CALIPSO/CloudSat

Delta Launch Vehicle Programs

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Media Kit for Delta II Launch of CALIPSO/CloudSat

A Boeing Delta II will launch two satellites into orbit: The Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) and CloudSat missions will analyze Earth's clouds and aerosol layers.

Live Webcast

NASA Live Webcast
Friday, April 28, 1:00 AM -- 5:00 AM PDT

Media Kit Pages

Backgrounders

CALIPSO/CloudSat Mission Description

- The Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) mission will combine an active lidar instrument with passive infrared and visible imagers to probe the vertical structure and properties of thin clouds and aerosols over the globe.

- The CloudSat mission will provide from space the first global survey of cloud profiles and cloud physical properties, including seasonal and geographical variations, which are needed to evaluate the way clouds are parameterized in global models. Data collected from this mission will be used to contribute to predictions of weather and climate and to better understand cloud-climate interaction.

CALIPSO and CloudSat in the A-Train

CALIPSO and CloudSat are highly complementary and together will provide new, never-before-seen 3-D perspectives of how clouds and aerosols form, evolve, and affect weather and climate. CALIPSO and CloudSat will fly in formation with three other satellites in the A-Train constellation to enable an even greater understanding of our climate system from the broad array of sensors on these other spacecraft.

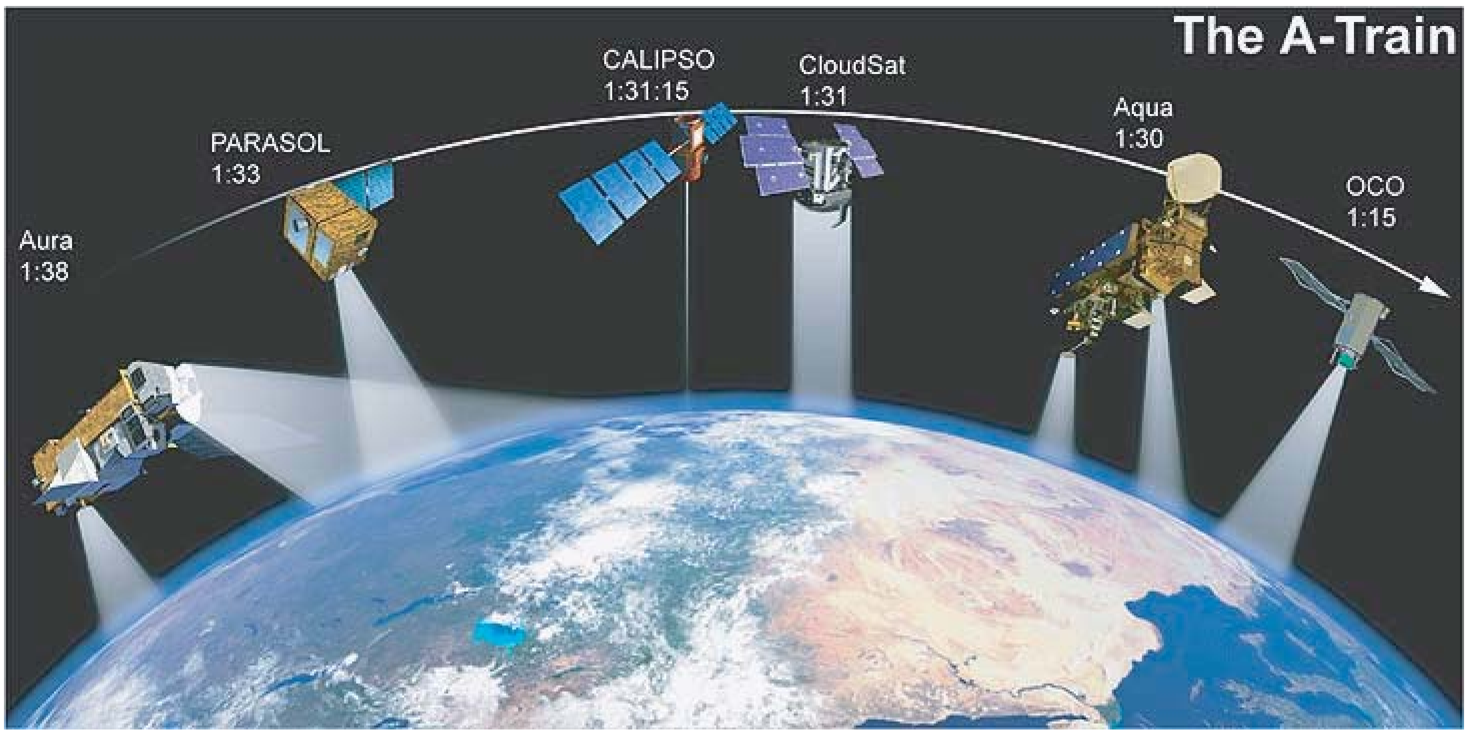


Photo Credit: NASA

CALIPSO's Science Instruments

- Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP)—CALIOP is a two-wavelength polarization-sensitive lidar that provides high resolution vertical pro les of aerosols and clouds.

