Bluedog Design Bureau

Delta Rocket Family User Guide

Revision 1

JB
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Introduction

The Delta family is a long running, reliable series of rockets with options available for every payload range from smallsats to heavy manned spacecraft and station components. There are two distinct groups of Delta rockets. Most of the family consists of a kerolox lower stage, usually augmented by SRBs, and a storable propellant upper stage. This configuration is suitable for LEO missions. For GTO missions, a solid kick stage is usually added. The other group uses a similar lower composite, but an RL-10 powered hydrolox upper stage that allows GTO missions without a kick motor, though one can always be added if needed, for instance for interplanetary missions. The Delta IV subfamily ditches the traditional core, using a powerful hydrolox CBC lower stage instead. It descendants maintain this arrangement.

Reference missions

Name	Apoapsis	Periapsis	Inclination	Transfer	Transfer ΔV	Insertion ΔV
LEO	200km	200km	28.5°	N/A	N/A	N/A
LEO-SD	N/A	200km	28.5°	200km Ap	N/A	1200m/s
GTO-SD	250km	Suborbital	28.5°	8948km Ap	1290m/s	905m/s
GTO-LO	350km	150km	28.5°	8948km Ap	1090m/s	940m/s
GTO-MD	2000km	300km	28.5°	8948km Ap	817m/s	840m/s
GTO-HI	3800km	300km	28.5°	8948km Ap	774m/s	774m/s
GTO-VH	4500km	300km	28.5°	8948km Ap	692m/s	774m/s
LTO	150km	150km	27°	10km Moon Pe	1534m/s	428m/s

All reference missions use PVG except when noted, with 50m/s turn start, 0.5°/s turn. LEO is a standard insertion to a 200km circular orbit. GTO-LO is a standard insertion for low TWR restartable upper stages, with a low parking orbit and a large transfer burn. GTO-MD is a middle of the road trajectory used by Delta J to optimize its staging setup. GTO-HI is a high energy insertion to reduce required kick motor performance, balancing it between the core and the kick motor. GTO-VH is a maximum energy trajectory, not much higher than GTO-HI, for vehicles limited primarily by their kick motor. Beyond this, ΔV requirements for the transfer do not reduce significantly with increasing apogee. Insertion ΔV is not significantly reduced because most of it already goes into fixing the inclination. LTO is a standard lunar transfer orbit, from 27 degrees of inclination to a 10km periselene. In practice, with the given ΔV, slight variation in burn timing can achieve anything from a distant flyby to a lunar impact. GTO-SD is a special profile for Delta B that follows the “Classic Ascent Patch” with a turn start at 50m/s and a 70% turn profile, 620km altitude. This will launch the rocket to a suborbital trajectory with an apoapsis of 620km, from which a circularization burn is used after a coast to transfer directly to GTO. LEO-SD is similar, but uses a 200km periapsis and transfer is to 200km apoapsis. It is used for Burner stages. Note: low TWR upper stages may require slightly higher ΔV than shown in the table to complete the maneuver. This is normal.

Stage build guide

Square indicates the main stack. Black circle indicates node attachment to the part above, hollow circle indicates radial attachment to the part above.

First stages

Viking 1

- Vanguard 490 Liquid Fuel Tank
- Vanguard XLR50-GE-2/X-405

Thor

- *Thor 1.25m to 0.9375m structural adapter
- Thor Fuel Tank 600
- Thor 1400/2040/2600 Lower Liquid Fuel Tank, var. Basic/LT
- Thor Engine Fairing
    - 2xLR-101 Vernier
    - **4xDelta Aerodynamic Fin
- Engine

* Replace with Thor 1.25m to 0.9375m structural adapter on early designs.
**Attach fins only if no boosters are carried.

Long Tank Thor (LTT)

- Thor Fuel Tank 1400/1560 Upper Liquid Fuel Tank, var. LT/ELT
- Thor 1400/2040/2600 Lower Liquid Fuel Tank, var. Basic/LT
- Thor Engine Fairing
    - 2xLR-101 Vernier
- Engine

Extended Long Tank Thor (ELTT)

- Thor 1400/1560 Upper Liquid Fuel Tank, var. LT/ELT
- Thor 1400/2040/2600 Lower Liquid Fuel Tank, var. ELT
- Thor Engine Fairing
    - 2xLR-101 Vernier
- Engine

Extra Extended Long Tank Thor (EELTT)

- Thor Fuel Tank 1400/1560 Upper Liquid Fuel Tank, var. EELT
- Thor 1400/2040/2600 Lower Liquid Fuel Tank, var. EELT
- Thor Engine Fairing
    - *2xLR-101 Vernier
- Engine

*Do not install verniers when using the stage in a double configuration, or as a booster.

Expanded Extended Long Tank Thor (XELTT)

- Delta-III 1700 Liquid Fuel Tank
- Thor 1400/2040/2600 Lower Liquid Fuel Tank, var. EELT
- Thor Engine Fairing
    - 2xLR-101 Vernier
- Engine

Wide Body Extended Long Tank Thor (XELTT)

- Atlas V 7700 CCB Fuel Tank
    - 8xSTAR 5F Atlas V Separation Motor
- EP-25 Engine Plate, var. 3x, Short
- T-25 Structural Tube, var. Medium-Short
- 3xEngine

Common Booster Core (CBC)

- *Delta IV Heavy 3.125m Nose Cone
- Delta IV Common Core Booster 6210 Upper Tank
    - *Delta IV Heavy 3.125m Radial Decoupler
- Delta IV Common Core Booster 20790 Lower Tank
- RS-68, var. Boattail insulated (no SRBs) or Boattail shielded (with SRBs).

*Only when used as a side booster.

Widebody Common Booster Core (WCBC)

- *Saturn 4.25m Nose Cone
- Saturn S-IVB 14300 Cryogenic Fuel Tank, var. S-IVB
- Saturn S-IE-16K Liquid Fuel Tank, var. 6.6m Extension
    - *Saturn 4. 25m Radial Decoupler
- Saturn S4B 4.25m Adapters (inverted), var. 3.75
- EP-37 Engine Plate
- Engines

*Only when used as a side booster.

Delta Lite

- Castor 120/Peacekeeper SR-118, var. Castor 120 AIR
- Minotaur 1.5 Interstage, var. Full
- Castor 120/Peacekeeper SR-118, var. Castor 120, 65% thrust.

Second stages

Able

- Vanguard 0.625m Fairing Base
- Vanguard Guidance Unit
- Vanguard Able 60 Liquid Fuel Tank, var. Able
    - AJ10-37, var. AJ-10-37
- Vanguard 0.625m Interstage

Able 2

- Payload Adapter
- BD-AFB 0.625m Fairing Base
- Thor Able Guidance Unit
- Thor Able/Delta 60/85 Liquid Fuel Tank, var. Thor Able/Able II 60 (0.5m)
    - AJ10-37, var. AJ-10-37
- Thor Able/Delta Interstage

Ablestar

- Payload Adapter
- Ablestar Fairing Base
- Ablestar 160 Liquid Fuel Tank
    - AJ10-37, var. AJ-10-104
- Thor 0.9375m Interstage

Delta

- Payload Adapter
- Thor Able Guidance Unit
- BD-AFB 0.625m Fairing Base
- Thor Able/Delta 60/85 Liquid Fuel Tank, var. Thor Delta B/C/D 85 (0.5m)
    - AJ10-37, var. AJ-10-118D
- Thor Able/Delta Interstage

Delta E

- Payload Adapter
- Standard Agena Clamshell Fairing
- TAID 210 Liquid Fuel Tank
    - AJ10-37, var. AJ-10-118E
- Thor 0.9375m Interstage

Delta F

- Payload Adapter
- Standard Agena Clamshell Fairing
- TAID 210 Liquid Fuel Tank
    - Delta F AJ10-118F
- Thor 0.9375m Interstage

Delta F (Delta 1000/2000)

- Payload Adapter
- Delta-P/K 1.5m Fairing Adapter
    - TAID 210 Liquid Fuel Tank
    - Delta F AJ10-118F
- Delta-K Interstage

Delta P

- Payload Adapter
- Delta-P/K Avionics Core
- Delta-P/K 1.5m Fairing Adapter
    - Delta-P 180 Liquid Fuel Tank
    - TR-201
- Delta-K Interstage

Delta K

- Payload Adapter
- Delta-P/K Avionics Core
- Delta-P/K 1.5m Fairing Adapter
    - Delta-K 240 Liquid Fuel Tank
    - AJ10-118K
- *Delta-K Interstage

*Substitute for Delta IV Small 3.125m to 1.5m interstage when mating with a CBC.

Delta X

- Payload Adapter
- Delta-P/K 1.875m Fairing Adapter
    - HOSS Avionics
    - Thor X400 Liquid Fuel Tank
    - HOSS Engine Mount
    - AJ10-118X
- Centaur 1.875m Interstage

HOSS

- Payload Adapter
- *Standard Agena Clamshell Fairing
- HOSS Avionics
- HOSS
- HOSS Engine Mount
    - RL-10A-3
- Delta-K Interstage, var. Short

*Omit the base if launching inside a larger fairing.

Delta Cryogenic Second Stage (DCSS) 4m

- Payload Adapter
- Delta III 2.5m Fairing Base
- 2.5m Delta Cryogenic Second Stage, var. Delta III (short) or Delta IV (long)
    - RL10-B-2 Extendable Cryogenic Engine
- DCSS Interstage, var. 2.5m for Delta III or 3.125m (Delta IV) for Delta IV

Delta Cryogenic Second Stage (DCSS) 5m

- Payload Adapter
- Delta IV DCSS 3.125m Fairing Base
- 3.125m Delta Cryogenic Second Stage
    - RL10-B-2 Extendable Cryogenic Engine
- Delta IV 3.125m Interstage

Centaur D

- Payload Adapter
- Centaur Avionics and Control System
- Atlas II MPF 2.08m Fairing Base
- Centaur D 1800 Fuel Tank
- Centaur Engine Mounting Plate, var. Centaur D
    - 2xRL-10A-1 Cryogenic Engine, var. RL-10A-3
- Atlas V 4XX 1.875m-2.5m Adapter Interstage

Centaur E

- Payload Adapter
- Centaur Avionics and Control System
- Atlas II MPF 2.08m Fairing Base
- Centaur-II-2160 Fuel Tank, var. Centaur III
- Centaur Engine Mounting Plate, var. Centaur II
    - 2xRL-10A-1 Cryogenic Engine, var. RL-10A-3
- Atlas V 4XX 1.875m-2.5m Adapter Interstage

Burner 1

- Payload Adapter
- Star-20 Altair, var. GCR Star-20
- 0.3125m Spin Motor Decoupler
- BD-AFB 0.625m Fairing Base
- Thor Able/Delta Interstage (decoupler disabled)
    - HLR-3x-MPS Monopropellant Sphere (inside interstage)
    - 4x Place Anywhere 1 Linear RCS Port

Burner 2

- Payload Adapter
- Burner II
- Star-37BV, var. Star-37BV
- BD-SPD 0.625m Decoupler.

