BOEING

GOES-P

ULA™
United Launch Alliance

NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

NASA

Introduction

The Boeing Company and United Launch Alliance are pleased to launch the GOES-P satellite, the third spacecraft in a new series of Geostationary Operational Environmental Satellites that will provide advanced Earth observation technology to enhance America's safety and economic security.

The launch of GOES-P is the culmination of a strong partnership among Boeing Defense, Space & Security, NASA, United Launch Alliance, and the National Oceanic and Atmospheric Administration (NOAA). The GOES team includes thousands of people across the country who have dedicated a substantial portion of their careers to making this program a success.

The multimission GOES series will be a vital contributor to weather, solar, and space operations and science. On board GOES-P will be a highly advanced attitude control system that will foster enhanced instrument performance for improved weather service quality. GOES-P data will add to the global climate change databases of knowledge, embracing many civil and Government environmental forecasting organizations that work to benefit people everywhere and help save lives.

GOES-P will be launched aboard a Delta IV Medium+ (4,2) configuration launch vehicle from Space Launch Complex 37B at Cape Canaveral Air Force Station (CCAFS), Fla., and will be the fifth flight of this configuration and the twelfth flight of the Delta IV family of launch vehicles. United Launch Alliance provides the Delta IV launch vehicle and mission services under a commercial contract administered by Boeing Launch Services. The GOES-P satellite is manufactured by Boeing's Space and Intelligence Systems.

GOES-P will be the third NASA spacecraft to launch on the Delta IV launch vehicle family. Our congratulations to the entire Boeing, ULA, NASA, and NOAA team for your dedicated efforts in achieving this milestone and our thanks to NASA for selecting Boeing and the Delta launch system.

Ken Heinly
Director, Boeing Launch Products & Services
The Boeing Company

Jim Sponnick
Vice President, Delta Product Line
United Launch Alliance

GOES-P Mission Overview

The multimission Geostationary Operational Environmental Satellites (GOES) series N through P will be a vital contributor to weather, solar, and space operations and science. The National Aeronautics and Space Administration (NASA) Goddard Space Flight Center selected Boeing's satellite manufacturing business, located in El Segundo, Calif., for the GOES N–P contract award. NASA and the National Oceanic and Atmospheric Administration (NOAA) are actively engaged in a cooperative program to expand the existing GOES system, beginning with the launch of the GOES-N satellite. Goddard is responsible for procuring, developing, and testing the spacecraft, instruments, and unique ground equipment for the next generation of Earth-observation satellites.

NOAA is responsible for the overall program, funding, system in-orbit operation, and identification of satellite replacement needs. NOAA has operational responsibility for the ground system needed to process and disseminate data from the GOES-P satellite sensors.

GOES-P Mission Overview

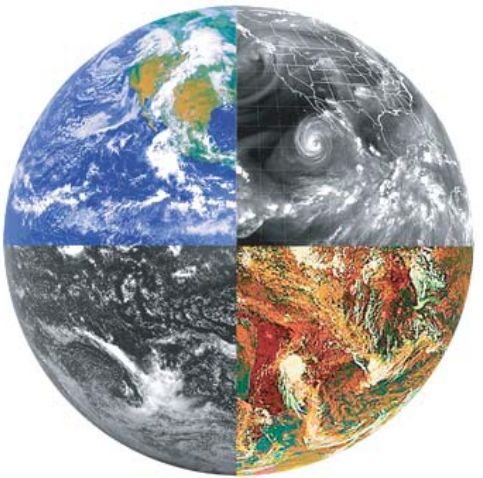
Continued

The third of the next-generation GOES space systems, the GOES-P NASA and NOAA mission represents the best of mission integration as Boeing Space & Intelligence Systems and Boeing Launch Services launch the Boeing 601 satellite on board a United Launch Alliance Delta IV Medium+ (4,2) configuration launch vehicle. GOES-P will provide more accurate prediction and tracking of severe storms and other weather phenomena, resulting in earlier and more precise warnings to the public. Supporting NOAA and NASA scientists collecting and analyzing real-time environmental data, as well as the US Coast Guard searching the open seas, GOES-P stands ready as the most advanced multimission weather and Earth-observation satellite ever built for NOAA geosynchronous operations.

GOES-P Mission Overview

Continued

GOES-P will provide enhanced weather monitoring and prediction capability, communications subsystems to rebroadcast data, and space environmental monitoring instruments and sensors from an operational orbital slot of 75 deg or 135 deg West. In addition, the satellite will provide more accurate location of severe storms and other weather phenomena, resulting in earlier and more precise warnings to the public.



Search and Rescue

GOES-P is designed with links that include a search-and-rescue capability to detect distress signals from maritime vessels and aircraft. The added capability allows emergency responders to obtain accurate, real-time information quickly and enables them to deploy appropriate resources to save lives.