- Wide-Field Camera (WFC)—The WFC is a xed, nadir-viewing imager with a single spectral channel covering the 620-270 nmi region, selected to match band 1 of the MODerate resolution Imaging Spectroradiometer (MODIS) instrument on Aqua.

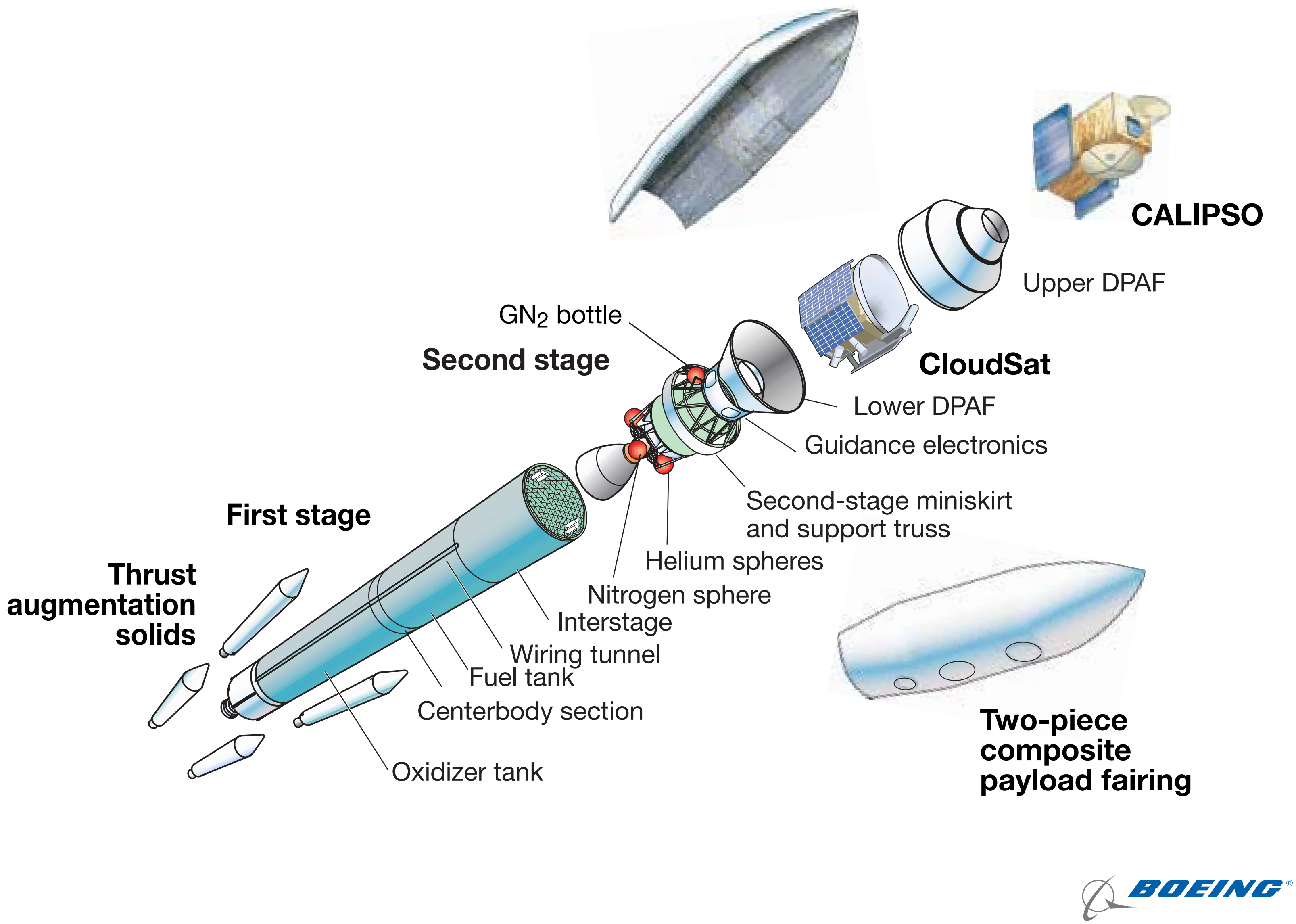
- Imaging Infrared Radiometer (IIR)—The IIR is a nadir-viewing, nonscanning imager having a 64 km by 64 km swath with a pixel size of 1 km. The CALIOP beam is nominally aligned with the center of the IIR image.

