



# COSMO-SkyMed

## COSMO-1

*Delta Launch Vehicle Programs*

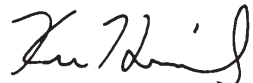




# COSMO-1

Boeing Launch Services and United Launch Alliance are honored to launch the first COSMO-SkyMed (Constellation of Small Satellites for Mediterranean basin Observation) satellite, COSMO-1. COSMO-1 will be launched aboard a Delta II launch vehicle from Vandenberg Air Force Base (VAFB). The launch vehicle will deliver the satellite into a circular sun-synchronous orbit where the satellite will begin its mission of data observation and data recording to meet the needs of both the military and civil communities.

United Launch Alliance provides the Delta II launch vehicle and mission services under a commercial launch service contract administered by Boeing Launch Services for Thales Alenia Space Italia. We are pleased that Thales Alenia Space Italia, a Thales/Finmeccanica company, has selected the Delta II for this first COSMO-SkyMed satellite. Our congratulations to the entire Delta team for their significant efforts that resulted in achieving this milestone.



Kenneth A. Heinly  
Vice-President, Boeing Launch Services  
The Boeing Company



Kristen T. Walsh  
Director, NASA/Commercial Programs  
United Launch Alliance

## **COSMO-SkyMed System Overview**

COSMO-SkyMed, the new system for Earth observation, entirely developed and produced in Italy, is based on a constellation of four radar satellites. Each satellite is equipped with a high-resolution Synthetic Aperture Radar (SAR) operating in X-band and flexible and innovative transmission equipment for high speed downlink of acquired data to the receiving ground stations.

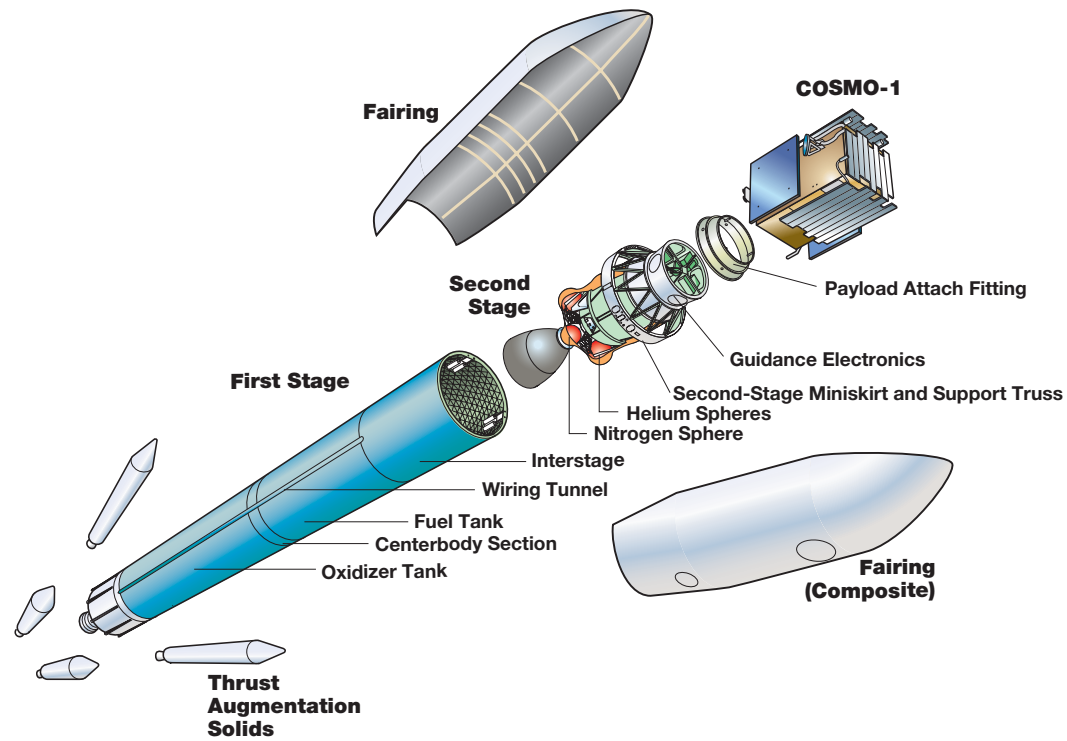
The system ground segment consists of infrastructures devoted to the management of the constellation (Mission Planning and Control Centre and Satellite Control Center); services for the management and planning of user requests; and services for the gathering, processing, archiving, and distribution of data to the users.

