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DELTA II (MODEL 7925) DEVELOPMENT AND FLIGHT RESULTS

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ABSTRACT

This paper describes the design changes to the latest Delta Launch vehicle, Delta II Model 7925. The results of developments on five main subsystems are described. The paper includes the flight results of Delta II launches to date.

DELTA HISTORY

The McDonnell Douglas Space Systems Company (MDSSC) Delta launch vehicle has been a NASA space "workhorse" for 31 years. It had its beginnings in the mid-1950s with the Thor vehicle. Subsequently, the NASA Goddard Space Flight Center contracted for the development of an interim space launch vehicle using a modified Thor first stage with Vanguard missile components for the second and third stages. This new Delta vehicle was first launched in May 1960 with the Echo I passive communications satellite.

Delta has had a remarkable record. With the latest launch, NATO IV-A, Delta has successfully orbited 190 spacecraft in 202 attempts.

For 31 years, the Delta has compiled an overall reliability record of 94.06%, with a record of 98.53% over the most recent 15 years, as shown in Figure 1. However, most significant number to remember is 100% over the last 24 launches.

The capability of the Delta has been continuously increased through the years in response to the ever-increasing needs of the spacecraft community. The equivalent geosynchronous transfer orbit (GTO) capability of the first Delta launch in 1960 was approximately 100 lb. The capability of the most powerful version of the vehicle to fly before Delta II, the 3920/PAM, was slightly more than 2800 lb to GTO. Many of the changes that achieved this performance growth are shown in Figure 2, which presents the vehicle GTO capability from the USA Eastern launch site. As shown, the many vehicle modifications included booster capability increases, larger and more powerful second and third stages, strap-on motors for boost assist, larger payload fairings, and main engine changes.

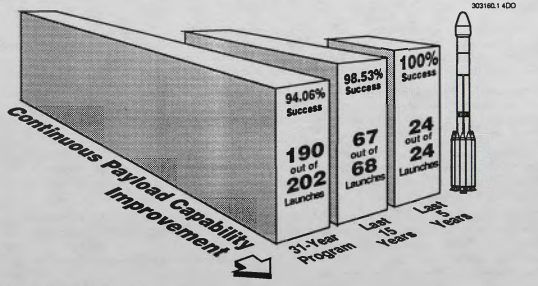

Figure 1. Delta Reliability History

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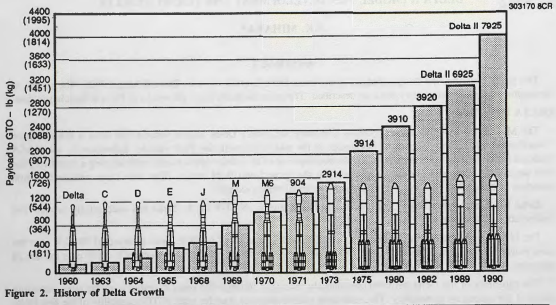

Figure 2. History of Delta Growth

FAST LAUNCH RECOVERY

The Delta launch vehicle's ability to recover from a problem has been demonstrated to be the fastest in the industry. This was illustrated when, after a string of 43 straight successful launches over an 8-year period, a problem with an early shutdown of the first-stage engine resulted in a failure to achieve orbit. The problem was corrected, and the next Delta was successfully launched only 4 months later.

DELTA II

The Challenger accident prompted the need for new-generation expendable launch vehicles (ELV) in the quest for continued access to space. In the medium launch vehicle (MLV) class, the primary need was to launch Global Positioning System (GPS) satellites for which Space Transportation System (STS) launches were originally slated. The MDSSC Delta II concept was selected to fill this need and was also made available to the commercial community.

This Delta MLV is based on proven concepts that further improve vehicle performance to meet the needs of the GPS mission (e.g., stretched propellant tanks, increased performance solid strap-ons, and improved booster engine performance). The results of these changes are summarized in Figure 3, which illustrates the Delta 3920/PAM, Delta II 6925, and Delta II 7925 configurations.

