LAUNCH VEHICLES

Thor and Atlas Derivatives

The earliest launch vehicles used by the Air Force were Thor and Atlas missiles modified by the Air Force Ballistic Missile Division and Space Systems Division to serve as space boosters. Indeed, the Air Force achieved its first partial success in space with a lunar probe that was launched by a Thor missile with a Vanguard second stage, a configuration called the Thor Able, on 11 October 1958.[6] Its first satellite was Project SCORE, an Atlas B developmental missile containing a communications repeater in one of its side equipment pods. AFBMD launched the entire missile (minus the spent half stage) into orbit on 18 December 1958. Thor and Atlas missiles with only minor modifications continued to be used as space boosters for a long time, especially for military and civilian weather satellites. The last Thor launch occurred on 15 July 1980, and the last launch of a modified Atlas missile occurred on 24 March 1995, with both boosters carrying military weather satellites. As time went by, Thor and Atlas vehicles were improved and standardized, and families of Standard Launch Vehicles were created. The Thor gave rise to the series known as Standard Launch Vehicle 2, and the Atlas gave birth to the several varieties of Standard Launch Vehicle 3. Upper stages such as the Agena, the Burner II, and the Stage Vehicle System were developed for use with these vehicles. Together with their associated upper stages, Thor and Atlas launch vehicles constituted the backbone of the American space program.

The launch vehicles developed by the Air Force Ballistic Missile Division and its successors were used not only by the Air Force, but also by the National Aeronautics and Space Administration (NASA), created in 1958. Civilian programs began using boosters based on the Thor missile immediately, and in 1959, NASA began developing the Delta upper stage for it from the second stage of the Thor Able—the first step in developing the highly successful Delta launch vehicle. NASA started using the Atlas vehicle in 1959, and its first manned space program, Project Mercury, relied on the Atlas for its orbital flights. Project Gemini, the agency's next manned program, employed Titan II boosters developed and procured by Space Systems Division. The Gemini Target Vehicle, an Agena upper stage, was also developed by Space Systems Division (SSD). The Agena was later modified by NASA and employed extensively by both agencies. The Centaur upper stage, the most powerful upper stage in the national inventory, was born as an Air Force program before being transferred to NASA in 1960. It is noteworthy that much of this cooperation in developing and using launch vehicles was the result of a carefully considered series of written agreements, initiated in 1959 and expanded during the early 1960s, which made up a National Launch Vehicle Program.

Titan III

Thor and Atlas boosters were complemented by the Titan III, a powerful booster capable of launching large, heavy payloads. Development of the Titan III was initiated in late 1961, and the first research and development vehicle was flown on 1 September 1964. This vehicle, a Titan IIIA, consisted of a modified Titan II core topped by an upper stage called the Transtage. A new configuration, the Titan IIIC, was successfully launched from Cape Canaveral on 18 June 1965. The IIIC used two strap-on solid rocket motors that generated around one million pounds of thrust each. From 1965 through 1989, Titan III vehicles performed well in a wide variety of missions and configurations.

The family expanded to include the Titan IIIB Agena D, the Titan IIID, and the Titan IIIE Centaur, which was used by NASA for space projects such as the Viking missions to Mars. The final variety of Titan III, the Titan III (34)D, was used during the 1980s as a backup and alternative to the manned Space Shuttle. The last 34D was launched on 4 September 1989.

Space Transportation System

During the 1970s, NASA developed a Space Transportation System employing a manned, reusable Space Shuttle to replace most expendable launch vehicles. In addition to monitoring the development of the Shuttle to ensure that it would satisfy DOD's requirements, SAMSO contributed several important elements to allow DOD to make full use of the system. It developed and almost completed a launch and landing site at Vandenberg AFB to allow the Shuttle to be launched into polar orbits. It also developed the Inertial Upper Stage (IUS), an upper stage for large Shuttle payloads requiring higher orbits. The IUS was adapted for use with the Titan III and, later, the Titan IV expendable system as well. Although it had a troubled and costly developmental period, the IUS came to be considered an accurate and reliable launch system.

On 28 January 1986, a Space Shuttle exploded during launch, killing the crew of the orbiter *Challenger*. NASA was forced to suspend all Shuttle launches while it investigated the cause of the explosion and assessed its implications. Military payloads as well as civilian payloads scheduled for the Shuttle had to obtain launches on expendable boosters or wait. Shuttle flights did not resume until 29 September 1988. The disaster had further implications for SSD. Development of the Shuttle facilities at Vandenberg ended after the disaster because of deficiencies in the design of the launch pad and because of national policy changes in favor of returning to expendable launch vehicles for national security missions.

Although eventually the Air Force was able to shift some of its most critical payloads to Titan vehicles, the Titan program happened to be suffering from launch failures of its own when the *Challenger* disaster occurred. After consecutive launches of Titan 34Ds failed on 28 August 1985 and 18 April 1986, further launches were suspended while the causes were investigated. They resumed on 26 October 1987, restoring the only available alternative to the Space Shuttle for large payloads.

Titan IV

The *Challenger* disaster gave added weight to the argument for having a variety of expendable launchers available so that failures in one type would not again affect so many payloads. Space Division had already begun the development of a larger, more capable Titan booster known as the Titan IV in 1985. Launched for the first time on 14 June 1989, the Titan IV could be used with either an IUS or a newly developed version of the Centaur upper stage. It was capable of placing 10,000 pounds into geosynchronous orbit using the Centaur. The Titan IV's performance would be considerably enhanced by upgraded solid rocket motors. Their development was delayed when the first qualification motor exploded during a test firing on 1 April 1991, but they successfully completed the final test firing on 12 September 1993. Vehicles without the upgraded motors were known as Titan IVAs, and those with the new motors were called Titan IVBs. For some smaller payloads, Space Division began converting the obsolete Titan II ballistic missiles that had been removed from their silos during 1982-1987.[7] They could place about 4,200 pounds into low-earth, polar orbit, and the first was launched on 5

September 1988.