C. COMMERCIAL LAUNCH VEHICLE INFORMATION AND DESCRIPTION

1. The Atlas Space Launch Vehicle

a. Description - The typical Atlas is a space launch vehicle which uses RP-1 and liquid oxygen (LOX). The vehicle is ten feet in diameter, 104.7 feet tall and weighs 293,000 pounds at lift-off. It develops 437,500 pounds of thrust at lift-off and is capable of inserting 3,000 pounds of payload into synchronous transfer orbit.[13] See **Figure 10**[14] for a typical Atlas launch vehicle. The Atlas is slightly different from most vehicles in that it has three motors. The two outside motors are referred to as the booster motors and the center motor as the sustainer. At staging, the booster motors slide off rails and the sustainer continues to thrust until burnout.

b. Hazards - The primary hazards are blast over-pressures and fragments from a propellant explosion. There are no toxic hazards associated with the liquid propellants of this launch vehicle.

c. Trajectory - The Atlas is launched on azimuths varying from 158-195 degrees. It nominally clears the land mass in approximately 55 seconds.

d. In-Flight Events - The Atlas lifts off with the two booster engines and the sustainer engine burning and remains in this configuration until booster engine cutoff and jettison of the booster package. The sequence of in-flight events for a typical mission is shown in **Table 7**[4].

e. Atlas Airborne FTS - The FTS consists of two antennas, one coupler, two receivers and one dual channel S&A device. A one pound block of explosive attached to the inter-tank area causes mixing and burning of the liquid propellants when destruct action is taken.[15]