The initial version of the Delta II, the 6925, had booster propellant tanks extended a total of 12 ft (Figure 4), and used Morton Thiokol Castor IVA solid motors (Castors IVs with higher performance propellant), increasing its GTO capacity to 3190 lb. The vehicle also had a new fairing, shown in Figure 5, with a 9.5-ft center section to replace the standard 8-ft fairing, permitting the launch of larger diameter satellites.

The second step in Delta II growth is the 7925, which was launched on November 26, 1990 successfully placing a GPS NAVSTAR satellite into orbit. It had additional improvements over the 6925, including an improved RS-27 booster engine (nozzle expansion ratio increased from 8:1 to 12:1), shown in Figure 6, and used Hercules graphite epoxy motor case strap-ons (Figure 7), which replaced the Castor metal motor cases and are approximately 6 ft longer. This vehicle has a GTO capability of 4,010 lb.

Figure 8 shows a cutaway of the Delta II launch vehicle, which has five major assemblies: first stage, interstage, second stage, third stage, and payload fairing.

The first-stage engine section accommodates the RS-27 main engine and two vernier engines and provides attachments for the nine strap-ons. The cylindrical isogrid fuel and oxidizer tanks are separated by a center body

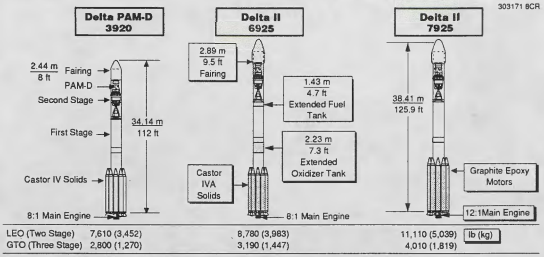

Figure 3. Launch Vehicle Configuration

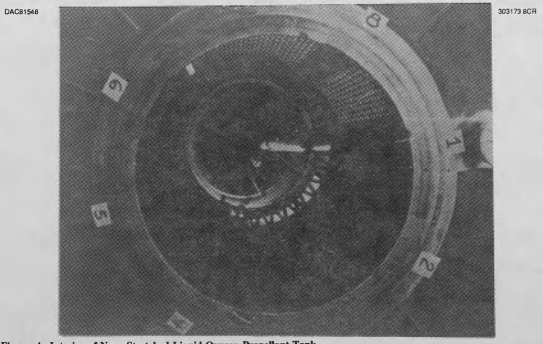

Figure 4. Interior of New, Stretched Liquid-Oxygen Propellant Tank

section that houses control electronics, ordnance sequencing equipment, and telemetry. Six of the solid strap-on motors are ignited at lift-off, while the remaining three are ignited in flight after burnout of the first six.

The second stage uses the storable-propellant Aerojet engine derived from the US Air Force Improved Transtage Injector Program (ITIP). The forward section of the second stage houses guidance and control equipment that provides guidance sequencing and stabilization signals for both the first and second stages. The strap-down, all-inertial guidance system consists of a Delta redundant inertial measurement system (DRIMS) and a Delco guidance computer.

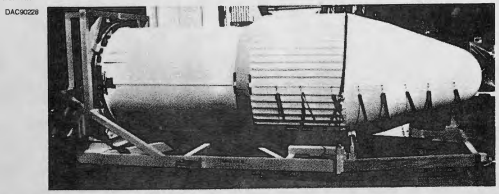

Figure 5. New 9.5 ft Diameter Fairing

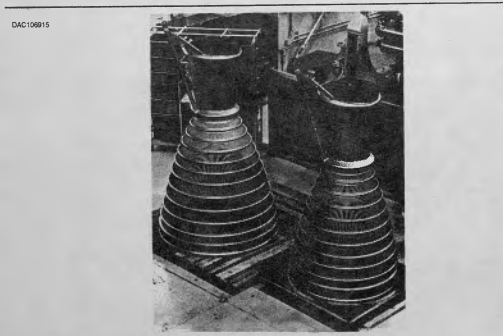

Figure 6. New 12:1 Nozzle for First-Stage Engine (Left) and 8:1 Nozzle (Right)

The vehicle third stage is a Delta PAM stage, consisting of payload attach fairing, STAR-48B solid rocket motor, and spin table. The spin table, which mates to the top of the second stage and contains a spin bearing, allows the PAM-D/spacecraft assembly to be spun up before deployment through the use of spin rockets. An ordnance sequencing system is used to release the assembly after spin-up, to fire the motor, and to separate the spacecraft after burnout. The payoad attach fitting provides the Delta-established mechanical and electrical interfaces with the spacecraft and includes a nutation control system to suppress coning near the end of motor burn.