# Mission Objectives

The overall objective of the COSMO-SkyMed program is global Earth observation and the Mediterranean area in particular. Specific applications include:

- Territorial surveillance and prevention of natural disasters
- Coastal surveillance to assess coastal erosion and sea/river pollution
- Control of farming, forestry resources, and urban buildings
- Mapping using images with a resolution in the order of 1 m
- Territorial security and strategic defense

# Delta II 7420-10 Launch Vehicle



# Mission Requirements

• DTO Spacecraft Mass (kg/lb)	1900 /4189
• Launch Window	19:21 – 19:34 PDT (02:21 – 02:34 UTC, next day)
• Orbit Requirements*	
– Semi-Major Axis (km/nmi)	7006.742/3783.338
– Eccentricity	0.00127
• Apogee Altitude (km/nmi)	637.5/344.2
• Perigee Altitude (km/nmi)	619.7/334.6
• Inclination (deg)**	97.8598
• Argument of Perigee (deg)**	68.5
• Free Molecular Heating Rate (FMHR)	<0.1 BTU/ft <sup>2</sup> -sec (1135 W/m <sup>2</sup> ) at fairing jettison
• Post-Separation Deposition of Contaminants onto Spacecraft	<10 Angstroms

\*(Defined at First Ascending Node Crossing)

\*\* (True-of-Date Coordinate System)

## Flight Mode Description – Boost-to-Orbit

- 7420-10 launch from Vandenberg Air Force Base (VAFB) SLC-2W
- Flight azimuth of 196 deg
- Four GEM solid motors ignited at liftoff
- GEM solid motors burnout at 1 min, 4.0 sec, and are jettisoned at 1 min, 22.5 sec to assure clearance of coastal oil platforms
- Dog-leg maneuver performed from 1 min, 25 sec to 2 min, 0 sec to attain required orbital inclination
- Main Engine Cutoff (MECO) occurs at 4 min, 24.0 sec after liftoff when first-stage propellants are depleted
- Stage I-II separation occurs 8 sec after MECO
- Stage II ignition occurs 5.5 sec after Stage I-II separation
- Payload fairing jettisoned when free molecular heating rate  $< 0.1 \text{ BTU/ft}^2\text{-sec}$  ( $1135 \text{ W/m}^2$ )
- Command Receiver Decoders (CRDs) turned off at 7 min, 17.5 sec
- Stage II first burn cutoff (SECO-1) occurs at 11 min, 25.1 sec
  - Vehicle inserted into a 185 x 645 km (100 x 348 nmi) orbit with an inclination of 97.80 deg
- Telemetry coverage provided by WR sites until approximately 7 min, 10 sec and then by Instrumented Aircraft (IA) through SECO-1



## Sequence of Events – Boost-to-Orbit

Event	Time (hr:min:sec)
Liftoff	0:00:00.0
Mach 1	0:00:30.5
Maximum Dynamic Pressure	0:00:45.4
4 Solid Motors Burnout	0:01:04.0
4 Solid Motors Jettison	0:01:22.5
Begin Dog-Leg Maneuver	0:01:25.0
End Dog-Leg Maneuver	0:02:00.0
Main Engine Cutoff (MECO)	0:04:24.0
Stage I/II Separation	0:04:32.0
Stage II Ignition	0:04:37.5
Jettison Fairing	0:04:41.5
CRD Turnoff	0:07:17.5
First Cutoff – Second Stage (SECO-1)	0:11:25.1

