

Launch is controlled from a special complex located 1.6 Km from the launch complex. At the moment of liftoff, the service mechanism rises with the SLV and tracks for the first few fractions of a second. The SLVs azimuth guidance is provided by its control system which can correct the rocket at the initial phase of flight to the calculated angle. This mechanism is then separated and withdrawn by a pneumatic accelerator and is secured behind an armored steel firewall cover. This steel cover helps to form part of the launch pad flame deflector.

Tsyklon Series (F-Class, Tsyklon)

As a SLV, Tsyklon was initially introduced as the F-1 booster. The SLV F-1-r (SL-10) was introduced in 1966 and followed a year later by the F-1-m (SL-11) (**Fig. 20-11**). Tsyklon is a derivative of the SS-9 SCARP ICBM.

The F-1 has been used mainly for military purposes; first for offensive weapons such as the Fractional Orbital Bombardment System (FOBS), then as an anti-satellite (ASAT) interceptor. Further, it has launched electronic/radar ocean reconnaissance satellites (EORSAT/ RORSAT). The FOBS version is often referred to as F-1-r, with the r standing for "retro-rocket" stage. This portion is actually part of the payload used to place the entire payload into a reentry trajectory. Similarly, the ASAT and the EORSAT/ RORSAT SLV is referred to as the F-1-m. The ***m*** stands for "maneuverable" stage, which is part of the payload.

Fig. 20-11. SL-11

The F-2 (SL-14) introduced in 1977, is an F-1 with an added small third stage. It performs a number of missions previously flown on the Kosmos and Vostok. These include launching communications, meteorology, remote sensing, science, geodesy, electronic intelligence and minor military payloads. The F-2 is launched from PK at a highly automated launch complex, placing payloads into orbits with inclinations between 73.5º and 82.5º.

The name "Tsyklon" (Cyclone), identified as part of the F-class of medium boosters, appeared first in 1987. Named by Glavkosmos, the Russian organization that markets space hardware on a commercial basis, the F-2 was offered as a commercial launch vehicle capable of delivering 4,000 Kg payloads into a circular orbit with a 200 Km altitude. The Tsyklon is comprised of three tandem-arranged stages and a shroud. It is fueled by nitrogen tetroxide and asymmetric dimethylhydrazine. The third stage and the payload are enclosed within the shroud.

The first stage has six thrust chambers and four verniers for thrust. The second stage has two thrust chambers and four verniers for thrust. The F-2 can boost several spacecraft into orbit simultaneously. It also can subsequently inject them into their individual orbits by using up to three low-thrust engines firing from the third stage. The third stage sustainer engine can be restarted twice under weightless conditions, permitting spacecraft placement in various orbits required for specific space missions. Typically, a single starting of the third stage sustainer is used for payload injection into orbits ranging from 200-250 Km in altitude;

double starting of the engine is used for injection into orbits higher than 250 Km. Russian documents indicate that out of the first 75 F-2s launched, 73 were successful. The Tsyklon **(Fig. 20-12)** was one of the boosters that was built in the Ukraine during the Soviet era and now be being built

Fig. 20-12. SL-14 Tsyklon

and marketed by Ukraine.

Launch Processing. The Tsyklon is assembled, mated with the spacecraft and transported to the pad in the horizontal position. Once the rocket is placed vertically on the launch pad, manual access to the SLV is lost. The ground servicing system of the Tsyklon provides for a high degree of automation of prelaunch and launch operations. This ground automation reduces the need for personnel at the launch pad and contributes to pad safety.

Zenit Series (J-Class, Zenit)

Zenit (J-1/SL-16) (**Fig. 20-13**) is another booster that the Ukraine built during the period of the Soviet Union. This system first appeared in 1985 launching two sub-orbital and two orbital tests, was the first totally new Soviet launch vehicle in 20 years. In May 1989, it was officially acknowledged as "Zenit" by vehicle designer Yuri A. Smetanin of the Soviet space agency Glavkosmos.

The SLV is a two stage, liquid oxygen/kerosene booster. The first stage is virtually identical to the Energia strap-on booster described below. The second stage has one sustainer engine and one four-chamber vernier powered by the same propellant. The two stage SLV can place a payload into a 1,500 Km orbit. A three stage version (Zenit-3) is also available. The third stage is similar to a Proton fourth stage (Block D). All launches of the Zenit occur from Baikonur Cosmodrome.

Currently, the Zenit supports a small military Electronic Intelligence (ELINT) program as well as remote sensing, scientific satellites and possible photo reconnaissance platforms.

Fig. 20-13.
SL-16 Zenit

A modified three stage Zenit has been developed for use by an international commercial launch corporation. This new booster, the SL-23 or Zenit-3SL is for use by the SeaLaunch International Corporation. A new upper, third stage was developed as well as improved electronics for the first and second stage.

The first launch of this booster **(Fig. 20-14)** was in May 1999.

Fig. 10.14 SL-23 Zenit-3SL

Energia Series (K-Class, Energia)

The history of the Energia (Energy) SLV (K-1/SL-17) and the Buran (Snowstorm) space shuttle dates back to the unsuccessful Soviet moon program planned to be flown on the N-1 (SL-15/G-1-e) heavy lift vehicle.

Begun in the 1970s, the Energia/Buran program design of this SLV was placed under the direction of NPO Energia. NPO Energia's direct predecessor was an enterprise headed by Sergei Korolev, who designed the first Sputniks and Vostok as well as the N-1. The Energia **(Fig. 20-15)** is designed with four strap-on liquid oxygen and kerosene boosters attached to a large diameter core that is capable of delivering 88,000 Kg to LEO with a kick stage. The core uses four liquid oxygen and liquid hydrogen propellant engines, the first cryogenic engines of their kind in the CIS fleet. Payloads are side mounted and are either an unmanned cargo carrier or the Buran orbiter. The Energia is only launched out of Baikonur Cosmodrome from pads associated with the N-1 moon launcher. At liftoff, the 60m tall Energia generates 7.8 million pounds of thrust.

The introduction of the Energia and Buran at Baikonur Cosmodrome required the construction of a very large infrastructure. The work began in 1978 with the construction of a landing strip for the shuttle. The landing strip is also used by the world's largest aircraft to bring in the Energia parts. The first parts of the Buran were delivered to Baikonur in 1982.

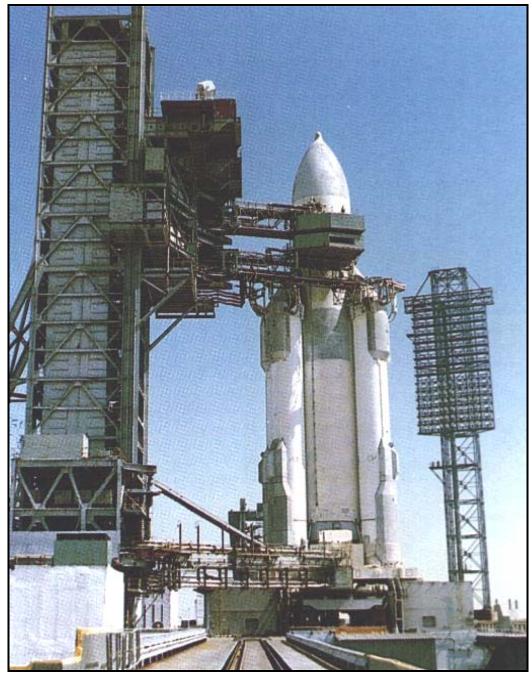

Fig. 20-15. SL-17 Energia

In 1985, the Zenit was successfully launched on its maiden launch. This was significant since the Zenit first stage is used as one of the four strap-ons of the Energia. Numerous successful launches of the Zenit and a successful ground test program enabled the decision to be made for the first Energia launch.

In 1987, the Energia was ready for launch. General Secretary Gorbachev visited Leninsk and the Baikonur Cosmodrome from 11 to 13 May. The report from his visit stated the Baikonur Cosmodrome was preparing to launch of a new all-purpose carrier rocket. News of the actual launch did not appear until the following day providing a launch time of 1730 GMT on May 15. The launch was conducted from a static test stand that was pressed into service for this first test launch. The announcement said the first stage landed in Soviet territory as planned. The second stage followed the flight plan precisely delivering the payload, a full size and weight mock-up of a satellite, to the calculated position. At the time of separation from the payload, the second stage fell into the pre-planned area in the Pacific Ocean.

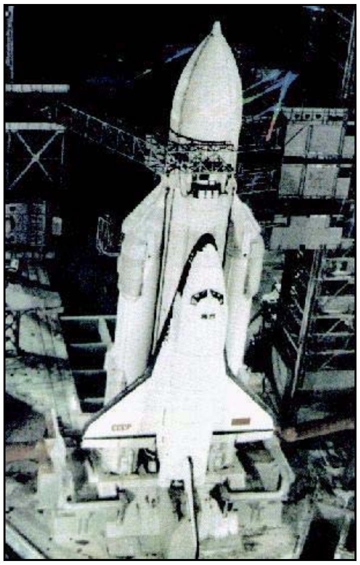

Fig. 20-16. SL-17 with Buran Space Shuttle

Apparently, the payload should have injected itself into orbit by means of its own engine. However, because of a malfunction of its onboard systems, it failed to do so and also fell into the Pacific Ocean. Although the mission was something less than a success, the launch announcement claimed that "the aims and objectives of the first launching have been fully met."