GOES-P Satellite

The three-axis Boeing 601 body-stabilized spacecraft design is equipped to enable the GOES-P primary sensors to “stare” at Earth, allowing the instruments to continuously image clouds and monitor Earth’s surface and atmospheric temperatures. The satellite capability of the Boeing 601 enables tracking of atmospheric phenomena, ensuring real-time coverage of short-lived dynamic events, such as severe local storms and tropical hurricanes and cyclones, two types of meteorological events that directly affect public safety, property, and ultimately, economic health and development.

GOES-P Satellite

Continued

Payload

S-Band	One downlink Five uplinks
L-Band	Seven downlinks
UHF	One downlink Two uplinks

Power

Solar	
Beginning of life	2.3 kW
End of life	2 kW
Panels	One wing, with one panel of dual-junction, gallium arsenide solar cells
Batteries	24-cell NiH_2, 123 Ah

Propulsion

Liquid apogee motor	110 lbf (490 N)
Stationkeeping thruster (bipropellant)	12 x 2 lbf (9 N)

Antennas

Two S-band, cup-shaped with dipole
One Omni antenna (aft)
One UHF, cup-shaped with dipole
2 L-band cup-shaped with dipole
One S-band horn

Dimensions

In Orbit	L, solar array: 26 ft 9 in (8.2 m) W, antenna: 7 ft 4 in x 11 ft (2.25 m x 3.37 m)
Stowed	H: 12 ft (3.63 m) W: 7 ft 4 in x 11 ft (2.25 m x 3.37 m)
Weights	
Launch	7,136 lbm (3,238 kg)
In orbit (beginning of life)	4,823 lbm (2,189 kg)

Spacecraft Instruments

Imager

The terrestrial imager is a multispectral five-channel instrument that produces visible and infrared images of Earth's surface, oceans, cloud cover, and severe storm developments.

Sounder

The multispectral sounder provides vertical temperature and moisture profiles of the atmosphere, augmenting data from the imager. Sounder data are also used in computer models, which produce mid- and long-range weather forecasts.

Solar X-ray Imager

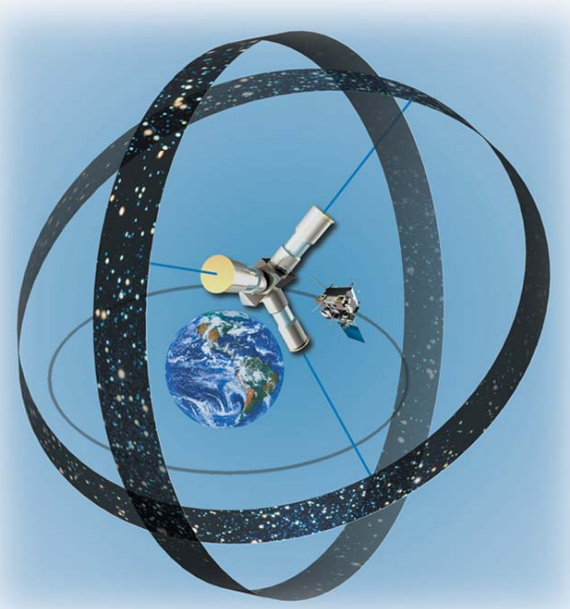
In addition to the terrestrial imager, GOES-P incorporates a sophisticated solar X-ray imager that will monitor the Sun's X-rays for the early detection of solar flares and other phenomena. This early warning is important because solar flares affect not only the safety of humans in high-altitude missions, such as human spaceflight, but also military and commercial satellite communications.

Space Environmental Monitoring

The GOES-P satellite is equipped with space environmental monitoring instruments, which monitor X-rays, extreme ultraviolet, and particle emissions—including solar protons, alpha particles, and electrons. These space environmental monitoring instruments include a magnetometer that samples the Earth's magnetosphere.