## Flight Mode Description – Coast and Restart

- Following SECO-1, vehicle reoriented to restart burn attitude
- At end of reorientation maneuver, thermal roll maneuver of 1 deg/sec initiated at 19 min, 20 sec and terminated at 51 min, 25 sec
- Second-stage restart occurs at 53 min, 27.0 sec over the Hartebeesthoek, South Africa tracking station
  - Restart burn duration of 12.4 sec
  - At end of restart burn (SECO-2) vehicle in 619.8 x 631.5 km (334.7 x 341.0 nmi) orbit with an inclination of 97.86 deg
    - Following SECO-2, vehicle reoriented to spacecraft separation attitude
- Spacecraft separation occurs at 58 min, 0 sec over the Hartebeesthoek tracking station
  - COSMO-SkyMed uses a 4717 payload attach fitting (PAF) with a secondary latch system
  - PAF clampband released at 57 min, 30 sec and secondary latches are released at 58 min, 0 sec separating the spacecraft

## Sequence of Events – Coast and Restart

Event	Time (hr:min:sec)
Begin Thermal Conditioning Roll	0:19:20.0
End Thermal Conditioning Roll	0:51:25.0
Restart Second Stage	0:53:27.0
Second Cutoff – Second Stage (SECO-2)	0:53:39.4
Begin Maneuver to Separation Attitude	0:54:00.0
End Maneuver to Separation Attitude	0:57:20.0
Release Clampband	0:57:30.0
Spacecraft Separation (release latches)	0:58:00.0
Spacecraft First Ascending Node Crossing	1:00:01.5

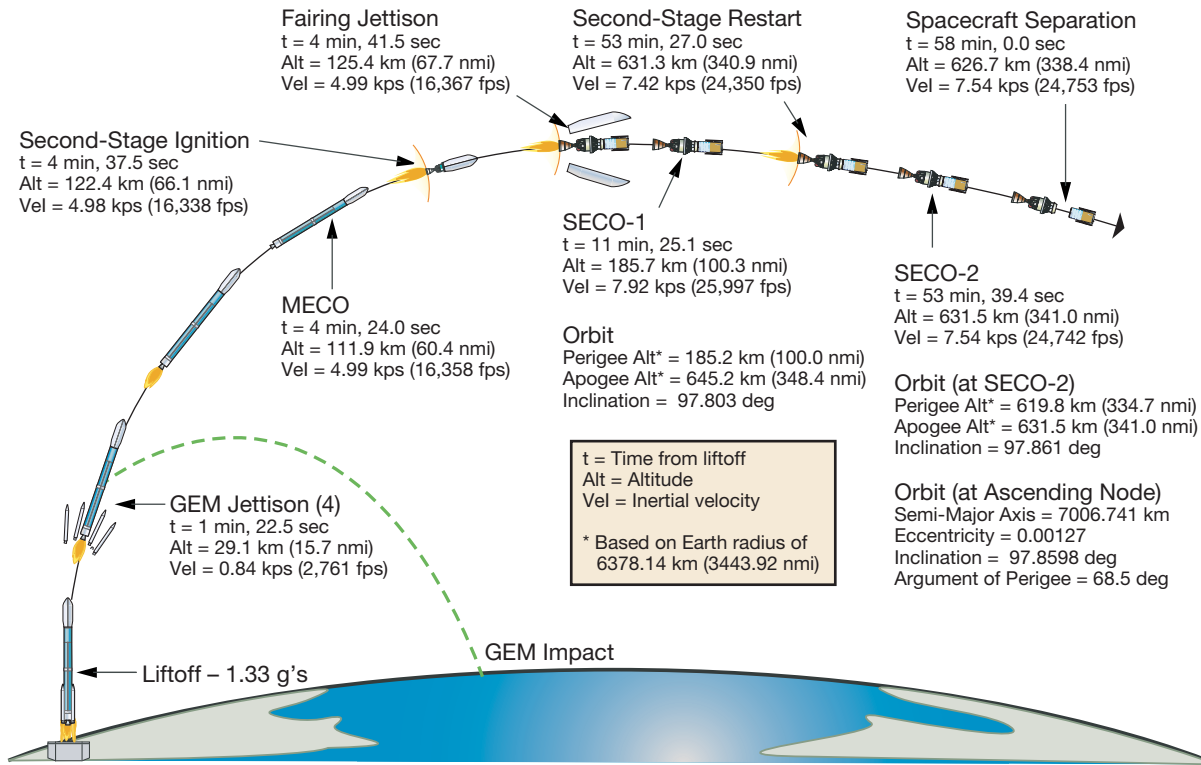
## Flight Mode Description – Post Separation