CloudSat's Science Instrument

- Cloud Profiling Radar (CPR)—The CPR is a nadir-looking 94 GHz radar that measures the power backscatter from clouds as a function of distance from the CPR. The CPR will allow for the most detailed study of clouds to date and should better characterize the role clouds play in regulating the Earth's climate.

Delta II 7420 Launch Vehicle

10-ft Fairing



CALIPSO/CloudSat Mission Requirements

• Launch Period	04/21/2006 - 05/15/2006
• Launch Window	Instantaneous (no window)
• DTO Spacecraft Mass (Nominal)	
– CALIPSO	1,283.49 lb (582.2 kg)
– CloudSat	1,867.55 lb (847.1 kg)
• Free Molecular Heating Rate at Fairing Separation	<0.1 Btu/ft^2-sec
• Orbit Requirements*	
– Semi-Major Axis (km/nmi)	7071.880 / 3818.510
– Eccentricity	0.0011
– Inclination (deg)	98.231
– Argument of Perigee (deg)	65.3
– Mean Anomaly (deg)	294.8

* Osculating elements, defined at ascending node nearest to SECO-2

Flight Mode Description–Boost-to-Orbit

- Launch from VAFB SLC-2W down flight azimuth of 196 deg
- Four GEM solid motors ignited at liftoff, jettisoned at 1 min, 22.5 sec
- Dog-leg maneuver (1 min, 25 sec to 2 min) performed to attain required orbital inclination
- MECO occurs approximately 4 min, 24 sec after liftoff
- First stage separated 8 sec after MECO; second stage ignited 5.5 sec later
- Payload fairing jettisoned when free molecular heating rate < 0.10 Btu/ft^2-sec
- Command receiver decoders (CRDs) turned off at 7 min, 51.6 sec (Pt. Mugu elevation angle of 0.5 deg)
- Second-stage first burn places vehicle in a 100 x 377 nmi (185 x 698 km) orbit at a 98.09 deg inclination
  - Mobile telemetry (MT) required for coverage of last portion of second-stage burn
- Coast-phase thermal maneuver performed following SECO-1
  - 1 deg/sec nominal roll rate

Sequence of Events–Boost-to-Orbit

Event	Time (hr:min:sec)
Liftoff	00:00:00.0
Mach 1	00:00:31.1
Maximum dynamic pressure	00:00:45.8
4 solid motors burnout	00:01:05.2
Jettison 4 solid motors	00:01:22.5
Begin dog-leg maneuver	00:01:25.0
End dog-leg maneuver	00:02:00.0
MECO	00:04:26.4
Stage I/II separation	00:04:35.0
Stage II ignition	00:04:40.5
Jettison fairing	00:04:45.0
First cutoff - second stage (SECO 1)	00:11:16.2
Begin maneuvers to thermal attitude	00:12:05.5
Thermal attitude achieved	00:12:56:0
Begin coast-phase thermal roll	00:15:54.0
End coast-phase thermal roll	00:58:04.0

Flight Mode Description

Continued

- First second-stage restart occurs at 60 min in view of Mombasa tracking station
  - Restart burn duration of approximately 12.2 sec
  - 370.4 x 378.8 nmi (686.0 x 701.5 km) orbit at 98.231 deg inclination

- Following SECO-2, vehicle is reoriented for CALIPSO separation at 1 hr, 2 min, 25 sec in view of Mombasa (22.0 deg elevation angle)
  - $+X_{LV}$ axis aligned within 5 deg of inertial velocity vector
  - Separation ΔV of 1.8 fps
  - 11.8 min before reaching 10 deg elevation at Kiruna tracking station, with CALIPSO visible to Kiruna for more than 9.4 min

- Following CALIPSO separation, vehicle is reoriented for upper DPAF separation and coast-phase thermal maneuver
  - 180 deg from inertial velocity vector at time of DPAF separation
  - 1 deg/sec nominal roll rate, with direction reversed halfway through the maneuver

Sequence of Events–Restart to CALIPSO Separation

Event	Time (hr:min:sec)
Begin maneuvers to restart attitude	00:53:14.0
Restart attitude achieved	00:58:04.0
Restart second stage	01:00:00.0
Second cutoff – second stage (SECO-2)	01:00:12.2
Maneuvers to CALIPSO separation attitude	01:00:34.5
CALIPSO separation attitude achieved	01:01:34.5
Separate CALIPSO	01:02:24.5
Begin maneuvers to DPAF separation attitude	01:03:24.5
DPAF separation attitude achieved	01:08:24.5
Begin second stage thermal roll	01:09:42.5
End second stage thermal roll	01:34:52.5