Although the Buran program was publicly denied and decried as economically unjustified, it was no longer a secret in the spring of 1983. At the Paris Air Show that year, Cosmonaut Igor Volk announced that the Soviets were building a space shuttle, the dimensions of which were approximately the same as those of the U.S. Space Shuttle (**Fig. 20-16**). The most complicated problems in developing the Buran were associated with its thermal protection system for the aluminum structure and landing system for a wide range of weather conditions.

As stated earlier, valuable data on heat resistant reentry materials and transonic aerodynamics was gathered during four flights of the BOR-4 sub-scale space plane between 1982 and 1984, which were launched by the Kosmos SLV. Experience with the Buran's handling capability during the final atmospheric flight portion was obtained in an experimental orbiter. This orbiter was equipped with jet engines which allowed it to take off from a normal airfield. Overall, 18 of the 24 flights performed by this experimental orbiter were fully automatic.

The only space flight of the Buran was on 15 November 1988. This flight was fully automated with no cosmonauts on board. After two orbits the unmanned spacecraft landed at Tyuratam's 4.5 Km long runway. Ironically, at this moment of triumph, the entire Soviet space effort was on the verge of huge cutbacks and cancellations due to the collapse of the Communist system.

New Systems

Despite current problems in the their space program, the Russians are continuing to design and develop new space boosters. Currently, new SLVs have been developed by converting ballistic missiles into launch systems.

Fig. 20-17 Start-1 SLV

Start Series

Start (SL-18)

The Start-1 SLV (**Fig. 20-17**) is based on the three stage SS-25 road-mobile ICBM. Start-1 consists of the SS-25's three solid motor stages plus an additional fourth solid motor stage. The system also employs a small liquid-propellant postboost stage to increase the accuracy of the final orbit injection. The first commercial launch of the Start-1 was in March 1997 and was also the initial launch from the Svobodny Cosmodrome **(Fig. 20-18)**

Fig. 20-18 SL-18 launch

Start (SL-20)

Like the Start-1 booster, the SL-20 Start SLV is also based on the three stage SS-25 road-mobile ICBM. By essentially inserting a duplicate second stage between the Start-1 second and third stage, the SL-20 Start is transformed into a five stage configuration. The first attempted launch of the Start was made March 1995, but was unsuccessful. To date, no additional launches of this booster have taken place.

Rokot Series (SL-19)

The Rokot SLV **(Fig. 20-19)** is based on the SS-19 ICBM. Due to the deactivation of numerous SS-19's because of arms reduction treaties, Russia decided to convert many of these highly reliable missiles into SLVs. Using SS-19 first and second stages with a newly designed third stage the SL-19 can place 1,900 kilogram satellites into low-earth orbit. The Breeze third stage is re-ignitable and has small thrusters for fine tuning of the final orbit maneuvers. An enlarged payload fairing containing a double launch system, "DOLASY," allows two satellites to be launched on one Rokot.

Fig. 20-19 SL-19 Rokot

There were three successful test flights of the Rokot system, two sub-orbital and one orbital, between 1990 and 1994. The first launch of the Rokot was in May 2000 with a test satellite from the Plesetsk Cosmodrome. This commercial launch is contracted by a joint German-Russian venture, EUROCKET. Several launches from at least three different sources have been contracted by EUROCKET.

Shtil (SL-21)

The SL-21 is a converted SS-N-23 liquid-fuel sea-launched ballistic missile. It was proposed for satellite launches by its builder, Makeyev of Russia. Since 1991, Makeyev has marketed and tested several SLBM's as satellite launchers. The Shtil ("Calm Sea") is the first to have been successfully marketed.

This SLV is capable of launching small satellites in place of its normal warhead. While advertised as being able to lift around 400 kilograms to LEO, the Shtil's first satellite payload was only ten kilograms. Makeyev plans to demonstrate the capability of its converted sea-launched ballistic missiles in order to attract potential customers. The first launch of the Shtil was in July 1998 **(Fig. 20-20).**

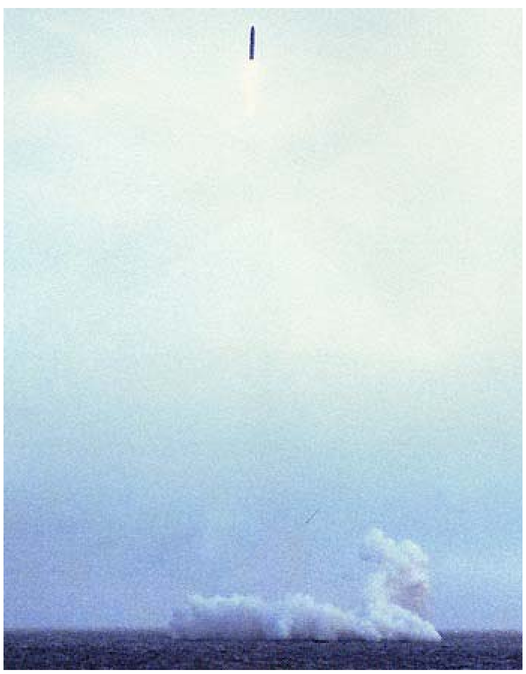

Fig. 20-20 SL-21 launch

One of the unique features of this system is that the launch platform is an active duty Russian Delta-VI ballistic missile submarine **(Fig. 20-21)**. Payment for this launch was reported to be directly to the Russian Navy. The launch of a German university satellite was the first ever launch of a satellite from a submerged submarine at sea.

Fig. 20-21. Delta-IV

Dnepr Series (SL-24)

The *Dnepr* SLV's boosters are based on the SS-18 ICBM **(Fig. 20-22).** As with the SL-19, Russia is required to eliminate its SS-18 by 2007 and has elected to convert them into space boosters. This requires the help of Ukraine, which designed and built the SS-18 in the former Soviet Union. The booster is essentially identical to the SS-18, with the missile's post-boost vehicle serving as a small orbital insertion stage. The small size of this third stage limits the basic version to delivering satellites to relatively low-earth orbits.

Fig. 20-22. SS-18 ICBM

An improved *Dnepr* may employ the same third stage of the Tsyklon (SL-14) in place of the SS-18 third stage, providing increased performance to higher circular and elliptical orbits.

This booster is marketed by a joint Ukrainian/Russian company. The first commercial, in fact the first launch, of the *Dnepr* was in April 1999 with a British built satellite.

RESEARCH AND DEVELOPMENT SYSTEMS

Russia is currently working several new boosters to replace many of their older Soviet era systems. One of the goals of this program is to have these new boosters built totally in Russia. During the Soviet era some of the design and building of booster or their components was done in other former republics.

Soyuz-2 (Rus)

The Soyuz-2 is the conversion of an upgraded A-class vehicle to replace the current Soyuz (SL-4) and Molniya (SL-6) boosters. The Soyuz-2 will preserve the basic A-class configuration. The strap-ons and core first stage will remain externally unchanged, although the engines will reportedly be modified. The core second stage is to be upgraded with a modern guidance system for improved accuracy. The Molniya core third stage will be replaced by a slightly larger stage.

The term "Rus," commonly reported as the name of the upgraded A-class launch vehicle, actually refers to the upgrade program, not the vehicle itself.

It appears that much of the development of this new version of the Soyuz family is being sponsored by Starsem. This joint French-Russian company markets the Soyuz booster for international launches. New, improved booster would improve the marketability of the company and its boosters.

Angara Series

The Angara is a space booster family designed for injecting satellites into low, middle, high circular and elliptical orbits, including both geo-stationary as well as interplanetary trajectories. This all-new Russian built booster is expected to replace the Ukrainian built Zenit and possibly the Russian built Proton.

Fig. 20-23. Angara model

The system is designed around a common core center stage. Changes to the upper stage give different capabilities to the basic version, producing the 1.1 and 1.2 boosters. Heavier payloads can be lifted by add additional common core stages to the first stage. This system allows for the 3.0 version with two additional stages and the 5.0 version with four additional cores **(Fig. 20-23).** All the components are sized for rail transport to the cosmodromes at Plesetsk and Svobodny

Lift goals for the Angara booster are stated as 26,000 kilograms to LEO and 4,500 kilograms to geosynchronous transfer.

There are several other existing or planned launcher projects such as follow-ons of the SL-21 "Shtil", new upper stages for older boosters and other totally new projects like the "Arkc" spaceplane and "Burlak" air-launched booster, about which little is known .

Table 20-1. Russian/CIS Space Launch Systems

Russian/CIS Name	DOD Designation	Sheldon Designation
Vostok	SL-3	A-1
Soyuz	SL-4	A-2
Molniya	SL-6	A-2-e
Kosmos (Interkosmos)	SL-7	B-1
Kosmos	SL-8	C-1
Tsyklon	SL-11	F-1
Proton (Gorizont)	SL-12	D-1-e
Proton	SL-13	D-1
Tsyklon (Meteor)	SL-14	F-2
Zenit	SL-16	J-1
Energia	SL-17	K-1
Start-1	SL-18	N/A
Rokot	SL-19	N/A
Start	SL-20	N/A
Shtil	SL-21	N/A
Soyuz-Ikar	SL-22	N/A
Zenit-3SL	SL-23	N/A
Dnepr-1	SL-24	N/A
Proton (Breeze)	SL-25	N/A
Soyuz-Fregat	SL-26	N/A

EUROPEAN SPACE PROGRAM

The idea of creating an independent space power in Europe goes back to the early 1960s. In 1962, Belgium, France, Germany, Italy, the Netherlands, the United Kingdom and Australia formed the European Launcher Development Organization (ELDO) to develop and build a launcher system.