- Following spacecraft separation, second-stage retro initiated to move stage away from the spacecraft
- After second-stage retro, vehicle is reoriented to the attitude for the second-stage evasive burn, which will move the second stage farther away from the spacecraft
- Ignition of 5-sec evasive burn occurs at 1 hr, 16 min, 40 sec over the Oakhanger, England tracking station
  - Burn inserts stage into a 185 x 616 km (100 x 332 nmi) orbit with an inclination of 97.87 deg
  - Worst case spacecraft contamination level from evasive burn meets requirement of <10 Angstroms
- Following the second-stage evasive burn, vehicle is reoriented to the attitude for the second-stage propellant depletion burn, which will save the stage and also remove the stage from the spacecraft orbit plane
- Stage II depletion burn occurs at 1 hr, 26 min, 40 sec over the Thule, Greenland tracking station
  - Orbit at end of nominal depletion burn is 185 x 605 km (100 x 327 nmi) orbit with an inclination of 98.33 deg

## Sequence of Events – Post-Separation

Event	Time (hr:min:sec)
Begin Retro Maneuver	0:58:00.5
End Retro Maneuver	0:58:42.0
Begin Maneuver to Evasive Burn Attitude	1:00:10.0
End Maneuver to Evasive Burn Attitude	1:14:20.0
Restart Second Stage – Evasive Burn	1:16:40.0
Third Cutoff – Second Stage (SECO-3)	1:16:45.0
Begin Maneuver To Depletion Burn Attitude	1:17:05.0
End Maneuver To Depletion Burn Attitude	1:24:35.0
Restart Second Stage – Depletion Burn	1:26:40.0
Second Stage Depletion Initiation	1:26:51.1
Depletion Cutoff – Second Stage (SECO-4)	1:27:08.0

