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The Path to Delta IV

Vehicle, Facilities, and Ground Processing Comparisons Between Delta II/III and Delta IV at Cape Canaveral Air Station

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Prefatory Note

Acronyms and abbreviations are used extensively throughout this report. Those which are generally accepted and used throughout the industry are not defined. Those which are less common or are brand new, are defined the first time they are used.

Introduction

The Evolved Expendable Launch Vehicle (EELV) is an Air Force effort to reduce launch costs and assure access to space. One of the EELVs currently in development is the Boeing Delta IV, an outgrowth of the existing Delta II and Delta III. The Delta IV employs so much new hardware and innovations, that it might well be considered a new launch vehicle in its own right. Bringing Delta IV to a reality is now underway. Construction of the assembly plant in Decatur, Alabama has begun, as has Eastern Range launch site construction at Cape Canaveral Air Station, Florida. The purpose of this report is to follow the evolutionary path to Delta IV and offer comparisons to its predecessors.

Vehicle Evolution

The roots of the Delta launch vehicle lie in the Air Force's ballistic missile program of the 1950s and 1960s. The newly formed NASA was looking for launch vehicles for its many planned space missions and selected the (then) Douglas-built Thor IRBM for modification to perform in this role. The first launch of a Thor-Delta (as the early versions were known) occurred on 13 May 1960. While this first launch of an Echo passive communications satellite was a failure, Delta has gone on to become one of the most reliable launch vehicles in history.

Delta proved to be a workhorse launch vehicle in the 1960s and 1970s; however, it was slated for phase-out (along with most other expendable launch vehicles) in favor of the Space Shuttle. Shuttle program delays as well as lower than planned launch rates caused the Delta program phase-out date to be extended. The 1986 Challenger disaster resulted in a re-thinking of U. S. launch policy, and revived the expendable launch vehicle concept (including of course, Delta).

Delta continued to be improved and updated bit by bit to the vehicle now in use today (which bears little resemblance to the original configuration). Currently, the Delta II consists of a LOX/RP1 first stage with a Rocketdyne RS-27 engine producing 207,000 lb. thrust. First stage thrust is augmented by three, four, or nine graphite epoxy solid rocket motors (GEM), each producing nearly 100,000 lb. thrust. Stage 2 consists of a hypergolic powered Aerojet engine which produces 9,600 lb. thrust. The optional third stage has a solid propellant (HTPB) powered motor producing an average thrust of 15,000 lb. The most powerful Delta II configuration can place up to 11,220 lb. to a 28° LEO, or 4,060 lb. to GTO.

A Delta III configuration will soon be flying (it is hoped) which will offer twice the GTO payload capability of the Delta II (the initial Delta III launch attempt ended in failure when the Stage 1 steering system prematurely depleted its hydraulic fluid and the vehicle lost control). Delta III shares many components with the Delta II. In common are the RS-27 first stage engine and LOX tank, and the avionics package. The GEMs have been stretched for Delta III and three of the ground-lighted motors now have thrust vector control. Total lift-off thrust (solid and liquid) exceeds 1,000,000 lb. Stage 1 now has a fuel tank that matches the diameter of the new 13 ft. diameter PLF. The third stage has been eliminated and a new all-cryogenic second stage

has been developed. Performance capabilities are 18,280 lb. to a 28° LEO, or 8,400 lb. to GTO.

Delta IV represents a giant leap on the evolutionary ladder. While many components are utilized from the existing Delta II and Delta III configurations, Delta IV will employ a new ground processing and launch concept as well as a totally new and simplified first stage (also referred to as the common core). The chart below presents the new vehicle's key components and their heritage.

<u>Delta IV Component</u>	<u>Heritage</u>
Stage 0 GEM (medium configuration)	Delta III
Stage 0 Liquid Strap-Ons (heavy configuration)	Delta IV
Stage 1 (common core) Engine and Tankage	New
Stage 2 (light configuration)	Delta II
Stage 2 (medium and heavy)	Delta III
PLFs	Delta II/III, Titan IV

The liquid strap-ons of the heavy configuration (which will fly last in the program development) are virtually identical to the common core of Stage 1, and are therefore of Delta IV heritage. The new RS-68 engine of the common core produces over 600,000 lb. thrust and has 95 percent fewer parts than the Space Shuttle Main Engine.

Delta II/Delta III Facilities and Processing

To fully appreciate the processing concepts which will be utilized by Delta IV, it may help to review the methods utilized by Delta II and Delta III. Current Delta launch operations are conducted at Complex 17 at Cape Canaveral Air Station. The facilities at Complex 17 include two pads ("A" to the north, and "B" to the south), a reinforced blockhouse, two mobile service towers, and a horizontal processing facility. Pad B has been modified to accommodate the Delta III configuration. The blockhouse, which contains launch processing equipment, and at one time housed the LCC, is no longer occupied during final launch operations. The LCC is now housed in the Operations Center located east of Phillips Parkway on CCAS.

Current Delta processing involves the assemble-on-pad concept. Activities are divided between off-pad and on-pad operations. Stages 1, 2, the interstage section, and PLF arrive from the factory and are transferred to Hangar M at CCAS for receiving and inspection activities. Stages 1 and 2 are then transferred to the adjacent Delta Mission Checkout facility for subsystem electrical checks. The next stops are Area 55 and then the Horizontal Processing Facility at Complex 17 for additional preparations to include destruct charge and separation ordnance installation. GEM preparation is conducted at Area 57 and is completed with the destruct igniter installation. Stage 3 processing is conducted at the Navstar Processing Facility.