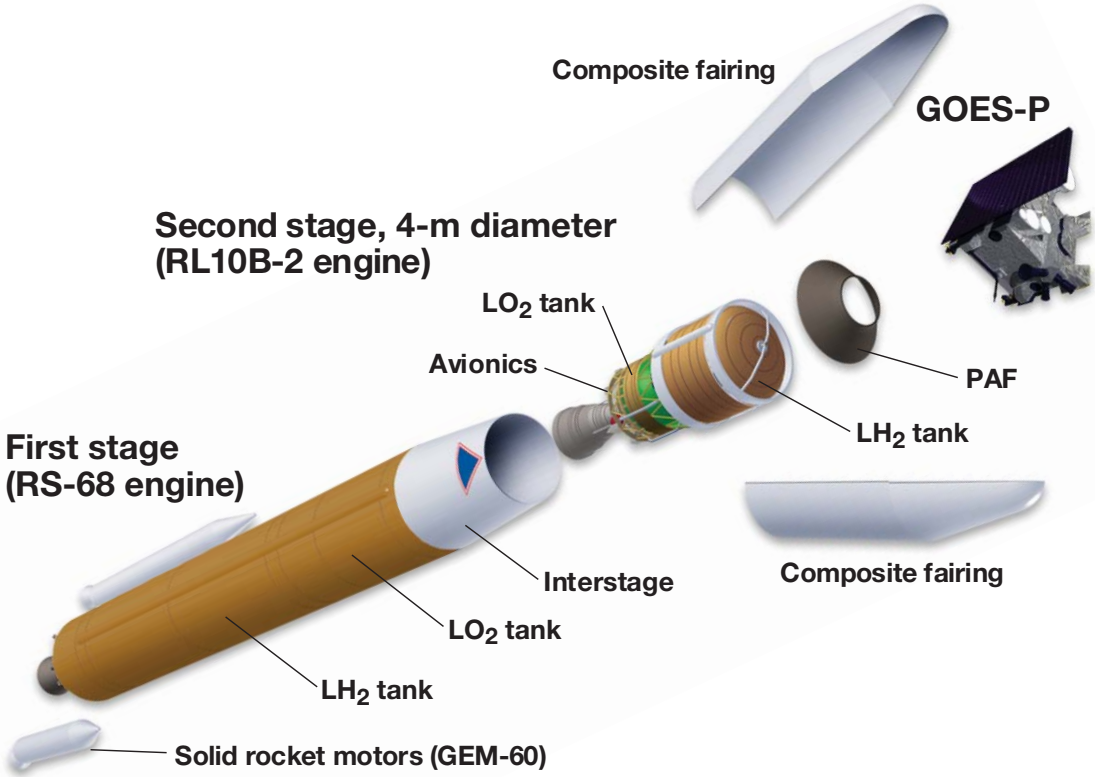
Star Tracker

The GOES P spacecraft will improve image accuracy by a factor of four using a geosynchronous star sensor attitude determination and control system. The star trackers act like small cameras. Two primary sensors and one backup, angled wide (approximately 120 deg) apart, constantly observe their portion of the sky and select the five brightest stars in view. Every 1/10th sec, the trackers send their current collection of five stars to the spacecraft's onboard computer. Factoring the time of day, the computer identifies the readings from its catalog of 5,000 known stars and determines the exact spacecraft position. The onboard computer calculates the difference between the reported star positions and their predicted positions. The computer applies this difference, along with angular rate information from the inertial reference units, to direct speed changes in the four reaction wheels that reorient the spacecraft to the precise desired attitude.



The result is a steady, precisely pointed observation bench that enables the instruments to achieve maximum pointing accuracy.

Delta IV M+ (4,2) Launch Vehicle



GOES-P Mission Description

- Launch date..... March 2010
- GOES-P final orbit target
  - Orbit apogee altitude..... 18,994 nm
  - Orbit perigee altitude..... 3,576 nm
  - Inclination ..... 12.0 deg
- Launch window (EDT)..... ▼

Date	Open	Close	Duration	Date	Open	Close	Duration
3/1/2010	18:19	19:19	1:00	3/14/2010	18:08	19:08	1:00
3/2/2010	18:19	19:19	1:00	3/15/2010	18:07	19:07	1:00
3/3/2010	18:18	19:18	1:00	3/16/2010	18:06	19:06	1:00
3/4/2010	18:17	19:17	1:00	3/17/2010	18:05	19:05	1:00
3/5/2010	18:17	19:17	1:00	3/18/2010	18:04	19:04	1:00
3/6/2010	18:16	19:16	1:00	3/19/2010	18:03	19:03	1:00
3/7/2010	18:15	19:15	1:00	3/20/2010	18:02	19:02	1:00
3/8/2010	18:14	19:14	1:00	3/21/2010	18:01	19:01	1:00
3/9/2010	18:13	19:13	1:00	3/22/2010	18:00	19:00	1:00
3/10/2010	18:12	19:12	1:00	3/23/2010	17:59	18:59	1:00
3/11/2010	18:11	19:11	1:00	3/24/2010	17:58	18:58	1:00
3/12/2010	18:10	19:10	1:00	3/25/2010	17:57	18:57	1:00
3/13/2010	18:09	19:09	1:00	3/26/2010	17:56	18:56	1:00

Flight Mode Description

Liftoff to SECO-1

- The GOES-P spacecraft will be launched from the Eastern Range Space Launch Complex 37B at Cape Canaveral Air Force Station
- Flight azimuth of 95 deg
- Direct flight azimuth mode employed (combined pitch/yaw)
- Both GEMs ignited at liftoff
- Boost trajectory designed to meet controllability, structural, and environmental constraints while maximizing performance
- RS-68 engine begins to throttle down at 210 sec
  - The time duration to throttle from 102 to 57% is 5 sec
  - 3.99 g's nominal
- Main engine cutoff occurs at propellant depletion; approximately 266.7 sec after liftoff
- Payload fairing jettisoned ~10 sec after second-stage ignition
  - Free molecular heating rate is much less than maximum allowable
- Second-stage first burn inserts vehicle into a 100.55 by 298.57 nm orbit with an inclination of 28.4 deg at SECO-1
  - Total first burn time of ~470 sec
  - Elevation angle from Antigua tracking station is 2.0 deg
  - Slant range from Antigua tracking station is 808 nm

