1. LOCKHEED MARTIN LAUNCH VEHICLE FAMILY

- **ATLAS**

  The ATLAS vehicle has evolved through various United States Air Force (USAF) and National Aeronautics and Space Administration (NASA) programs over the years.

  The ATLAS launch vehicle started out as an ICBM (Inter Continental Ballistic Missile), first launched in 1957. It consists of a pressure-stabilized stainless steel structure that has resulted in the highest stage to mass ratio until today. The "one-and-a-half stage" concept was likewise revolutionary.

  Commercial applications for ATLAS have developed to include the manned Mercury programme and scientific missions. The addition of the Centaur cryogenic upper stage, brought more technical innovations in the launch vehicle arena.

  In 1981, the ATLAS G booster was developed to improve ATLAS/Centaur performance by increasing propellant capacity and upgrading engine thrust. In 1987, the General Dynamics Space Systems Division (now Lockheed Martin Astronautics) decided to develop and build 18 ATLAS-Centaur designated **ATLAS 1** for commercial sale. This baseline evolved into today’s **ATLAS 2, 2A and 2AS** launch vehicle family.

  In November 1995, Lockheed Martin announced the development of the **2AR** (R means re-engined) to replace all previous models. This radical redesign was intended to reduce costs by adopting the Russia’s RD-180 main engine and a single engine Centaur. In 1998, a change of designation was decided: ATLAS 2AR would become **ATLAS 3A** and a variant known as the 2ARS would become the **ATLAS 3B** (with a longer Centaur stage).

  The successful launches of the first **ATLAS 3A** and **ATLAS 3B** paved the way for transitioning into the next generation family **ATLAS 5** which was at first designed as part of the US Air Force Evolved Expendable Launch Vehicle (EELV). After a competition phase between Lockheed Martin and Boeing (with its DELTA 4 EELV project), USAF was persuaded that the commercial market was large enough to support the development of the two programs. The **ATLAS 5-400** and **ATLAS 5-500** series combine a Common Core Booster (CCB) with 4 m or 5 m diameter various fairings to perform a large variety of missions.

  An **ATLAS 5 Heavy Lift Vehicle (HLV)** combining 3 CCB also has been designed to deliver the US national largest security missions; the Air Force has cancelled development of the launcher which will not be built until an order is placed.

  The figure below shows ATLAS evolution since its first launch.
Launch services

ATLAS is offered to commercial and government launch services users through International Launch Services (ILS), a joint venture formed in 1995 between the Lockheed Martin Corporation and the Lockheed-Khrunichev-Energia International Incorporated (LKEI) joint venture. ILS markets and manages ATLAS and Proton launch services.

All ATLAS contracts, for both commercial and government customers, are held by Lockheed Martin Commercial Launch Services (LMCLS), while all Proton contracts are administered by Lockheed Khrunichev Energia International (LKEI).

TITAN

Developed by Martin Marietta, (now Lockheed Martin Astronautics), the TITAN family consists of expendable launchers derived from the TITAN ICBM of the 1960s. By 1988, three basic models with several different upper stages were proposed for military and commercial purposes:

- **TITAN 2 SLV** (Space Launch Vehicle), mainly used for Gemini programme (10 manned and 2 unmanned missions). Since 1988, 14 of the retired intercontinental ballistic missiles TITAN 2 (1969-1987) have been refurbished for use as space launch vehicles under the name of TITAN 2-23G which made his last flight in 2003.

- **TITAN 3** commercial launch vehicle, without upper stage or with Transtage upper stage (TITAN 3T). The last TITAN 3 was launched on 25.09.1992.

- **TITAN 4A** the most powerful version developed for USAF. This version replaced the TITAN 34D model, removed from service following its 15th and final launch in September 1989. TITAN 4A, which at first was called TITAN 34D7 (as it had two 7-segment SRM), was in use until August 1998.

As of December 2003, one TITAN version is operational:

- **TITAN 4B** featuring new electronics and upgraded strap-on boosters (SRMU) compared with the previous TITAN 4A version. The first TITAN 4B was launched from Cape Canaveral in February 1997. Lockheed Martin completed building the final TITAN 4B launcher in April 2002; no further production is planned. The last TITAN 4B should be launched from Vandenberg in 2005.

Launch services

Lockheed Martin and U.S. Air force teams are coordinating TITAN launch operations.
In 1987, Lockheed began studying the conversion of submarine-launched ballistic missiles to space launch vehicles but, in 1990, gave up this approach and instead chose, for a best reliability, the option of using existing hardware and rocket motors.

In May 1993, the development of the LLV (Lockheed Launch Vehicles) was announced. In 1995, after Lockheed merged with Martin Marietta, launchers were renamed LMLV (Lockheed Martin Launch Vehicles). The first LMLV 1, launched in August 1995, ended in failure about 3 minutes after liftoff. The second launch on 22 August 1997 was successful.