TABLE 7. ATLAS FNOMINAL SEQUENCE OF EVENTS

EVENT	TIME (SEC)
ST I/SM IGN	T + 0
DOGLEG	T + 65
BECO	T + 121
SECO	T + 235
VECO	T + 344

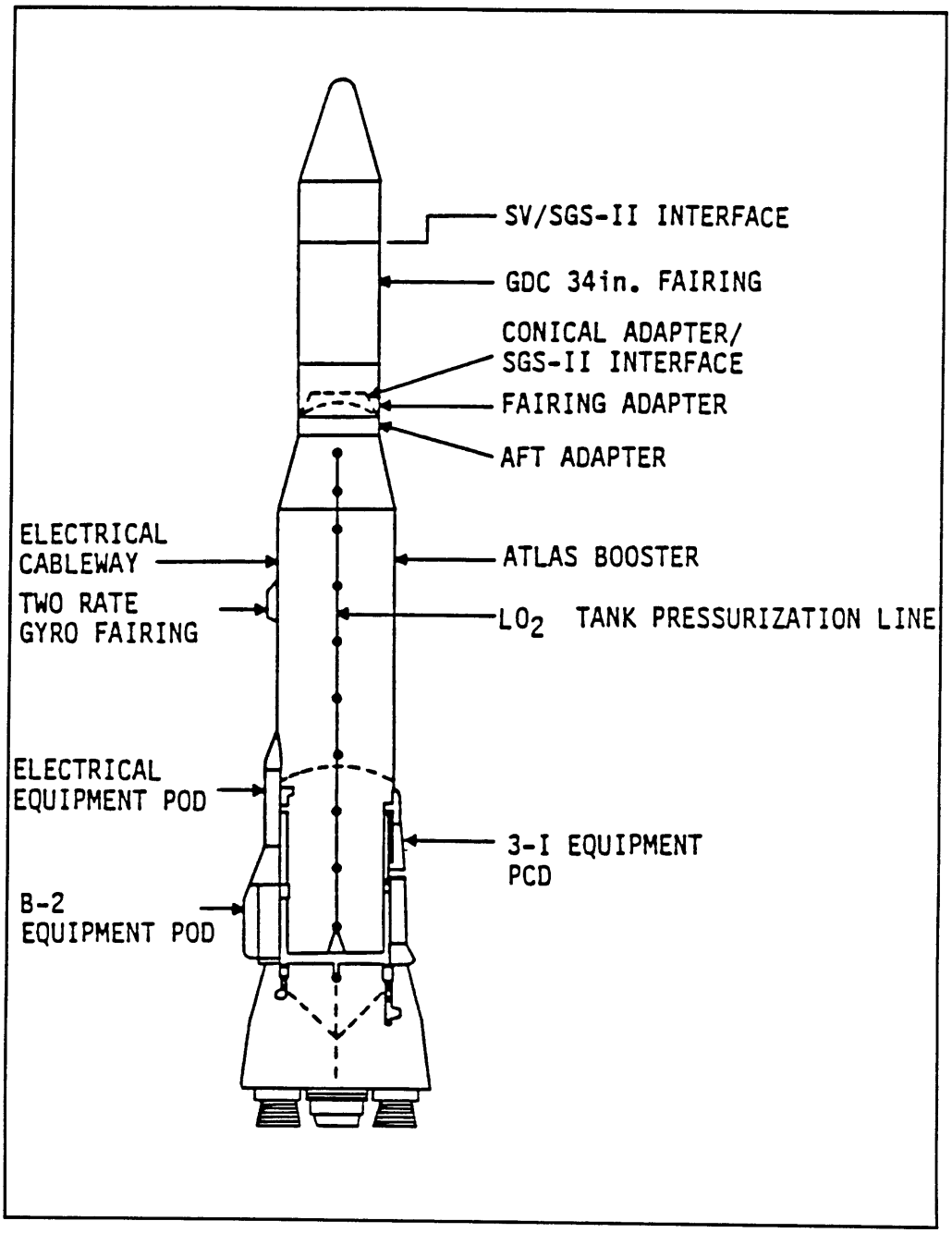

FIGURE 10. ATLAS F VEHICLE

2. The Delta Space Launch Vehicle

a. Description - The typical Delta is a two or three stage, liquid propellant vehicle with nine solid propellant "strap on" booster motors. It uses RP-1 and liquid oxygen (LOX) in the first stage and Nitrogen Tetroxide and Aerozine 50 in the second stage. An optional third stage is a Payload Assist Module (PAM) with a solid rocket motor. The "strap on" solids are Morton Thiokol Castor IV Thrust Augmentation Motors. The vehicle is 8 feet in diameter, 116 feet tall and weighs approximately 422,100 pounds at lift-off. The Delta vehicle develops 565,000 pounds of thrust at lift-off and is capable of placing 2,800 pounds of payload into a synchronous transfer orbit.[13] A typical Delta vehicle is shown in **Figure 11**[16].

b. Hazards - The potential hazards associated with the Delta are blast over-pressure and fragments from exploding vehicle propellants and toxic vapors from the second stage propellants. Normally, there is not a toxic problem due to the relatively small amount of propellantsinvolved. They would disperse before reaching the Range boundaries if released under normal atmospheric conditions.

c. Trajectory - The Delta vehicle is launched on azimuths of approximately 176-213 degrees. It nominally clears the VAFB land mass in approximately 28 seconds.

d. In-Flight Events - The Delta launch vehicle lifts off with the first stage core vehicle and six of the nine solid rocket motors burning. After these solids burn out, the other three are ignited and the burned out motors are jettisoned. The last three burn out and are jettisoned before the main engine cuts off and the first stage is separated. The sequence of events for a typical mission is shown in **Table 8**[4].

TABLE 8. DELTA NOMINAL SEQUENCE OF EVENTS	
EVENT	**TIME (SEC)**
LAUNCH	T + 0
SM BURNOUT (6)	T + 59
SM IGNITION	T + 63
SM JETT	>T + 70
SM BURNOUT (3)	T + 122
SM JETT	T + 124
MECO	T + 224
ST I SEP	T + 232
ST II IGNITION	T + 237
FAIRING JETT	T + 245
ST II BURNOUT	T + 654