Agena A

- Payload Adapter
- *Standard Agena Clamshell Fairing
- Agena Telemetry Response Unit
    - Agena Infrared Horizon Sensor Module
- Agena-120A Liquid Fuel Tank
- Agena Engine Mount
    - Agena A/B Equipment Rack
        - 2xAgena A/B Ullage Motor
    - XLR81 Agena Engine Series, var. XLR-81-8048
- Agena 1.25m to 0.9375m Interstage

*Replace with the Agena fairing of your choice, or with the spacecraft.

Agena B

- Payload Adapter
- *Standard Agena Clamshell Fairing
- Agena Telemetry Response Unit
    - Agena Infrared Horizon Sensor Module
- Agena-240BD Liquid Fuel Tank, var. Agena B
- Agena Engine Mount
    - Agena A/B Equipment Rack
        - **2xAgena A/B Ullage Motor
    - XLR81 Agena Engine Series, var. XLR-81-8081
- Agena 0.9375m Interstage, var. Stripes

*Replace with the Agena fairing of your choice, or with the spacecraft.
**Add as many pairs as planned Agena burns.

Agena D

- Payload Adapter
- *Standard Agena Clamshell Fairing
- Agena Telemetry Response Unit
    - 2xAgena Infrared Horizon Sensor Module
- Agena-240BD Liquid Fuel Tank, var. Agena D
- Agena Engine Mount
    - Agena D Equipment Rack
    - XLR81 Agena Engine Series, var. XLR-81-8096
- Agena 0.9375m Interstage, var. Black

*Replace with the Agena fairing of your choice, or with the spacecraft.

Advanced Cryogenic Evolved Stage (ACES)

- Payload Adapter
- Delta IV DCSS 3.125m Fairing Base
- LDC 3.125m Avionics Unit
- Delta IV Common Core Booster 6210 Upper Tank
- LDC Second Stage Engine Mount, var. 4 Nodes
    - 4 or 2xRL10 Cryogenic Engine, var. RL10C-3
    - 2xR-4Dx3 Triple RCS Thruster, var. R-4Dx/45
- Delta IV 3.125m Interstage

Advanced Cryogenic Evolved Stage – Widebody (ACES W)

- Payload Adapter
- BD-AFB-425 4.25m Fairing Base
- Saturn S-IVB Instrument Unit
- Saturn S-IVB 14300 Cryogenic Fuel Tank, var. S-IVB
- Saturn S-IVB Engine Mount, var. S-II
    - 4xRL10 Cryogenic Engine, var. RL10C-3
    - 2xR-4Dx3 Triple RCS Thruster, var. R-4Dx/45
- Saturn I S-IVB Interstage

Advanced Cryogenic Evolved Stage – Extra Large (ACES XL)

- Payload Adapter
- BD-AFB-425 4.25m Fairing Base
- Saturn S-IVB Instrument Unit
- Saturn S-IVB 14300 Cryogenic Fuel Tank, var. 3m Extension
- Saturn S-IVB Engine Mount, var. S-II
    - 4xRL10 Cryogenic Engine, var. RL10C-3
    - 2xR-4Dx3 Triple RCS Thruster, var. R-4Dx/45
- Saturn I S-IVB Interstage

Kick motors

Altair I

- 0.3125m Payload Separator
- Star-20 Altair, var. ABL X-248
- 0.3125m Spin Motor Decoupler

Altair II

- 0.3125m Payload Separator
- Star-20 Altair, var. ABL X-258
- *0.3125m Spin Motor Decoupler

*For stacked configurations only one spin table is needed.

Altair III

- 0.3125m Payload Separator
- Star-20 Altair, var. GCR Star-20
- *0.3125m Spin Motor Decoupler

*For stacked configurations only one spin table is needed.

Star-37D

- 0.625m or 0.3125m Payload Separator
    - *2xY0-Y0 De-Spin Device
- Star-37BV, var. Star-37DV
- Spin Motor Decoupler 0.625m

*Only if payload is not spin-stabilized.

Star-37E

- 0.625m or 0.3125m Payload Separator
    - *2xY0-Y0 De-Spin Device
- Star-37FMV, var. Star-37EV
- Spin Motor Decoupler 0.625m

*Only if payload is not spin-stabilized.

Star-37FM

- 0.625m or 0.3125m Payload Separator

    - *2xY0-Y0 De-Spin Device
- Star-37FMV, var. Star-37FMV
- Spin Motor Decoupler 0.625m

*Only if payload is not spin-stabilized.

Star-48B

- 0.9375m or 0.625m Payload Separator
    - *2xY0-Y0 De-Spin Device
- Star-48BV, var. Star-48BV
- Spin Motor Decoupler 0.9375m

Dual Payload Adapters

Agena, Delta K and DCSS 5m support dual payload launches. In all cases, they work similar: the top payload is detached first by an appropriate payload decoupler, then the DPA is jettisoned, and the second payload is detached, possibly following a maneuver by the upper stage. Adequate avoidance maneuver is required by either the upper stage or the payload.

Delta II

- Payload Adapter
- TSS-2B Delta II Dual Payload Adapter
- TSS-2B Delta II Dual Payload Adapter Base
    - Payload Adapter
- Launch Vehicle (Delta 10L fairing)

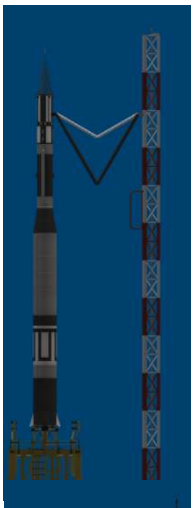
Delta IV

- DSS-5 Dual Payload Adapter
- DSS-5 Dual Payload Adapter Base
    - Payload Adapter
- Launch Vehicle (Delta IV Composite Long fairing)

Agena

- Agena Multiple Payload Adapter
- Standard Agena Clamshell Fairing (Dual Payload Node: Yes)
    - Payload Adapter
- Agena

Launch Infrastructure

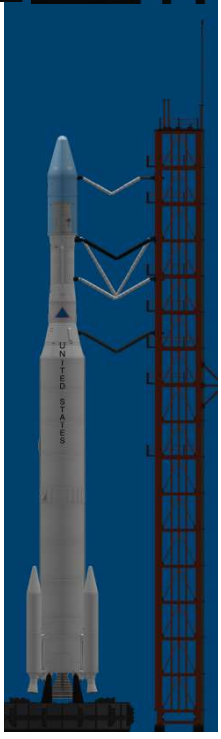


Vanguard

Vanguard uses its own dedicated pad and tower, with two parallel umbilicals going to the middle of the cylindrical section of the fairing.

Thor

Direct Thor derivatives use a simple arrangement: a Thor-Delta stand with a Thor-Delta fallback tower. The fallback tower comes with three umbilicals: one for the fairing, one for the upper stage, right below it, and one for the lower stage. The fairing umbilical might be omitted, and when solid upper stages are used, the upper stage umbilical is not used.

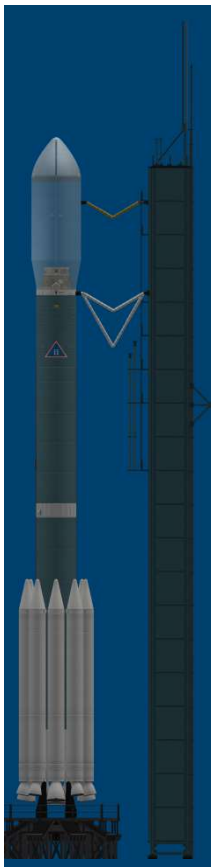


Long Tank Thor

With the switch to Long Tank Thor, the tower is exchanged for a single piece Delta tower and the stand changed to a Delta II variant. Umbilical arrangement is similar, except now the upper umbilical is doubled, and there is an additional lower umbilical on lower part of the upper stage. The lower umbilical, now a gray rocket power cable, is now optional.

Delta I to III

All numbered Deltas before Delta IV use a similar pad design, differing only in placement of umbilicals and in color. Stand used is still Delta II style. Powering the lower stage is no longer needed, so the lowermost umbilical from the LTT tower is not present, but the remaining three are still there. The fairing umbilical is yellow. The tower is fully enclosed and can be red, gray or blue. For Delta III, a number of umbilicals is added. DCSS has an additional pair on the upper part of the interstage, a yellow AC umbilical in the middle of the interstage, and a white umbilical on the bottom of the interstage section.

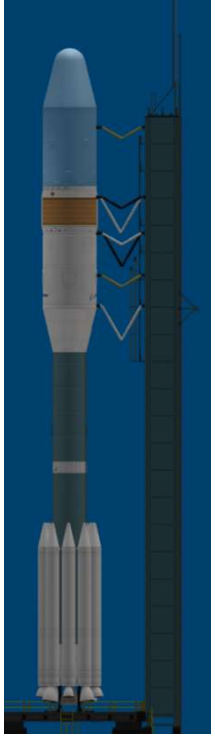


Widebody Delta

Due to very different requirements, the widebody Delta variants use a tower derived from Atlas-Centaur tower, and a new launch stand. General Round Launch Stand is used, with tall holddown bolts. The tower is a 25m high General Service Tower Medium. A medium and a small swing arm service the Centaur, as on Atlas, and the fairing has a white umbilical near the top of the cylindrical section, and a large basic swing arm at the bottom.

