III. LAUNCH VEHICLES

(A) CURRENT & "NEAR" FUTURE

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UNITED STATES LAUNCH VEHICLE SYSTEMS

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Abstract. United States policy for national space launch capability provides for a balanced mix of launches, utilizing the Space Shuttle and Expendable Launch Vehicles (ELVs). It also directs government agencies to encourage and support the development of a domestic commercial expendable launch vehicle industry. This is to be accomplished by contracting for necessary ELV launch services directly from the private sector and by facilitating access by commercial launch firms to national launch and launch-related property and services they request to support these commercial operations.

The current mixed fleet includes the Space Shuttle and four expendable launch vehicles – Titan, Atlas, Delta and Scout. New small class launch vehicles, including Pegasus, are in development. In addition, studies are underway to assure that the United States has cost-effective, reliable access to space, heavy-lift launch capability, and a new manned spacecraft after the current Space Shuttle reaches the end of its operational life. This paper will highlight the current capabilities of the mixed fleet and summarize the plans for new or modified United States launch vehicles through the first decade of the next century.

1. Introduction

Assured access to space, sufficient to meet defined space goals, is at the heart of United States National Space Policy. Space transportation systems are to provide a balanced, robust, and flexible capability with sufficient resiliency to allow continuous operations even if failures in any one system occur. During the past four years, the focus of United States space launch strategy has been to restore the launch vehicles that were in use prior to 1986 to safe and reliable flight. The Shuttle, Titan, Delta and Atlas/Centaur vehicles all suffered significant failures that resulted in extensive accident investigations for all, as well as extended downtime for both Shuttle and Titan. The Shuttle and Titan programs have since made vehicle and launch processing improvements to increase vehicle reliability. The Space Shuttle has flown 9 successful missions since its return to flight in September 1988. Four of the eight planned flights in Fiscal Year 1990 have been completed. It is scheduled for ten flights in Fiscal Year 1991, eleven in Fiscal Years 1992 and 1993, and will achieve a planned steady flight rate of twelve in Fiscal Year 1994 and beyond. The Delta II launch vehicle has flown seven times, and the Titan III and Atlas I vehicles once each. The first launch of the Titan IV will be in 1990 and the first Atlas II in 1991.

National policy now mandates that the Space Shuttle only be utilized for those missions that require the presence of man, the Shuttle's unique capabilities, or where it is determined that the use of the Shuttle for launch of a payload is dictated by