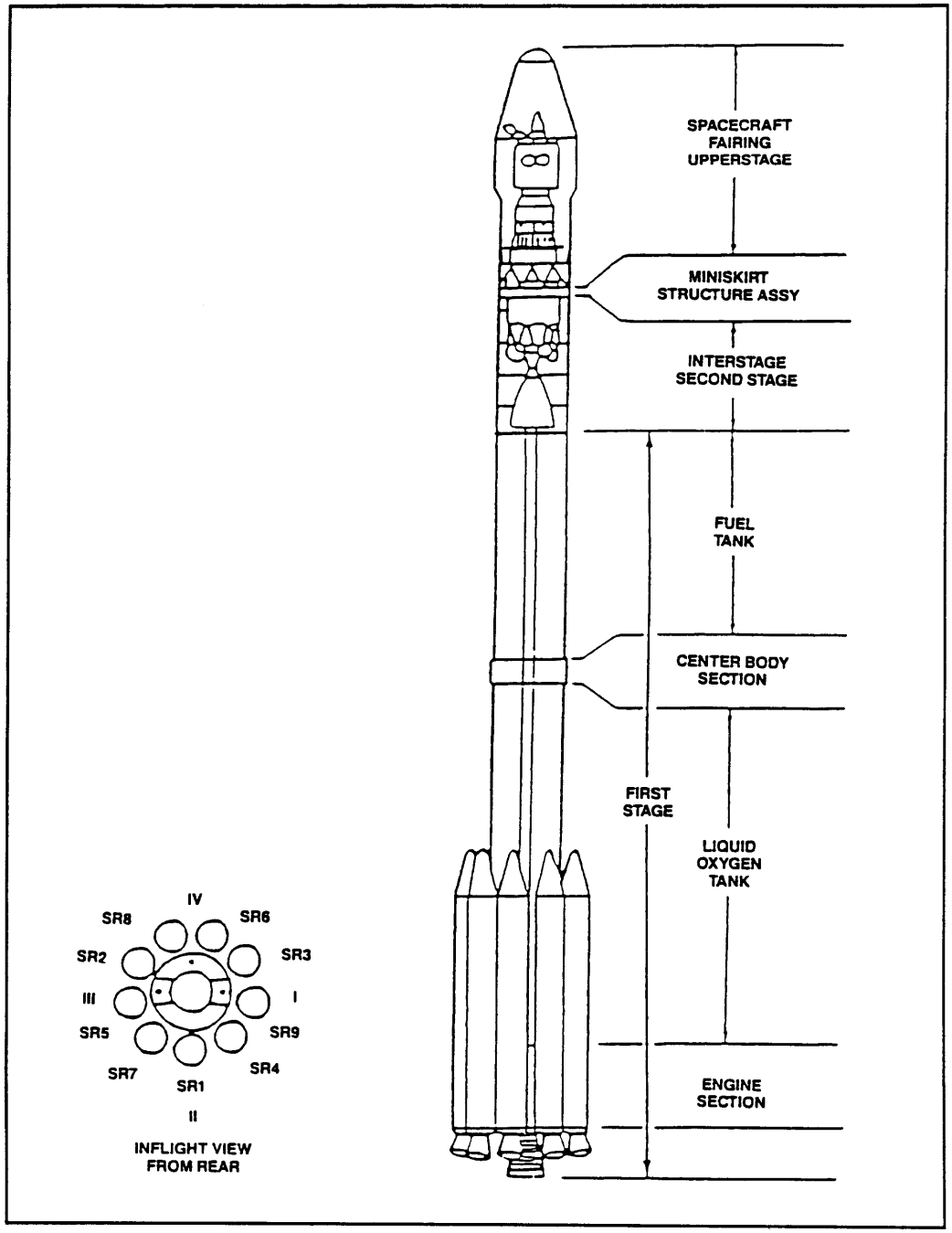

FIGURE 11. DELTA 3920 VEHICLE

e. Delta Airborne FTS - This system consists of two antennas and two receivers on the second stage and two antennas and one receiver on the first stage with connections to four single-channel S&A devices, two on each stage. Redundancy is maintained by using the outputs from one of the second stage receivers to connect to one of the first stage S&A's. The other first stage S&A is connected to the first stage receiver. After first/second stage separation, the two second stage receiver outputs remain connected to the two second stage, single-channel S&A's. In addition to the destruct ordnance on the first stage core vehicle, the first stage S&A's initiate shaped charges on the forward domes of the nine solid rocket motors attached to the first stage. There is no Inadvertent Separation Destruct System on these solids. Plans are to remove the single-channel, lanyard-operated S&A devices and replace them with one dual-channel, electrically operated S&A on each stage. The second stage destruct system is connected by an ordnance link to small shaped charges aimed at the payload booster motor. These charges are initiated by the second stage system.[17]

