GOES N

Mission Booklet

BOEING

5T035001

Introduction

The Boeing Company is pleased to launch the GOES N satellite, the first 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 N is the culmination of a strong partnership among Boeing Integrated Defense Systems, NASA, 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 N Series will be a vital contributor to weather, solar, and space operations and science. On board GOES N will be a highly advanced attitude control system that will foster enhanced instrument performance for improved weather service quality. GOES N 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 N will be launched aboard a Delta IV Medium+ (4,2) from Space Launch Complex 37B at Cape Canaveral Air Force Station (CCAFS), Fla., and will be the second flight of this configuration and the fifth flight of the Delta IV family of launch vehicles. Both the Delta IV rocket and the GOES N satellite were manufactured by Boeing.

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

Howard E. Chambers
Vice President and General Manager
Space and Intelligence Systems and Chief Executive Officer
Boeing Satellite Systems International, Inc.
Boeing Integrated Defense Systems

Dan Collins
Vice President and General Manager
Expendable Launch Systems
The Boeing Company

BOEING®

GOES N 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 determining satellite replacement needs. NOAA has operational responsibility for the ground system needed to process and disseminate data from the GOES N satellite sensors.

BOEING®

GOES N Mission Overview

Continued

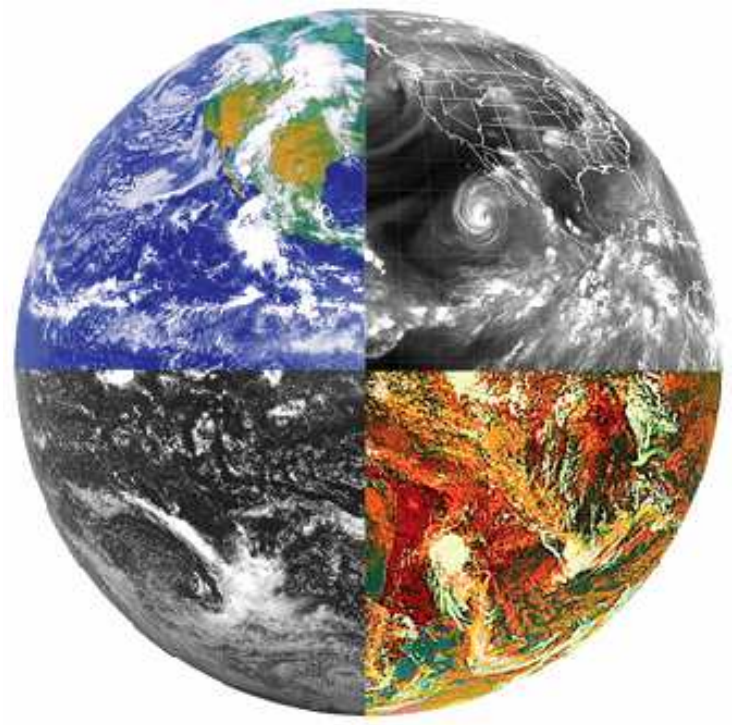
The first of the next-generation GOES space systems, the GOES N NASA and NOAA mission represents the best of mission integration as Boeing Space & Intelligence Systems and Boeing Expendable Launch Systems launches the Boeing 601 satellite onboard a Boeing Delta IV Medium+ (4,2) configuration launch vehicle. GOES N 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 U.S. Coast Guard searching the open seas, GOES N stands ready as the most advanced multimission weather and Earth observation satellite ever built for NOAA geosynchronous operations.

BOEING®

GOES N Mission Overview

Continued

GOES N 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 degrees or 135 degrees W. 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.



BOEING®

GOES N Satellite

The three-axis Boeing 601 body-stabilized spacecraft design is equipped to enable the GOES N 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.

BOEING®

GOES N Satellite

Continued

Payload

S-Band	1 downlink 5 uplinks
L-Band	7 downlinks
UHF	1 downlink 2 uplinks

Propulsion

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

Antennas

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

Power

Solar	
Beginning of life	2.3 kW
End of life	2 kW
Panels	1 wing, w/1 panel of dual-junction, gallium arsenide solar cells
Batteries	24-cell NiH_2, 123 Ah

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 41 x 11 ft (2.25 m x 3.37 m)
Weights	
Launch	7,088 lb (3,215 kg)
In orbit (beginning of life)	3,969 lb (1,800 kg)

BOEING®

Search and Rescue

GOES N 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.

BOEING®

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 N 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.