Y. Kondo (ed.), Observatories in Earth Orbit and Beyond, 325–332.

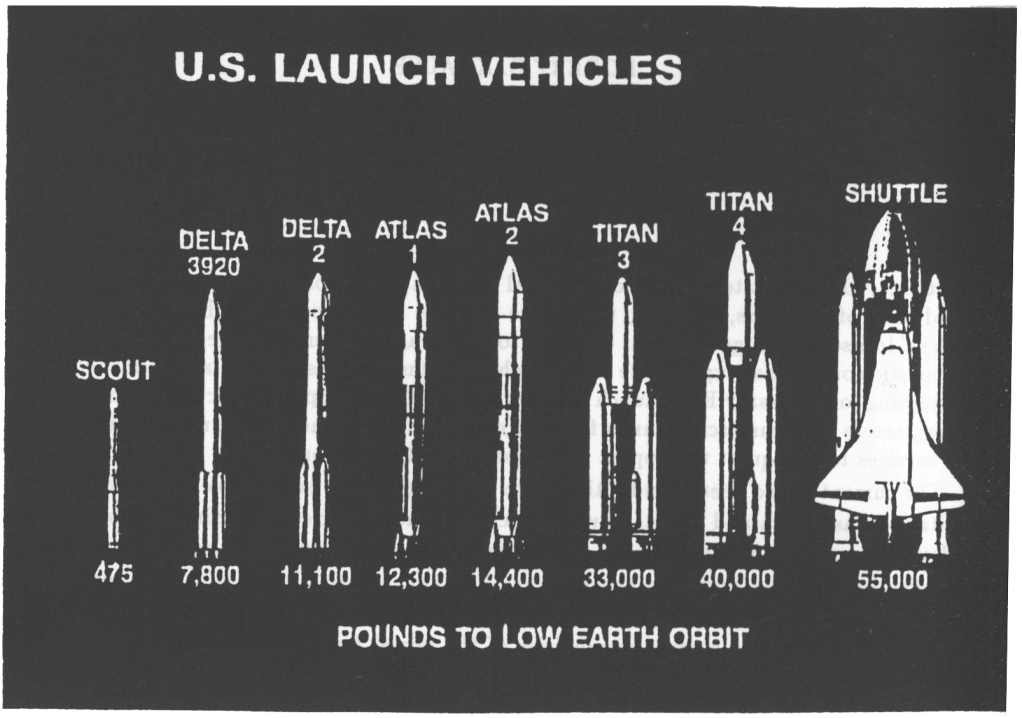

Fig. 1.

national security or foreign policy considerations. Commercial payloads have, therefore, been off-loaded from the Shuttle and a domestic commercial launch industry has been encouraged by NASA through purchase of needed ELV launch services directly from the private sector.

In the near-term, United States launch strategy is characterized by the introduction of several new production expendable launch vehicles, growth of the commercial launch services industry and continued improvement in the Space Shuttle.

In the long-term, a number of advanced space transportation systems studies and related technology programs are underway. These include the Shuttle-C cargo carrier element, an Advanced Launch System, the next manned spacecraft, and the Aerospace Plane.

2. Current and Near-term Launch Vehicle Studies

The current and near-term launch vehicles in the United States inventory are shown in Figure 1. A summary of Expendable Launch Vehicle performance capabilities is shown in Figure 2. A brief description of the capabilities by launch vehicle follows:

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U.S. EXPENDABLE LAUNCH VEHICLES

VEHICLE	AVAILABILITY	PERFORMANCE (I = 28°) LBS			PAYLOAD FAIRING DIAMETER	ESTIMATED VEHICLE LAUNCH SERVICES COSTS 1990 $
		LEO	GTO	GSO		
SCOUT - ETR - WTR	NOW	570 460			2.9 AND 3.5 FT	$10-20M
DELTA II MODEL 6925 MODEL 7925	FEBRUARY 1989 1990	8,780 11,110	3,190 4,010	1,600 2,000	8 AND 9.5 FT 10 FT (FEBRUARY 1990)	$45-50M
ATLAS I	NOW	13,000 12,550	5,150 4,950		11 FT 14 FT	$65-70M
ATLAS II *	EARLY 1991	14,950 14,500	6,100 5,900		11 FT 14 FT	$70-80M
ATLAS IIA	1992	15,700 15,250	6,400 6,200		11 FT 14 FT	$80-90M
ATLAS IIAS	1992	19,000 18,500	8,000 7,700		11 FT 14 FT	$110-120M
TITAN II * (WTR)	SEPTEMBER 1988	4,200			10 FT	$35-40M
TITAN III WITH SRMU	1989 1992	30,500 38,000	11,000		13.1 FT	$145-155M
TITAN III / TOS	1992		13,000		13.1 FT	$190-200M
TITAN III / IUS WITH SRMU	1989 1992			4,200 5,000	10 FT	$245-255M
TITAN IV * / NUS WITH SRMU	1989 MID 1991	39,000 49,000			16.7 FT	$180-240M
TITAN IV * / IUS WITH SRMU	1989 MID 1991	49,000	15,000	5,200 6,600	16.7 FT	$280-340M
TITAN IV * / CENTAUR WITH SRMU	1990 MID 1991			10,200 13,500**	16.7 FT	$260-320M

* NOT COMMERCIALLY AVAILABLE
** CURRENT CENTAUR IS STRUCTURALLY LIMITED TO 11,500 LBS

Fig. 2.

2.1. Space Shuttle

The Space Shuttle, developed and operated by NASA, provides the nation's only means of manned access to, transportation in, and return from space. The unique capabilities of the Space Shuttle allow support of a wide variety of tasks, including lifting heavy payloads into orbit; retrieving, servicing and repairing satellites; and returning payloads to the earth. The task of satellite servicing and repair will become extremely important in the future as large facility-class assets, such as NASA's Great Observatories and Space Station Freedom, are in orbit for extended periods of time.