# Flight Profile

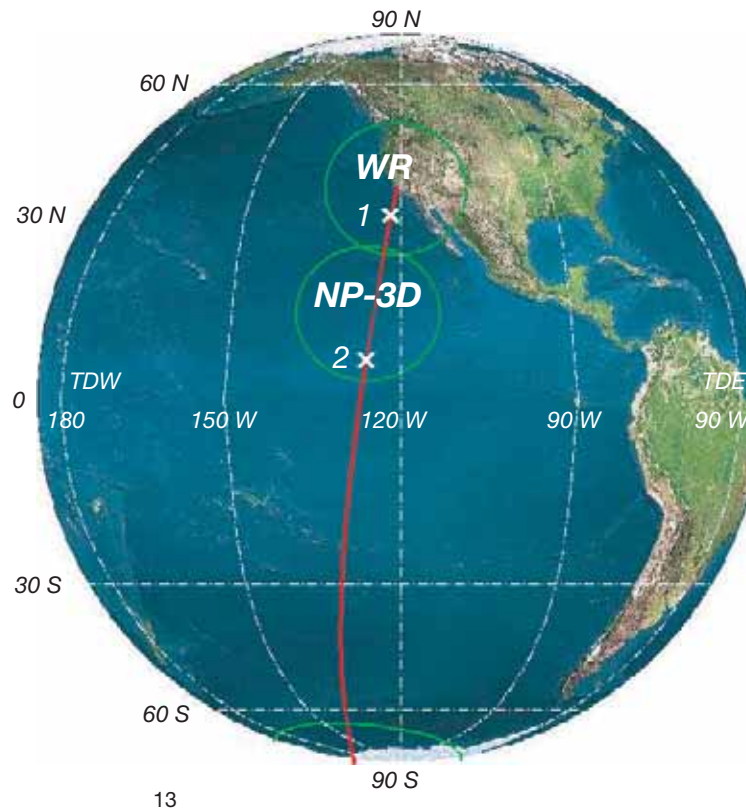


# Orbit Trace – Boost-to-Orbit

**Legend (time, sec)**  
1 – Main Engine Cutoff (264.0)  
2 – SECO-1 (685.1)

**WR Tracking Sites**  
VTS – AFSCN Vandenberg  
TRS – WR Telemetry Receiving Station  
SNI – NAWC San Nicolas Island

**NP-3D**  
P-3 – NAWC Instrumented Aircraft

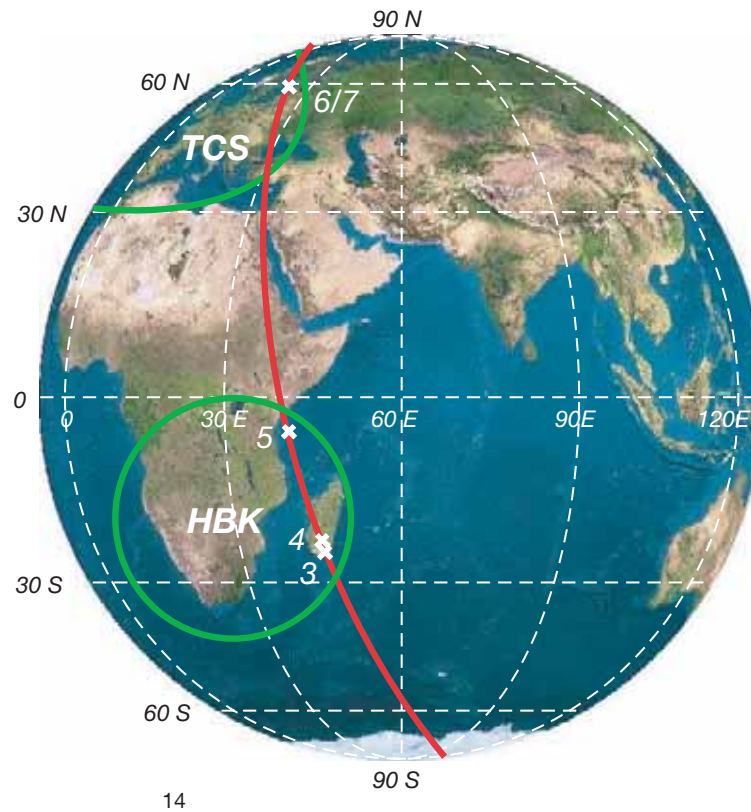


# Orbit Trace – Coast and Restart

Legend (time, sec)	
3	– First Restart (3207.0)
4	– SECO-2 (3219.4)
5	– Spacecraft Separation (3480.0)
6	– Second-Stage Restart (4600.0)
7	– SECO-3 (4605.0)

Downrange Tracking Site(s)	
HBK	– Satellite Applications Center Hartebeesthoek, South Africa
TCS	– AFSCN Oakhanger, England