3. The Scout Space Launch Vehicle

a. Description - The configuration of a typical Scout space launch vehicle is a four-stage, solid-propellant vehicle which is made up of the Algol III-A first-stage motor, the Castor II-A second-stage motor, the Antares III-A third-stage motor and the Altair III-A fourth-stage motor. It is 3.7 feet in diameter, 75.1 feet tall and weighs 47,200 pounds at lift-off. It develops 107,000 pounds of thrust at lift-off and is capable of placing a 400 pound payload into a 345 statute mile orbit.[13] See **Figure 12**[18] for a typical Scout vehicle.

b. Hazards - The primary hazards of this launch vehicle are scattered pieces of burning propellant resulting from a pressure rupture of the separate stages. There are no explosive or toxic hazards associated with this launch vehicle.

c. Trajectory - The Scout is launched on azimuths of 149^0 to 200^0 and normally clears the VAFB land mass in approximately 34 seconds.

d. In-Flight Events - The sequence of in-flight events for a typical mission is shown in **Table 9**[4].

TABLE 9. SCOUT D NOMINAL SSEQUENCE OF EVENTS

EVENT	TIME (SEC)	EVENT	TIME (SEC)
LAUNCH	T + 00	ST III IGNITION	T + 199
ST I BURNOUT	T + 85	ST II SEP	T + 199
ST II IGNITION	T + 88	ST III BURNOUT	T + 246
ST I SEP	T + 88	ST IV SPINUP	T + 586
ST II BURNOUT	T + 128	ST IV IGNITION	T + 592
HS EJECT	T + 197	ST IV BURNOUT	T + 625