Flight Mode Description

Continued

- DPAF (upper portion) separation occurs at 1 hr, 36 min, 9 sec in view of Vandenberg tracking station (6.8 deg elevation angle)
  - +XLV axis oriented 180 5 deg from velocity vector
  - Separation DV of 4.5 fps
- CloudSat separation occurs at 1 hr, 37 min, 29 sec in view of Vandenberg (8.3 deg elevation angle)
  - +XLV axis oriented 180 5 deg from velocity vector
  - Separation DV of 1.6 fps
- Following CloudSat separation, the second stage is reoriented for a 25-sec cold gas evasive maneuver (CGEM)
  - +XLV axis aligned with inertial velocity vector
  - DV of 1.2 fps imparted to second stage
- Following the CGEM, the second stage is reoriented for the second-stage evasive burn in view of McMurdo tracking station
  - Burn duration of 5 sec, beginning at 2 hr, 9 min, 14 sec after liftoff
  - 236 x 376 nmi (437 x 696 km) orbit at 98.49 deg inclination

Sequence of Events–DPAF Separation to Evasive Burn

Event	Time (hr:min:sec)
Separate DPAF (upper portion)	01:36:08.5
Separate CloudSat	01:37:28.5
CGEM attitude achieved	01:43:33.5
Begin CGEM	01:43:43.5
End CGEM	01:44:08.5
Begin maneuvers to restart attitude	01:45:03.0
Restart attitude achieved	01:58:33.5
Restart second stage – evasive burn	02:09:13.5
Third cutoff – second stage (SECO-3)	02:09:18.8

Flight Mode Description

Continued

- Evasive burn sequence and attitude are designed to minimize contamination potential
  - Contamination of CALIPSO and CloudSat spacecraft less than 10 angstroms
- Following evasive burn, the second stage is reoriented for the second-stage depletion burn in view of Hartebeesthoek tracking station
  - Depletion burn begins at 2 hr, 29 min, 14 sec after liftoff
  - Depletion burn:
    - Lowers vehicle perigee/increases vehicle inclination
    - Removes stage from vicinity of spacecraft
    - Safes the vehicle
  - At end of nominal depletion burn, second stage is in a 106 x 348 nmi (196 x 644 km) orbit with an inclination of 103.04 deg

Sequence of Events–DPAF Separation to Evasive Burn

Event	Time(hr:min:sec)
Begin maneuvers to restart attitude	02:09:54.0
Restart attitude achieved	02:27:24.0
Restart second stage – depletion burn	02:29:14.0
Depletion cutoff – second stage (SECO-4)	02:29:53.8