Sequence of Events

Liftoff to SECO-1

Event	Time (hr:min:sec)	Time (sec)
Stage I Liftoff	00:00:00.0	0.0
Begin Near-Zero Angle-of-Attack Flight	00:00:18.0	18.0
Mach Number = 1.05	00:00:47.5	47.5
Maximum Dynamic Pressure	00:01:00.7	60.7
(Two) GEM-60 Burnout (TVC Nozzle)	00:01:34.1	94.1
Jettison (Two) GEM-60 Casings (TVC Nozzle)	00:01:40.0	100.0
End Near-Zero Angle-of-Attack Flight	00:02:04.0	124.0
Maximum Fairing Skin Temperature	00:03:16.4	196.4
Initiate Booster Throttle-Down	00:03:30.0	210.0
Maximum Axial Acceleration	00:03:30.0	210.0
Booster Throttle at Minimum Power Level (MPL)	00:03:35.0	215.0
FMHR = 360 Btu/ft^2/hr	00:04:17.4	257.4
Main Engine Cutoff	00:04:26.7	266.7
End Main Engine Tailoff	00:04:28.3	268.3
Stage I-II Separation	00:04:32.7	272.7
Begin Prestart Chilldown	00:04:40.2	280.2
Stage II Ignition Signal	00:04:47.2	287.2
End Prestart Chilldown	00:04:47.2	287.2
Jettision Fairing	00:04:57.5	297.5
Ivory Coast IIP Standoff Longitude	00:11:54.9	714.9
Last Point of IIP Trace	00:12:19.4	739.4
Begin Post-SECO-1 Hydrazine Settling	00:12:37.2	757.2
First Cutoff – Stage II (SECO-1)	00:12:37.4	757.4

Flight Mode Description

SECO-1 to SECO-2

- Two hydrazine settling thrusters are on during the 568-sec coast period
- Continuous Venting System (CVS) is on from 2 sec after SECO-1 until 133 sec prior to first restart ignition (begin repressurization)
- Coast guidance mode reorients launch vehicle for first restart
- The first restart ignition occurs 628 sec after SECO-1
  – Pitch maneuver begins 6 sec into restart burn
- The first restart burn duration is ~242 sec, placing the vehicle in a 108.7 nm by 18,477 nm orbit at 26.7-deg inclination

Sequence of Events

SECO-1 to SECO-2

Event	Time (hr:min:sec)	Time (sec)
First Cutoff – Stage II (SECO-1)	00:12:37.4	757.4
Begin LH_2 Boiloff/Propulsive Venting	00:12:39.4	759.4
Hydrazine Settling – Two Thrusters Off	00:13:07.4	787.4
Begin Restart Burn Attitude Maneuver	00:13:07.4	787.4
End LH_2 Boiloff/Propulsive Venting	00:20:52.1	1252.1
Hydrazine Settling – All Four Thrusters On	00:22:35.1	1355.1
End Restart Burn Attitude Maneuver	00:22:35.1	1355.1
Begin Prestart Chilldown	00:22:47.1	1367.1
First Restart – Stage II	00:23:05.1	1385.1
End Prestart Chilldown	00:23:05.1	1385.1
End Post-SECO-1 Hydrazine Settling	00:23:10.1	1390.1
Begin Stage II Restart 1 Pitch Program	00:23:11.1	1391.1
End Stage II Restart 1 Pitch Program	00:27:07.3	1627.3
Begin Post-SECO-2 Hydrazine Settling	00:27:07.3	1627.3
Second Cutoff – Stage II (SECO-2)	00:27:07.5	1627.5

Flight Mode Description

SECO-2 to SECO-3

- Following SECO-2, the vehicle is reoriented to the required 90 +5/-15 deg with respect to (wrt) Sun line Passive Thermal Control (PTC) attitude
- Barbeque roll rate of +1.295 deg/s for 6,039.5-sec duration followed 5 sec later by a barbeque roll rate of -1.3 deg/s for 6,033.5 sec
- 10.5 sec after the end of the PTC maneuver, a roll-pitch-yaw rate sequence is initiated to orient the vehicle to the second restart burn attitude
- The second restart ignition occurs at 15,001.0 sec after liftoff, within view of Guam tracking station
- The second restart burn duration is ~56 sec, placing the vehicle in a 3,547 nm by 18,992 nm orbit at 12.1-deg inclination