The programme LMLV was again renamed ATHENA before the launch of the first LMLV 2. In January 1998, ATHENA 2 made its maiden flight from Cape Canaveral sending Lunar Prospector spacecraft to study the moon.

Although seven ATHENA configurations were once envisioned, only two versions are operational:

- **ATHENA 1** (Castor 120 first stage and Orbus 21D second stage) delivers up to 800 kg into LEO (3 successful launches as of December 2002).
- **ATHENA 2** (Castor 120 first and second stages, and Orbus 21D third stage) delivers up to 1900 kg into LEO (2 successful launches as of December 2002).

ATHENA had very few orders up to now. However, ATHENA 1 and 2 is kept alive by Lockheed Martin in a small launcher market extremely competitive.

**Launch services**

The ATHENA Programme is based at Lockheed Martin Astronautics in Denver and was realized by a strategic commercial partnership between Lockheed Martin, Thiokol, Pratt & Whitney and Primex Aerospace, each of whom invested in the development of their respective subsystems. Lockheed Martin assumes responsibility for the overall launch system, its integration and operation, and all launch services are provided to a customer.
2. BOEING LAUNCH VEHICLE FAMILY

- **DELTA**

The DELTA launch vehicle appeared in 1960, with the first launch of the new, NASA-developed vehicle carrying an Echo, passive communications satellite. Douglas Aircraft Missile & Space Systems Co., later McDonnell Douglas, now part of Boeing was the prime contractor of the first model. Using a modified Thor as the first stage and Vanguard components as second and third stages, it was rapidly developed into a NASA workhorse, and over the years was continuously uprated in line with the growing needs of the satellite community. Many of these upratings involved changes in the vehicle’s propulsion systems, such as increasing propellant tank storage capacity, uprating first and second-stage engines, increasing size of third-stage solid propellant engines, and adding strap-on solid propellant boosters.

The 1960 initial DELTA used a Rocketdyne MB-3 first stage engine and an Aerojet AJ 10-118 second stage engine. Castor 1 strap-on boosters were added in 1964.

A major evolution occurred in 1973 when a more powerful Rocketdyne RS-27 engine replaced the MB-3 on the 2000 series. The DELTA configurations between 1975 and mid 1980s were designated the 3900 series with nine larger Castor 4 SRM and AJ 10-118K second stage engine.

In 1984, the production line was ordered to close down but the Shuttle’s failure in January 1986 resulted in its reactivation eight months later. A contract was awarded to McDonnell Douglas for the new DELTA 2 launchers called 6900 and 7900 series which were upgraded versions of the 3920/PAM-D vehicles.

Through the 1990s, the DELTA 2 manifest continued to expand with commercial GEO satellites rapidly growing too heavy to lift for this launcher; a new version was needed. In response, the DELTA 3 was developed: a first stage powered by one RS-27A engine and a second stage by a new cryogenic RL-10B2 engine. The first two DELTA 3 launches ended in failure in 1998 and 1999 before the third flight was successful in August 2000.

In October 1998, the US Air Force announced the procurement of 19 DELTA 4 launchers for the EELV programme. The DELTA 4 family includes 5 vehicles with GTO payload capabilities ranging from 3960 kg to 13130 kg: one medium, three medium-plus variants and one heavy version. The maiden flight of the series with a DELTA 4M+(4,2) version has been successful on 20 November 2002.

At the end of 2002, the total number of DELTA launches was 293 with a successful rate of 98%.
SEA LAUNCH SYSTEM

BOEING initiated the Sea launch joint venture in 1994 for three-stage ZENIT launch vehicle to be shipped to the US, assembled and then transported into international waters for near-Equator launches. In 1995, a consortium called SEA LAUNCH was formed by BOEING (40% share) with the Norwegian shipbuilding group KVAERNER (20%), RCS ENERGIA of Russia (25%) and YUZHNOYE of Ukraine (15%) to offer commercial ZENIT 3 launch services to GTO. Operating from a homeport in California, SEA LAUNCH uses a ship as command centre and a semi-submersible oil-drilling platform (“ODYSSEY”) as a floating launch pad.

The ZENIT 3 SL is a three-liquid propellant launch vehicle employing the first and second stages from ZENIT 2 with a Russian restartable Block DM third-stage. The first demonstration launch was successfully carried out in March 1999. Since then 8 commercial launches took place with one failure on March 12, 2000 caused by a simple ground software logic error. According to forecast, 2 to 4 launches per year should be implemented until 2010.

LAND LAUNCH SYSTEM

In addition to its sea-based launches, Sea Launch announced in October 2003 its intention to offer commercial launch services with its new launcher system, named Land Launch, from the Baikonur Cosmodrome in Kazakhstan.

There are two Land Launch configurations:

- The Zenit-3SLB (“B” for Baikonur), a three-stage launch vehicle closely derived from the Sea Launch Zenit-3SL, is suited for delivering payloads to medium and high, circular and elliptical Earth orbits, including GTO and GEO, as well as escape trajectories.
- The Zenit-2SLB, a two-stage launch vehicle based on the first two stages of the Sea Launch Zenit-3SL, is designed for delivering payloads to inclined low Earth circular and elliptical orbits.