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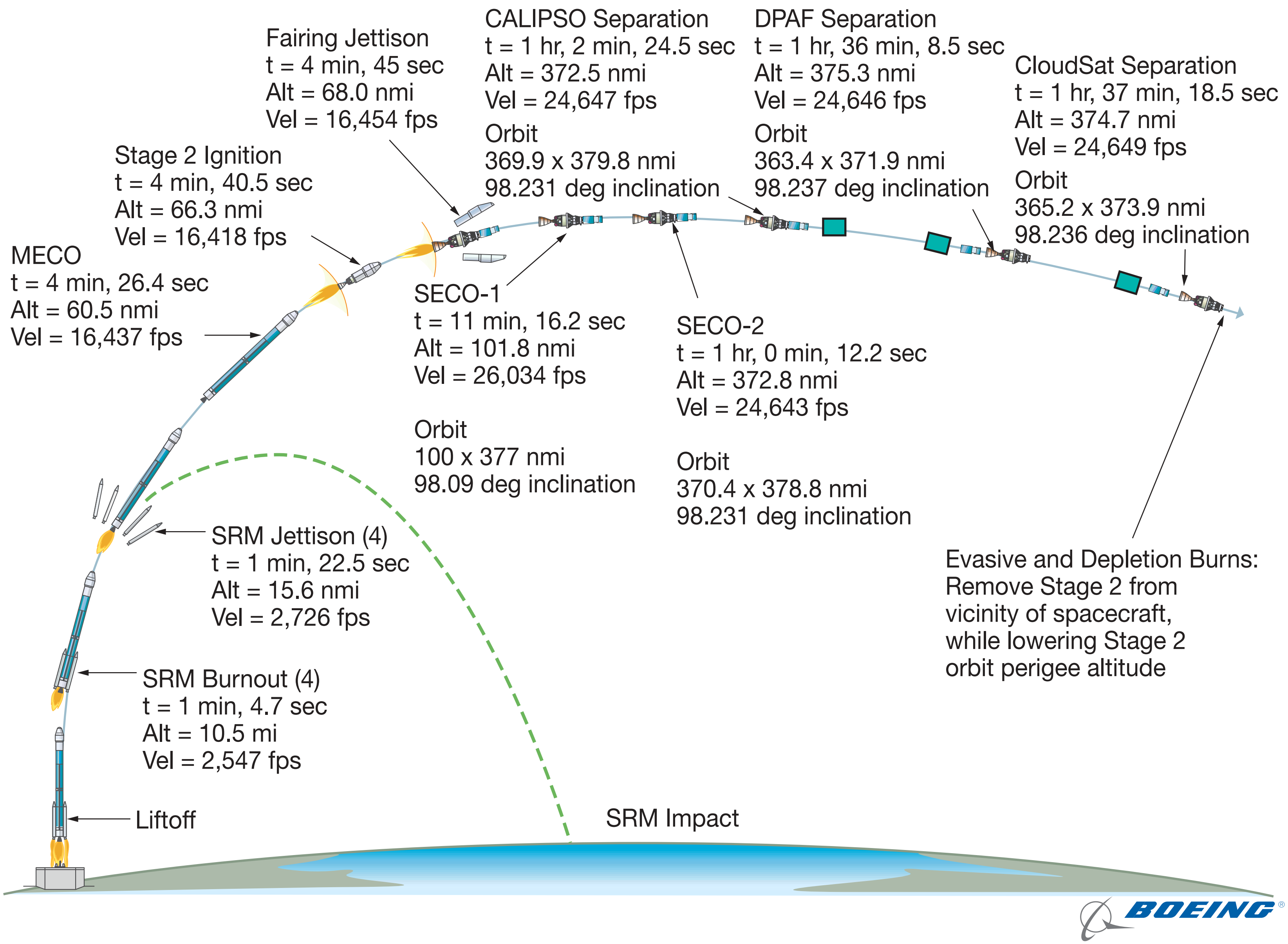
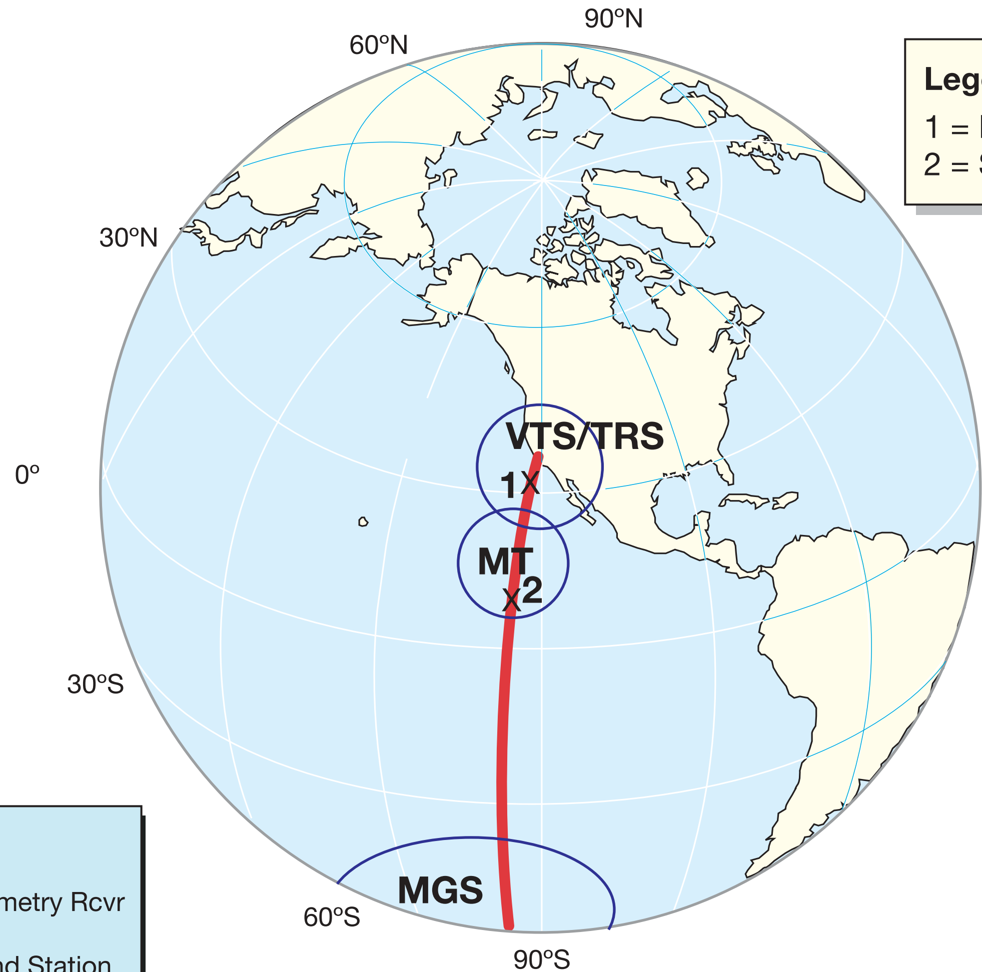
CALIPSO/CloudSat Flight Profile