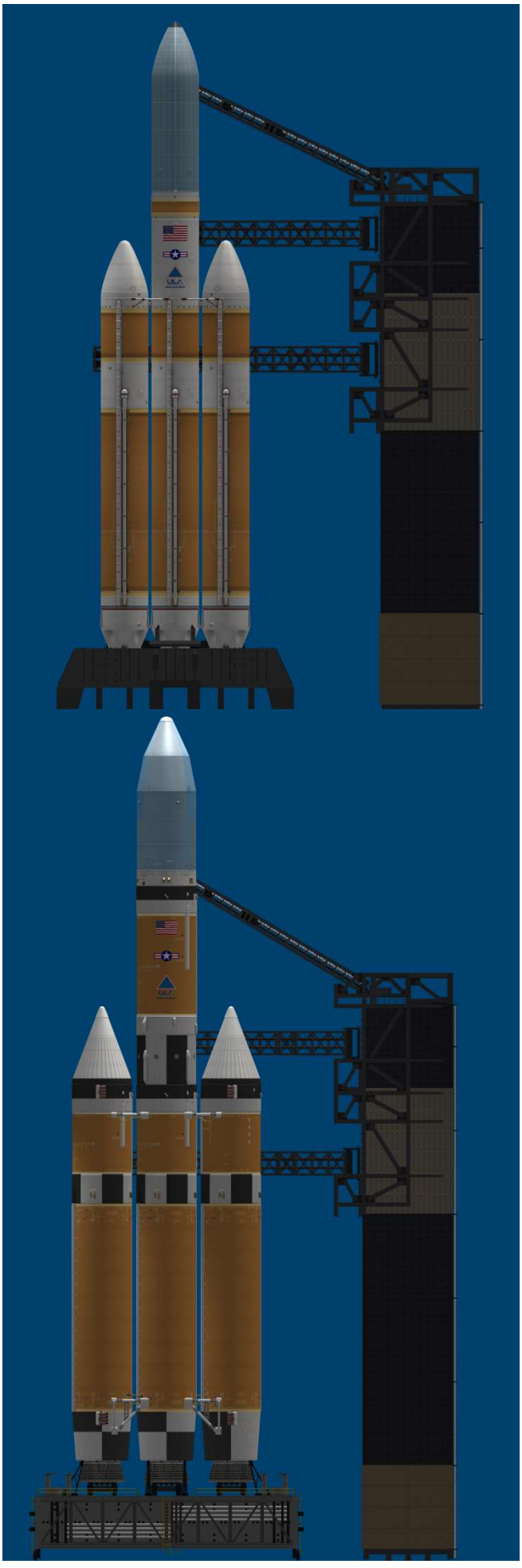
Double Barrel Delta

Double Barrel Delta requires a large pad modification. The tower's general layout is similar to previous towers, but height is increased. The stand used is the medium general launch plate, with a total of eight vertical holddown bolts, mimicking the arrangement of the regular plate on each core.



Delta IV

Delta IV uses its own stand and tower. The stand is universal, and can take from one to three cores. The tower has three arms with multiple umbilicals on each. This allows it to provide all the necessary services to the cores, DCSS and the payload. For Delta IV Small, the fairing arm is retracted and DCSS arm provides all the connections for both Delta K and the fairing. This arrangement is used for Delta V and VI, too.



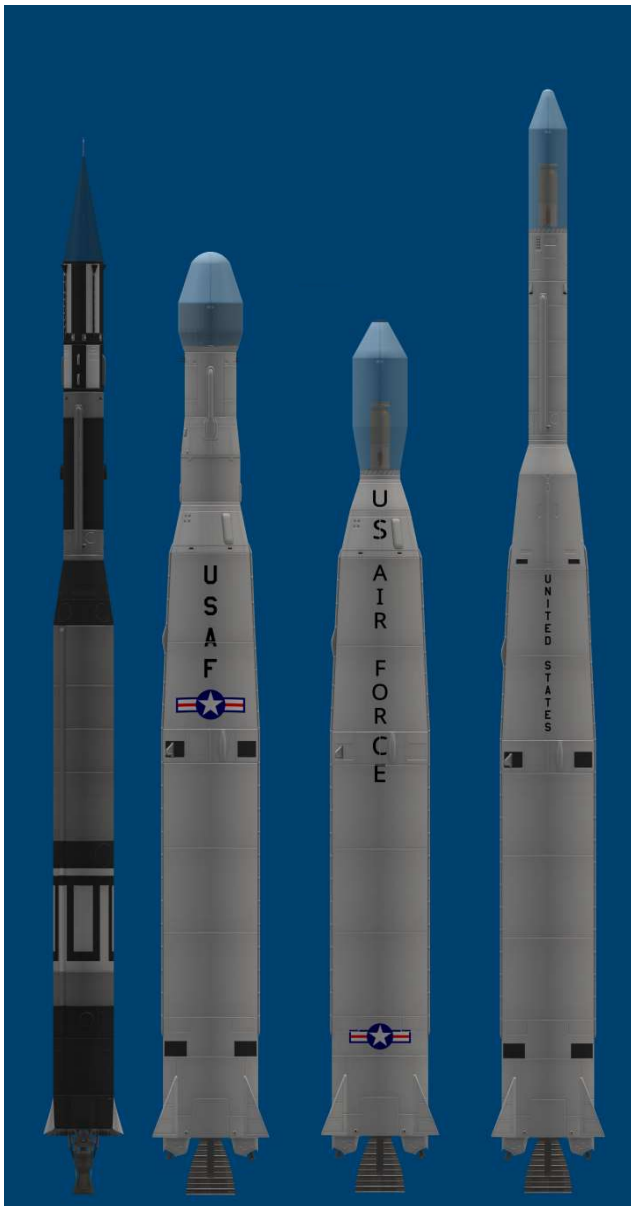
Delta VII

As a new design, Delta VII requires its own pad infrastructure. While derived from the Delta IV tower, its height is increased and the arms are repositioned. Main swing arms are shorter, and the fairing arm is longer in order to reach the lower part of the fairing. The pad is new, it has two vertical holddown tripods for each booster and four for the core, plus three tail service masts, one for each WCBC.

History - Vanguard and Thor

	Vanguard	Thor-Able	Thor-Ablestar	Thor-Burner	Thor-Burner 2	Thor-Delta
Payload	0.012T	0.07T	0.35T	0.08T	0.137T	0.18T
Ref. Mission	LEO	LEO	LEO	LEO-SD	LEO-SD	LEO
Stages	3	3	2	2	2	3
Liftoff TWR	1.29	1.31	1.22	1.53	1.48	1.29
Boosters	None	None	None	None	None	None
Core	Viking 1	Thor	Thor	Thor	Thor	Thor
Core Engine	GE-405	LR-79 NA11	LR-79 NA11	LR-79 NA11	LR-79 NA11	LR-79 NA11
Upper Stage	Able	Able 2	Ablestar	Altair-3	Burner 2	Delta
Kick Motor	Altair	Altair	None	N/A	N/A	Altair-2

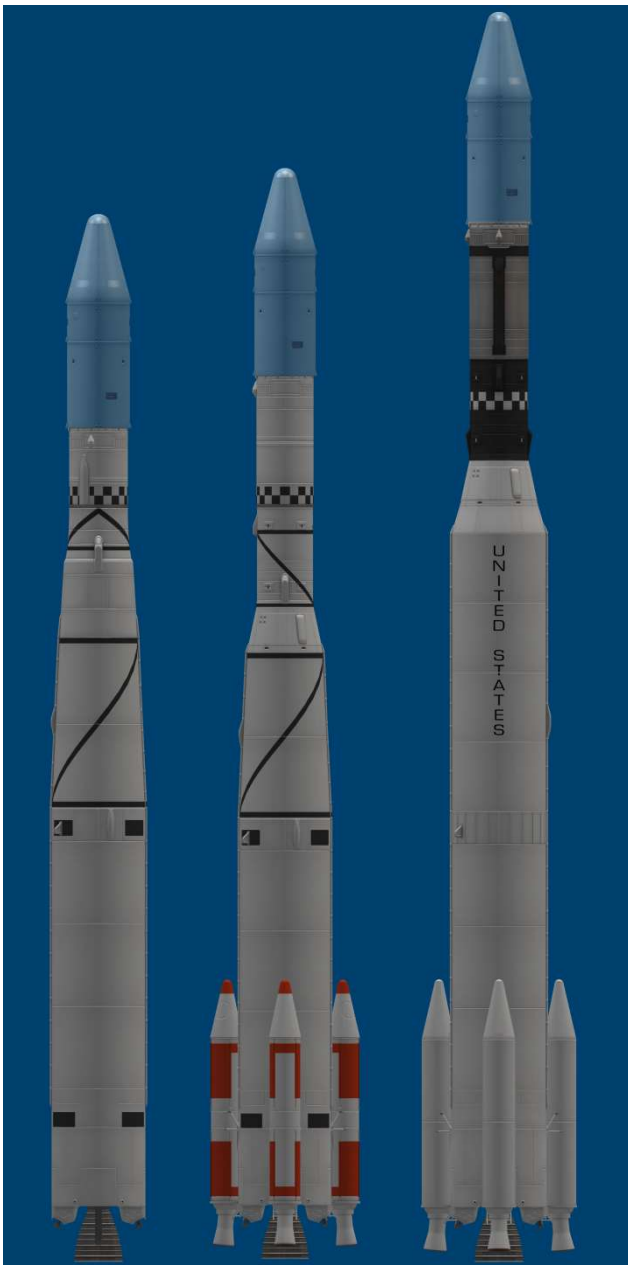
The Delta family is descended from the first civilian US orbital rocket, the Vanguard, and the Thor ballistic missile. The upper composite from Vanguard, that is, the Able upper stage and the Altair kick motor, forms the basis on which the Delta family is built for most of its history. The Thor, meanwhile, provides a first stage that, in various forms, powers Delta for just as long. This basic formula went through a few permutations before the Delta upper stage appeared. Able itself had no attitude control beyond engine cutoff, an issue that was fixed on the first Delta upper stage. Ablestar was a harbinger of things to come, being the first large diameter upper stage on Thor. Thor-Able could only orbit 70kg, with Thor-Delta bringing that up to 80kg. Thor-Burner is a very unusual series of vehicles, mounting the solid motor directly to the lower stage. Burner 1 is spin stabilized, so the rocket has small attitude thrusters added. Insertion using Burner 1 is not accurate. Burner 2 is unusual in that it can fire before or after its solid motor. To achieve maximum payload, it needs to complete the first stage burn and then fire again, to establish the final orbit.