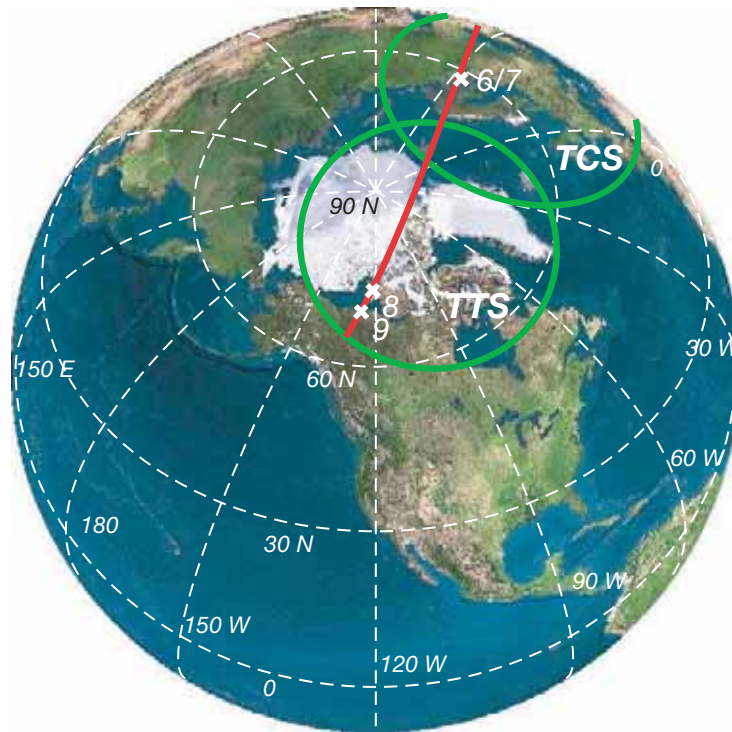




# Orbit Trace – Post-Separation

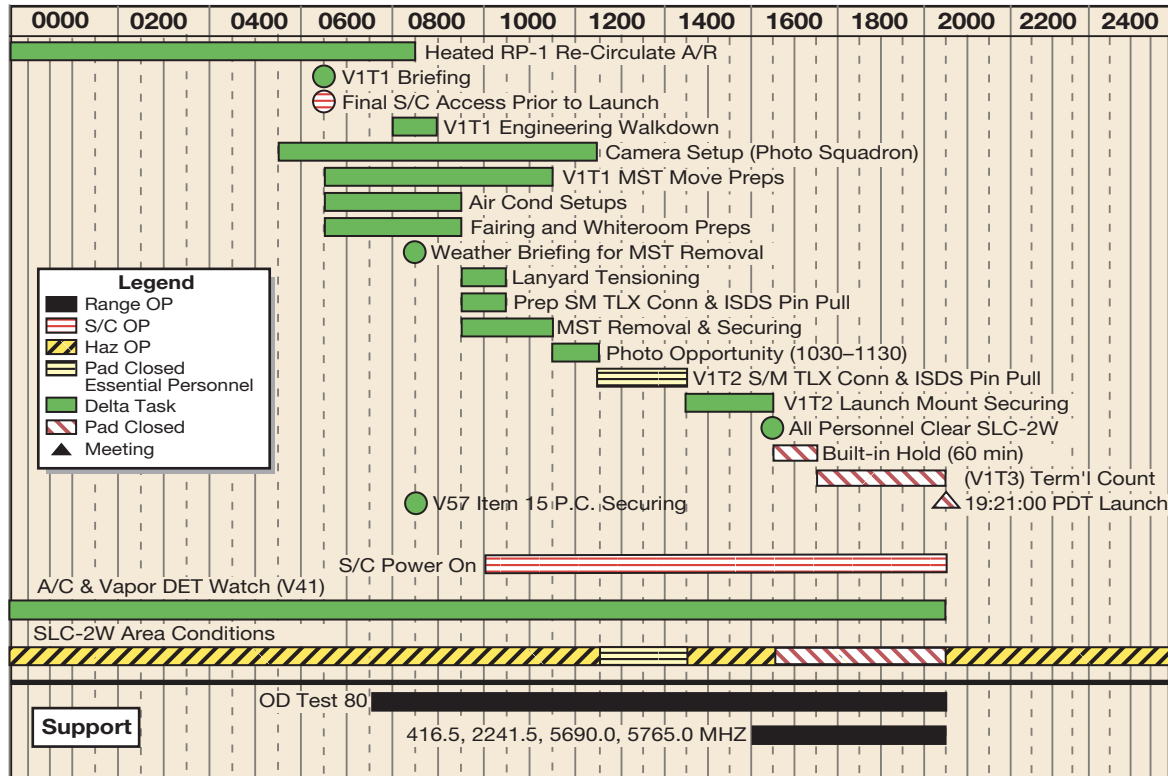
**Legend (time, sec)**  
6 – Second Restart (4600.0)  
7 – SECO-3 (4605.0)  
8 – Third Restart (5200.0)  
9 – SECO-4 (5228.0)