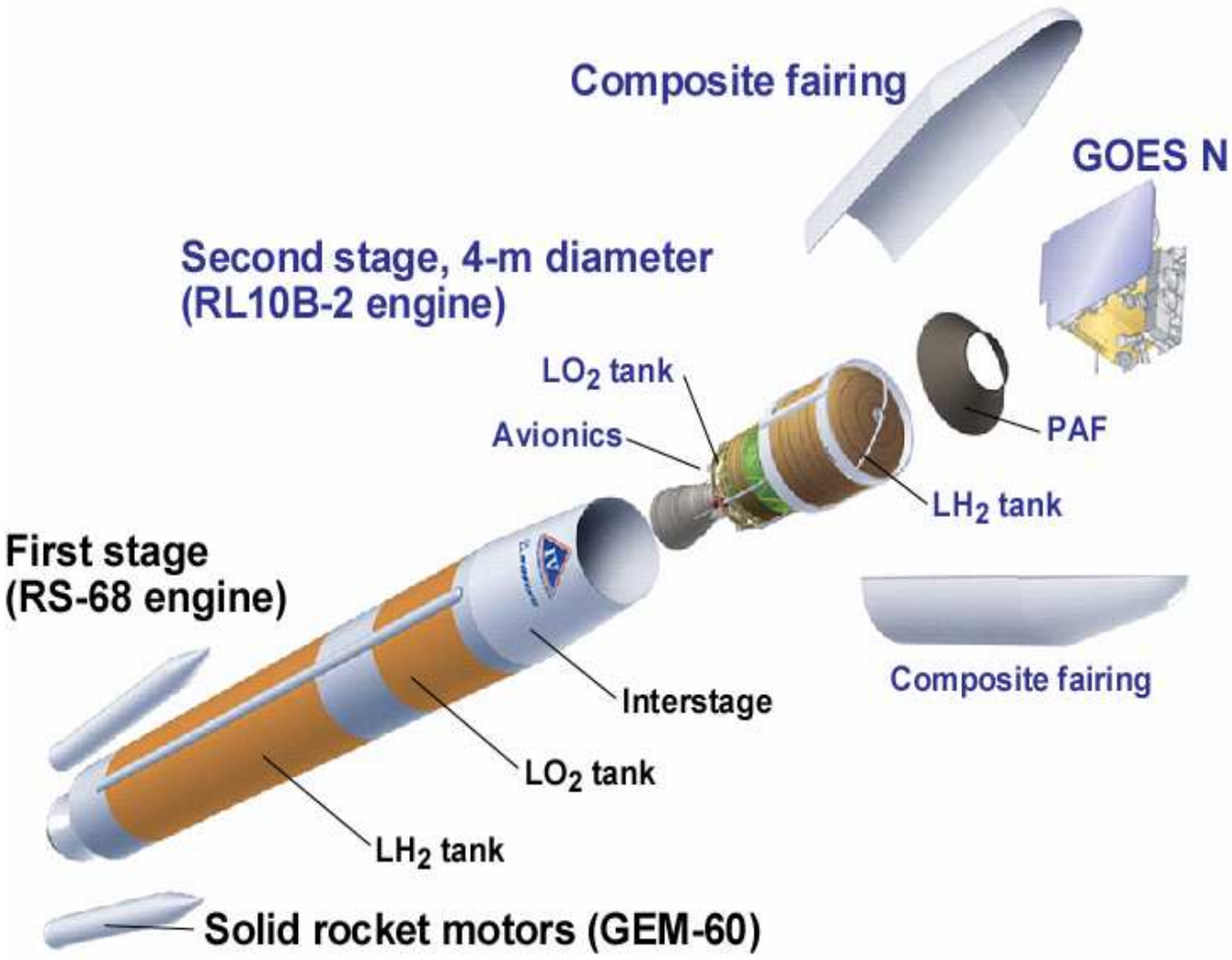
Space Environmental Monitoring
The GOES N satellite is equipped with space environment monitoring instruments, which monitor X-rays, extreme ultraviolet, and particle emissions—including solar protons, alpha particles, and electrons. These space environment monitoring instruments include a magnetometer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

Star Tracker

The GOES N 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 degrees) apart, constantly observe their portion of the sky and select the five brightest stars in view. Every 1/10th second, 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 re-orient 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.

BOEING®

Delta IV M+ (4,2) Launch Vehicle



BOEING®

GOES N Mission Description

- Launch date — May 2006
- GOES N final orbit target
  - Orbit apogee altitude — 18,994 nm
  - Orbit perigee altitude — 3,576 nm
  - Inclination — 12.0 deg
- Launch window

Date	Open	Close	Duration	Date	Open	Close	Duration
5/18/2006	22:14:00	23:14:00	60	5/30/2006	22:11:00	23:11:00	60
5/19/2006	22:14:00	23:14:00	60	5/31/2006	22:11:00	23:11:00	60
5/20/2006	22:14:00	23:14:00	60	6/1/2006	22:11:00	23:11:00	60
5/21/2006	22:13:00	23:13:00	60	6/2/2006	22:11:00	23:11:00	60
5/22/2006	22:12:00	23:12:00	60	6/3/2006	22:11:00	23:11:00	60
5/23/2006	22:11:00	23:11:00	60	6/4/2006	22:11:00	23:11:00	60
5/24/2006	22:11:00	23:11:00	60	6/5/2006	22:11:00	23:11:00	60
5/25/2006	22:11:00	23:11:00	60	6/6/2006	22:11:00	23:11:00	60
5/26/2006	22:11:00	23:11:00	60	6/7/2006	22:11:00	23:11:00	60
5/27/2006	22:11:00	23:11:00	60	6/8/2006	22:11:00	23:11:00	60
5/28/2006	22:11:00	23:11:00	60	6/9/2006	22:10:00	23:10:00	60
5/29/2006	22:11:00	23:11:00	60	6/10/2006	22:10:00	23:10:00	60