The final element is the payload fairing, an aluminum shell structure that mates with the forward frame of the second-stage miniskirt and accommodates the spacecraft envelope. The aft end is derived from the standard Delta 8-ft isogrid fairing. The fairing separates into two sections through a flight-proven, contamination-free separation joint. A photo of the new Delta Model 7925 is shown in Figure 9.

A new option of the fairing, with a diameter of 10 feet and a long cylinder section, is now available and is shown during lift-off of NASA's ROSAT mission in Figure 10.

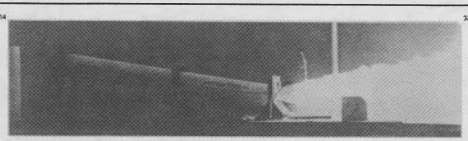

Figure 7. New Graphite Epoxy Motor (GEM) Static Test

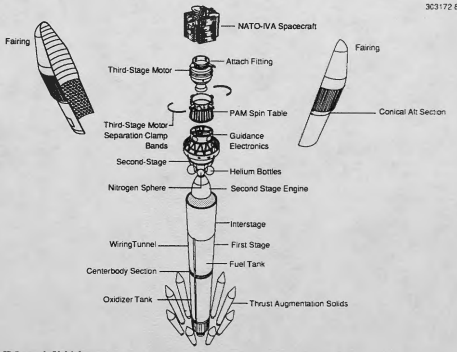

Figure 8. Delta II Launch Vehicle

A closeup view of the new graphite epoxy motors installed on Delta II, NAVSTAR II-10, is seen in Figures 11 and 12. The lift-off of NAVSTAR II-10, the first Model 7925, is seen in Figure 13. The launch was successful.

DELTA FLIGHT RESULTS

As of the publication date of this paper, there have been sixteen Delta II flights, NAVSTAR II-1 through NAVSTAR II-10, LOSAT, Palapa B-2R, BSB-R2, INMARSAT-2 (F1), ROSAT, and NATO IVA. The launch of the first commercial Delta Model 4925, for the British Satellite Broadcasting/Hughes satellite R1 is seen in Figure 14. All have been completely successful.

The first launch of a commercial Delta II using the Delta II Model 7925 was the NATO-IVA mission and is seen in Figure 15.

A summary of all launches, beginning with the first Delta II, is seen in Figures 16 and 17.

Figure 9. Delta II NAVSTAR II-10, the First Delta Model 7925, Is Ready for Launch on Pad 17A at Cape Canaveral

Figure 10. New 10-ft Fairing is Now Available as an Option—Shown on Delta ROSAT Mission for NASA on 1 June 1990

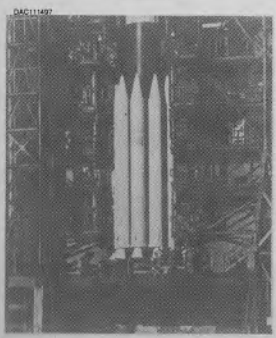

Figure 11. Close-Up View of the New Graphite Epoxy Motors (GEM) for Delta Model 7925

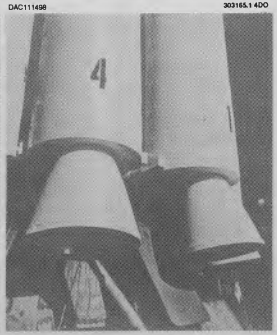

Figure 12. Close-Up View of New GEM Nozzles on Delta Model 7925

DAC105635

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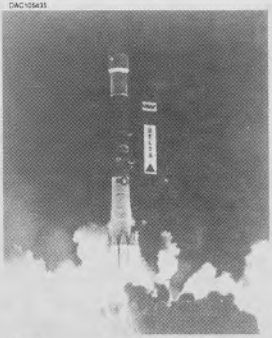