In the same year, these countries plus Denmark, Spain, Sweden and Switzerland formed the European Space Organization (ESRO) to develop satellite programs. Ten years later these partners merged the activities of the two separate bodies into a single organization and laid down the foundation for the European Space Agency (ESA).

In 1975, Ireland applied to join these ten countries and become a member of ESA. On 30 October 1980, the final signature ratifying the Convention gave legal existence to ESA. Since then, the founding members have also been joined by Austria, Norway and Finland.

Each country has their own space program and organization, but the members cooperate on various launcher, satellite, control and subsystems that are of interest or benefit to their own country.

ESA Space Launch Facility

ESA has one operational spaceport located near Kourou, French Guiana in South America (5.2°N, 52.8°W). The site at Kourou (see **Fig. 20-24**) was chosen by the French space agency (CNES) in 1964.

This was to replace its former launch site in Algeria, which was closed in 1967 as part of the Algerian independence agreement. The geographical location of the site is exceptionally good. Because of its proximity to the equator, the site enables launchers to take full advantage of the Earth's rotation and also avoids the need for costly maneuvers after launch to achieve the equatorial orbit required for geostationary positions.

The Guiana Space Center (CGS) became operational in 1968 and the first orbital launch was in 1970. Since then, there have been more that 100 launches from Kourou using a variety of launch vehicles. Due to lack of obstacles both to the East and North, orbital inclinations attained from Kourou, range from 5 degrees to 100 degrees. This permits launches into equatorial, polar and sun-synchronous orbits. There are two active launchpads at the site. They are the second Ariane facility, ELA-2, used for the

Fig. 20-24. ESA Locations/Facilities

Ariane-4 series SLV and the newest, ELA-3, (**Fig. 20-25**) used for the Ariane-5 SLV. Earlier pads for the Europa and Diamant as well as the first Ariane launch facility, ELA-1, are no longer used.

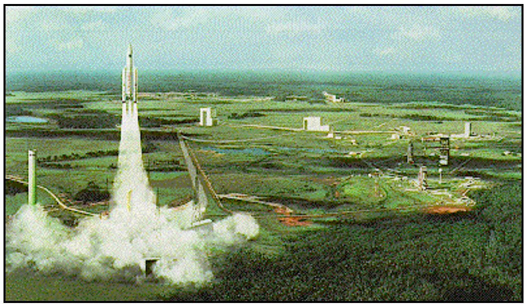

Fig. 20-25. ELA-2/ELA-3

ESA Space Launch Vehicles

The first ESA launcher was the Diamant. Initially part of an earlier French program, it was used between 1965 and 1975. Launches between 1965 and 1967 were from the French launch site in Hammaguir, Algeria. The first Diamant launch from Kourou was in March 1970. The Diamant had six successful launches out of a total of eight attempts. The Europa launcher was a joint British, French and German booster tested between 1964 and 1971. Five of the 11 launch attempts made with the Europa booster were successful. Only the last launch of this series was made from Kourou, all the rest being launched from Woomera, Australia.

In 1973, the nations who subsequently formed the European Space Agency, chose the Ariane program as their launch vehicle. This program was based on proven know-how and technologies gained in various national programs. One of the defining concepts of the Ariane launcher was it had to be able to subsequently evolve. Ideas about how it should evolve took shape early in the program.

The first Ariane booster flew on 24 December 1979. Since then, the Ariane family of boosters has become a prime commercial satellite launcher used by many countries.

Ariane-1/2/3

The Ariane-1 was flown 11 times between 1979 and 1986. The three-stage launcher was capable of placing a 1,850 Kg payload into a geostationary transfer orbit (GTO).

Derived from the Ariane-1, both the Ariane-2 and 3 had an improved third stage, while the Ariane-3 also mounted two strap-on boosters. Payload lifting ability to GTO was improved to 2,175 Kg and 2,700 Kg, respectively. There were a total of 17 launches of the Ariane-2/3 series between 1984 and 1989. To increase the utility of the Ariane booster, a system was developed to launch two satellites on the same booster. The Ariane Dual Launch System or Systeme de Lancement Double Ariane (SYLDA) had one satellite sitting on top while it served as a shroud for the second satellite.

Ariane-4

In 1982, ESA embarked on the development of the Ariane-4 program. Having become a leading commercial launching company, ESA needed to be able to adapt to a variety of payloads in the commercial market. The Ariane-4 program gave rise to a true family of launchers. The core stage of the Ariane-4 is longer than Ariane-3, with an increased capacity for propellant. Various combinations of solid or liquid propellant boosters are strapped to this core section, providing a total of six possible versions.

The satellite payload fairings are also developed in different sizes. Short, long or extra-long versions are available and may be combined with the SYLDA or a new dual satellite launch structure (SPELDA) which also comes in three different lengths.

All Ariane-4 boosters are launched from the ELA-2 launch pad. Nine to twelve Ariane-4's in many combinations/ configurations can be launched per year.

Fig. 20-27. Ariane-42P

Ariane-40

This is the basic core vehicle for the entire Ariane-4 family of Space Launch Vehicles. The launcher consists of three stages with no strap-on boosters. It is capable of lifting 4,600 Kg to LEO, 2,705 Kg to sun-synchronous orbit or 1,900 Kg to GTO. While the first launch of an Ariane-4 series launcher was in 1988, the Ariane-40 version did not have its first flight until January 1990.

Ariane-42L

The Ariane-42L (**Fig. 20-26**) consists of the core vehicle with two liquid fuel strap-on boosters. It can lift 7,270 Kg to LEO or 3,200 Kg to GTO. The first launch of this version was May 1993.

Ariane-42P

This version of the Ariane-4 family (**Fig. 20-27**) adds two solid fuel strap-on boosters to the core vehicle. The "P" is for Powder to indicate solid fuel. The lift capability of the Ariane-42P is 6,000 Kg to LEO and 3,000 Kg to GTO. The first flight of the Ariane-42P was in November 1990.

Fig. 20-26. Ariane-42L Liftoff from ELA-2

Fig. 20-28. Ariane-44L

Ariane-44L

The Ariane-44L version (**Fig. 20-28**) has four liquid strap-on boosters around the core vehicle. Lift capacity is 9,590 Kg to LEO (the most for any of the Ariane family) and 4,200 Kg to GTO. The initial launch for this version was in June 1989.

Ariane-44P

Four solid fuel strap-on boosters are added to the core vehicle to produce the Ariane-44P variant. This configuration can lift 6,500 Kg to LEO or 3,400 Kg to GTO. The first flight of this version was in November 1990.

Ariane-44LP

The Ariane-44LP (**Fig. 20-29**) was the first of the Ariane-4 family to fly. Its configuration is two solid fuel and two liquid fuel strap-on boosters to the core vehicle. Payload lift capability for this versions is 8,300 Kg to LEO or 4,200 Kg to GTO (the most GTO lift for the Ariane-4 family). The first flight of this version and the inaugural flight of the Ariane-4 series were June 1988. The first seven launches of the Ariane-4 series were Ariane-44LP versions.

Fig. 20-29. Ariane-44LP

Ariane-5

ESA adopted the Ariane-5 program in 1987 and development began in 1988. The program is more than just a follow-on from the Ariane-1 through Ariane-4 launchers; its goal is to establish the premier space transport system by developing a launcher that is even more powerful, more reliable, more economical and better matched to the 21st century payloads.

With an architecture that is radically different from earlier Ariane launchers, the Ariane-5 (**Fig. 20-30**) is a new-generation family of boosters geared for launching satellites in the early 2000s. For reliability and flexibility, the Ariane-5 comes in two sections; a "lower composite" which will be the same for all missions and an "upper composite" matched to the mission and payload.

The initial design of the Ariane-5 was to lift 18,000 Kg. to LEO, 12,000 Kg to Polar LEO, 6,800 Kg to GTO (single payload) or 5,900 Kg to GTO (duel payload). Like the Ariane-4, the ability to lift two major satellites into orbit with

Fig. 20-30. Ariane-5 on ELA-3

one launch was a prime consideration in the overall design. Due to the increasing weight of communication satellites, improvements are already being worked on to increase the lift capability of the Ariane-5.

The initial launch attempt of the Ariane-5 was in June 1996 (**Fig. 20-31**). Flight 501 failed when the booster exploded 32 seconds into the launch. Investigations revealed that some Ariane-4 software commands were loaded into the on-board computer. The differences between the Ariane-4 and Ariane-5 launch profiles were such that the computer was unable to identify and handle the launch when it tried to correct the Ariane-5 launch profile based on Araine-4 data. Software corrections and other improvements were incorporated into the next Ariane-5. Flight 502 was successfully launched on 30 October 1997 and injected two separate payloads into orbit. The third launch of the Ariane-5 was in October of 1998. This mission launched a mock-up satellite demonstrator and the European Atmospheric Reentry Demonstrator, (ARD). The knowledge gained from the ARD will assist ESA in work on the Crew Rescue Vehicle for the International Space Station, (ISS).

Following this flight the Ariane-5 was declared commercially ready. The first commercial launch, Flight 504, occurred in 1999.

Launch Processing. Assembly of the Ariane series boosters takes place at Kourou. Satellite and booster sections are either flown in or brought in by ship.

Fig. 20-31. First attempted launch of the Ariane-5

The Araine-4 and Ariane-5 systems have separate assembly areas and each is connected to its respective launch pad.

The payload preparation complex, also called the spacecraft preparation room, is designed to house both launch customers and their satellites. This provides customers the ability to make final satellite preparations before the satellite is mated to the launcher during the final assembly phase. Simultaneous processing of up to five satellites is possible. A satellite "campaign" takes three to six weeks, and the satellites "appointment" with its launcher is set for only eight days prior to launch.