Flight Mode Description

Liftoff to SECO-1

- The GOES N spacecraft 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 begins to throttle down at 209.5 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 265.4 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 in a 100.6 x 298.7 nm orbit with an inclination of 28.4 deg at SECO-1
  - Total first burn time of ~469 sec
  - Elevation angle from Antigua tracking station is 2.0 deg
  - Slant range from Antigua tracking station is 808 nm

BOEING®

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	00:00:47.2	47.2
Maximum Dynamic Pressure	00:01:00.5	60.5
GEM-60 (2) Burnout (TVC Nozzle)	00:01:33.8	93.8
GEM-60 (1) Burnout (TVC Nozzle)	00:01:35.3	95.3
Jettison Two GEM-60 Casings (TVC Nozzle)	00:01:40.0	100.0
End Near-Zero Angle-of-Attack Fit	00:02:04.0	124.0
Maximum Fairing Skin Temperature	00:03:14.4	194.4
Initiate Booster Throttle-Down	00:03:29.5	209.5
Maximum Axial Acceleration	00:03:29.5	209.5
Booster Throttle at Minimum Power Level (MPL)	00:03:34.5	214.5
FMHR = 360 Btu/ft^2-hr	00:04:16.1	256.1
Main Engine Cutoff	00:04:25.4	265.4
End Main Engine Tail-Off	00:04:27.0	267.0
Stage I-II Separation	00:04:33.0	273.0
Begin Pre-Start Chilldown	00:04:40.5	280.5
Stage II Ignition Signal	00:04:47.5	287.5
End Pre-Start Chilldown	00:04:47.5	287.5
Jettison Fairing	00:04:57.5	297.5
Ivory Coast IIP Standoff Longitude	00:11:54.1	714.1
Last Point of IIP Trace	00:12:18.4	738.4
Begin Post-SECO-1 Hydrazine Settling	00:12:36.2	756.2
First Cutoff – Stage II (SECO-1)	00:12:36.5	756.5

BOEING®

Flight Mode Description

SECO-1 to SECO-2

- Two hydrazine settling thrusters are on during the 567.5 sec coast period
- Continuous Venting System (CVS) is on from 2.5 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 108.6 nm x 18,461 nm orbit at 26.6 deg inclination

Sequence of Events

SECO-1 to SECO-2

Event	Time (hr:min:sec)	Time (sec)
First Cutoff – Stage II (SECO-1)	00:12:36.5	756.5
Begin LH_2 Boiloff/Propulsive Venting	00:12:39.0	759.0
Begin Restart Burn Attitude Maneuver	00:13:06.5	786.5
Hydrazine Settling – Two thrusters Off	00:13:07.0	787.0
End Restart Burn Attitude Maneuver	00:19:33.5	1173.5
End LH_2 Boiloff/Propulsive Venting	00:20:51.5	1251.5
Hydrazine Settling – All Four Thrusters On	00:22:34.5	1354.5
Begin Pre-Start Chilldown	00:22:46.5	1366.5
First Restart – Stage II	00:23:04.5	1384.5
End Pre-Start Chilldown	00:23:04.5	1384.5
End Post-SECO-1 Hydrazine Settling	00:23:09.5	1389.5
Begin Stage II Restart 1 Pitch Program	00:23:10.5	1390.5
End Stage II Restart 1 Pitch Program	00:27:06.1	1626.1
Begin Post-SECO-2 Hydrazine Settling	00:27:06.1	1626.1
Second Cutoff – Stage II (SECO-2)	00:27:06.5	1626.5

BOEING®

Flight Mode Description

SECO-2 to SECO-3

- Following SECO-2, vehicle 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 degrees per second for 6039.5 sec duration followed 5 sec later by a barbeque roll rate of –1.3 degrees per second for 6033.5 sec
- 10 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
- Second restart ignition occurs at 15,000.5 sec after liftoff, within view of Diego Garcia and Guam tracking stations
- Second restart burn duration is ~55 sec, placing the vehicle in a 3,548 nm x 18,995 nm orbit at 12.1 deg inclination

BOEING®

Flight Mode Description

SECO-2 to SECO-3

Event	Time (hr:min:sec)	Time (sec)
Second Cutoff - Stage II (SECO-2)	00:27:06:5	1626.5
Begin LH_2 Boiloff/Propulsive Venting	00:27:08.5	1628.5
Begin Maneuver to PTC Attitude	00:27:09.5	1629.5
Hydrazine Settling – Two Thrusters Off	00:27:36.5	1656.5
End LH_2 Boiloff/Propulsive Venting	00:35:20.5	2120.5
End Post-SECO-2 Hydrazine Settling	00:35:20.5	2120.5
End Maneuver to PTC Attitude	00:36:26.5	2186.5
Begin Passive Thermal Control (BBQ)	00:36:47.5	2207.5
Begin LH_2 Boiloff/Propulsive Venting	00:40:30.5	2430.5
End Roll Rate – Coast Phase	02:17:27.0	8247.0
Begin Roll Rate – Coast Phase	02:17:32.0	8252.0
End Passive Thermal Control (BBQ)	03:58:05.5	14285.5
Begin Pre-Start Hydrazine Settling	03:58:05.5	14285.5
Begin Restart Burn Attitude Maneuver	03:58:15.5	14295.5
End LH_2 Boiloff/Propulsive Venting	04:04:58.5	14698.5
End Restart Burn Attitude Maneuver	04:05:49.5	14749.5
Begin Pre-Start Chilldown	04:08:57.5	14937.5
Hydrazine Settling – All Four Thrusters On	04:08:57.5	14937.5
Second Restart – Stage II	04:10:00.5	15000.5
End Pre-Start Chilldown	04:10:00.5	15000.5
End Pre-Start Hydrazine Settling	04:10:05.5	15005.5
Begin Post-SECO-3 Hydrazine Settling	04:10:55.3	15055.3
Third Cutoff – Stage II (SECO-3)	04:10:55.7	15055.7