Siblings - Thor-Agena

	SLV2 Agena A	SLV2 Agena B	SLV2 Agena D	SLV2A Agena B	SLV2A Agena D	SLV2G Agena B	SLV2H Agena D
Payload	0.25T	0.45T	0.53T	0.75T	0.83T	1.14T	1.15T
Ref. Mission	LEO	LEO	LEO	LEO	LEO	LEO	LEO
Stages	2	2	2	2	2	2	2
Liftoff TWR	1.26	1.17	1.17	1.89	1.89	1.55	1.54
Boosters	None	None	None	3xCastor 1	3xCastor 1	3xCastor 2	3xCastor 2
Core	Thor	Thor	Thor	Thor	Thor	LTT	LTT
Core Engine	S-3D	LR-79 NA11	LR-79 NA13	LR-79 NA13	LR-79 NA13	LR-79 NA13	LR-79 NA13
Upper Stage	Agena A	Agena B	Agena D	Agena B	Agena D	Agena B	Agena D
Kick Motor	None	None	None	None	None	None	None

Delta is primarily a GTO-oriented light lifter, while Thor-Agena provides a highly versatile option for military LEO launches. All Agenas can coast, which is a notable advantage. Even the Agena A is a very capable stage, also capable of serving as a spacecraft bus, though payload capacity is small. It is recommended to use an exposed spacecraft and launch without a fairing for that reason. In addition to propulsion, it also provides attitude control and communications. While it can be restarted, limited tank volume means this will is not usually done. The Agena B provides both a large propellant tank and a restart capability, putting it ahead of Delta E in that regard, though it's limited by its solid ullage motors. Agena D further improves on it, with a sump tank system obviating the need for ullage motors, as well as addition of an equipment truss which can be used to carry additional maneuvering jets, solar panels or even subsatellites. While SLV2-Agena D does not match Delta E in terms of raw payload to LEO, its ability to serve as a spacecraft bus more than makes up for it. The stretched "Thor Advanced", or Thorad, lower stage that SLV2G and SLV2H are based on further improve lifting capability, up to a point where fairing volume is the primary limitation. It also forms the basis of the second generation of the Delta family.



First Generation – Thor-Delta

	Delta A	Delta B	Delta C	Delta C1
Payload	0.2T	0.125T	0.32T	0.33T
Ref. Mission	LEO	GTO-SD	LEO	LEO
Stages	3	4	3	3
Liftoff TWR	1.29	1.28	1.27	1.27
Boosters	None	None	None	None
Core	Thor	Thor	Thor	Thor
Core Engine	LR-79 NA11	LR-79 NA11	LR-79 NA11	LR-79 NA11
Upper Stage	Delta	Delta	Delta	Delta
Kick Motor	Altair-2	2xAltair-2	Altair-2	Altair-3

The first generation of Delta rockets are useful for launching small satellites. The Delta stage uses an AJ-10-118D engine and 3-axis attitude control, and as such, is capable of coasting with full attitude control. This allows a precise orbital insertion using a solid upper stage. There's no need to tailor the upper stage, as the upper stage can be shut down early. For this reason, orbital insertion can be quite precise. All rockets in this family require a coast phase to be set. There are two options for kick motors in this family, Altair-2 and Altair-3. Of note is the dual Altair-2 option available to Delta-B, which makes it the first Delta capable of reaching GTO with a useful, if still very small payload. Due to its unusual configuration with two spin stabilized kick motors, it requires a special flight profile in order to be able to reach its target orbit.

First Generation Plus – Thrust Augmented Thor

	Delta D	Delta E	Delta E1	Delta F	Delta G	Delta H	Delta J
Payload	0.59T	0.8T	0.142T	0.58T	0.74T	0.53T	0.308T
Ref. Mission	LEO	LEO	GTO-HI	LEO	LEO	LEO	GTO-MD
Stages	3	3	3	3	2	2	3
Liftoff TWR	2.16	2.02	2.1	1.31	2.04	1.32	2.07
Boosters	3xCastor 1	3xCastor 1	3xCastor 1	0	3xCastor 1	0	3xCastor 1
Core	Thor	Thor	Thor	Thor	Thor	Thor	Thor
Core Engine	LR-79 NA13	LR-79 NA13	LR-79 NA13	LR-79 NA13	LR-79 NA13	LR-79 NA13	LR-79 NA13
Upper Stage	Delta	Delta E	Delta E	Delta E	Delta E	Delta E	Delta E
Kick Motor	Altair-3	Altair-2	Altair-3	Altair-3	None	None	Star-37D

A major upgrade to the first generation Delta rockets, TAT uses a trio of Castor 1 boosters in order to increase liftoff TWR and provide additional ΔV. As a next step, the upper stage is replaced with a widebody model using the AJ-10-118E engine, designated Delta E. It uses Ablestar tankage and an Agena shroud. The core tankage is the same, but the engine is upgraded to LR-79 NA13, which is more powerful. While payload envelope is small, this is a very capable small rocket system for its tech level. Its various configurations provide for different kick motor variants, including their complete lack, or for removal of Castor boosters.

Second Generation

	Delta K	Delta K6	Delta K9	Delta L	Delta M	Delta M6	Delta N	Delta N6
Payload	0.64T	0.74T	0.89T	0.165T	0.309T	0.38T	1.54T	1.84T
Ref. Mission	GTO-LO	GTO-LO	GTO-LO	GTO-VH	GTO-HI	GTO-VH	LEO	LEO
Stages	2	2	2	3	3	3	2	2
Liftoff TWR	1.52	1.96	1.77	1.62	1.6	2.06	1.52	1.96
Boosters	3xCastor 2	6xCastor 2	9xCastor 2	3xCastor 2	3xCastor 2	6xCastor 2	3xCastor 2	6xCastor 2
Core	LTT	LTT	LTT	LTT	LTT	LTT	LTT	LTT
Core Engine	LR-79 NA13	LR-79 NA13	LR-79 NA13	LR-79 NA13	LR-79 NA13	LR-79 NA13	LR-79 NA13	LR-79 NA13
Upper Stage	HOSS	HOSS	HOSS	Delta E	Delta E	Delta E	Delta E	Delta E
Kick Motor	None	None	None	Altair-3	Star-37D	Star-37D	None	None

The second generation uses a Long Tank Thor first stage, developed for the Thorad launch vehicle. This considerably increases its burn time, bringing with it a major ΔV increase. Boosters are also upgraded to the better optimized Castor 2. This, in turn, allows the use of a larger kick motor in form of Star-37D. While already used on Delta J, the first stage upgrade allows the larger kick motor to be utilized to its full extent. It is at this point that Delta family becomes primarily GTO-oriented, with LEO options created by removing the kick motor. This is also the point at which the first cryogenic Delta variant appears, the Delta K. This provides a vast increase in GTO payload, and allows it to use the GTO-LO mission profile. While it's one of the smallest cryogenic stages available, the Hydrogen-Oxygen Upper Stage is nonetheless very capable, giving the rocket GTO performance that would only be matched late in the next generation. The K9 is unusual in that it uses a skirt from the next generation of Delta family to mount nine Castor 2 SRBs.

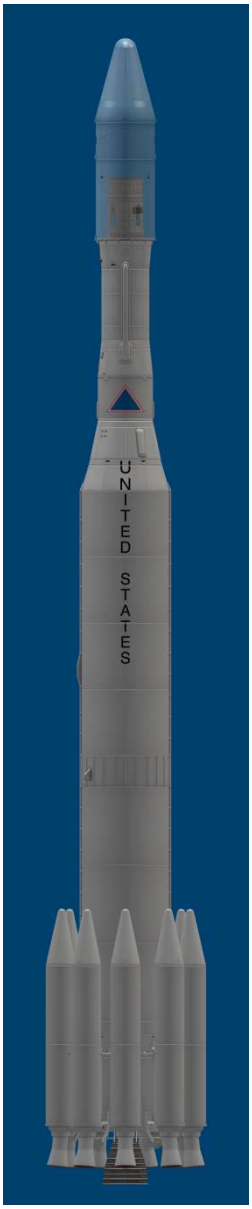
Third Generation – Numbered Deltas

The third generation offers the most variety in terms of sub-families of the Delta series rockets. To that end, the Delta Numbering system is introduced. It is capable of handling any possible configuration of third generation Delta series stages. In addition to the four digit number, a letter can be appended. The "heavy" configuration usually means replacing the usual GEM-40 boosters with larger GEM-46, while "double" means that the rocket uses a dual first stage tank, with two engines. In case of such rockets, boosters are counted per core, so "6" would mean a 12-booster configuration, six to each core. Configurations of up to six boosters all ignite all the motors at liftoff, while nine booster configurations ignite the first six at liftoff, and then the following three after the first six burn out. Due to relatively limited gimbal authority of the first stage engines, highly asymmetrical booster configurations are not practical, although four booster configurations have some asymmetry due to how mounting points are arranged.

	First	Second	Third	Fourth	Letter
0	LTT+LR-79+Castor 2	No SRMs	Delta F	None	H – Heavy
1	ELTT+LR-79+Castor 2	1xSRM	Delta P	Altair-2	D – Double
2	ELTT+RS-27+Castor 2	2xSRMs	Delta K	Altair-3	W - Widebody
3	ELTT+RS-27+Castor 4	3xSRMs	4m DCSS	Star-37D	
4	ELTT+LR-79+Castor 4A	4xSRMs	5m DCSS	Star-37E	
5	ELTT+RS-27+Castor 4A	5xSRMs	ACES	Star-48B	
6	EELTT+RS-27+Castor 4A	6xSRMs	HOSS	Star-37FM	
7	EELTT+RS-27A+GEM-40	7xSRMs	Delta X		
8	XELTT+RS-27A+GEM-46	8xSRMs			
9	CBC+RS-68+GEM-60	9xSRMs			

Delta 0000

	Delta 0300	Delta 0900	Delta 0903
Payload	1.74T	1.94T	0.38T
Ref. Mission	LEO	LEO	GTO-VH
Stages	2	2	3
Liftoff TWR	1.52	1.77	1.85
Boosters	3xCastor 2	9xCastor 2	9xCastor 2
Core	LTT	LTT	LTT
Core Engine	LR-79 NA13	LR-79 NA13	LR-79 NA13
Upper Stage	Delta F	Delta F	Delta F
Kick Motor	None	None	Star-37D

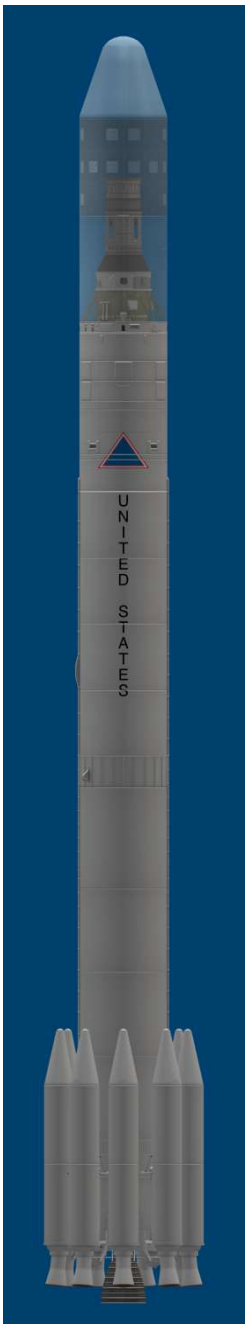


Early model numbered Deltas do not offer much over Delta M and N, aside from being able to take up to nine Castor 2 SRBs. Delta E tankage is still used, but the engine is replaced by a much higher performing AJ-10-118F, resulting in the Delta F. Other than that, there is very little difference, though the new engine does provide a performance advantage. GTO configurations do not benefit because of the limitations of the Star-37D, but the standardization lays ground for rockets that do.