The Ariane-4 complex (**Fig. 20-32**) physically separates the assembly and launch zones. This arrangement allows for considerable flexibility in launch campaigns, reducing the time between launches to as little as three weeks.

The Ariane-5 launch complex (**Fig. 20-33**) is also divided into two zones, launcher preparation and launch pad. Facilities at the launch site also include manufacturing plants for both solid boosters and cryogenic propellants (liquid hydrogen and oxygen plant). The Araine-5 complex is designed to support a launch rate of eight launches per year.

Italy - San Marco Project

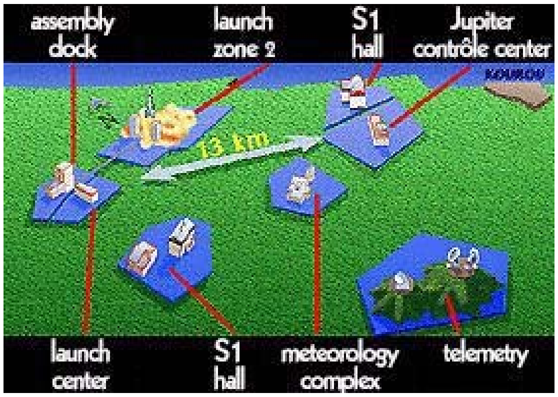

Fig. 20-32. Ariane-4 ELA-2 Complex

In 1962, the University of Rome and NASA created the San Marco Project as a joint space research project. The project was approved by the U.S. and Italian governments. Italy's portion of funding provided the University of Rome the ability to promote and initiate space research. The project activities concerning satellite

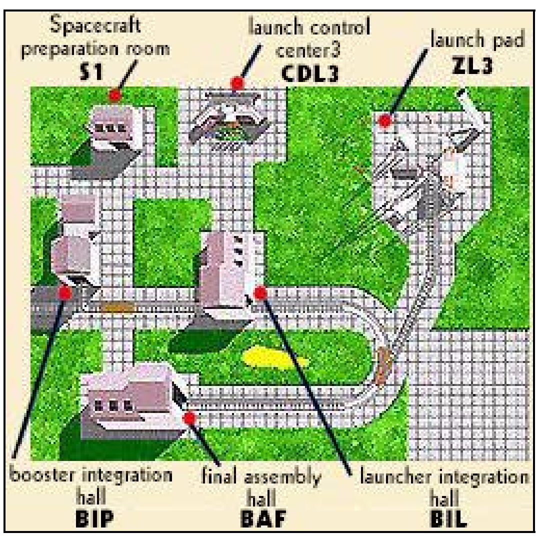

Fig. 20-33. Ariane-5 ELA-3 Complex

design, building and testing were performed in Rome. Space launches and satellite telemetry support was performed in Kenya from San Marco Equatorial Range (SMER). The project has developed and maintained active, fruitful and mutually advantageous cooperation between NASA and ESA.

San Marco Equatorial Range (SMER)

The SMER is located near the town of Malindi on Kenya's Indian Ocean coast at 3° South latitude. The launch area consists of three "off-shore-type" platforms standing on steel legs above the ocean floor **(Fig. 20-34)** and include the San Marco platform for booster assembly, test and launch; the Santa Rita platform for communications, telemetry and commanding; and the Santa Rita II platform for radar. The platforms have been certified up to year 2014. The main support area is located on land and contains telemetry stations, support facilities, housing, administration offices and machine shops.

Fig. 20-34. SMER Launch Platform

Between 1967 and 1988, nine launches were made using U.S.-supplied Scout boosters to place small satellites into LEO. Launches included Italian, NASA and U.K. scientific payloads.

The Scout has a lift capability of 560 lbs to LEO. The last Scout rocket was launched in 1994.

CHINESE SPACE PROGRAM

In 1956, the People's Republic of China laid the foundations for its astronautics industry. As a developing nation, the country recognized the need to develop space technology for its own purposes. Research and development on launch vehicles began in the early 1960's.

As a result of this effort, the first version of the Long March family of SLVs was developed. The Long March (LM) family is also known as Chang Zheng (CZ). In 1969, China launched its first vehicle, marking the country's entry into the space age. On 24 April 1970, China's first satellite, Dong Fang Hong 1, was placed into a low-earth orbit using the first CZ-1. This event highlighted China's capability to develop its own launch technology using Chinese materials.

Fig. 20-35. Chinese Launch Sites

Launch Sites

China's growing indigenous space industry has built three major launch complexes **(Fig. 20-35**). By Western standards, the facilities are austere and make limited use of advanced technologies; however, they are functional and adequate to support current Chinese space programs. Each site generally launches satellites into specific orbits based on safety, geographic or political constraints. Between them, the three launch complexes currently have six active launch pads.

Shuang Cheng-tzu (also called Jiuquan)

Shuang Cheng-tze, China's first launch site (40.6^{o}N/99.9^{o}E), is located in the Gobi desert, 1,000 miles west of Beijing in northwest China. There are two primary launch pads located about 300 meters apart. Long March 1 and 2 SLV's have been launched from this facility. The first space launch attempt on 1 November 1969 was a failure. It was followed by a successful sub-orbital flight on 10 January 1970. The first successful orbital launch was on 24 April 1970. Historically, orbital missions are launched to the Southeast to avoid overflying Mongolia and Russia. In 1999, China test launched its first man-rated system from a new launch facility.

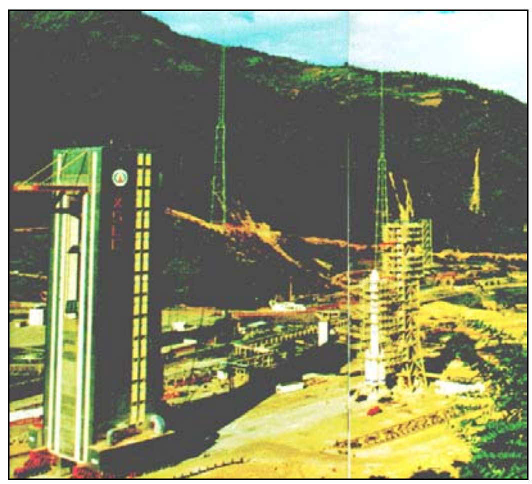

Fig. 20-36. Xichang Launch Complex

Xichang

Xichang, **(Fig. 20-36)** China's second launch site, is located in a mountainous area 40 miles northwest of Xichang City in south China (28^{o}N/102^{o}E). It became operational in 1984 and is used for launching CZ-2 and CZ-3 SLV's. Xichang is China's primary site for geostationary launches. There are three launch pads; the original pad, now inactive, built for the CZ-3 series; and two newer pads, built between 1989 and 1990, capable of handling a CZ-2E or

CZ-3A. China's first commercial launch mission, the Hong Kong AsiaSat 1, was launched from Xichang in April 1990.

Taiyuan

Taiyuan is China's newest launch facility. This site is located 270 miles southwest of Beijing (38^{o}N/112^{o}E) in eastern China. The facility is used to launch CZ-4 SLVs in a southward direction in order to place satellites into polar orbits. Its first use was to place a Chinese weather satellite into orbit on 6 September 1988.

Launch vehicles

The China Academy of Launch Vehicle Technology (CALT), under the Ministry of Aerospace Industry of China, is responsible for the development, production and testing of launch vehicles. The Shanghai Bureau of Astronautics (SBA), also known as the Shanghai Academy of Spaceflight Technology (SAST), is also involved in the development and building of space boosters. Certain versions of the Long March family have been designed by either CALT or SBA, while other versions have been produced jointly.

Successive improvements since the first CZ-1 include stage upgrading, new motors, addition of third stages (solid, storable liquid and cryogenic fuels) and strap-on boosters.

Long March 1 (CZ-1) Series

The CZ-1 was derived from the CSS-3 IRBM. Development began in 1965 with the only two known launches occurring in 1970 and 1971.

Fig. 20-37. CZ-1D

Several improvements had been proposed or developed for the SLV incorporating improve-ments to the third stage. The CZ-1C was to have a liquid-propelled third stage while the CZ-1M was to have an Italian solid propellant third stage. Neither of these are now expected to reach operational status.

The only improved version of the CZ-1 considered operational and being offered as a launcher is the CZ-1D (**Fig. 20-37**). Although data is limited, it is estimated that the booster has improved capabilities over the original CZ-1. The Chinese did launch a single CZ-1D on a sub-orbital test flight. The Chinese appear to be waiting for a civilian contract before they launch another CZ-1D. The CZ-1D is designed to place small payloads (around 750 kilograms) into LEO.

Long March 2 (CZ-2) Series

Development of a successor for the CZ-1 began in 1970 with the parallel development of the two stage CSS-4 ICBM. The first launch of the CZ-2 in 1974 ended in failure after a few seconds. Based on lessons learned, the control system design was modified. Quality control during production and functional checkout was also improved. In addition,


Fig. 20-38. CZ-2C Long March

payload capability was increased and the modified launch vehicle was designated as the CZ-2C (**Fig. 20-38**).

CZ-2A was the original designation for what became the CZ-4 class of boosters. CZ-2B was the original designation for what became the CZ-3 series of boosters.

The first launch of the CZ-2C was on 26 November 1975. The flight was a complete success, with China's first recoverable satellite being placed into orbit. Since then, the CZ-2C has become the most utilized Chinese launcher. The CZ-2C has been commercially available for launch services since 1976.