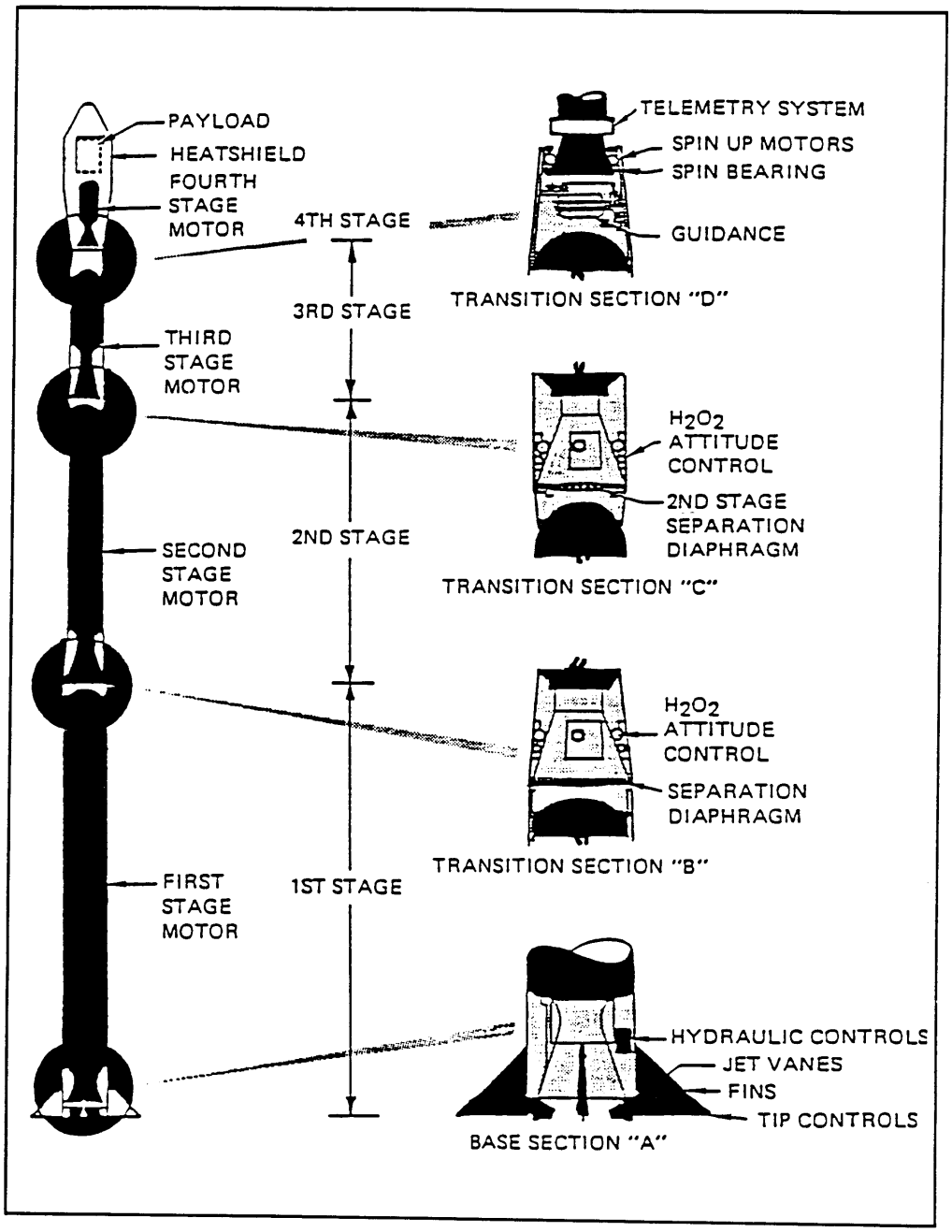

FIGURE 12. SCOUT D VEHICLE

e. Scout Airborne FTS - The Scout FTS consists of two antenna pairs, two receivers and one Destruct Relay Unit mounted on the third stage, with S/A devices and shaped charges on each of the first three stages. ISDS systems are located on the first and second stages. The fourth stage does not have a destruct system; however, if the destruct command is sent, the third stage shaped charges destroy the fourth stage ignition wiring. Therefore, all stages are either destroyed or rendered non-propulsive.[19]

4. The Titan 34D Space Launch Vehicle

a. Description - The Titan is a large space launch vehicle consisting of a two-stage, liquid-propellant core vehicle to which is attached two very large solid rocket motors and, as required, an upper stage which places the payload into orbit. The commercial version of the Titan III is essentially the same basic configuration as the Titan 34D. A typical Titan vehicle is shown in **Figure 13**[20]. The liquid propellants used in the core vehicle are Aerozine 50 and Nitrogen Tetroxide from which highly toxic vapors are released in the event of a spill or during venting operations. One of the optional upper stages, the Transtage, also uses these same propellants.

The Titan core vehicle is 10 feet in diameter and the solids are 10.2 feet. The launch vehicle is 145 feet tall and weighs approximately 1,514,600 pounds at lift-off. It develops 2.36 million pounds of thrust at lift-off and, with a Transtage upper stage, inserts approximately 4,200 pounds into synchronous orbit.[13]

b. Hazards - The potential hazards associated with the Titan vehicle are blast over-pressures and fragments from exploding propellants and toxic vapors from leaks or catastrophic rupture of propellant tanks during pre-launch or launch operations.

c. Trajectory - The Titan is launched on azimuths varying from 147-210 degrees. It nominally clears the land mass in approximately 51 seconds.

d. In-Flight Events - The Titan 34D lifts off with only the two SRM's burning. The first stage of the core vehicle is not ignited until approximately 108 seconds in flight when the missile is approximately 25 nautical miles from the launch site. The sequence of events of a typical launch is shown in **Table 10**[4].

TABLE 10. TITAM 34D NOMINAL SEQUENCE OF EVENTS	
EVENT	**TIME (SEC)**
ST 0 IGNITION	T + 000
ST I IGNITION	T + 109
ST O SEP	T + 117
ST II IGNITION	T + 274
FAIRING JETT	T + 299
ST II BURNOUT	T + 485