CALIPSO/CloudSat Launch Ground Trace–Boost-to-Orbit

(ESTAR Min. for T/M Sites = 2.00 deg)



Legend (time, hr:min:sec)

1 = MECO (00:04:26.4)

2 = SECO-1 (00:11:16.2)

T/M Tracking Sites

VTS = Vandenberg AFB

TRS = Vandenberg Telemetry Rcvr

MT = Mobile Telemetry

MGS = McMurdo Ground Station

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CALIPSO/CloudSat Launch Ground Trace
Restart to CALIPSO Separation

(ESTAR Min. for T/M Sites = 2.00 deg)

Legend (time, hr:min:sec)

3 = Restart Ignition (01:00:00.0)
4 = SECO-2 (01:00:12.2)
5 = CALIPSO Separation (01:02:24.5)

T/M Tracking Sites

HBK = Hartebeesthoek, So. Af.
HIKE = Mombasa, Kenya
AUS = Aussaguel, France
ESX = Kiruna, Sweden

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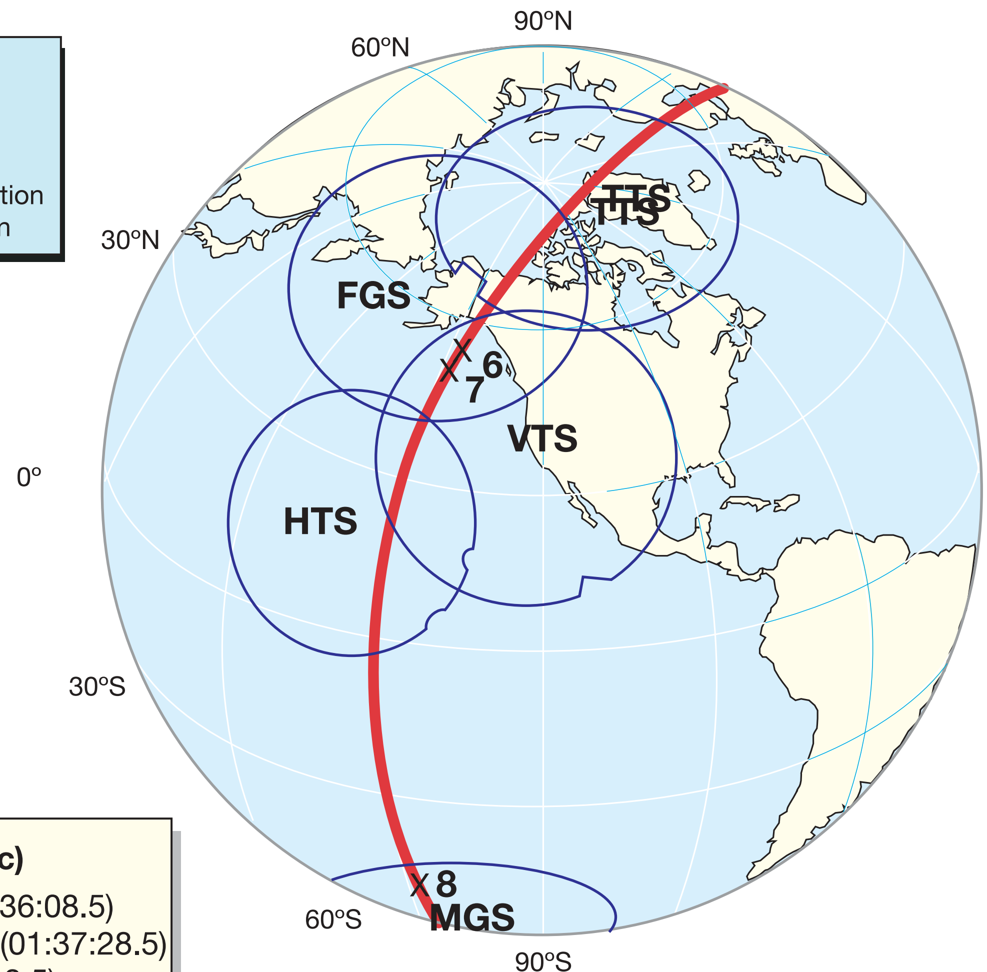
CALIPSO/CloudSat Launch Ground Trace
DPAF Separation to Evasive Burn

(ESTAR Min. for T/M Sites = 2.00 deg)