BOEING®

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 disabled 2.0 sec prior to payload separation; venting was enabled after completion of reorientation maneuver

- Payload separation occurs 630 sec after SECO-3 at the required attitude and within view of Diego Garcia and Guam tracking stations
  - Time after liftoff = 15,686.0 sec
  - Apogee altitude = 18,998 nautical mile (nm)
  - Perigee altitude = 3,578 nm
  - Inclination = 12.0 deg

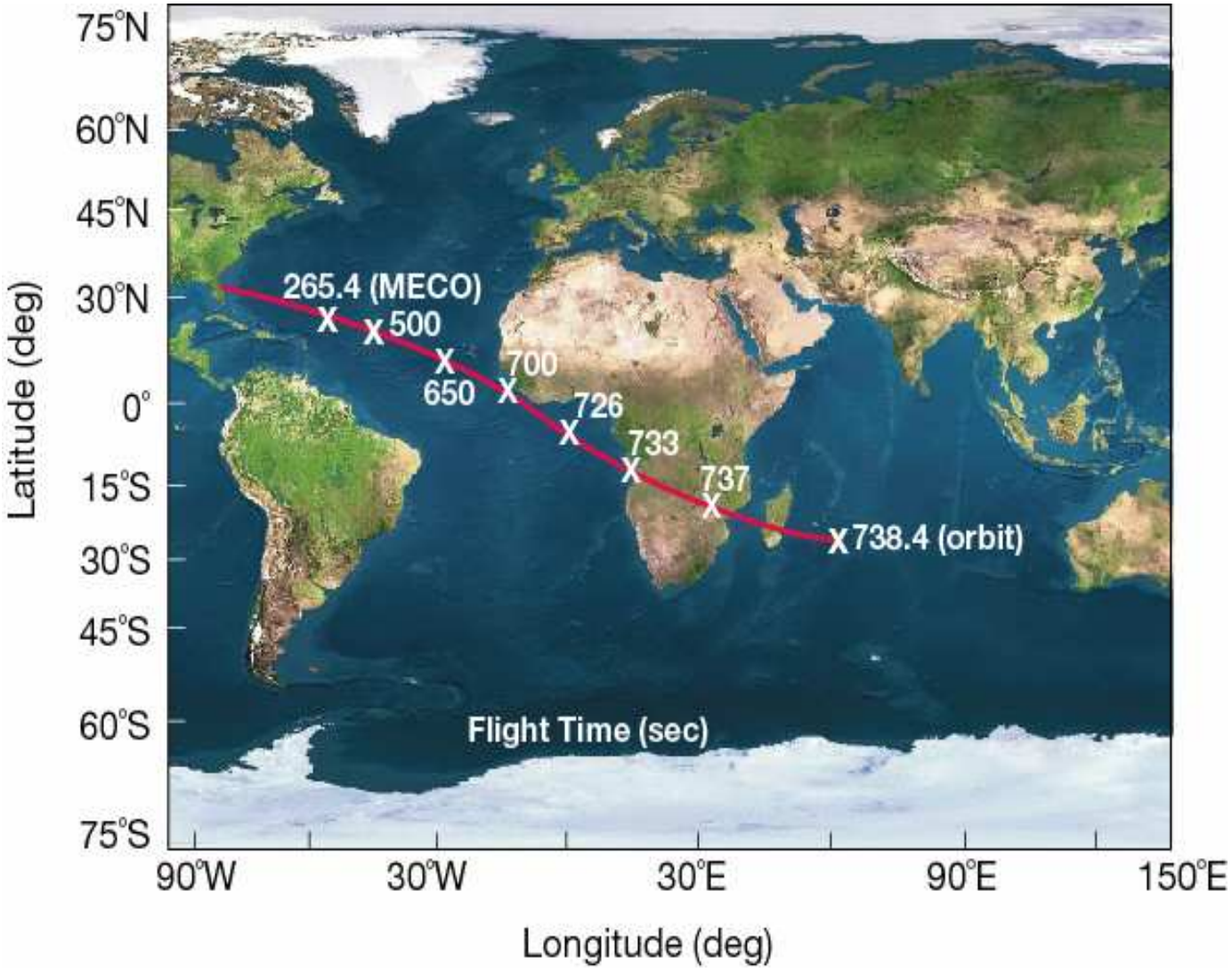
BOEING®

Flight Mode Description

SECO-3 to Spacecraft Separation

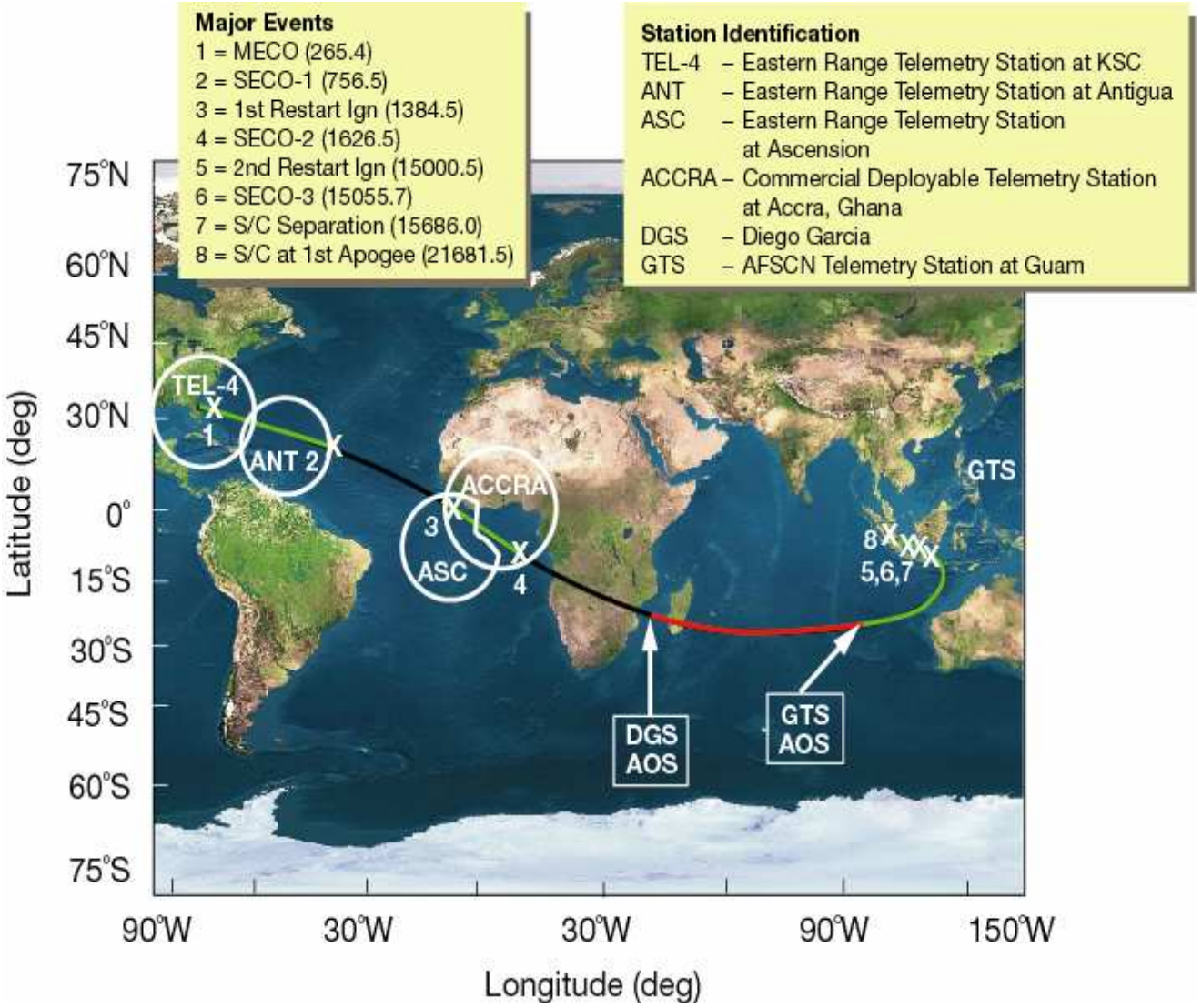
Event	Time (hr:min:sec)	Time (sec)
Third Cutoff – Stage II (SECO-3)	04:10:55.7	15055.7
Begin LH_2 Boiloff/Propulsive Venting	04:10:58.0	15058.0
Hydrazine Setting – Two Thrusters Off	04:11:25.5	15085.5
Begin Maneuver to Separation attitude	04:11:25.5	15085.5
End LH_2 Boiloff/Propulsive Venting	04:11:26.0	15086.0
End Post-SECO-3 Hydrazine Settling	04:11:26.5	15086.5
End Separation Attitude Maneuver	04:16:16.0	15376.0
Begin Hydrazine Settling – Two Thrusters On	04:16:26.0	15386.0
Begin LH_2 Boiloff/Propulsive Venting	04:16:46.0	15406.0
Begin Spacecraft Spin-Up Maneuver	04:17:16.0	15436.0
Begin Roll Rate – Coast Phase	04:17:30.0	15450.0
Begin Roll Rate – Coast Phase	04:17:42.0	15462.0
Begin Roll Rate – Coast Phase	04:17:54.0	15474.0
Begin Roll Rate – Coast Phase	04:18:06.0	15486.0
Begin Roll Rate – Coast Phase	04:18:18.0	15498.0
End LH_2 Boiloff/Propulsive Venting	04:21:24.0	15684.0
End Hydrazine Settling	04:21:24.0	15684.0
Disable Control System	04:21:25.5	15685.5
Spacecraft Separation	04:21:26.0	15686.0