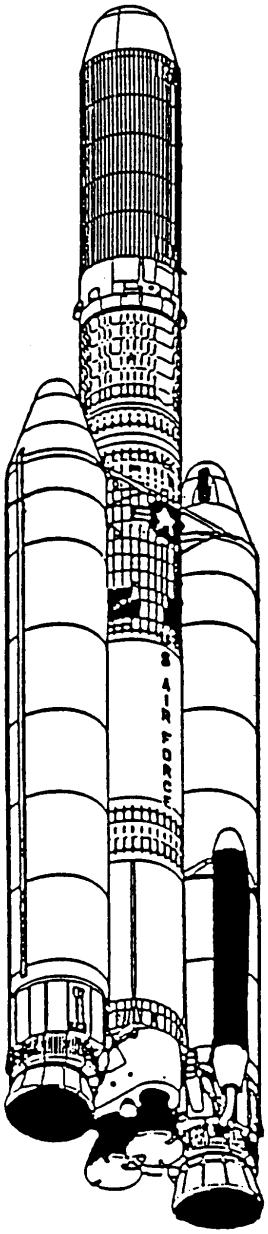

FIGURE 13. TITAN 34D VEHICLE

e. Titan Airborne FTS - The FTS consists of two antennas, a hybrid junction (coupler) and two receivers mounted on the upper stage of the core vehicle plus an Inadvertent Separation Destruct System on each of the two solid rocket motors and the first stage of the core vehicle. Destruct ordnance consists of "pancake" charges between the tanks of each stage of the core vehicle and linear shaped charges which are attached to the sides of the SRM's and their thrust vector control system tanks. Upper stages used with the Titan, such as the Transtage, Inertial Upper Stage (IUS) or Centaur, are also equipped with destruct systems.[21] Refer to **Table 11**[13] for typical vehicle characteristics.