Delta 1000

	Delta 1410	Delta 1603	Delta 1604	Delta 1900	Delta 1910	Delta 1913	Delta 1914
Payload	1.9T	0.38T	0.57	1.6	1.5	0.46T	0.49T
Ref. Mission	LEO	GTO-VH	GTO-VH	LEO	LEO	GTO-LO	GTO-LO
Stages	2	3	3	2	2	3	3
Liftoff TWR	1.45	1.78	1.76	1.57	1.59	1.63	1.63
Boosters	4xCastor 2	6xCastor 2	6xCastor 2	9xCastor 2	9xCastor 2	9xCastor 2	9xCastor 2
Core	ELTT	ELTT	ELTT	ELTT	ELTT	ELTT	ELTT
Core Engine	LR-79 NA13	LR-79 NA13	LR-79 NA13	LR-79 NA13	LR-79 NA13	LR-79 NA13	LR-79 NA13
Upper Stage	Delta P	Delta F	Delta F	Delta F	Delta P	Delta P	Delta P
Kick Motor	None	Star-37D	Star-37E	None	None	Star-37D	Star-37E

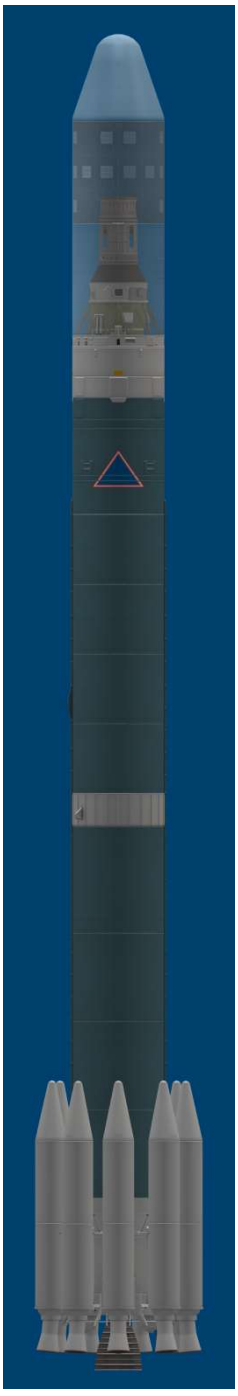
This is the point where Delta family takes on a very different shape. Known as “straight eight”, it introduces a large diameter fairing, complete with a shroud inside of which the Delta stage is suspended. Both Delta P and Delta F can be used. While the fairing is heavier, the expanded payload envelope is a major benefit over the constrained Agena fairings used earlier. There is no significant change in performance compared to Delta 0000 series when using the Delta F, but Delta P offers a big jump in payload capacity. On top of the specific impulse improvement, which is modest, the biggest change is that Delta P uses a new, restartable TR-201 engine derived from LMDE. This allows it to use a very different ascent profile, with insertion to a relatively low orbit, following by a long burn to GTO, which is started by the upper stage and finished by the solid motor.



Delta 2000

	Delta 2310	Delta 2313	Delta 2910	Delta 2913	Delta 2914
Payload	1.8T	0.5T	1.9T	0.51T	0.54T
Ref. Mission	LEO	GTO-LO	LEO	GTO-LO	GTO-LO
Stages	2	3	2	3	3
Liftoff TWR	1.44	1.53	1.71	1.77	1.76
Boosters	3xCastor 2	3xCastor 2	9xCastor 2	9xCastor 2	9xCastor 2
Core	ELTT	ELTT	ELTT	ELTT	ELTT
Core Engine	RS-27	RS-27	RS-27	RS-27	RS-27
Upper Stage	Delta P	Delta P	Delta P	Delta P	Delta P
Kick Motor	None	Star-37D	None	Star-37D	Star-37E

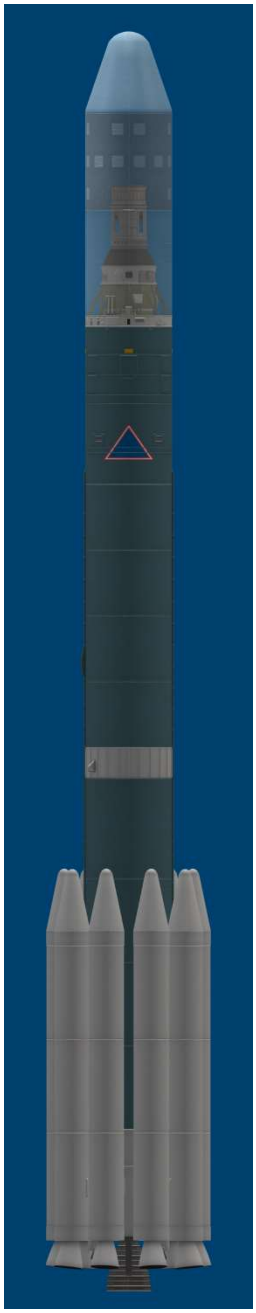
A significantly more mature development of the "straight eight" Delta family, the 2000 uses the same core stage as the 1000, but upgrades the engine to a H-1 derived RS-27. Like before, it can fly with Delta P or Delta E upper stages, and Star-37D or E as an upper stage.



Delta 3000

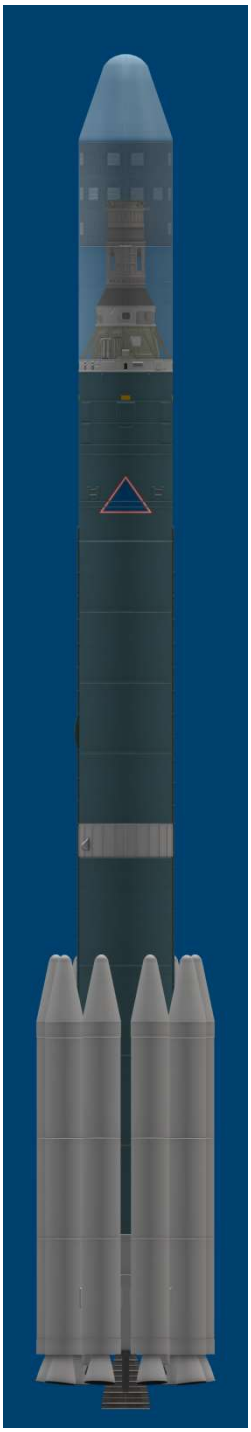
	Delta 3910	Delta 3913	Delta 3914	Delta 3915	Delta 3920	Delta 3924	Delta 3925
Payload	2.4	0.58	0.65T	1.3	2.9	0.88	1.65
Ref. Mission	LEO	GTO-LO	GTO-LO	GTO-LO	LEO	GTO-LO	GTO-LO
Stages	2	3	3	3	2	3	3
Liftoff TWR	1.77	1.84	1.83	1.79	1.74	1.8	1.77
Boosters	9xCastor 4	9xCastor 4	9xCastor 4	9xCastor 4	9xCastor 4	9xCastor 4	9xCastor 4
Core	ELTT	ELTT	ELTT	ELTT	ELTT	ELTT	ELTT
Core Engine	RS-27	RS-27	RS-27	RS-27	RS-27	RS-27	RS-27
Upper Stage	Delta P	Delta P	Delta P	Delta P	Delta K	Delta K	Delta K
Kick Motor	None	Star-37D	Star-37E	Star-48B	None	Star-37E	Star-48B

Delta 3000 increases the performance considerably by substituting Castor 2 solid motors for Castor 4, which are much more powerful and longer burning. This simple upgrade allows for a large increase in payload.



Delta 4000

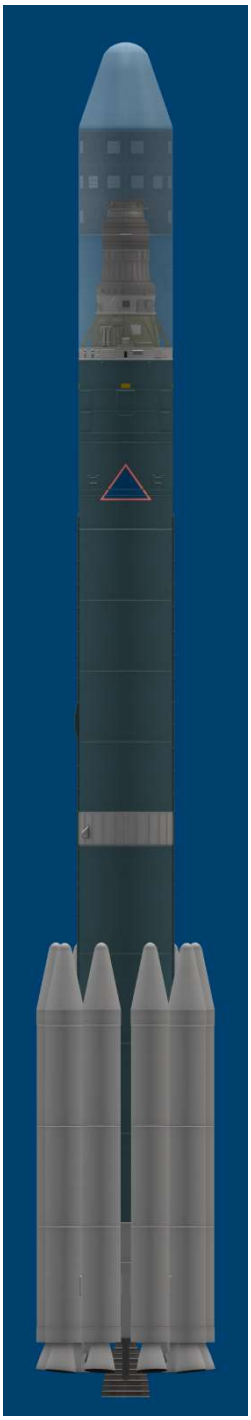
	Delta 4920	Delta 4924	Delta 4925	Delta 4926
Payload	3T	0.93T	1.7T	0.94T
Ref. Mission	LEO	GTO-LO	GTO-LO	GTO-LO
Stages	2	3	3	3
Liftoff TWR	1.45	1.78	1.92	1.63
Boosters	9xCastor 4A	9xCastor 4A	9xCastor 4A	9xCastor 4A
Core	ELTT	ELTT	ELTT	ELTT
Core Engine	LR-79 NA13	LR-79 NA13	LR-79 NA13	LR-79 NA13
Upper Stage	Delta K	Delta K	Delta K	Delta K
Kick Motor	None	Star-37E	Star-48B	Star-37FM



The Delta 4000 is sort of a middle stop in the Delta family, created to fly off older hardware on an otherwise last generation stack. It goes back to LR-79 engine, and it's the last Delta officially offered with Star-37D kick motor. Its motors are upgraded to Castor 4A, which give it an increase in payload, despite using other outdated technology.