The CZ-2C is offered principally for low-earth orbit and/or sun-synchronous launches. The booster is capable of lifting over 2,000 kilograms to low-earth orbit or in conjunction with the Chinese FSU recoverable microgravity platform, returning 150 kilogram payloads to earth. A version with an extended 2nd stage is being developed for GTO.

One of the most active versions of the CZ-2C is the CZ-2C/SD or Smart Dispenser version. This newly designed upper stage is indented for the duel launch requirements of Iridium satellites.

CZ-2D

The CZ-2D is an improved CZ-2C and serves as the basis for the CZ-4 class of boosters. The CZ-2D was designed as a three stage booster with stages one and two being a Chinese liquid-propelled booster and the third stage a McDonnell Douglas PAM-D (Payload Assist Module).

Only two launches have been performed, both launching the FSW-2 recoverable platform. These launches were in 1992 and 1994. Chinese statements in 1989 indicated that the CZ-2D was only a design study.

CZ-2E

The CZ-2E is the most powerful of the CZ-2 family (**Fig. 20-39**). Its subsystems are essentially the same as the subsystems of the CZ-2C using the first and second stages of the CZ-3, including engines, propellant feeding systems, guidance system and main structures. In addition, four liquid propellant strap-on boosters are added to the first stage. First launched on 16 July 1990, commercial flight operations began in August 1992 with an Australian payload launch.

Fig. 20-39. CZ-2E

The CZ-2E can lift about 8,800 kilograms into LEO or over 3,400 kilograms into GTO, depending on the perigee kick motor (PKM) used.

CZ-2F

The CZ-2F is a follow-on to the -2E and is upgraded and man-rated. One test flight was conducted in November 1999 and one in January 2000. Few details are available on the booster.

Long March 3 (CZ-3) series

Beginning in 1975, studies were made for the development of a cryogenic (very cold, liquefied gases) propellant. A program for upgrading the third stage of the CZ-2 into a GEO-class launcher using this propellant began in 1977. The booster was initially referred to as the CZ-2B, but later renamed the CZ-3.

The CZ-3 first and second stage boosters were developed on the basis of the CZ-2C. The third stage was a newly developed liquid oxygen and liquid hydrogen engine with a restart capability.

In January 1984, the CZ-3's debut established China as only the third user of cryogenic propulsion, after the U.S. and ESA. The second launch on 8 April 1984 produced China's first GEO satellite.

The CZ-3 has a payload capability of placing around 1,400 kilograms into GEO. Offered for commercial launches in 1986, the first commercial launch was on 4 April 1990.


Fig. 20-40. CZ-3A

CZ-3A

The CZ-3A incorporates a stretched, upgraded first stage and an improved cryogenic third stage that almost doubles the basic CZ-3's GTO lifting capability. Originally scheduled to be commercially avail-able in 1992, Chinese officials stated in 1990 that its introduction had been delayed until 1994. On 8 February 1994, the first CZ-3A was launched (**Fig. 20-40**). This improved version can lift 2,300 kilograms to GEO.

CZ-3B

The CZ-3B was created by adding the strap-on boosters of the CZ-2E to the CZ-3A launcher (**Fig. 20-41**). Although initial designs included an improved CZ-2E, the CZ-2E/HO, that would use the cryogenic third stage of the CZ-3A, this version was never developed.

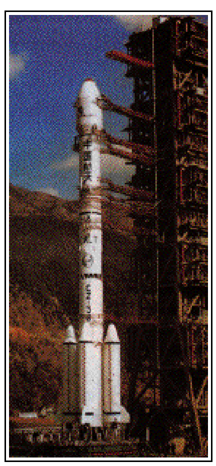
Fig. 20-41. CZ-3B

The configuration of the CZ-3B created the most powerful launch vehicle in the Chinese inventory. The first launch attempt took place on 14 February 1996 but ended in failure, destroying the IntelSat 708 payload. Since then, China has successfully launched four CZ-3B boosters, two each in 1997 and 1998.

The design lift of the CZ-3B is 4,800 Kg to GTO. The booster is also designed to launch planetary missions.

CZ-3C

China is currently working on another version of the CZ-3 booster. The CZ-3C will have only two strap-on boosters vice the CZ-3B's four. The design lift is 3,800 Kg to GTO.

Long March 4 (CZ-4) Series

The CZ-4 is an outgrowth of the development of the CZ-2C and CZ-3A programs. The first and second stages have enlarged CZ-3A fuel tanks for additional fuel. The third stage uses a new storable propellant optimized for sun-synchronous payloads.

CZ-4A

The first launch of the CZ-4A booster (**Fig. 20-42**) was 6 September 1988 and the second was 3 September 1990. Currently the CZ-4A has only been launched two times. Both launches placed satellites into sun-synchronous orbits.

Advertised lift capability is 2,500 kilograms to sun-synchronous orbit and 4,000 kilograms to low-earth orbit.

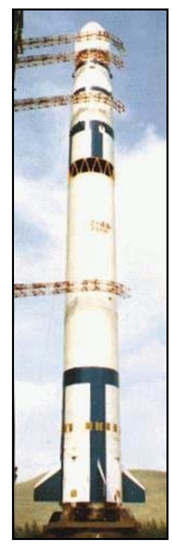
Fig. 20-42. CZ-4A

CZ-4B

In May 1999, China launched an improved CZ-4 Series, the CZ-4B for the first time. The CZ-4B has an enhanced third stage and fairing. This first launch placed two Chinese built satellites into sun-synchronous orbits. Payload capacity is stated at 1,500 kilograms.

Launch processing

Most of the knowledge concerning Chinese payload and launch processing has been gained from observation at the Xichang launch site, their main commercial facility. Processing at the other sites is believed to be very similar.

Long March stages are shipped to the launch facility generally via rail or by a river/rail combination **(Fig. 20-43).**

Fig. 20-43. CZ-2E en route to launch site

A booster will spend several weeks at the launch vehicle checkout hanger in a horizontally mated position for checkout **(Fig. 20-44).** After checkout, the booster is disassembled and transported in stages to the launch pad. Boosters are reassembled vertically on the launch pad **(see Fig. 20-45).** Integrated checkout of the vehicle and payload is also done on the pad.

Fig. 20-44. CZ-4B undergoing checkout

China's man-rated booster, the CZ-2F appears to use a more western method. A vertical assembly building has been built at Jiuquan. After vertical assembly in the facility, the booster is transported erect to the launch pad.

There is a payload preparation building for nonhazardous assembly, integration and testing operations of spacecraft and upper stages, if required by the mission. Another building is for processing hazardous assembly operations, spacecraft propellant fueling and pressurization, solid motor integration and other hazardous testing. The satellite is taken to the launch pad inside an environmentally controlled payload container or inside the launch fairing.

At the launch area, the tasks of mating, testing and checkout, direction orientation, propellant filling, and launching are done.

The China Great Wall Industry Corporation (CGWIC) is the company responsible for marketing and negotiating launch services and contract execution. CGWIC is the primary interface with customers, undertaking all coordination between the customer and the other elements of the launch services organization.

Fig. 20-45. CZ-3 being stacked

A comparison of the China's Long March boosters is in **Figure 20-46**. This chart includes active, retired and developmental launchers.

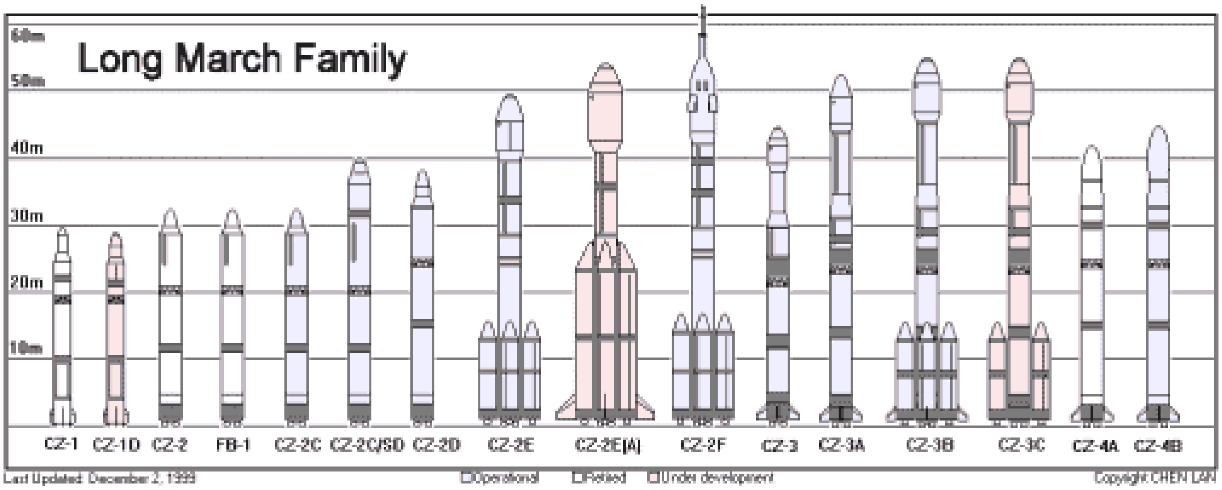

Fig. 20-46. PRC Long March Launch Vehicles (to scale)

JAPANESE SPACE PROGRAM

The Space Activities Commission (SAC) is Japan's most senior space advisory group. Established in 1968, its purpose is to unify the space activities of various government agencies and actively promote them. SAC formulates plans, deliberates, makes decisions on space matters and submits its opinions to the Prime Minister for adjudication.