Launch services will be managed by SIS (Space International Services based in Moscow) via a subcontract from Sea Launch. The initial launch is scheduled for the end of 2006.
3. ORBITAL SCIENCES CORPORATION (OSC) LAUNCH VEHICLE FAMILY

- **PEGASUS**
  
The PEGASUS vehicle is the product of a privately funded joint venture of Orbital Sciences Corporation (OSC) and Hercules Aerospace Company (now Alliant TechSystems).
  
  In July 1988, OSC was awarded a first development contract from DARPA (Defense Advanced Research Projects Agency). It is a three-stage, solid propellant, inertially guided, all composite winged space booster. It is carried aloft by a conventional transport-bomber aircraft to approximately 13,000 m altitude. The initial vehicle attained orbit 5 April 1990 after being released from a B-52 near Monterey (California). PEGASUS can operate from a number of established airfields and ranges which are used for carrier aircraft take-off. In 1992, OSC acquired a Lockheed L-1011 Tristar transport aircraft as their launch carrier.

  A lengthened version, PEGASUS XL, was conceived to satisfy the need of greater payload performance. The first launch, on 27 June 1994, ended in failure. After a second launch failure on 22 June 1995, the third flight was successful in March 1996. The last PEGASUS standard version was launched in May 1996; no more mission was flown with that version.

  Some further PEGASUS XL launches are scheduled at least until 2004 as the market for small launch vehicles faces hard competition. OSC also has designed PEGASUS-derivative launch vehicles for the NASA X-43A unmanned research aircraft Hyper-X.

- **TAURUS**
  
  TAURUS, an inertially guided 3-axis stabilized solid propellant standard small vehicle (SSLV), is a four-stage launcher developed in 1989 by OSC. The vehicle’s three upper stages were derived from PEGASUS, supported by a 2.38 m diameter Thiokol Peacekeeper stage 1.

  Following the successful maiden flight (13.03.1994), OSC initiated the development of a commercial version which uses the Thiokol’s Castor 120 as a first stage. Since February 1998, five missions took place from Vandenberg (California) with one failure in September 2001.

  An upgraded model, the TAURUS XL, which will use the same stretched motor as the PEGASUS XL is being developed. Its first flight is planned in late 2003 carrying a remote sensing satellite. An XLS variant with two Castor 4B strap-on rocket motors could be available if additional payload capability were required.

- **MINOTAUR**
  
  OSC have developed the four-stage MINOTAUR Space Launch Vehicle (SLV) for the US Air Force under the Orbital/Suborbital Program (OSP), providing a low-cost, reliable solution for launch services of government-sponsored payloads. The vehicle utilizes residual Minuteman 2 missile first and second stages and the upper stages of PEGASUS XL.

  MINOTAUR made its inaugural flight in January 2000 and extended its success less than six months later in July 2000. MINOTAUR's payload capability can be considered between those of PEGASUS XL and TAURUS.

4. SCOUT LAUNCH VEHICLE FAMILY

The SCOUT launch vehicle programme was conceived in 1957 by personnel at NASA’s Langley Research Center. The aim was to provide an inexpensive launch vehicle for relatively small, research spacecraft, probes and re-entry vehicles.

On January 1, 1991, after more than 30 years, NASA Langley transferred the management of SCOUT programme to the NASA Goddard Space Flight Center.

In use since July 1960, it was generally a solid-propellant four-stage vehicle, which evolved as shown below. The original SCOUT's first stage was based on earlier version of the Navy's Polaris missile motor; the second stage was derived from the Army’s Sergeant missile; the third and fourth stage motors were adapted from the Navy’s Vanguard missile.

As of October 1979, the SCOUT G-1 configuration was used. SCOUT flights ended in 1994 after 118 missions.
5. CONESTOGA LAUNCH VEHICLE FAMILY

In 1982, Space Services Inc. (SSI), a privately funded company, conducted from Matagorda Island (Texas), a preliminary suborbital demonstration launch of a vehicle called CONESTOGA 1 using a single Minuteman 1 second stage motor. In 1984, a CONESTOGA 2 project was planned: it had a modular configuration by using a simple building block approach of Morton Thiokol Castor strap-on motors in multi-unit parallel mountings and different upper stages based on Star motors.

SSI acquired in December 1990 by EER Systems Corp., designed a new CONESTOGA solid propellant family of orbital launchers capable of handling up to 1800 kg into LEO. Four orbital versions based on Castor 4A/4B solids with Star injection stages were defined.

The CONESTOGA 1620 model was selected to provide launch services for a NASA sponsored microgravity mission. On October 23, 1995, the maiden flight from Wallops Island (Virginia) ended in failure. As EER company ran out of money, the programme was stopped and there were no further launches.

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