Delta 5000

	Delta 5920	Delta 5925	Delta 5926
Payload	3.1T	1.7T	0.94T
Ref. Mission	LEO	GTO-LO	GTO-LO
Stages	2	3	3
Liftoff TWR	1.89	1.92	1.96
Boosters	9xCastor 4A	9xCastor 4A	9xCastor 4A
Core	ELTT	ELTT	ELTT
Core Engine	RS-27	RS-27	RS-27
Upper Stage	Delta K	Delta K	Delta K
Kick Motor	None	Star-48B	Star-37FM



The 5000 series is the latest and greatest in Delta I family. Combining the improved Castor 4A boosters with RS-27 engine and high performance kick motors, it offers the highest performance of all third generation Delta rockets.

Third Generation Plus – Widebody Deltas

Delta 4000W

	Delta 4000W	Delta 4030W	Delta 4060W	Delta 4090W	Delta 4120W	Delta 4125W
Payload	1.7T	1.8T	2.2T	2.4T	2.7T	2.3T
Ref. Mission	GTO-LO	GTO-LO	GTO-LO	GTO-LO	GTO-LO	LTO
Stages	2	2	2	2	2	3
Liftoff TWR	1.3	1.68	1.97	1.78	1.63	1.62
Boosters	None	3xCastor 4A	6xCastor 4A	9xCastor 4A	12xCastor 4A	12xCastor 4A
Core	WBELTT	WBELTT	WBELTT	WBELTT	WBELTT	WBELTT
Core Engine	3xRS-27	3xRS-27	3xRS-27	3xRS-27	3xRS-27	3xRS-27
Upper Stage	Centaur D	Centaur D	Centaur D	Centaur D	Centaur D	Centaur D
Kick Motor	None	None	None	None	None	Star-48B

A major upgrade to the Delta family, the widebody variants are an alternate direction for the Delta designs to take. The core is widened to keep height under control, and a Centaur upper stage is used, instead of hypergolic Delta series. Castor boosters are retained, as is the RS-27 engine, but three engines are used, obviating the need for verniers. Unlike in regular variants, the widebody Deltas can fly with no boosters at all, just the core. Star-48B is retained as a kick motor option, but it's not required for regular GTO missions. Centaur fairings are used, which allows a considerable range of options to be used, including large diameter shrouds. Due to the ability to attach a larger number of boosters, the numbering system is adjusted, with two digits in the middle standing for the number of boosters, and the final one for the upper stage.

Delta 5000W

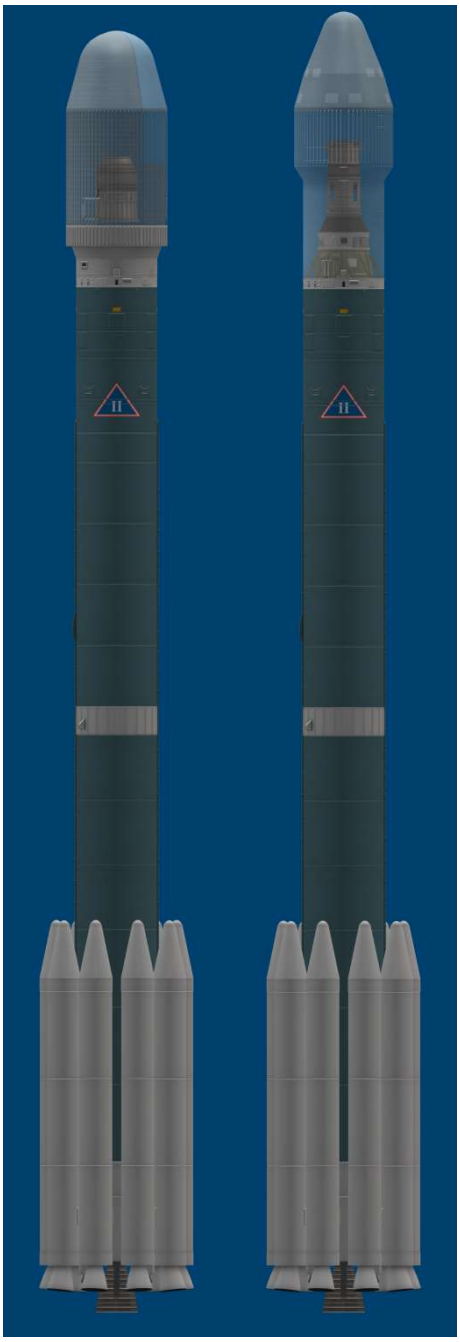
	Delta 5000W	Delta 5010W	Delta 5020W	Delta 5030W	Delta 5040W	Delta 5050W	Delta 5060W	Delta 5065W
Payload	2.7T	2.9T	3.1T	3.3T	3.5T	3.6T	3.9T	3.2T
Ref. Mission	GTO-LO	GTO-LO	GTO-LO	GTO-LO	GTO-LO	GTO-LO	GTO-LO	LTO
Stages	2	2	2	2	2	2	2	3
Liftoff TWR	1.19	1.31	1.42	1.51	1.59	1.66	1.72	1.73
Boosters	None	1xGEM-46	2xGEM-46	3xGEM-46	4xGEM-46	5xGEM-46	6xGEM-46	6xGEM-46
Core	WBELTT	WBELTT	WBELTT	WBELTT	WBELTT	WBELTT	WBELTT	WBELTT
Core Engine	3xRS-27	3xRS-27	3xRS-27	3xRS-27	3xRS-27	3xRS-27	3xRS-27	3xRS-27
Upper Stage	Centaur E	Centaur E	Centaur E	Centaur E	Centaur E	Centaur E	Centaur E	Centaur E
Kick Motor	None	None	None	None	None	None	None	Star-48B

The widebody variant of Delta 5000 is a further upgrade to Delta 4000W. The principal upgrade is to the Centaur, which is replaced by Centaur E from advanced Saturn variants. In addition, variants that carry boosters are fitted with up to six GEM-46 motors. Asymmetrical configurations are now fully feasible, although only single and five GEM configurations actually need to make use of this capability, as all booster attachment points are retained, so there are no difficulties fitting any other number symmetrically. It retains the adjusted numbering system, as it is, theoretically, capable of supporting up to 12 boosters.

Fourth Generation – Delta II

Delta II 6000

	Delta 6920	Delta 6925	Delta 6926
Payload	3.5T	2T	1.05T
Ref. Mission	LEO	GTO-LO	GTO-LO
Stages	2	3	3
Liftoff TWR	1.89	1.76	1.96
Boosters	9xCastor 4A	9xCastor 4A	9xCastor 4A
Core	EELTT	EELTT	EELTT
Core Engine	RS-27	RS-27	RS-27
Upper Stage	Delta K	Delta K	Delta K
Kick Motor	None	Star-48B	Star-37FM



The 6000 series might seem like a modest upgrade from the 5000, and to some extent that's true, but it's the first upgrade to the lower stage fuel tank in a long time. Delta II also supports new fairing options, a heavy, large diameter Titan-derived trisector shroud for large LEO satellites, and a new, expanded diameter shroud with a cylindrical section for a kick motor. Note that to achieve the rated payload mass, the latter shroud must be used. With the Titan shroud, only 2.9T can be carried to LEO, although payload volume is greatly increased.

Delta II 7000

	Delta 7320	Delta 7326	Delta 7420	Delta 7425	Delta 7426	Delta 7920	Delta 7925	Delta 7926
Payload	3.3T	1.08T	3.6T	2	1.17T	4.1T	2.2T	1.8T
Ref. Mission	LEO	GTO-LO	LEO	GTO-LO	GTO-LO	LEO	GTO-LO	GTO-LO
Stages	2	3	2	3	3	2	3	3
Liftoff TWR	1.39	1.47	1.54	1.58	1.62	1.51	1.61	1.58
Boosters	3xGEM-40	3xGEM-40	4xGEM-40	4xGEM-40	4xGEM-40	9xGEM-40	9xGEM-40	9xGEM-40
Core	EELTT	EELTT	EELTT	EELTT	EELTT	EELTT	EELTT	EELTT
Core Engine	RS-27A	RS-27A	RS-27A	RS-27A	RS-27A	RS-27A	RS-27A	RS-27A
Upper Stage	Delta K	Delta K	Delta K	Delta K	Delta K	Delta K	Delta K	Delta K
Kick Motor	None	Star-37FM	None	Star-48B	Star-37FM	None	Star-48B	Star-37FM

Delta II 7000 improves on the 6000 series by replacing the steel cased Castor boosters with Graphite Epoxy Motors, or GEMs. The GEM-40 series is more capable, and it also features different nozzles for air and ground lit motors, increasing efficiency. This generation of Delta standardizes on the GEM series, with options of three, four and nine boosters covering the full range of payloads. Since the boosters burn longer, the engine is replaced by RS-27A, which has a larger nozzle for improved efficiency at altitude. It also introduces two new large diameter composite fairings and a dual payload adapter option.