The Science and Technology Agency (STA) plans and promotes basic space-related policy, conducts the overall coordination of space activities among government agencies and performs research and development activities through the National Aerospace Laboratory and the National Space Development Agency (NASDA).

National Space Development Agency (NASDA)

NASDA was established in October 1969 as the central body responsible for the development of space technology in Japan and the promotion of space activities solely for peaceful purposes. The main tasks of NASDA are to develop satellites and launchers; to launch and track satellites; to promote the utilization of space technology; and to devise methods, facilities organizations in accordance with the Space Development Program.

Institute of Space and Astronautical Science (ISAS)

Directly under the auspices of the Ministry of Education, Science, Sports and Culture is ISAS, a central institute for space and astronautical science in Japan. ISAS conducts scientific research using space vehicles. For this purpose, it develops and operates sounding rockets, satellite launchers, scientific satellites, planetary probes and scientific balloons.

In late 1999, NASDA suffered several partial and total failures of their primary launch vehicle, followed in early 2000 by ISAS having a major in flight failure of their primary booster. These events have lead to an on-going study over the future and direction of the space program.

Launch Centers

Japan maintains two launch centers. Each agency maintains and operates their own complex. Both sites are located in the southern islands of Japan.

Launch windows are a major concern as launches from both sites are normally restricted to two 45-day windows; January/February and August/September. This restriction is because of range safety and an influential fishing lobby. Japanese space officials want to extend the launch window to minimum of 140 days a year and a maximum of 200 days a year in the near future.

Tanegashima Space Center (NASDA)

The Tanegashima Space Center is NASDA's largest facility (**Fig. 20-47**). It is located on the southeast tip of Tanegashima Island (30.4°N/130.9°E), some 1,000 Km southwest of Tokyo. There are three launch areas at the center; Yoshinobu complex, Osaki range and Takesaki range.

The Yoshinobu complex is dedicated to the servicing and launching of the H-2 booster. It contains launcher and payload processing facilities, a Vehicle Assembly Building (VAB) with its mobile platform, first stage engine test facility, a non-destructive test facility for the solid rocket boosters and the launch pad. Currently, the facility can support two annual launches; increasing this rate would require an additional mobile platform, as a minimum. The Osaki range includes pads for the J-1 and H-1 booster and was used to launch the H-2 prior to construction of the Yoshinobu complex. The Takesaki range handles sounding rockets, provides facilities for the H-2 solid booster static firing and contains the H-2 Range Control Center.

Kagoshima Space Center (ISAS)

The Kagoshima Space Center (**Fig. 20-48**) is run by ISAS. It is primarily a sounding rocket site, but handles some scientific satellites. The center is 50 Km north of Tanegashima on the southern tip of Kyushu Island, the southern most major island of Japan (31.2°N/131.1°E). Kagoshima is restricted by government directive to all-solid propellant launch vehicles.

Launch facilities at Kagoshima consist of numerous sites built on leveled hilltops. The first sounding rockets and suborbital flights of the Japanese space program were launched from here. In 1970, Japan's first orbital launch was conducted from this center on the M3-SII booster.

The M3-SII was retired in 1995 and the facility has been upgraded to support the next generation solid booster, the M-5. A satellite processing facility is linked with the "M" pad and assembly area.

Fig. 20-47. Osaki J-1/H-1 launch pad (Front) Yoshinobu H-2 VAB and launch pad (Back)

Fig. 20-48. Kagoshima SC "M" launch pad (right)

Launch Vehicles

NASDA and ISAS continue the operation of two distinct launcher types; ISAS is constrained to science missions and solid propellant boosters, while NASDA provides the national capability for launching applications satellites aboard liquid boosters of increasing capabilities. NASDA's goal is an indigenous vehicle for two-ton GTO and LEO applications, with a view to commercialization.

NASDA launchers

"N" Series. Development of orbital launchers began with the "N" series of launchers. The N-1 and N-2 launchers provided the initial expertise, but they were based on the McDonnell Douglas Delta booster built under license. This license prohibited orbiting of third-party payloads without U.S. approval. The N-1 was a version of the Thor-Delta launcher. It was a two-stage launcher with three solid motor strap-on boosters. Its lift capability was 1,200 kilograms to LEO or 130 kilograms to GEO. The N-2 was very similar to the N-1, with nine strap-on solid boosters, first stage tank extended, second stage engine improvements and an inertial guidance system. This version had a payload capacity of 2,000 kilograms to LEO or 350 kilograms to GEO. All seven N-1 launches and eight N-2 launches have been successful.

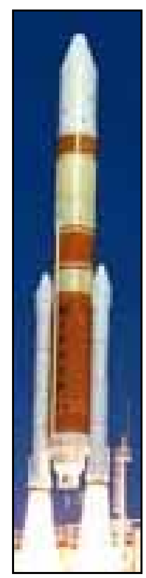

Fig. 20-49. H-1 Rocket

"H" Series. The H-series of launchers were designed for Japan to enter the commercial market with their own booster. The H-1 (**Fig. 20-49**) was very similar to the N-2 launcher. It employed a new cryogenic second stage, improved inertial guidance system and solid upper stages; all Japanese built. The N-2's first stage and solid strap-ons were retained for the H-1. Eight launches of the H-1 were performed and all were successful. The lift capability of the H-1 booster was 3,200 Kg to LEO or 550 Kg to GEO. The H-series significantly enhanced Japan's capability in design and SLV use.

H-2

Based on experience gained through the H-1, NASDA developed the H-2 launch vehicle entirely with Japanese technology. The H-2 is designed to serve as NASDA's workhouse in the 1990's. Freed from U.S. licensing restrictions experienced under the "N" series, the H-2 is offered for commercial launch.

The launcher consists of a cryogenic first and second stage and a pair of solid strap-on boosters. The H-2 **(Fig. 20-48)** can also mount twin solid sub-boosters when mandated by mission requirements.

Fig 20-48 H-2 at Tanegashima

The first launch of the H-2 was on 4 February 1994. Lift capability for the H-2 is 10,500 kilograms to LEO or 2,200 kilograms to GEO.

The H-2 has not been a commercial success for the Japanese. The cost of H-2 launches for commercial customers has been almost twice the price of equivalent U.S. or ESA launches. NASDA is developing the H-2A, an improved launcher, to be its commercial launcher after the year 2000. To aid in reducing the cost of H-2 launches and orders for H-2A launches, a consortium of Japanese companies formed the Rocket Systems Corporation (RSA).

"J" Series**.** NASDA began developing the J-1 solid propellant launcher to lift payloads too small for the H-2 launcher (**Fig. 20-49**). Minimum development cost and risk were obtained by adapting existing hardware. The J-1 booster uses a H-2 solid strap-on booster for the first stage and ISAS developed M3-SII rocket stages for the second and third. Lift capability was 870 Kg to LEO. The first flight was on 12 February 1996. For numerous reasons, including cost and suitable payloads, the future of the J-1 is in doubt. Plans to scrap the J-1 in favor of a remodeled version have been made by NASDA. The new version's goal is to develop a highly reliable, advanced J-1 rocket capable of launching a one ton payload at commercially competitive prices. This advanced version is currently referred to as the J-1A.

Fig. 20-49. J-1

ISAS launchers

"L" Series. Launchers produced by ISAS are all solid-fuel rockets; the first developed was the L-4S, a modified sounding rocket. The first successful launch of the L-4S was in February 1970. This launch gave the Japanese the confidence to continue in SLV development. To orbit larger payloads, a new vehicle design was needed.

"M" Series. The first of the "M" series (sometimes referred to as "Mu") was the M-4S. This booster was a four stage, solid-fuel vehicle capable of lifting 180 kilograms to LEO.

To expand launch capabilities, the M-3C was designed. This booster retained the M-4S first stage, but improved the second and third stages. It could lift 195 kilograms to LEO.

The next improved version was designated the M-3H. This booster increased the size of the first stage core motor by one third. The capability of the M-3H was twice that of the M-3C, lifting 290 kilograms to LEO.

The next improvement in the M-series was the M-3S. Similar to the M-3H, the

M-3S incorporated a first stage guidance and control capability.

In 1981, research and development began on the M-3SII (**Fig. 20-50**), built primarily for the Haley's Comet mission. This was the first Japanese interplanetary flight. Unlike the previous M-series step-by-step improvement approach, signifi-cant enhancement to the launch capa-bility was required. Only the first stage was inherited for the M-3S.

Fig. 20-50. M-3SII

The size and thrust of the second and third stages were increased. The eight small strap-on motors of the M-3S were replaced by two much larger strap-ons. These modifications enabled the launch of 780 kilogram payloads to LEO, which is 2.7 times the performance of the M-3S.

The first two M-3SII launches, with an added optional fourth stage, injected the initial Japanese interplanetary probes on 7 January 1985. Since then, it has become the main launch vehicle for scientific satellites from Japan.

To keep up with the increasing demand on payload capability and en-able anticipated inter-planetary missions, ISAS initiated the M-V launcher pro-gram in 1989.

The M-V (**Fig. 20-51**) is a three-stage solid-propel-lant system, with an optional kick stage for high-energy missions. It is the largest solid propellant rocket ever built in Japan. The design calls for a lift capability of 1,800 kilograms to LEO or 300-400 kilograms for planetary missions. To achieve this payload, all the stages of the M-V had to be newly developed with no direct heritage from the M-3SII series. The first launch of the M-V was on 12 February 1997.

Launch Preparation

The facilities used for the M-series launch preparation include the Satellite Preparation Building (SPB), the Mu Assembly Building (MAB) and the Mu Launch Complex (MLC) at Kagoshina Space Center.