Instantaneous Impact Point Trace



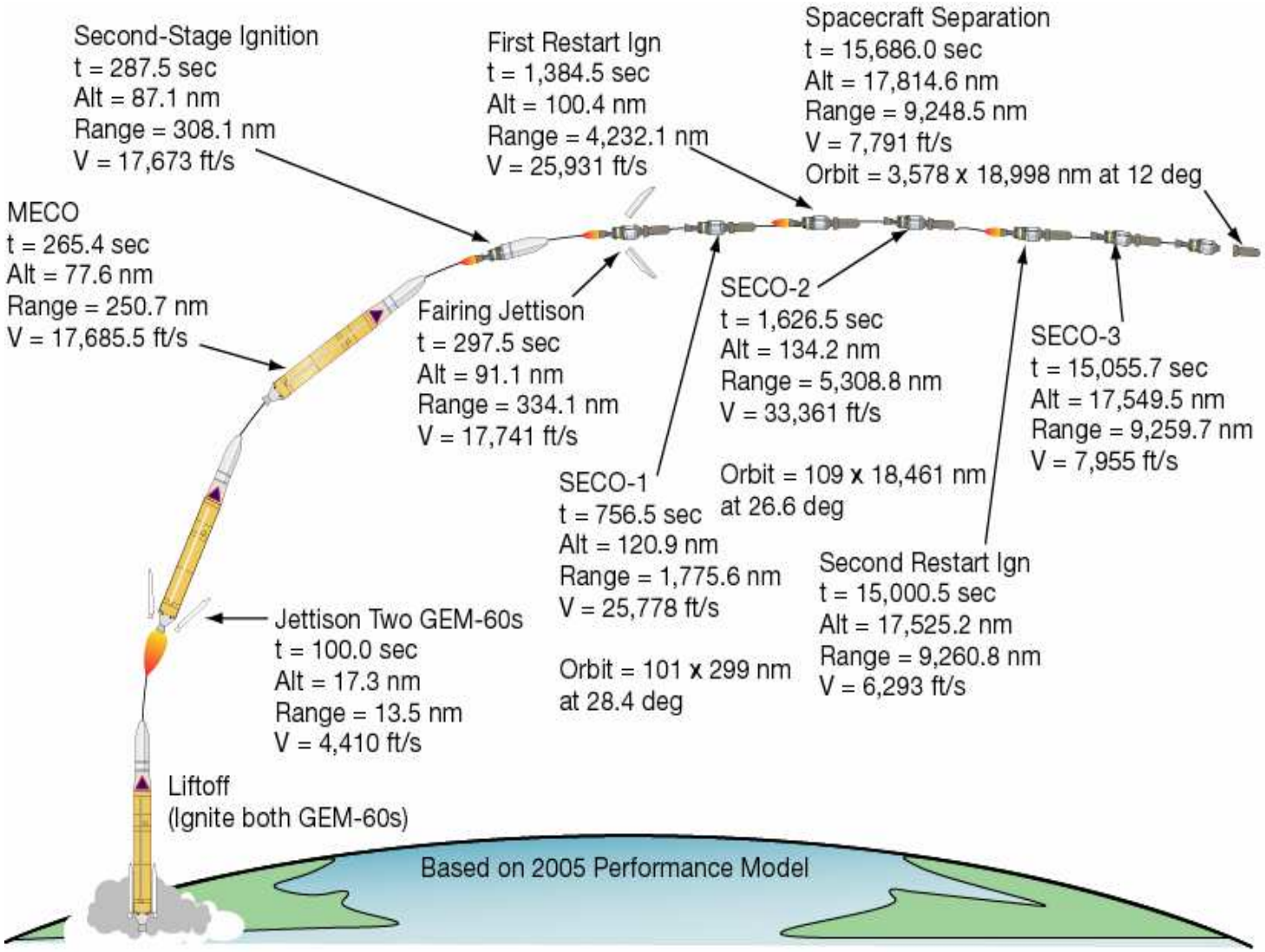
BOEING®

GOES N Orbit Trace



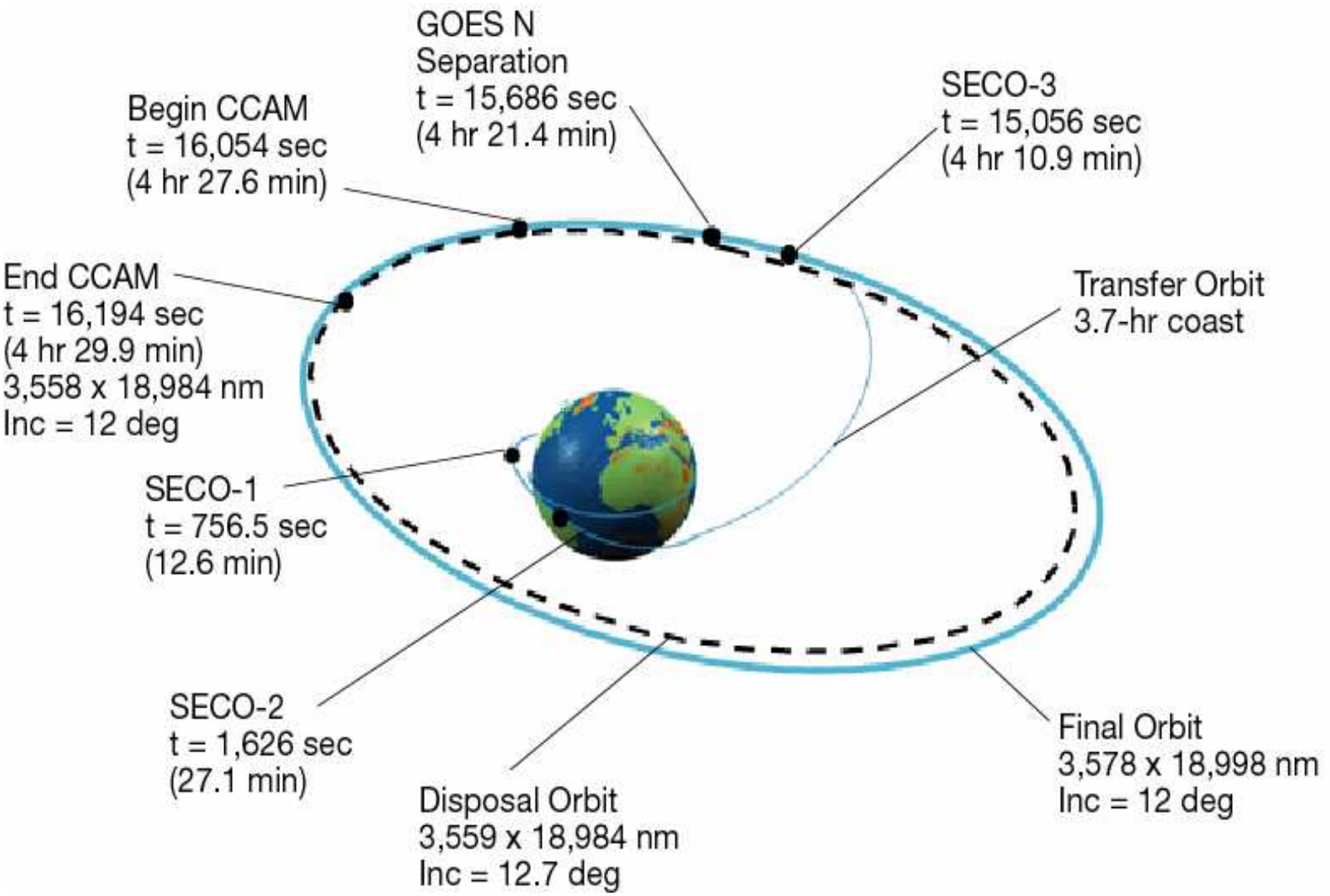