Fourth Generation Plus - Delta II Heavy and Lite

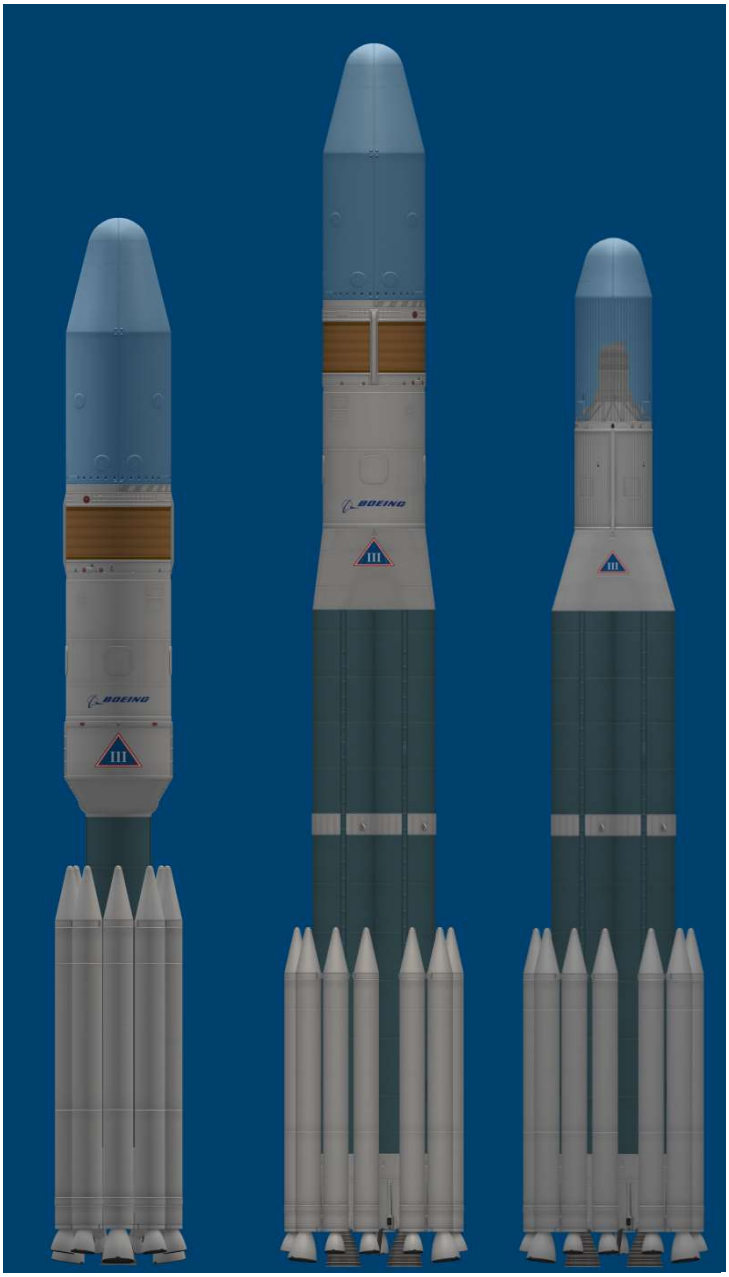
	Delta 7920H	Delta 7925H	Lite
Payload	4.9T	1.7T	1.1T
Ref. Mission	LEO	GTO-LO	GTO-LO
Stages	2	3	4
Liftoff TWR	1.42	1.67	1.45
Boosters	9xGEM-46	9xGEM-46	2xCastor 4A
Core	EELTT	EELTT	Delta Lite
Core Engine	RS-27A	RS-27A	Castor 120
Upper Stage	Delta K	Delta K	Delta K
Kick Motor	None	Star-48B	Star-37FM

Delta II Heavy is an offshoot of Delta II 7000 series and the later Delta III, it combines the latter's GEM-46 boosters with the former's core. This is a cheap and easy way to increase payload of the legacy Delta II. This is the most powerful of the classic Delta configurations. On the other side, there's Delta Lite, which is a small GTO launcher using a solid core and Castor 4A boosters to launch a Delta 7000 series upper composite. While not nearly as powerful, it's a fairly low cost lifter. Two Titan 23G Attitude Control System blocks are installed on Delta K interstage to provide roll control. In case of PVG failing to converge for Delta Lite, fix coast to 250s at launch.

Fifth Generation – Delta III

	Delta 8930	Delta 7630D	Delta 7630DH	Delta 7670D	Delta 7670DH	Delta 7675D	Delta 7960
Payload	3.2T	4T	4.4T	7.1T	8.1T	3.2T	1.7T
Ref. Mission	GTO-LO	GTO-LO	GTO-LO	LEO	LEO	GTO-LO	GTO-LO
Stages	2	2	2	2	2	3	2
Liftoff TWR	1.37	1.37	1.31	1.35	1.3	1.41	1.46
Boosters	9xGEM-46	12xGEM-40	12xGEM-46	12xGEM-40	12xGEM-46	12xGEM-40	9xGEM-40
Core	XELTT	2xEELTT	2xEELTT	2xEELTT	2xEELTT	2xEELTT	EELTT
Core Engine	RS-27A	2xRS-27A	2xRS-27A	2xRS-27A	2xRS-27A	2xRS-27A	RS-27A
Upper Stage	DCSS 4m	DCSS 4m	DCSS 4m	Delta X	Delta X	Delta X	HOSS
Kick Motor	None	None	None	None	None	Star-48B	None

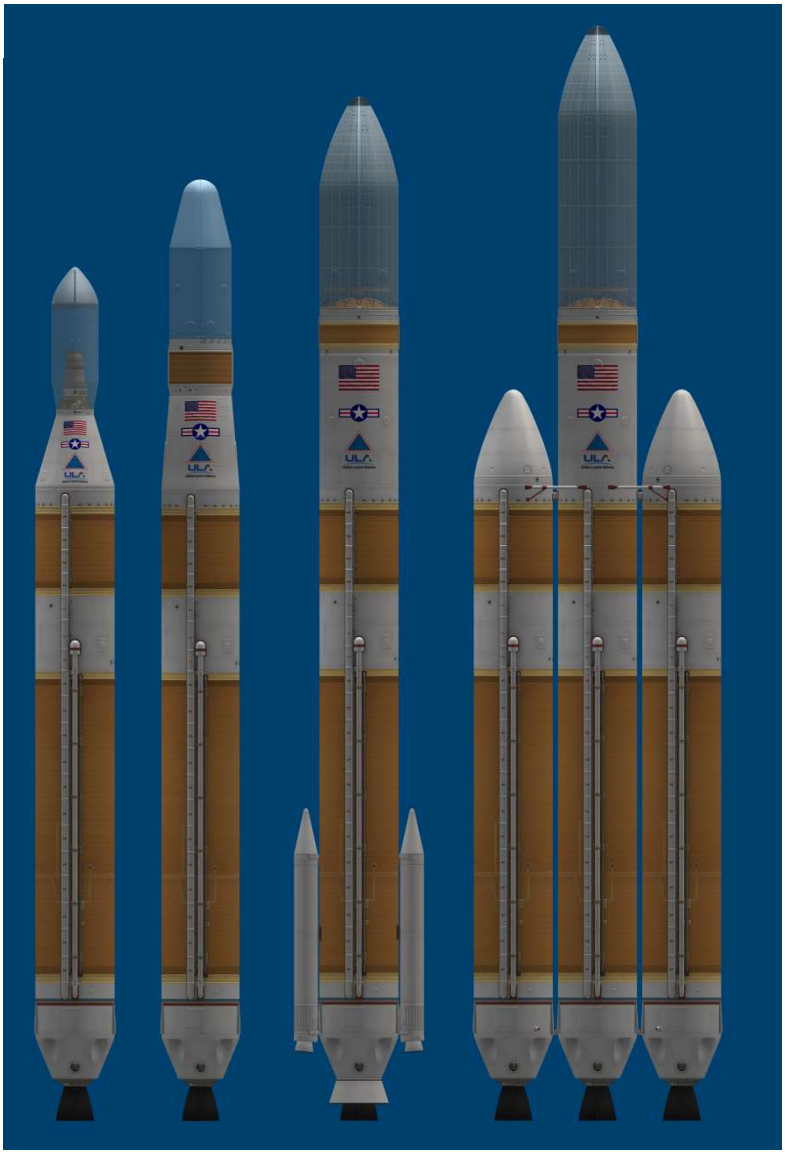
Delta III brings a dramatic increase in payload, which is achieved by a dramatic redesign of the launch vehicle. The hydrogen stage makes a comeback, now much larger and equipped with a more powerful engine. The first stage upgrade takes two approaches: enlarged boosters or dual core. While the dual core provides more performance overall, enlarging the boosters to GEM-46s is a simpler and somewhat more reliable option. The options can be combined, if performance has to be pushed to the max. Two upper stages can be used, cryogenic DCSS and Delta X, which is a Delta with a large diameter tank and an engine upgrade. The most modest option, barely qualifying as a generational leap, simply replaces the upper stage with a derivative of HOSS from Delta K, which provides a modest increase in payload to GTO.



Sixth Generation – Delta IV

	Delta 9025 Small	Delta 9030 Medium	Delta 9230 Medium+ 4,2	Delta 9430 Medium+ 4,4	Delta 9240 Medium+ 5,2	Delta 9440 Medium+ 5,4	Delta 9040H Heavy
Payload	2.1T	3T	3.7T	4.4T	4.4T	5.1T	10.7T
Ref. Mission	GTO-LO	GTO-LO	GTO-LO	GTO-LO	GTO-LO	GTO-LO	GTO-LO
Stages	3	2	2	2	2	2	2
Liftoff TWR	1.42	1.33	1.53	1.67	1.46	1.6	1.17
Boosters	None	None	2xGEM-60	4xGEM-60	2xGEM-60	4xGEM-60	2xCBC
Core	CBC	CBC	CBC	CBC	CBC	CBC	CBC
Core Engine	RS-68	RS-68	RS-68A	RS-68A	RS-68A	RS-68A	RS-68A
Upper Stage	DCSS 4m	DCSS 4m	DCSS 4m	DCSS 4m	DCSS 5m	DCSS 5m	DCSS 5m
Kick Motor	Star-48B	None	None	None	None	None	None

The most advanced generation of Deltas, the Delta IV retains little from the previous entries of the family, though it remains compatible with legacy hardware through Delta IV Small. The boosters are replaced by GEM-60s, which can vector their thrust, and which are much more powerful than even GEM-46s. The biggest change, though, is the core, which is entirely replaced by the hyrolox Common Booster Core. With DCSS, it allows Delta IV to fly as an all hydrolox launch vehicle, a configuration exemplified by Delta IV Medium. Solid upper stages are generally not used except for Delta IV Small. The most powerful vehicle in this lineup is Delta IV Heavy, a true HLV capable of launching very large payloads to GTO, and with considerable LEO capacity, as well, though it's not an optimal choice due to low TWR of its upper stage.