The various booster elements, such as the stage motors, fins, nose fairings and payload are transported to the launch facility by road. Inspection of the stages and payload fairing take place within the MAB. Most assembly takes place at the MLC. After satellite checkout in the SPB, the satellite, payload fairing and the third stage are assembled in the MAB prior to transport to the MLC.

Fig. 20-51. M-V

Vehicle integration is carried out inside the assembly tower of the MLC. The launcher is built vertically starting with the first stage, then the solid strap-on, the second stage followed by the third stage with the satellite in place.

INDIAN SPACE PROGRAM

India's space program is an outgrowth of a concerted effort to develop an indigenous scientific and technological base in the country. This effort was established to ensure that India would be able to find solutions within the country and not have to rely on outside assistance to satisfy its needs. India has one of the most accomplished and capable space programs among developing nations. India's space program began in 1963; the Indian Space Research Organization (ISRO) was established in 1969; and a national framework created in 1972 with the Space Commission and Department of Space. ISRO is the primary developer of launchers and satellite hardware, complemented by separate communications and remote sensing agencies.

In July 1980, India was the seventh nation to achieve orbit capability. It has concentrated its space activities on developing various applications satellites, communications and remote sensing, and launcher technology. India wishes to be self sufficient in both satellite manufacturing and domestic space launchers around the year 2000.

Launch Center

SHAR Center (Sriharikota Range)

SHAR Center, (13.7^{o}N/080.2^{o}E.) located on Sriharikota Island off the eastern coast of India, is ISRO's only satellite launching facility. Currently there are two launch facilities; however, a third is under construction. The complex also includes a solid propellant booster plant, static test and evaluation complex (STEX), vehicle integration building (VIB), and is tied into ISRO's Telemetry, Tracking & Command Network (ISTRAC).

ISRO's Range Complex (IREX), headquartered at SHAR, is responsible for space launch operations as well as sounding rocket operations at SHAR, Thumba and Balasore.

Launch Vehicles

Although launcher and propulsion development represent ISRO's largest single area of expenditure, the relatively modest sums have dictated a gradual evolution of space launch vehicles. Early emphasis was on sounding rockets, which led to the first Indian Space Launch Vehicle (SLV).

SLV-3

The SLV-3 was an all solid booster developed in the late 1970s. This launcher was capable of lifting 42 kilograms to LEO. The first attempted launch on 10 August 1979 was unsuccessful due to a second stage thrust failure. The next three flights were all successful, placing test payloads and imaging systems into orbit.

ASLV

The Augmented SLV (ASLV) was developed largely by adding strap-on boosters derived from the SLV-3 first stage. This raised the lift ability to 150 kilograms to LEO. The first attempted launch of the ASLV on 24 March 1987 failed when the second stage failed to ignite. The second launch was also a failure due to insufficient control gain in the first stage. The first successful launch was 20 May 1992; however, insufficient spin stabilization for the satellite caused a low perigee and short life span. The last launch of the ASLV was a total success on 4 May 1994.

PSLV

The Polar SLV (PSLV) represents India's first attempt in acquiring launcher autonomy for applications satellites. Designed for placing one ton earth resources satellites into 900 kilometer sun-synchronous orbits from SHAR, the PSLV also offers growth potential as the follow-on Geo-synchronous SLV (GSLV) to handle 2.5 tons to GTO.

The PSLV (**Fig. 20-52**) employs an unusual combination of liquid and solid stages. An Indian liquid fuel system is used for the second and fourth stages as well as the clustering of six ASLV strap-ons around the solid fuel first stage. The third stage is also a solid fuel booster.

The initial attempted PSLV launch on 20 September 1993, failed due to a software error that prevented orbit from being obtained. The next two developmental launches in 1994 and 1996 respectively, were both successful.

In October 1994, the government of India approved the procurement of six additional PSLVs. India eventually plans to offer the PSLV for commercial launches.

Fig. 20-52. Indian PSLV

Current lift capability of the PSLV is 3,000 kilograms to LEO, 1,000 kilograms to sun-synchronous orbit and 450 kilograms to GTO. The PSLV booster is capable of lifting larger payloads, but geographical and range safety issues limit launches. Without these limitations, capacity would raise to 1,600 kilograms for a sun-synchronous orbit.

Geosynchronous SLV (GSLV)

The latest Indian SLV under development is a geosynchronous launcher capable of handling 2.5 ton satellites. The GSLV uses proven technology from the PSLV as well as new technology. The GSLV booster replaces the six solid strap-ons of the PSLV with four liquid boosters around the solid first stage and substitutes cryogenic boosters for the second and third stages. The first cryogenic motors will be Russian until India can perfect its own cryogenic technology. Projected payload lift is 5,000 kilograms to LEO and 2,500 kilograms to GTO.

Launch Preparation

The ASLV launcher is integrated in the Vehicle Preparation Building (VIB) and completed by the addition of the strap-on boosters on the launch pad within a Mobile Service Structure.

The Vehicle Assembly, Static Test and Evaluation Complex (VAST) and the Solid Propellant Space Booster Plant (SPROB), used for casting and testing PSLV solid motors, are located at SHAR.

PSLV booster assembly is done vertically on the launch pad using a Mobile Service Tower (MST). All solid motors are processed in the Solid Motor Preparations Facility (SMPF) prior to transfer to the MST. Liquid stage fueling is remotely controlled on the pad from the Launch Control Center (LCC).

Satellite Preparation (SP) and integration is done in three SP cleanroom facilities. SP-1 at the LCC provides satellite inspection, subsystem tests, Reaction Control System leak tests and solar panel deployment testing. SP-2 is used for satellite fueling and PSLV adapter compatibility. SP-3 is located within the MST for integrating payloads with the launcher.

ISRAELI SPACE PROGRAM

The Israeli space program began with university-based research in the early 1960's. The Israel Academy of Sciences and Humanities formally established the National Committee for Space Research in 1963. In the early 1980s, Israel set its sights on developing an industrial and scientific infrastructure required for full-fledged membership in the "Space Community." The Israel Space Agency (ISA) was established in 1983 and charged with the coordination of the nation's space program. On September 19, 1988, Israel became the eighth nation to fully enter the space age. With the advent of the Ofeq satellite program, Israel has developed, produced, and launched from their own country, a satellite of their own with a locally developed launcher.

Launch Site

Palmachim Air Force Base

Israel has one launch facility located near Palmachim Air Force Base (31.0^{O} N /035.0^{O} E) south of Tel Aviv near the town of Yavne. Facilities are classified, although they are reportedly visible from the coast road. The site is restricted to retrograde (westward) launches for range safety and to avoid overflying Arab countries. Due to the need to launch into a retrograde orbit, the payload weight is reduced because of the increased fuel required.

Launch Vehicle

Shavit

Israel currently has only one launch vehicle, the solid-fuel, three-stage Shavit (**Fig. 20-53**) developed by Israel Aircraft Industries (IAI). This vehicle is believed to be derived from or duel-developed with the Jericho II ballistic missile. The Shavit is able to lift 155 kilograms into a retrograde low-earth orbit. Calculations indicate that if launched from Cape Kennedy, the Shavit would lift up to 600 kilograms to LEO and if launched from Vandenberg AFB, it would lift up to 450 kilograms to polar orbits. There have been three successful launches of the Shavit; one each in 1988, 1990 and 1995. Although never acknowledged by the Israeli space program, a possible fourth launch was attempted in 1994, but it was believed to have been a failure. A confirmed launch failure occurred in January 1998.

Fig. 20-53. Israeli Shavit

Beginning around 1997, IAI began negotiations with the U.S. firm Coleman Research and France's Matra Marconi Space on adapting the Shavit for launches from the U.S. or Europe's Kourou launch site. This joint venture is being marketed under the name "LeoLink" and the upgraded boosters are referred to as LK-1 and LK-2.

LK-1 advertised payload is 340 Kg to LEO. First launch is planned for late 2001. LK-2, using a U.S. built Castor 120 motor as the first stage, will be capable of placing 1,000 Kg into a LEO polar orbit. This booster will be offered for launch from the end of the year 2000.

Launch Preparation

Little information is available regarding Shavit launch procedures. If Israel obtains commercial launch contracts, more information on launch procedures should be available.

Advertising for "LeoLink" states that the LK series uses a mobile stage assembly/transporter/erector facility and a launch preparation van that makes site operations flexible and short.

BRAZILIAN SPACE PROGRAM

Brazil is poised to become the ninth nation to achieve an indigenous space program. They have the ability to build and command their own satellites, have a space launch complex under development, and are developing their own booster. As a developing country, Brazil recognizes the need to emphasize and develop space technologies in order to address its unique problems. These include its large land mass, under-populated land borders, a huge coastline and the extensive natural resources still to be surveyed in its territory. Another goal of the space program is to progress toward an independent space launch capability.

The National Institute for Space Research (INPE, Instituto Nacional de Pesquisas Espaciais) was formed in 1971 and is responsible for the development of ground/space segments of applications satellite programs.

In 1994, the Brazilian Space Agency (AEB, Agencia Espacial Brasilera) was established to coordinate and plan Brazil's space program.

Launch site

Alcantara

Brazil is upgrading its sounding rocket facility at Alcantara into a space launch facility. The Alcantara Launch Center **(Fig.20-54)** (CLA, Centro Lancamentos de Alcantara) is on Brazils northern coast (2.2^{o}S /044.2^{o}W). The formal opening of Alcantara, as a sounding rocket facility, was in February 1990. Due to its location, Alcantara can launch from near geostationary to polar or retrograde orbits (from 2 to 100 degrees). The first space launch attempt was in November 1997 and their second in December 1999.