With its existing configuration, the Shuttle is capable of delivering up to 55,000 pounds to a 160 nautical mile low earth orbit (LEO) at an inclination of 28.5 degrees. A significant improvement in payload capacity will be achieved with the implementation of the Advanced Solid Rocket Motor (ASRM). The primary need for the ASRM is to improve Space Shuttle flight safety and reliability; however secondary benefits include reduced cost, improved performance, and assured access to space for large payloads. The design goal for the ASRM is to increase payload

to orbit capability by 12,000 pounds, which restores the Shuttle to its full design capability.

2.2. Titan

The Titan II was modified by the Department of Defense (DOD) for launches of smaller payloads to polar orbit. The Titan II vehicles were decommissioned ICBMs that were refurbished, equipped with hardware required for space launch, fully tested, and certified for space flight. The initial launch of the Titan II was in September 1988. It can place up to 4,200 pounds in low earth polar orbit from the United States Air Force (USAF) facility at Vandenberg Air Force Base (VAFB).

The Titan 34D is an operational DOD launch vehicle that is an evolution of the Titan III family of vehicles first launched operationally in 1966. With an Inertial Upper Stage (IUS), it is capable of delivering 4,200 pounds to geosynchronous orbit (GSO) from Cape Canaveral Air Force Station (CCAFS) and 27,600 pounds to polar orbit from VAFB. The commercial Titan III is almost identical to the Titan 34D except for a modified payload fairing.

Titan IV development began as a complement to the Space Shuttle and was expanded following the Challenger accident to launch critical payloads that were expected to be impacted by the Shuttle recovery schedule and cancellation of the Shuttle/Centaur program. The Titan IV with an IUS is scheduled for initial launch capability in 1990. It will be capable of delivering 5,200 pounds to GSO. Initial launch capability of the Titan IV/Centaur is planned for May 1990. It will be capable of delivery of 10,200 pounds to GSO. These Titan IV configurations will be launched from CCAFS. A Titan IV with no upper stage will be used for launches into polar and high inclination orbits from VAFB. It will be capable of delivering 39,000 pounds to a 100 nautical mile polar orbit.

A Titan Solid Rocket Motor Upgrade (SRMU) is under development and will provide improved reliability and producibility as well as 25 percent greater payload capability. It is planned for the eleventh Titan IV launch and can be utilized on the Titan III as well.

2.3. Atlas

The Atlas family of vehicles includes the Atlas E, which is a decommissioned ICBM, presently used to launch payloads up to 1,800 pounds to low polar orbit from VAFB; the Atlas/Centaur which can launch up to 2,860 pound payloads to GSO from CCAFS; and the Atlas II which will be an upgraded version of the Atlas/Centaur. The Atlas II will have its initial launch capability in early 1991 and will be capable of launching intermediate class payloads (up to 5,900 pounds) into geosynchronous transfer orbit (GTO) from CCAFS.

A commercial Atlas IIA, which will be available in 1992, will have uprated engines. This will increase its capability to GTO to 6,200 pounds. A commercial Atlas IIAS, also available in 1992, will have four strap-on boosters and be capable of placing 7,700 pounds in GTO.

2.4. Delta

The NASA Delta vehicle was derived from the Thor intermediate range ballistic missle, with improved first and second stages and the addition of several small solid rocket motors. Through a series of upgrades, the capability of this vehicle grew to approximately 1,450 pounds to GTO, 5,500 pounds to polar orbit and 7,600 pounds to LEO. The last NASA Delta vehicle was launched in 1989.

The Delta II launch vehicle was developed by the DOD as a medium class vehicle. The initial version, launched in February 1989 was capable of placing 8,780 pounds into a low earth orbit, 3,190 pounds into GTO, or 1,600 pounds into GSO. In 1990, an upgraded version will be introduced which will increase capability to 11,110 pounds to LEO, 4,010 pounds to GTO, and 2000 pounds to GSO.

2.5. Scout

The NASA Scout is a solid propellant, four stage booster with the capability to launch small payloads – approximately 570 pounds to low earth orbit and 460 pounds to polar orbit.

2.6. Pegasus

The Pegasus is an air launched, solid propellant, three stage booster, which was commercially developed and recently had its initial and successful launch. Its capability is about 600 pounds to a polar low earth orbit or 275 pounds to GTO, using a NASA B-52 aircraft as the launch platform.