On-pad operations involve stacking the vehicle, integrated checkout, propellant loading and terminal countdown. The vehicle stacking sequence is as follows: Stage 1, interstage, GEMs, Stage 2, Stage 3, payload, PLF. Prelaunch testing includes the flight sequence test which simulates launch events and verifies component performance while on internal power. The guidance computer, flight beacon, and range safety systems are also verified. Propellant operations load the hypergols first, followed by the cryogenics on launch day. Total time on pad is approximately 38 days, while total vehicle processing time averages 68 days.

Delta IV Facilities and Processing

Delta IV will be launched from Complex 37, site of eight previous Saturn 1 launches during the Apollo program (launches consisted of six Saturn 1s and two Saturn 1Bs, all unmanned and all from Pad B). The complex will essentially be rebuilt from the ground up, utilizing only the blockhouse and some support buildings from its previous configuration. The new complex will have a single pad initially; however, there are provisions to add a second pad to accommodate the projected increased flight rate which should come about as the program matures. Each pad will have its own MST and support equipment building (SEB). The SEBs are existing structures and will house air conditioning for the launch vehicle, payload, and pad. The blockhouse, which housed the LCC in the Apollo days, will serve as a common support building and will not be occupied during launch.

Not considered part of the complex, but adjacent to it, is the Horizontal Integration Facility (HIF) which will allow assembly of the entire launch vehicle (minus encapsulated payload) off-pad. The HIF will have two main assembly bays which can each accommodate either two single core configurations, or one triple core (heavy) configuration. A storage bay will accommodate two additional cores.

The Centaur Processing Facility (built to support the Titan IV program, but never activated) will become the Delta Operations Center and will house the LCC. A spacecraft control room adjacent to the LCC will provide payload monitoring during preparation and launch. Communications equipment will provide signal interface between the LCC and the launch pad.

One of the keys to increasing the flight rate for the Delta IV will be to conduct as much off-pad processing as possible, thus spending a minimum amount of time actually on the pad. Off-pad processing will also be streamlined to further enhance the ability to accommodate higher flight rates. Booster common core vehicles will arrive from the factory via ocean-going vessel in a fully tested and flight ready configuration. Elements will be transported directly to the HIF for integration (horizontal integration will also provide for an added margin of safety since most operations will be accomplished at or near ground level). Stage 1 is attached to a Launch Mate Unit (LMU) which serves not only as the launch mount, but also provides all the booster-to-GSE interfaces. Stage 2 is then mated to Stage 1, after which the vehicle is ready to be transported to the pad.

Pad operations will be very streamlined compared to Delta II. After a quarter mile trip to the pad, the launch vehicle is erected and ground support connectors are mated to the LMU. The vehicle is then ready to receive the payload. Total on-pad time will vary from 6 to 8 days, depending on the vehicle configuration. The total (off and on-pad time) will range from 21 to 23 days (a remarkable improvement over current operations, if it can be achieved).

Payload preparation also employs a method which is designed to reduce launch pad processing time. The payload customer (whomever it may be) will be required to test, fuel, and encapsulate the payload prior to pad transfer. An Encapsulated Payload Transporter (EPT) will move the vehicle/PLF as a unit, to the pad in a vertical orientation. Pad operations will simply involve mating the unit to the launch vehicle and conducting integrated tests. The goal for payload on-pad time is five days or less.

Conclusions

Delta IV indeed represents more than simply a new launch vehicle. It represents a dramatic improvement in the way the business of getting into space is conducted. The projected enhancements are described as follows:

A simplified vehicle would lend to simplified processing techniques, which in turn would result in reduced processing time (a 75 percent reduction from 1988 Delta II figures). The reduced processing time would have a two-pronged effect. The flight rate could increase appreciably (approaching fifty missions per year), and the workforce could be reduced (in spite of the increased launch rate).

A near-paperless processing system is also planned which would further enhance ground operations speed and efficiency. Collectively, all the improvements cited would ultimately serve to reduce launch costs (between 25 and 50 percent compared to current vehicles in use). An additional benefit (sure to be welcome news to all payload customers) will be a launch-on-notice reduction from five months to sixty days.

Challenges certainly lie ahead, and neglecting to address them could cause the program to achieve far less than its full potential. Customers should perhaps consider that a "perfect" launch vehicle is not a requirement for a successful mission. For the EELV program to truly be successful, standardization has to be the norm. The days of a customer wanting a custom-built launcher must come to an end. The customization is surely what increases processing time and drives up costs.

Range standardization is also a critical concern. With the current and projected variety of vehicles launching from the Cape, the range schedule can ill afford a 48 hour waiting period between launches of dissimilar vehicles. While the range may never again see the launch rates which were experienced in the early 1960s (201 for 1960 and 186 for 1961), the commercial launch demand is certainly on the increase, and the range must be able to accommodate it or the business will move elsewhere.

While the challenges are numerous and varied, the Delta IV program will be doing its part to address many of them, and certainly will make the Cape continue to be one of the most active launch centers for many years to come.

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