Sequence of Events

SECO-2 to SECO-3

Event	Time (hr:min:sec)	Time (sec)
Second Cutoff – Stage II (SECO-2)	00:27:07.5	1627.5
Begin LH_2 Boiloff/Propulsive Venting	00:27:09.5	1629.5
Hydrazine Settling – Two Thrusters Off	00:27:37.5	1657.5
End Post-SECO-2 Hydrazine Settling	00:35:21.5	2121.5
End LH_2 Boiloff/Propulsive Venting	00:35:21.5	2121.5
Begin Coast Phase Roll Program	00:36:48.0	2208.0
Begin Passive Thermal Control (BBQ)	00:36:48.0	2208.0
Begin LH_2 Boiloff/Propulsive Venting	00:40:31.5	2431.5
End First Roll Rate – Coast Phase	02:17:27.5	8247.5
Begin Second Roll Rate – Coast Phase	02:17:32.5	8252.5
End Second Roll Rate – Coast Phase	03:58:06.0	14286.0
Begin Prestart Hydrazine Settling	03:58:06.0	14286.0
End Passive Thermal Control (BBQ)	03:58:06.0	14286.0
Begin Restart Burn Attitude Maneuver	03:58:16.5	14296.5
End LH_2 Boiloff/Propulsive Venting	04:04:59.0	14699.0
End Restart Burn Attitude Maneuver	04:05:50.0	14750.0
Begin Prestart Chilldown	04:05:58.0	14938.0
Hydrazine Settling – All Four Thrusters On	04:08:58.0	14938.0
Second Restart – Stage II	04:10:01.0	15001.0
End Prestart Chilldown	04:10:01.0	15001.0
End Prestart Hydrazine Settling	04:10:06.0	15006.0
Begin Post-SECO-3 Hydrazine Settling	04:10:56.5	15056.5
Third Cutoff – Stage II (SECO-3)	04:10:56.7	15056.7

Flight Mode Description

SECO-3 to Spacecraft Separation

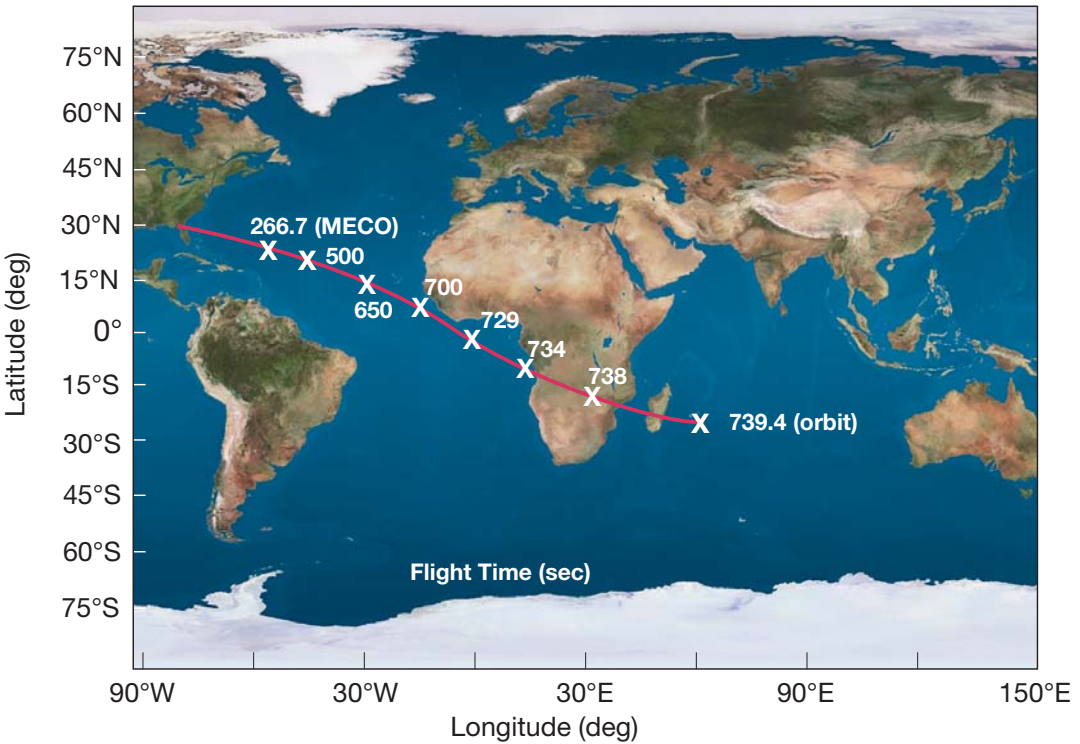
- 30 sec after SECO-3, a pitch-yaw maneuver (coast guidance) starts, which begins to orient the vehicle to the required spacecraft separation attitude
  - Maneuver performed under zero axial thrust condition to allow the propellants to float freely and quench the hot tank walls
- 80.5 sec after SECO-3, a roll-pitch-yaw maneuver (coast guidance) begins to complete reorientation to the required separation attitude
- Low relief venting is enabled after completion of reorientation maneuver; venting is disabled 2.0 sec prior to payload separation
- Payload separation occurs 630 sec after SECO-3 at the required attitude and within view of Guam tracking station
  - Time after liftoff: 15,686.7 sec
  - Apogee altitude: 18,994 nautical mile (nm)
  - Perigee altitude: 3,576 nm
  - Inclination: 12.0 deg