3. Long-term Launch Vehicle Systems

For the mid-1990s and beyond, a number of launch systems options are being considered. These include studies of the Shuttle-C cargo carrier element, the Advanced Launch System, the next manned spacecraft, and the National Aerospace Plane.

3.1. Shuttle-C

NASA is defining an unmanned cargo concept using the Space Shuttle Vehicle without the Orbiter. In its place is a cargo carrier to which the Space Shuttle main engines are attached. This concept, termed Shuttle-C (for cargo) would build on current Space Shuttle Program experience and infrastructure, using mature elements of the Program's ground and flight systems to provide a limited capability to satisfy potential future heavy-lift launch capability from 1994 through the point where the Advanced Launch System would be available.

Shuttle-C studies now underway will provide further definition of a Shuttle-derived launch vehicle that could be capable of delivering 100,000 to 150,000 pounds due east to low earth orbit or 85,000 to 115,000 pounds into polar orbit. The Shuttle-C concept could support Space Station Freedom assembly, enable planetary and geosynchronous missions, provide an alternate booster for Centaur-class payloads, and serve as a testbed for future launch vehicle elements.

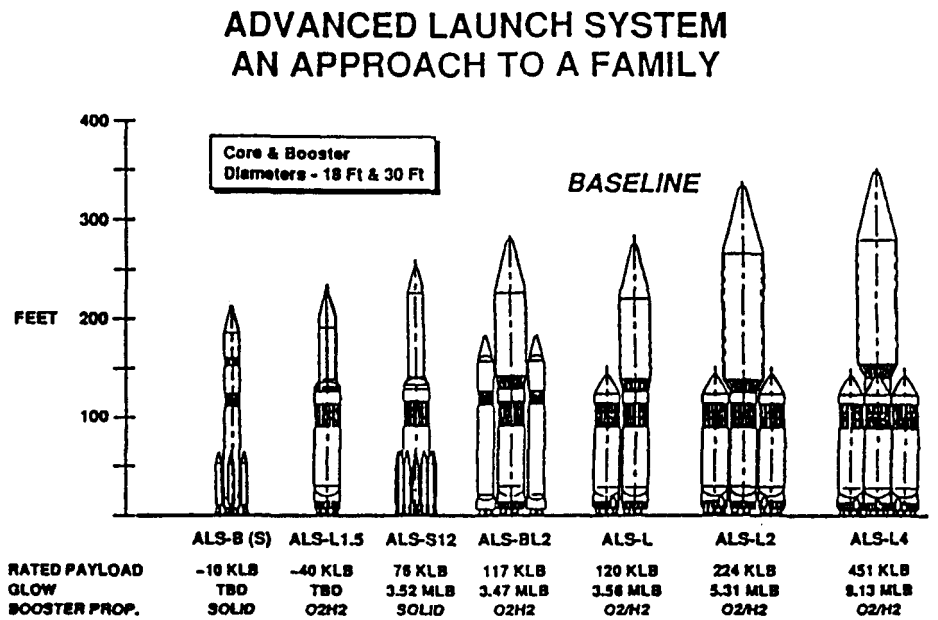

Fig. 3.

3.2. Advanced Launch System

The Advanced Launch System (ALS) is a joint DOD/NASA program to define concepts and develop technology applicable to a family of unmanned launch vehicles (see Figure 3). They are intended to provide a heavy-lift launch system that meets United States space launch needs and significantly reduces the cost of getting payloads into space. This program is intended to support a broad base of booster and propulsion concepts for both expendable and reusable vehicles with a payload capability range from 85,000 pounds to 150,000 pounds.

3.3. The Next Manned Spacecraft

The present Space Shuttle is expected to reach the end of its operational life in the 2005–2010 timeframe. Since a long lead-time is required to develop space transportation systems, planning for the next manned spacecraft is currently underway. Three concepts are being assessed: evolution of the present Space Shuttle system; a Personnel Launch System (PLS) in combination with man-rated cargo launch and return vehicles; and an Advanced Manned Launch System (AMLS) (see Figure 4). Several key objectives to improve cost effectiveness; increase reliability, maintainability and operability; and improve performance margins will be addressed in examining the three concepts.