Launch Vehicle

VLS

Brazil is developing its own space launch vehicle, based on the Sonda series

Fig. 20-54 Alcantara (CLA)

of sounding rockets. The VLS (Veiculo Lancador de Satelites) is a three stage booster with strap-ons, propelled by solid fuel. It is designed to place a 200 kilogram payload into LEO or a sun-synchronous orbit. The first and second stages as well as the strap on boosters are derived from the Sonda-4 series. The third stage is newly developed.

A 1/3 scale VLS was launched in 1989 to demonstrate strap-on separation. In 1993, the VS-40 version made a 24 min-

Fig. 20-55. First VLS launch attempt

ute flight test of the VLS's second and third stages.

The first orbital launch from Alcantara was attempted on 2 November 1997 using the VLS. Controllers were forced to destroy the booster 65 seconds after lift-off when one of the four strap-on engines failed to ignite **(Fig. 20-55).** A second launch was attempted December 1999. This VLS had a second stage failure.

AUSTRALIAN SPACE PROGRAM

In 1946, a joint United Kingdom and Australian test range was established in southern Australia for ballistic missiles and sounding rockets. Australia hoped that this test range would lead to a future satellite launch center. During the 1960s, development was done at this range on the British Blue Streak as the first stage of the European "Europa" rocket. However, a number of factors led to the demise of the range. First, a number of Europa launch failures occurred. Additionally, France preferred to develop its own center at Kourou as the European launch facility. In addition, it was decided that the Australian site was not suitable for equatorial launches. Finally, Britain announced that there would be no more work after 1976. Only two satellites were launched into orbit from Australia.

In 1987 the range was reopened for a scientific sounding rocket launch.

An Australian National Space Program was established in 1985 to provide a base for participation in the world space industry, followed by the formation of the Australian Space Office in 1987 as the focus for space-related activities. In 1993 the Australian Space Council (ACS) was established to support an Integrated National Space program with programmed funding. A major task was to formulate a five-year plan to set new directions for the National Space Plan and determine priorities. The ACS recommended the development and demonstration of a light launch capability. These would be the vehicles for carrying Australian-built demonstrations satellites, leading to the development of Earth observation and communications payloads. A goal of this program is for Australia to secure a share of the Asian space business in launches, small satellites and space-based services.

Launch Sites

Australia's only current space launch facility is at Woomera in South Australia (31.1^{O}S/136.8^{O}E). Both orbital launches from this site were on modified sounding rockets; the U.S.-built Redstone launched the first Australian satellite, the WRESAT, on 29 November 1967; and a British Black Arrow launched the British weather technology satellite Prospero on 28 October 1971. In 1997, the Japanese space agency, NASDA, used the facilities at Woomera for drop and test flights of its ALFLEX (Automatic Landing Flight Experiment). These tests suggest substantial progress in the revitalization of Woomera as a center for space-related activity

Studies are being conducted to address the feasibility of upgrading Woomera to an active space launch facility. In addition, other studies have been under taken to look at other locations in Australia for launch sites. Currently studies have been done for the Australian territory or Christmas Island in the Indian Ocean.

NORTH KOREA

On 31 August 1998, North Korea announced that it had launched a satellite. The expected first launch of the Taepo-Dong 1 ballistic missile was instead an apparent attempt to orbit a satellite. No independent confirmation of the event has been obtained, so it appears that the attempt was not successful.

Launch Site

Little is known of the North Korean launch site reported in Musudan-ri near the northeastern coast **(Fig 20-56).** Recent imagery of this site was obtained by a commercial satellite imaging company. Their pictures show an austere site with a single launch pad and limited infrastruc-

Fig. 20-56 Musudan-ri launch site

ture.

Launch Vehicle

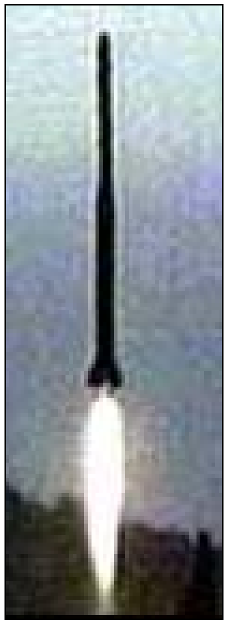
Fig. 20-57. Taepo-Dong-1

The booster used for this launch attempt appears to be a version of the Taepo-Dong 1 ballistic missile **(Fig. 20-57).** The missile is assessed to be a two stage system. The SLV version seen in August appears to have three stages or two stages and an orbital insertion motor. The first stage booster landed in the Sea of Japan while the second landed in the Pacific Ocean off the east coast of Japan. Reports indicate that the third stage or the failed satellite impacted in the Pacific Ocean south of Alaska, some 6,000 Km from North Korea.

INTERNATIONAL SPACE PROGRAMS

The International Space University is an interdisciplinary, intercultural and international institution which prepares individuals to respond to the current needs and the increasing and evolving demands of the space sector in a rapidly changing world. The University announced during its 1997 international symposium that:

"Space is no longer the special, protected domain that it was in the past, but is becoming integrated with the mainstream of economic activity."

Indeed, many new international commercial enterprises are being established to support the growing space market for expanding communications, earth resources and imaging systems. This includes a number of launch ventures.

International Launch Services (ILS)

International Launch Services was established in 1995 to market the American-built Atlas and the Russian-built Proton. ILS was formed by a joint venture between Lockheed Martin's Commercial Launches Services Company (LMCLS), Khrunichev Enterprise, and RSC Energia of Russia forming Lockheed-Khrunichev-Energia International (LKEI).

As of June 1999, ILS had launched 63 payloads, 11 on Proton and 52 on Atlas boosters. The Company has future commitments for an additional 30 Atlas and 16 Proton launches. These numbers are close to the launch commitment totals for ESA's Ariane booster.

Starsem

Starsem is a joint venture announced in July 1996, between Aerospatiale and Arianespace of France, the Russian Space Agency and Samara Space Center (makers of the Soyuz booster) to market the Soyuz launch system around the world.

Starsem is a contraction of "Space Technology Alliance, based on the R-7 SEMyorka" launch vehicles. Semyorka is the Russian name for SL-4 system. Starsem's SL-22 an SL-26 boosters are developments of the SL-4 with new upper stages and satellite dispensers. The partnership stems from Arianespace's need to respond to the launch demand for small satellites for which its Ariane-5 is not ideally suited.

In October 1996, Starsem announced its first launch order for three launches of the Globalstar system. A total of six launches for Globalstar were done in 1999. In addition, ESA has contracted for three launches, two launches for the

Cluster-II series in 2000 and one launch of ESA's Mars Express interplanetary probe.

Eurocket

In 1995, the joint Eurocket Launch Services company was formed between Germany's Daimler-Benz Aerospace Corporation and Russia's Khunichev Space Center to market the Russian Rocket, SL-19, booster. Formed to meet the need for small satellite launch services. Eurocket's first test launch was of two dummy satellites in May 2000. Eurorocket contracts include two launches for six E-SAT data satellites. The German Space Agency and NASA have also contracted for a launch in 2001.

Sea Launch

The Sea Launch venture was formed in April 1995 in response to a growing market for a more affordable, reliable, capable and convenient commercial satellite launch service. Engineering and market studies determined that a sea-based launch system could competent favorably with incumbent service providers. A partnership was formed between Boeing Commercial Space Company, RSA Energia of Russia, NPO Yuzhnove of the Ukraine and Kvaerner of Norway to build and market a sea launch facility. Long Beach, California was selected as the home port and ground breaking for facilities began in August 1996.

Two unique ships form the marine part of Sea Launch. The Assembly and Command Ship is an all-new, specially designed vessel that will serve as a floating rocket assembly factory as well as provide crew and customer accommodations and mission-control facilities at sea.

The Launch Platform is a modified ocean oil drilling platform (**Fig. 20-58**) and is a self-propelled, semi-submersible launch complex which houses the integrated launch vehicle in an environmentally controlled hanger during transit to the launch site.

Fig. 20-58. SeaLaunch Lift-off

Chosen to capitalize on the Earth's rotation, the launch location maximizes Sea Launch's performance. The primary launch site will be along the Equator in international waters of the Pacific Ocean about 1,000 miles south of Hawaii.

The selected booster for Sea Launch is the Ukrainian/Russian Zenit-35L, the SL-23. Modified to a three stage configuration, the Zenit was selected due to its highly automated launch procedures.

Hughes Space and Communications Company has ordered 13 launches from Sea Launch. The first launch from this platform was an instrumented satellite simulator in March 1999. SeaLaunch's first commercial launch occurred in October 1999. In March 2000 the SL-23 booster suffered an in flight failure. Launch operations resumed in July 2000. Currently there are a total of 19 launch commitments through 2003.

Cosmos International

A joint German-Russian venture, Cosmos International markets the SL-8 Kosmos booster, for commercial launches.

The first launch of this new provider was in April

1999, with a German and an Italian satellite. A second launch was performed in June 2000.

LeoLink

LeoLink is a joint venture between Israeli Aircraft Industries, Coleman Research of the U.S. and Matra Marconi Space-France. The venture is marketing improved versions of the Israeli Shavit booster. While the company has not yet launched any of it LK boosters, they were one of two companies to win NASA's light launcher competition.

Other International Launch Providers

Other international launch providers are attempting to market Russian launchers. Numerous companies are studying many other possibilities. These and other launch projects have no confirmed launch orders to date.

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