Sequence of Events

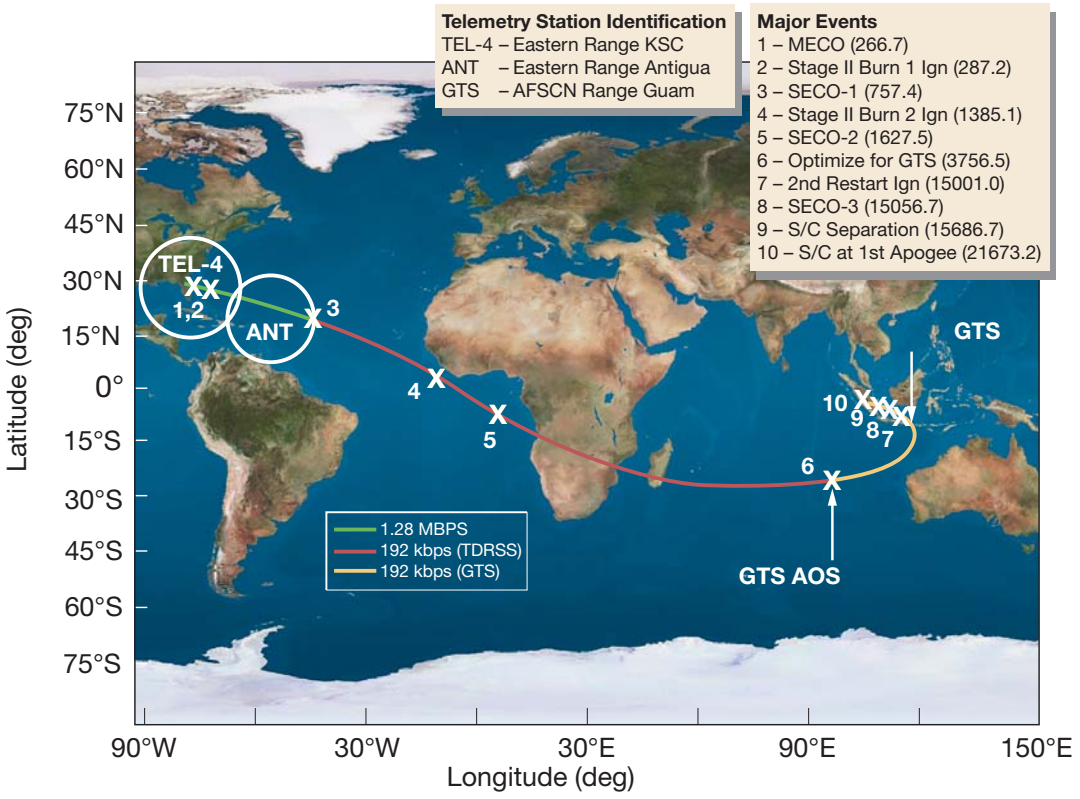
SECO-3 to Spacecraft Separation

Event	Time (hr:min:sec)	Time (sec)
Third Cutoff – Stage II (SECO-3)	04:10:56.7	15056.7
Begin LH_2 Boiloff/Propulsive Venting	04:10:58.7	15058.7
End Post-SECO-3 Hydrazine Settling	04:11:26.7	15086.7
End LH_2 Boiloff/Propulsive Venting	04:11:26.7	15086.7
Begin Separation Attitude Maneuver	04:11:26.7	15086.7
End Separation Attitude Maneuver	04:16:16.7	15376.7
Begin Hydrazine Settling – Two Thrusters On	04:16:26.7	15386.7
Begin LH_2 Boiloff/Propulsive Venting	04:16:46.7	15406.7
Begin Third Roll Rae – Coast Phase	04:17:16.7	15436.7
Begin Fourth Roll Rate – Coast Phase	04:17:30.7	15450.7
Begin Fifth Roll Rate – Coast Phase	04:17:42.7	15462.7
Begin Sixth Roll Rate – Coast Phase	04:17:54.7	15474.7
Begin Seventh Roll Rate – Coast Phase	04:18:06.7	15486.7
Begin Eighth Roll Rate – Coast Phase	04:18:18.7	15498.7
End LH_2 Boiloff/Propulsive Venting	04:21:24.7	15684.7
End Hydrazine Settling	04:21:24.7	15684.7
Spacecraft Separation	04:21:26.7	15686.7