BOEING®

GOES N Flight Profile



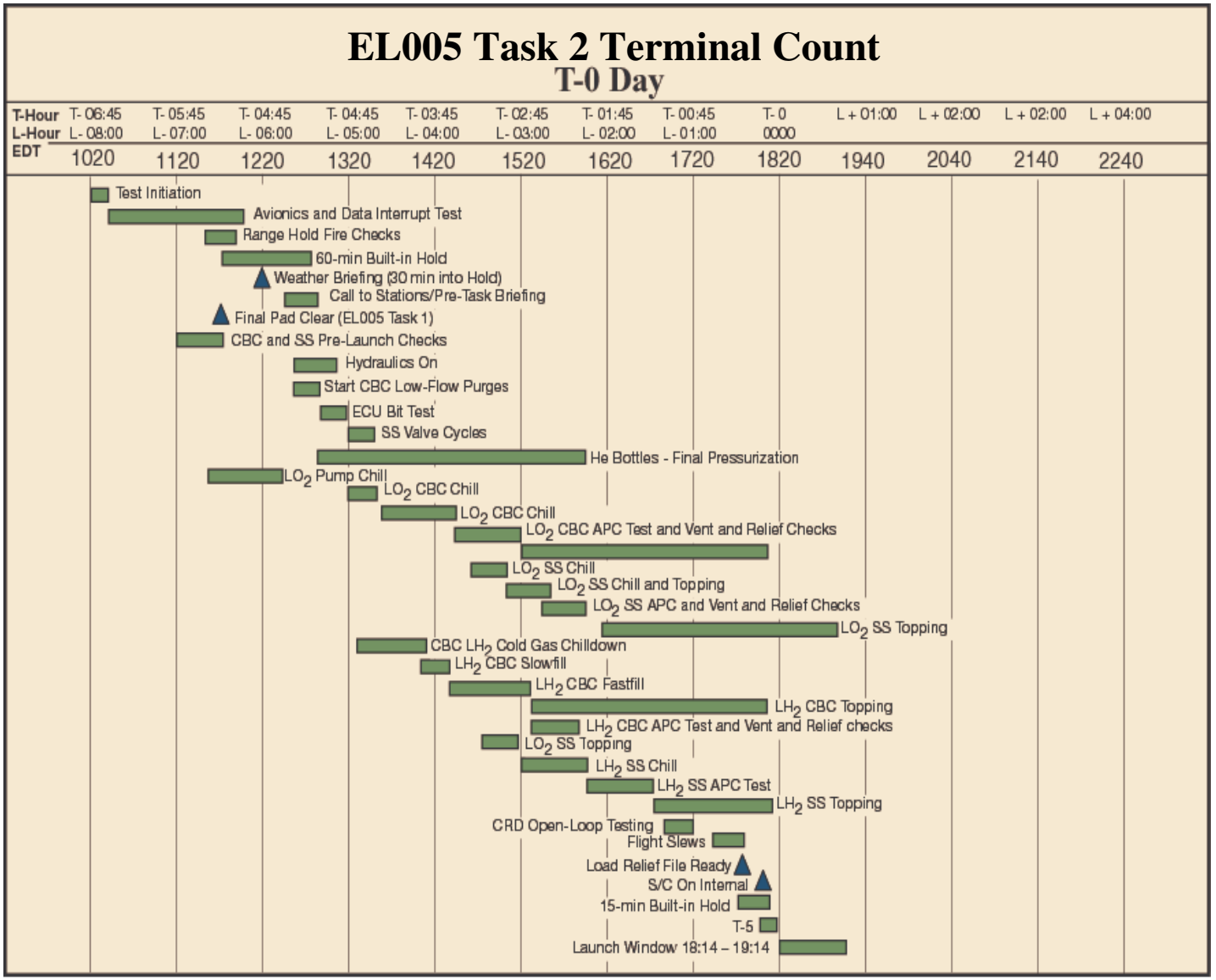
BOEING®

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