TABLE 11. LAUNCH VEHICLE CHARACTERISTICS

Vehicle Contractor/ Vehicle Name	User Agency	PROPULSION Stage No.	PROPULSION Engines	Stage Contractor	Stage or Motor Designation	Propellants (oxidizer/fuel)	Thrust (lb. sec.)	DIMENSIONS & WEIGHT Max. Dia. (ft.)	DIMENSIONS & WEIGHT Length (ft.)	DIMENSIONS & WEIGHT Launch weight (lb.)	PERFORMANCE Payload (lb.) Orbital	PERFORMANCE Payload (lb.) Escape
BASIC VEHICLES												
Martin Marietta												
Titan 34D Transtage	USAF	0	2 x 120-in. UA 1205(strap-on)	UTC	--	Solid	246,288,000	10.2	90.4	1,514,600	4,200[5]	--
		1	2 x Aerojet LR-87-AJ-11	Martin Marietta	--	N2O4/N2H4-UDMH	529,000	10.0	78.6			
		2	1 x Aerojet LR-91-AJ-11	Martin Marietta	--	N2O4/N2H4-UDMH	101,000	10.0	37.0			
		3	2 x Aerojet aj10-138	Martin Marietta	Transtage	N2O4/N2H4-UDMH	16,000	10.0	14.7			
Titan 34D No Upper Stage	USAF	0	2 x 120-in UA 1205(strap-on)	UTC	--	Solid	246,288,000	10.2	90.4	1,492,200	27,600	--
		1	2 x Aerojet LR-87-AJ-11	Martin Marietta	--	N2O4/N2H4-UDMH	529,000	10.0	78.6			
		2	1 x Aerojet LR-91-AJ-11	Martin Marietta	--	N2O4/N2H4-UDMH	101.000	10.0	31.3			
Titan 2 SLV No Upper Stage	USAF	1	2 x Aerojet LR-87-AJ-5	Martin Marietta	--	N2O4/N2H4-UDMH	430,000	10.0	70.2	340,000	4,200	--
			1 x Aerojet LR-91-AJ-5	Martin Marietta	--	N2O4/N2H4-UDMH	100,000	10.0	23.4			
Titan III (Comm)	Comm	0	2 x 120-in UA 1205(strap-on)	UTC	--	Solid	246,288,000	10.2	90.4	1,492,200	27,600	
		1	2 x Aerojet LR-87-AJ-11	Martin Marietta	--	N2O4/N2H4-UDMH	529,000	10.0	78.6			
		2	1 x Aerojet LR-91-AJ-11	Martin Marietta	--	N2O4/N2H4-UDMH	101,000	10.0	31.3			
Titan IV Centaur G Prime	USAF	0	2 x 120-in UA 1207(strap-on)	UTC	--	Solid	319,400,000	10.2	112.9	1,910,449	10,000	--
		1	2 x Aerojet LR-87-AJ-11	Martin Marietta	--	N2O4/N2H4-UDMH	546,000	10.0	86.5			--
		2	1 x Aerojet LR-91-AJ-11	Martin Marietta	--	N2O4/N2H4-UDMH	104,000	10.0	32.6			--
		3	2 x P&W RL10A-3-A3	GD Space Sys	--	LOX/LH2	33,000	14.2	29.3			--
Titan IV IUS	USAF	0	2 x 120-in UA 1207(strap-on)	UTC	--	Solid	319,400,000	10.2	112.9	1,885,525	5,300	--
		1	2 x Aerojet LR-87-AJ-11	Martin Marietta	--	N2O4/N2H4-UDMH	546,000	10.0	86.5			--
		2	1 x Aerojet LR-91-AJ-11	Martin Marietta	--	N2O4/N2H4-UDMH	104,000	10.0	32.6			
		3	1 x UTC solid rocket motor-1	Boeing	--	Solid	44,100	9.5	16.4			
			1 x UTC solid rocket motor-2	Boeing	--	Solid	16,800	9.5	16.4			
GD/ Space Systems												
Atlas G, Centaur D-1A/Atlas H	NASA	1/2	2 x Rocketdyne YLR89-NA7	GD/Convair	MA-5	LOX/RP-1	377,500	10.0	140.5	360,600	5,200	3,500
			1 x Rocketdyne YLR105-NA7	GD/Convair	--	LOX/RP-1	60,000	--	104.7	293,000	3,000	
Mc Donnell Douglas												
Delta 3914/ Delta 3924	NASA	1	1 x Rocketdyne RS-27	McD/Douglas	ELT Thor	LOX/RJ-1	205,000	8	73.4	420,500	2,065	1,390
		1	9 x Thiokol TX526-2	Thiokol	Castor 4	Solid	767,000	3.3	36.6	425,300	2,430	1,670
		2	1xTR201/AeroAJ10-118K	McD/Douglas	Delta	N2O4/N2H4-UDMH	9,850/10,000	8	19.3			
		3	1 x Thiokol TE 364-4	McD/Douglas	--	Solid	15,000	3.2	6.8			
Delta 3910/PAM-D	NASA	1	1 x Rocketdyne RS-27	McD/Douglas	ELT Thor	LOX/RP-1	207,000	8	73.4	422,100	2,450	1,740
Delta 3920/PAM-D		1	9 x Thiokol TX526-2	McD/Douglas	Castor 4	Solid	767,000	3.3	36.6	428,322	2,830	2,000
		2	1xTR201/AeroAJ10-118K	McD/Douglas	Delta	N2O4/N2H4-UDMH	9,850/10,000	8	19.3			
		3	1 x Thiokol Star 48	McD/Douglas	PAM-D	Solid	15,000	4	7.2			
Delta 6920(has 1st 2 stages only)	USAF	1	1 x Rocketdyne RS-27	McD/Douglas	Ex ELT Thor	LOX/RP-1	207,000	8	85.4	462,900	3,260	--
Delta 6925(3 stgs)		1	9 x Thiokol TX780	McD/Douglas	Castor 4A	Solid	878,000	3.3	36.6			
		2	1 x Aerojet AJ10-118K	McD/Douglas		N2O4/N2H4-UDMH	10,000	8	19.3			
		3	1 x Thiokol Star 48	McD/Douglas	PAM-D	Solid	15,000	4	7.2			
Delta 7920(has 1st 2 stages only)	USAF	1	1 x Rocketdyne RS-27	McD/Douglas	Ex ELT Thor	LOX/RP-1	201,000	8	85.9	483,000	3,720	--
Delta 7925(3 stgs)		1	9 x Hercules GEM	McD/Douglas	Gr-Ep Motor (GEM)	Solid	851,000	3.3	36.6			
		2	1 x Aerojet AJ10-118K	McD/Douglas		N2O4/N2H4-UDMH	10,000	8	19.3			
		3	1 x Thiokol Star 48	McD/Douglas	PAM-D	Solid	15,000	4	7.2			
Vought												
Scout SLV-1A	NASA/ USAF	1	1 x UTC Algol 3	LTV	Algol 3A	Solid	107,000	3.7	75.1	47,000	400	75
		2	1 x Thiokol Castor 2	LTV	Castor 2A	Solid	61,800	--	--			
		3	1 x Thiokol Antares 3	LTV	Antares 3A	Solid	21,000	--	--			
		4	1 x Thiokol Altair 2	LTV	Altair 3	Solid	5,700	--	--			