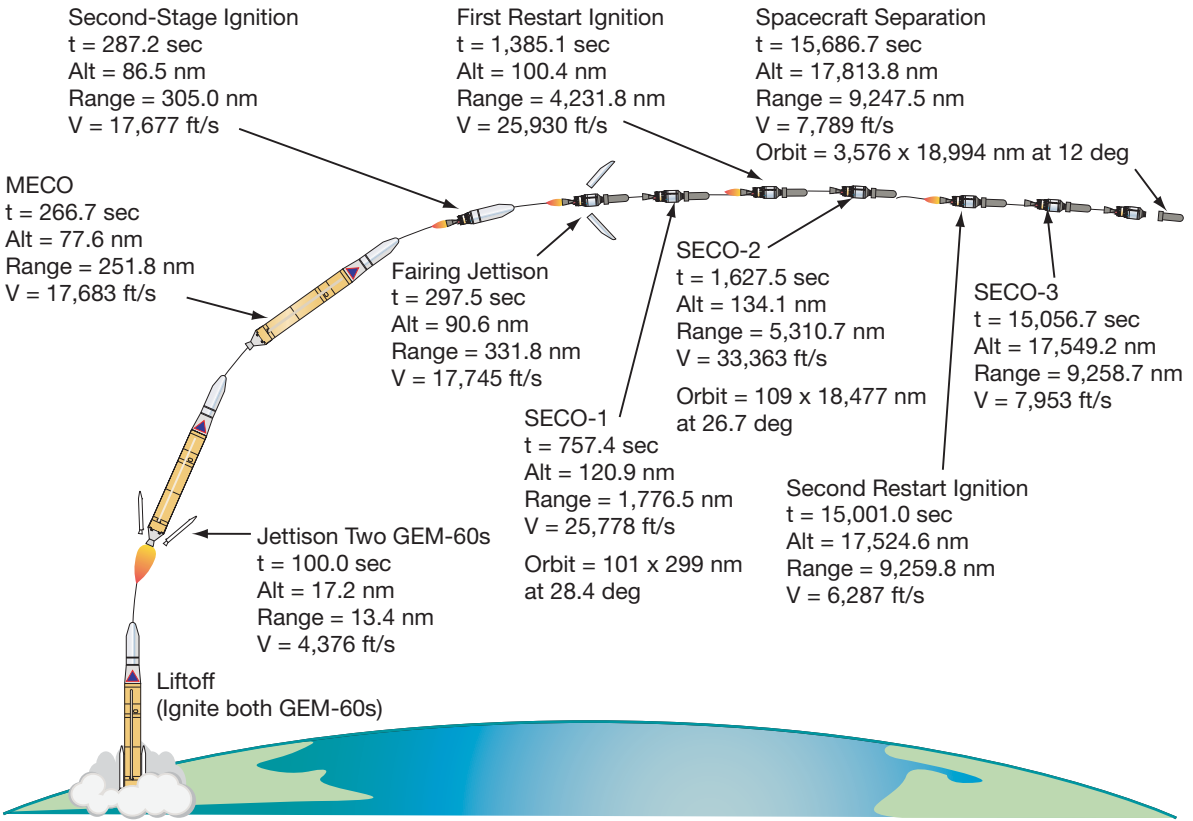
Instantaneous Impact Point Trace



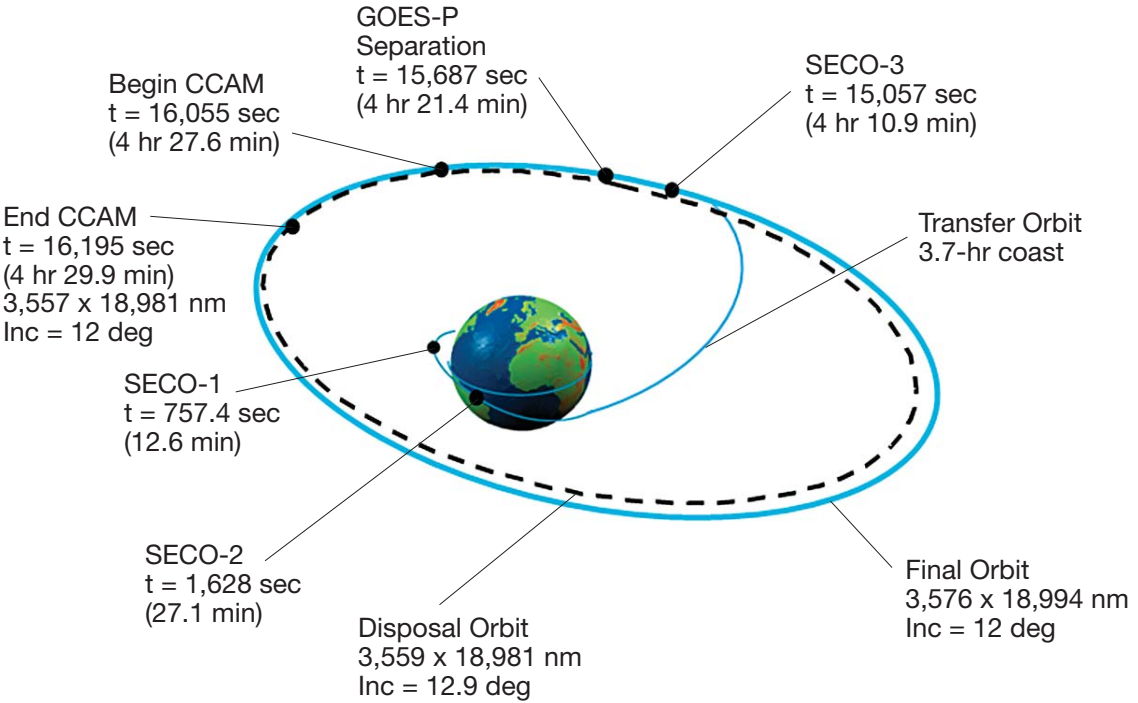
GOES-P Orbit Trace



GOES-P Flight Profile

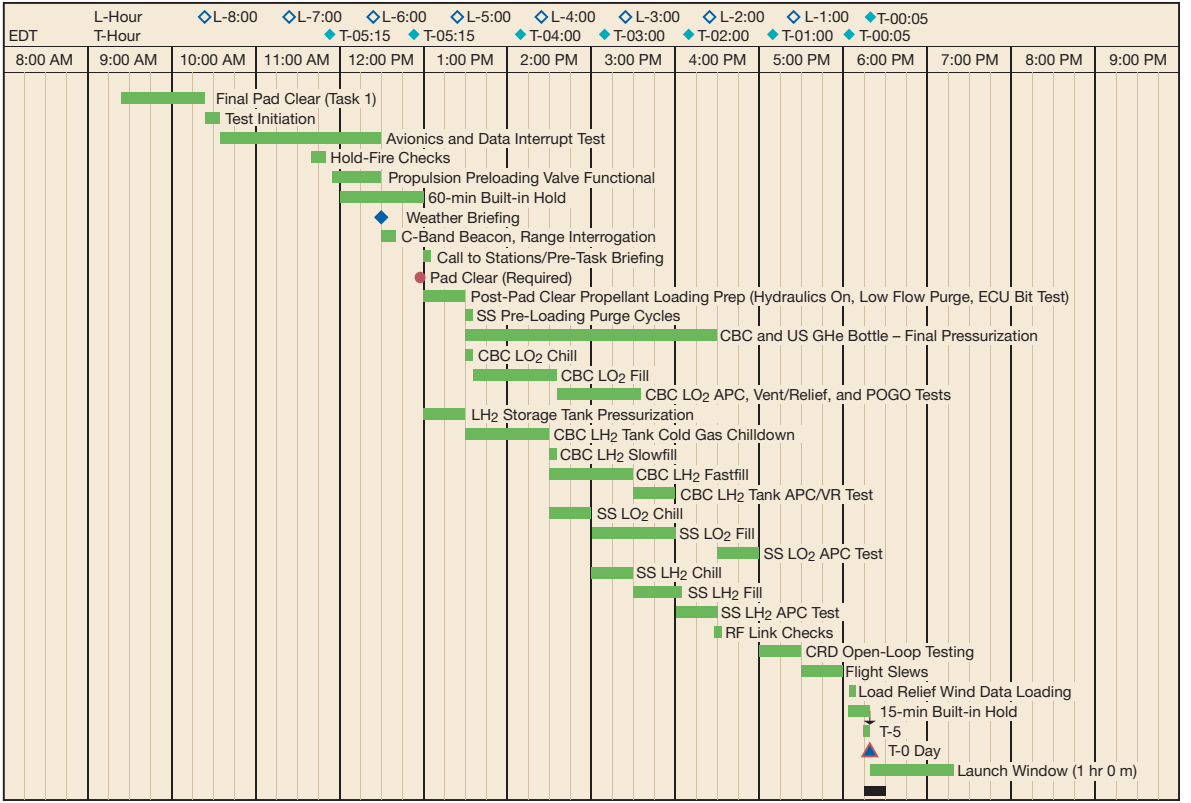


Delta IV M+ (4,2) GOES-P Mission Profile



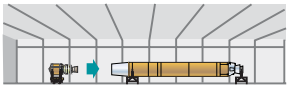
CCAFS GOES-P Mission

Terminal Count, T-0 Day



Delta IV Hardware Flow at Eastern Range

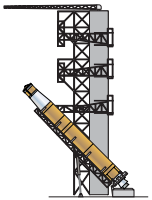
Delta Mariner delivers CBCs, 4-m upper stage, and 4-m fairings to launch site



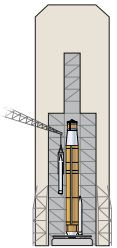
Horizontal integration and testing of CBC and second stage

GEM-60 solid rocket motors transportation to launch pad

Transport to launch pad



Erect vehicle on launch pad



GEM-60s attached to launch vehicle

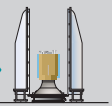
Payload encapsulation in parallel with Delta IV vehicle processing

Payload processing facility

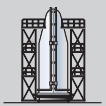
Erect and store fairing

Install payload attach fitting on buildup stand

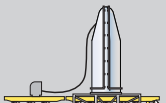
Integrate payload to PAF and perform integrated checkout



Prepare fairing bisectors for payload encapsulation

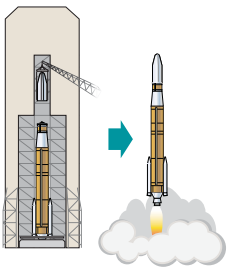


Encapsulate payload



Transport payload to launch pad

Payload lifted by crane and attached to launch vehicle



Launch


GOES-P
GOES-O
GOES-N
NASA • NOAA • ULA • ITT • LM • BOEING

Notes:

Boeing Launch Services

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