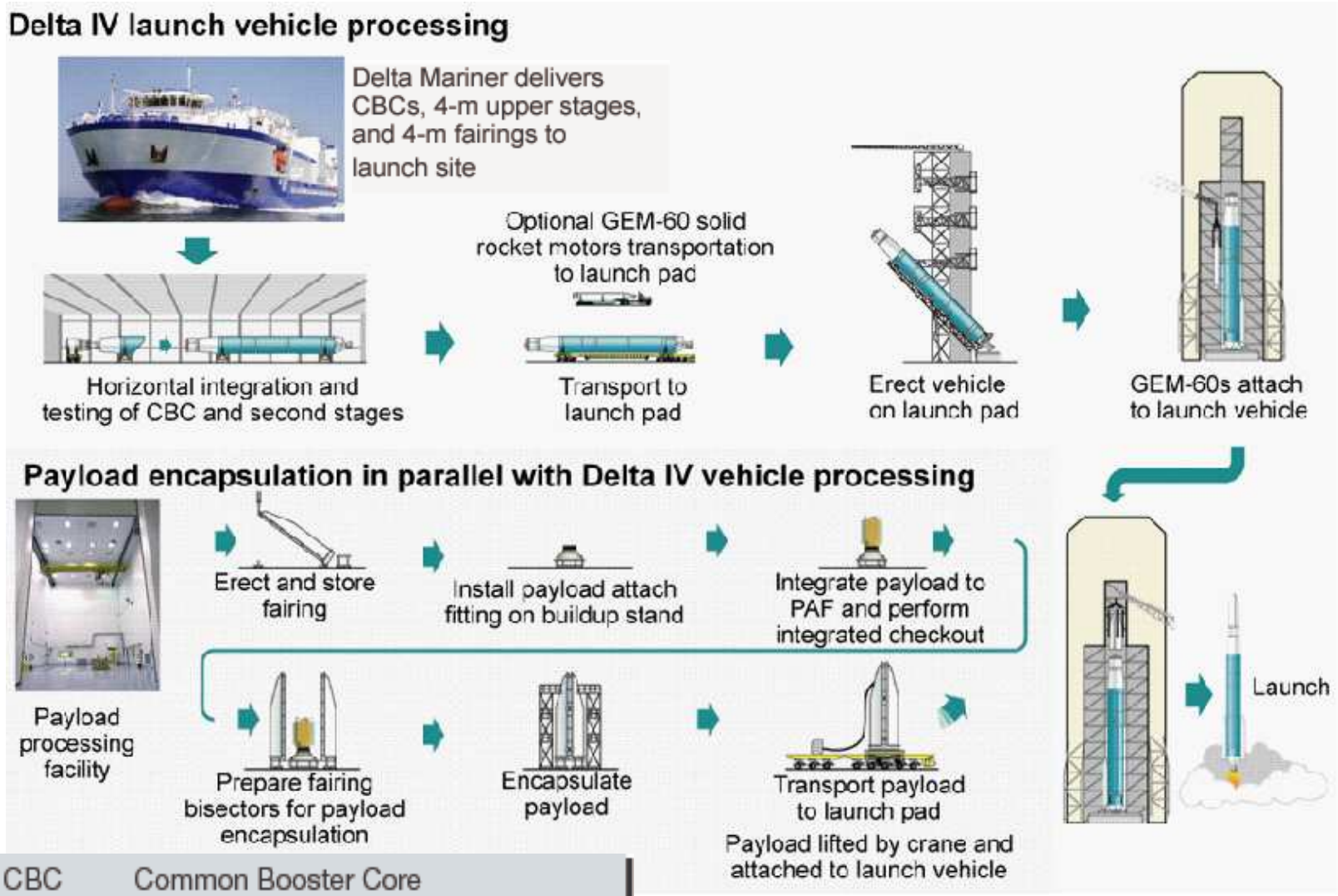


BOEING®

CCAFS GOES N Mission



Delta IV Hardware Flow at Eastern Range



Notes:

BOEING