Figure 13. The First Delta Model 7925 Was Successfully Launched on 26 November 1990 to Place NAVSTAR II-10 Into Orbit

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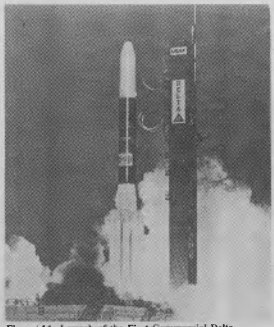

Figure 14. Launch of the First Commercial Delta—Model 4925 for the BSB-R1/Hughes Mission

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303178 4DO

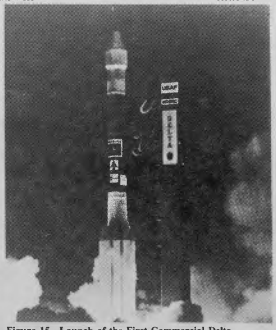
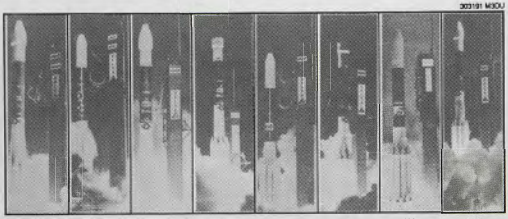
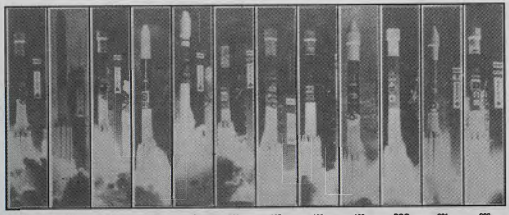


Figure 15. Launch of the First Commercial Delta Using Delta Model 7925 for the NATO-IVA Mission



Launch	184	183	185	186	187	188	189	190
Mission	Navstar II-1	Delta Star	Navstar II-2	Navstar II-3	BSB-2R	Navstar II-4	COBE	Navstar II-5
Date	14 Feb 89	24 Mar 89	10 Jun 89	18 Aug 89	27 Aug 89	21 Oct 89	18 Nov 89	12 Dec 89
Pad	SLC-17A	SLC-17B	SLC-17A	SLC-17A	SLC-17B	SLC-17A	SLC-2W	SLC-17B
Customer	USAF	SDIO	USAF	USAF	Commercial	USAF	NASA	USAF
Apogee (nmi)	10900	270	10900	10900	20090	10900	486	10900
Results	Success	Success	Success	Success	Success	Success	Success	Success

Figure 16. Delta 1989 Launches



Launch	191	192	193	194	195	196	197	198	199	200	201	202
Mission	Navstar II-6	LOSAT	Navstar II-7	Palapa B-2R	ROSAT	INSAT	Navstar II-8	BSB-R2	Navstar II-9	Inmarsat	Navstar II-10	NATO-IVA
Date	24 Jan 90	14 Feb 90	25 Mar 90	13 Apr 90	1 Jun 90	12 Jun 90	2 Aug 90	17 Aug 90	1 Oct 90	30 Oct 90	26 Nov 90	7 Jan 91
Pad	SLC-17A	SLC-17B	SLC-17A	SLC-17B	SLC-17A	SLC-17B	SLC-17A	SLC-17B	SLC-17A	SLC-17B	SLC-17A	SLC-17B
Customer	USAF	Commercial	USAF	Commercial	USAF/NASA	Commercial	USAF	Commercial	USAF	Commercial	USAF	Commercial
Apogee (nmi)	10900	295	10900	20400	313	21320	10900	20170	10900	19730	10900	19297
Results	Success	Success	Success	Success	Success	Success	Success	Success	Success	Success	Success	Success

Figure 17. Delta 1990 and 1991 Launches

The Delta Launch Vehicle Division in Huntington Beach, California, will be pleased to supply additional information relative to Delta launch vehicles and discuss the most current launch date availability. This group may be contacted at:

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