The Shuttle evolution concept includes near-term system improvements/evolution of ground and flight operations, fuel cells, the auxiliary propulsion system, and major block upgrades involving the Orbiter, its main engines, and the External Tank.

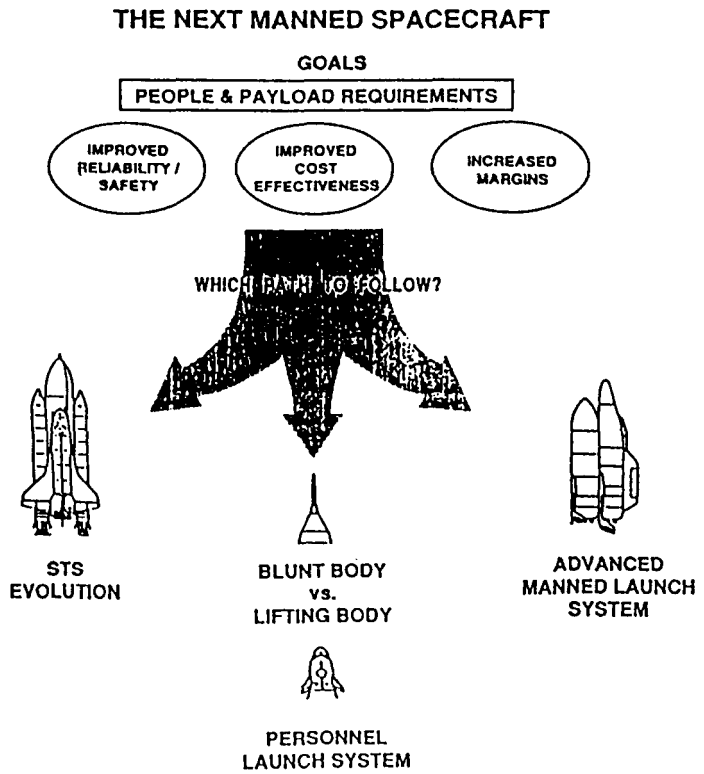

Fig. 4.

We will build on the existing engineering data base, while exploiting new technologies. Vehicle mold-line and configuration changes will be minimized.

The PLS concept will focus on possible vehicles dedicated to only carrying people. It includes configurations ranging from blunt body, Apollo-shaped vehicles to high lift-to-drag ratio winged vehicles launched on an expendable launch vehicle. This approach would also require unmanned cargo vehicles to deliver and return cargo and logistics support to the Space Station Freedom, using automated rendezvous and docking systems. The PLS configuration and size are to be studied.

The AMLS concept represents the next generation of a Shuttle system. It would fully exploit new technologies and provide improved design margins. The baseline AMLS concept is a two-stage reusable rocket configuration; however, partially reusable and expendable launch vehicle concepts will also be considered.

3.4. National Aerospace Plane (NASP)

The NASP is a program to demonstrate technologies for hypersonic flight and single-stage-to-orbit vehicles with potential space transportation applications. The NASP program is currently a research program intended to design, build and test

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fly an experimental flight research aircraft in the mid-1990s. If it is successful in demonstrating the technological basis for systems capable of horizontal takeoff from, and landing on, conventional runways; sustained hypersonic cruise and manuever in the atmosphere; and acceleration to orbit and return, the derived technology will be used to develop a follow-on space plane to be operational in the 2000–2005 timeframe.

4. Summary

The United States has established a balanced mix of manned and unmanned launch vehicles. Through government development of the Space Shuttle and Titan IV and commercial launch industry development/improvement of expendable launch vehicles, a capability margin above payload demand can be realized through the mid-1990s. Continued growth of mixed fleet capabilities is required to meet projected demands in the year 2000 and beyond. To this end, NASA is conducting systems definition studies of a Shuttle-derived cargo vehicle (Shuttle-C) and NASA and DOD are jointly conducting Advanced Launch Systems studies designed to introduce a new family of expendable launch vehicles by the turn of the century. Technology demonstrations in support of National Aerospace Plane development are being planned, with success leading to an operational space plane in the early part of the next century.