T/M Tracking Sites
FGS = Poker Flats, Alaska
TTS = Thule, Greenland
VTS = Vandenberg AFB
MGS = McMurdo Ground Station
HTS = Hawaii Tracking Station



Legend (time, hr:min:sec)
6 = DPAF Separation (01:36:08.5)
7 = CloudSat Separation (01:37:28.5)
8 = Evasive Burn (02:09:13.5)

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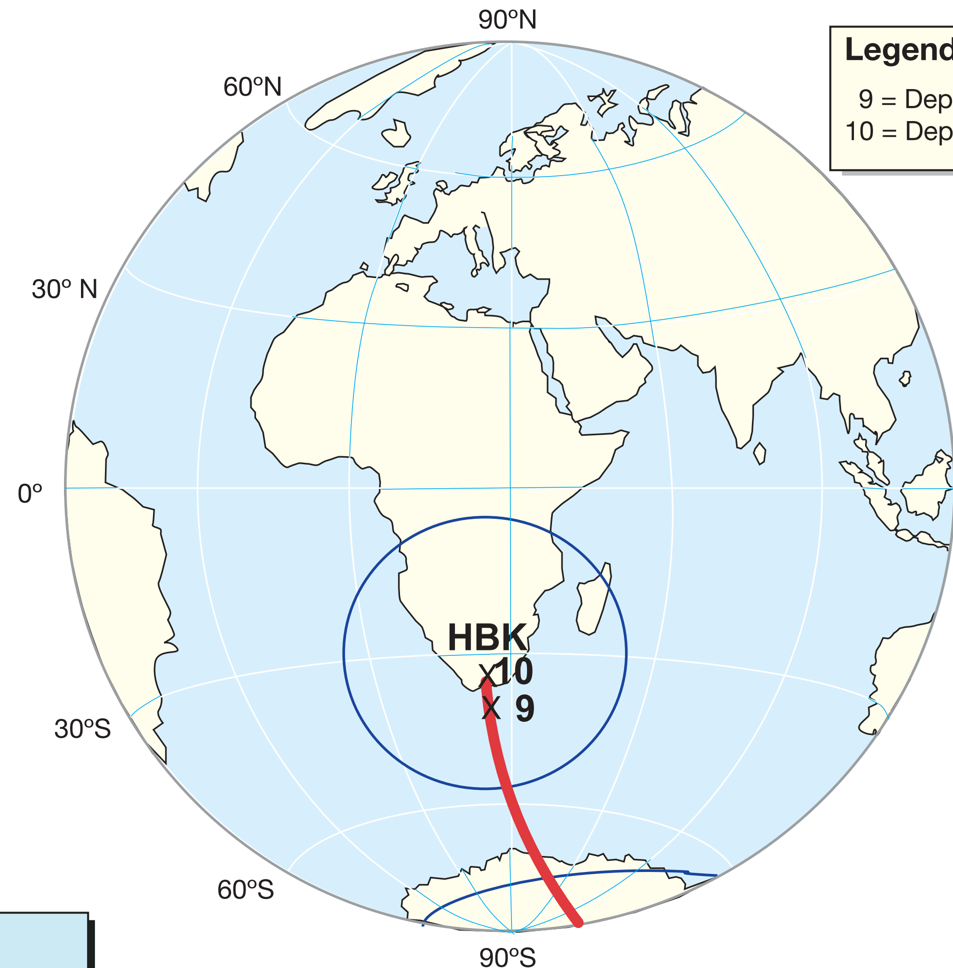
CALIPSO/CloudSat Launch Ground Trace–Depletion Burn

(ESTAR Min. for T/M Sites = 2.00 deg)



Legend (time, hr:min:sec)

9 = Depletion Restart (02:29:14.0)
10 = Depletion Cutoff (02:29:53.8)

T/M Tracking Sites

HBK = Hartebeesthoek, So. Af.