Sixth Generation Plus - Delta IV Medium++ and Heavy+

	Delta 9640 Medium++ 5,6	Delta 9840 Medium++ 5,8	Delta 9845 Medium++ 5,8S	Delta 9440H Heavy+ 4	Delta 9640H Heavy+ 6	Delta 9840H Heavy+ 8	Delta 9E40H Heavy+ 14
Payload	5.8T	6.4T	6.4T	12.7T	13.5T	13.7T	14T
Ref. Mission	GTO-LO	GTO-LO	LTO	GTO-LO	GTO-LO	GTO-LO	GTO-LO
Stages	2	3	2	2	2	2	2
Liftoff TWR	1.7	1.78	1.5	1.34	1.41	1.47	1.25
Boosters	6xGEM-60	8xGEM-60	8xGEM-60	4xGEM-60 2xCBC	6xGEM-60 2xCBC	8xGEM-60 2xCBC	14xGEM-60 2xCBC
Core	CBC	CBC	CBC	CBC	CBC	CBC	CBC
Core Engine	RS-68A	RS-68A	RS-68A	RS-68A	RS-68A	RS-68A	RS-68A
Upper Stage	DCSS 5m	DCSS 5m	DCSS 5m	DCSS 5m	DCSS 5m	DCSS 5m	DCSS 5m
Kick Motor	None	None	Star-48B	None	None	None	None

Delta IV Heavy does not exhaust the family's capacity for expansions. Indeed, it's just the start. For one, up to four additional booster attachment points could be added to the CBC, allowing an increase in number of boosters. This, in turn, allows a staggered jettison sequence to be used, with two or four boosters airlit. Another option is the addition of a third stage, the venerable Star-48B. Finally, as side CBCs on a Delta IV Heavy retain their booster attachment points, there is the option to fit them. Using standard CBCs, Delta IV Heavy can carry four or six, using modified ones, eight or up to sixteen, although this produces diminishing returns. Any further upgrades would require major changes to hardware and infrastructure. Delta IV Heavy+ involves an extension to the numbering system. For variants with more than nine boosters, a letter is used according to hexadecimal system convention.

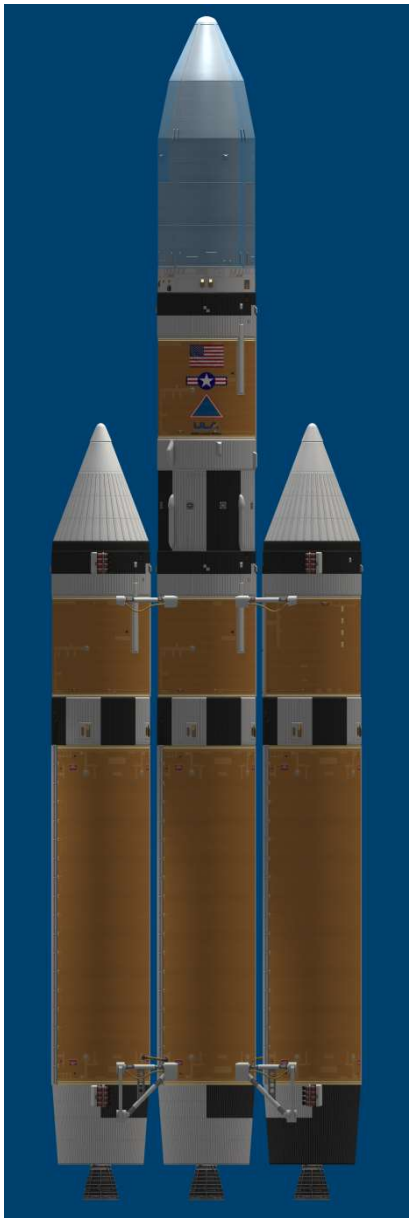
Seventh Generation – Delta V and Delta VI

	Delta 9640H Heavy 2,6	Delta 9850 Medium 2,8	Delta 9850 Medium+ 2,8	Delta 9650H Heavy 2,6	Delta 9650H Heavy+ 2,6	Delta 9650H Heavy+ 4,6	Delta 9E50H Heavy+ 4,16
Payload	26T	10.3T	14.2T	22T	31T	43.5T	34T
Ref. Mission	GTO-VH	GTO-LO	GTO-LO	GTO-LO	GTO-LO	LEO	GTO-LO
Stages	2	2	2	2	2	2	2
Liftoff TWR	1.23	1.39	1.21	1.35	1.19	1.14	1.24
Boosters	6xGEM-60 2xCBC	8xGEM-60	8xGEM-60	6xGEM-60 2xCBC	6xGEM-60 2xCBC	6xGEM-60 2xCBC	14xGEM-60 2xCBC
Core	CBC	CBC	CBC	CBC	CBC	CBC	CBC
Core Engine	RS-68K	RS-68A	RS-68K	RS-68A	RS-68K	RS-68K	RS-68K
Upper Stage	DCSS 5m	ACES	ACES	ACES	ACES	ACES	ACES
Kick Motor	None	None	None	None	None	None	None

Delta VI is the next step in evolution of Delta family. Taking the Delta IV Heavy+ as the baseline, it adds a much larger and more powerful ACES upper stage to it. This allows a far greater range of payloads to be carried. Even with just the ACES, payload is increased significantly, but further upgrades are also possible. Notably, the lower stage can be improved, with densified propellants and RS-68K engine with a regeneratively cooled nozzle. For Delta VI Heavy, propellant crossfeed from boosters to core is also implemented, further improving performance. Medium configurations are created by flying only the central core, similar to Delta IV, but with eight booster attachment points and, when available, first stage upgrades. Due to higher mass, the 6+2 booster ignition is the standard. This lower stage upgrade also resulted in a transition configuration, the Delta V, designed to fly off remaining DCSS hardware. It combines the improved lower stage with DCSS from Delta IV family, providing interim performance between the two families.

Eighth Generation – Delta VII

	Delta VII	Delta VII Heavy
Payload	44T	47T
Ref. Mission	GTO-LO	GTO-LO
Stages	2	2
Liftoff TWR	1.45	2.04
Boosters	2xWBCBC	2xWBCBC
Core	WBCBC	WBCBC
Core Engine	2xRS-68K	3xRS-68K
Upper Stage	ACES W	ACES XL
Kick Motor	None	None



A new rocket design using the baseline Delta design for hardware, the only thing Delta VII has common with older members of the family are the engines. Using a widebody CBC with two RS-68K engines, and a four engine widebody ACES variant, it represents the family's foray into the superheavy class. The Delta VII Heavy improves performance further by using a stretched upper stage and three engines on each CBC.

Closing Remarks

Almost all rockets in this guide are based on real, proposed or plausible rocket configurations, with the remainder from Eyes Turned Skywards, and a handful of my own fictional, but plausible configurations. The generations are chosen arbitrarily, and the naming system is modified where needed to avoid confusion.

Right up to TAT, all the configurations are real, flown hardware. TAT features a handful of unflown configurations, namely Delta F and H. In the second generation, only Delta K is an unflown proposal, with K6 being a plausible expansion and K9 requiring a boattail modification similar to early numbered Deltas. Out of numbered Delta Is, 0903 and 1603, as well as all of the 4000 and 5000 series except 4925 and 5920 have not flown. In fact, Deltas of this series only launched twice and once, respectively. Delta II 6000 series never launched in 6926 configuration, but all configurations of the 7000 from the user guide were flown at some point, including both heavies. Delta Lite is an unflown proposal.

Out of Delta III series, only the 8930 had flown, with little success. The rest are earlier concepts of how payload capacity of the Delta II could possibly be expanded, with two double barrel proposals, one with a hydrogen stage within a long fairing and one with a 3.2m hydrogen stage that is currently not possible to build. Configurations using GEM-46s on double barrel Deltas are my own inventions, the initial idea was that to lift the 4m DCSS, either larger boosters could be used or a doubled up core with 12 GEM-40s. It is not implausible that eventually, larger boosters would have been developed anyway, had the double barrel concept prevailed.

In the Delta IV family, the prominent unflown member is Delta IV Small, which was a proposal, its niche was ultimately filled by Delta II Heavy. Medium+ 4,4 also wasn't ever flown, what with the 4m upper stage not really needing that many SRBs. The other members of the family are real, but the next one is all fictional. Delta IV with six SRBs is straight from the Payload Planner's Guide, as is the Medium++ series, but the ones with even more boosters are my own invention, the idea being to use up every booster attachment point on the upgraded cores. As these would require a new pad (though it does fit the MLP one), it's not a terribly plausible proposition. The addition of the upper stage to one of them is just to acknowledge it's still an option and provide a variant that uses it. As per ULA, it could possibly be added to any Delta IV configuration.

As for widebody Deltas, they're from ETS, and quite frankly, they are not very well thought out, compared to other rockets in the AU. They would have required new tooling, new launch infrastructure and a hydrogen stage, basically abandoning all Delta hardware except for the Castor IV boosters and the RS-27. While they are decent launch vehicles, they represent a huge break within the Delta family, with less continuity than between Delta III and IV. Centaur E is essentially a Centaur III sized Centaur D, but since such a thing doesn't exist in BDB, the performance is replicated by using two lower performance RL-10 variants. It's highly likely it would have had SOFI instead of panels at that point, anyway. Numbering system is from ETS, though my own hex-based variation is probably more logical.

Delta V, Delta VI and Delta VII are my own interpretations of the further upgrades from the PPG. The second stage is a pre-Vulcan version of ACES, and the first stage applies all the upgrades proposed by ULA. The numbering is so that I could make Delta VII be the 7m version. Accordingly, this leaves out Delta V, but as this number was taken by the Atlas V (which skipped the IV), it would likely have been left out. Since I don't like gaps in numeration, I designed the Delta V, which is a sort of interim design where the upgraded first stage is mated to DCSS. There is precedence for that sort of thing in the Delta family, see Delta 4000, but the resulting vehicle is poorly matched. There's also a medium-class variant of Delta VI, which ULA didn't put in their guide, but which is a logical extension of the family, in order to standardize on ACES.

As far as Delta VII goes, it uses Saturn parts to approximate the 7m option. It's essentially a new rocket, with both first and second stage upgrades. Not much continuity except the name and the engines, but it does perform quite well. There are no medium variants because I found they perform very poorly, worse than Delta VI Medium+.

The final design in the PPG is one I'm calling Delta VIII, however this uses no BDB parts except engines. That and an interpretation of Delta IX from the Martian (an Ares V class rocket based on Delta tech) will be in another guide. Delta VIII uses three inline ET-length super-lightweight tanks with four RS-68Ks and a Jupiter-style upper stage with 6xRL10. It lifts 86T to GTO, but that might change since ORANGES is still in dev.