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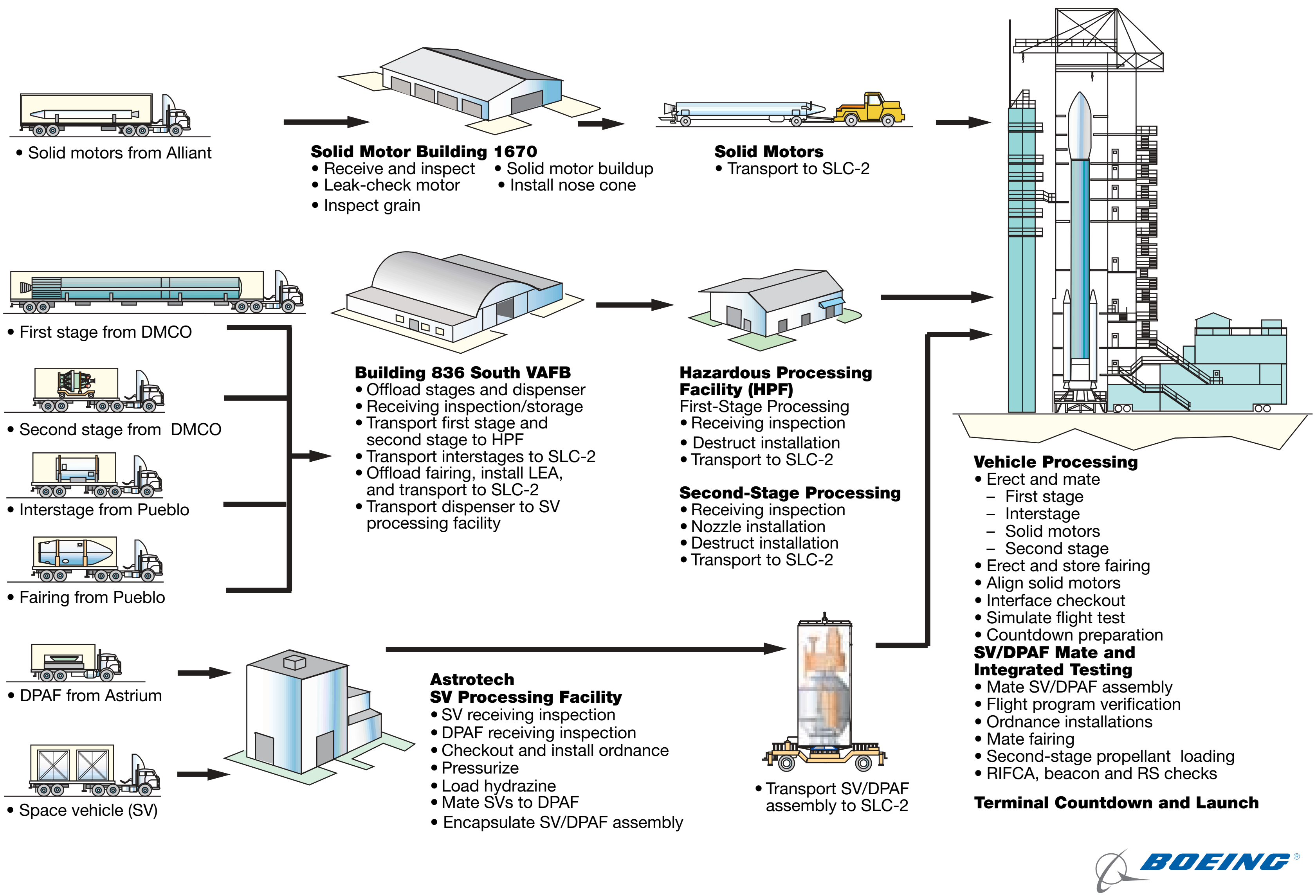
Delta II Hardware Flow at VAFB

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Fact Sheet

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Boeing Delta II
CALIPSO CloudSat Mission

Mission: Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO)
CloudSat

CALIPSO and CloudSat will provide new perspectives on Earth's clouds and aerosols, answering questions about how they form, evolve and affect water supply, climate, weather and air quality. They will be launched into an orbit where they will fly just 15 seconds apart as members of NASA's "A-Train," a constellation of Earth-observing satellites.

CALIPSO will provide the next generation of climate observations including an advanced study of clouds and aerosols, improving the ability to predict climate change and study air quality.

CloudSat's trio of satellites is the first spacecraft to study clouds on a global basis. They will use an advanced radar to slice through clouds to see their vertical structure, providing a completely new observational capability from space. CloudSat's goal is to furnish data needed to evaluate and improve the way clouds are represented in global models, contributing to better predictions of clouds, their role in climate change, and the cloud-climate relationship.

Date: April 21, 2006

Window: 3:02 a.m. PDT (Instantaneous window)

Separation: CALIPSO – 62 minutes after liftoff
CloudSat – 96 minutes after liftoff

Site: Space Launch Complex 2W
Vandenberg Air Force Base, CA

Vehicle: Boeing Delta II 7420-10 Configuration

- Two-stage launch vehicle
- Pratt & Whitney Rocketdyne RS-27A main engine
- Aerojet AJ10-118K second-stage engine
- Four Alliant Techsystems solid rocket motors
- 10-foot diameter payload fairing

Customers: **CALIPSO**
NASA Goddard Space Flight Center
NASA Langley Research Center
French Centre National D' Etudes Spatiales (CNES)

CloudSat
NASA Jet Propulsion Laboratory

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