**Downrange Tracking Site(s)**  
TCS – AFSCN Oakhanger, England  
TTS – AFSCN Thule, Greeland



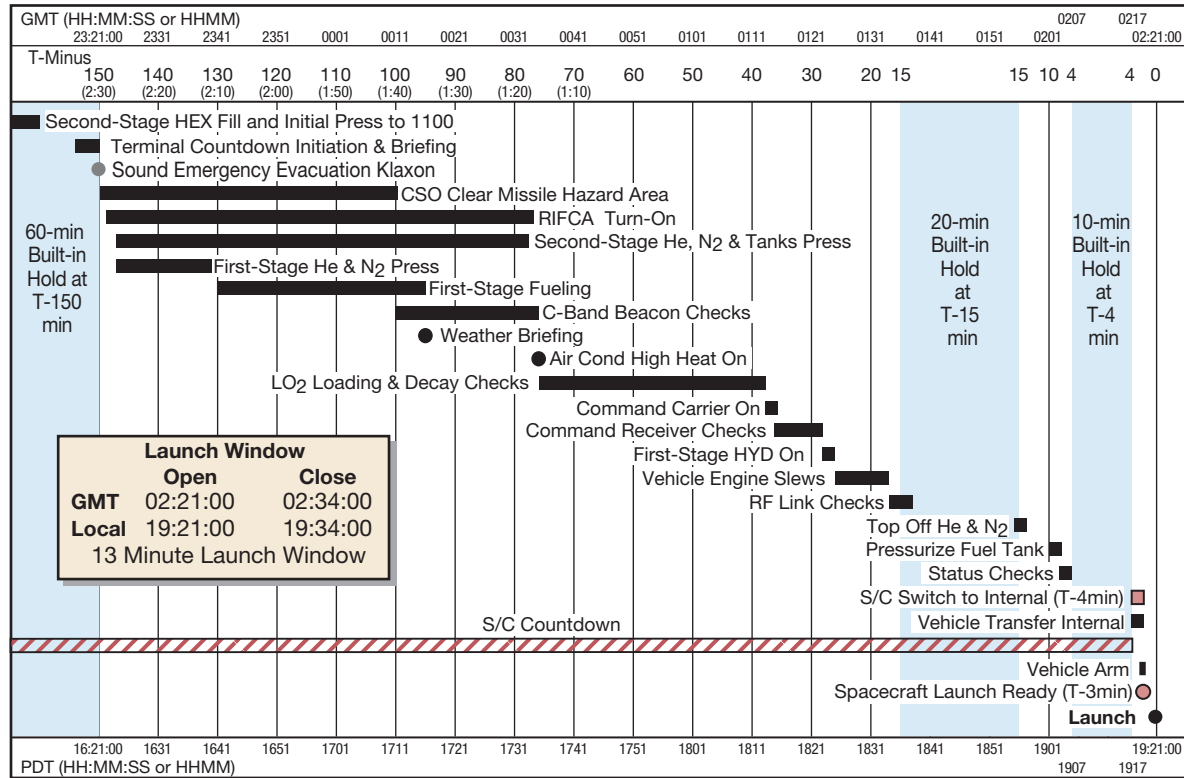
# Delta Countdown

## T-0 Day

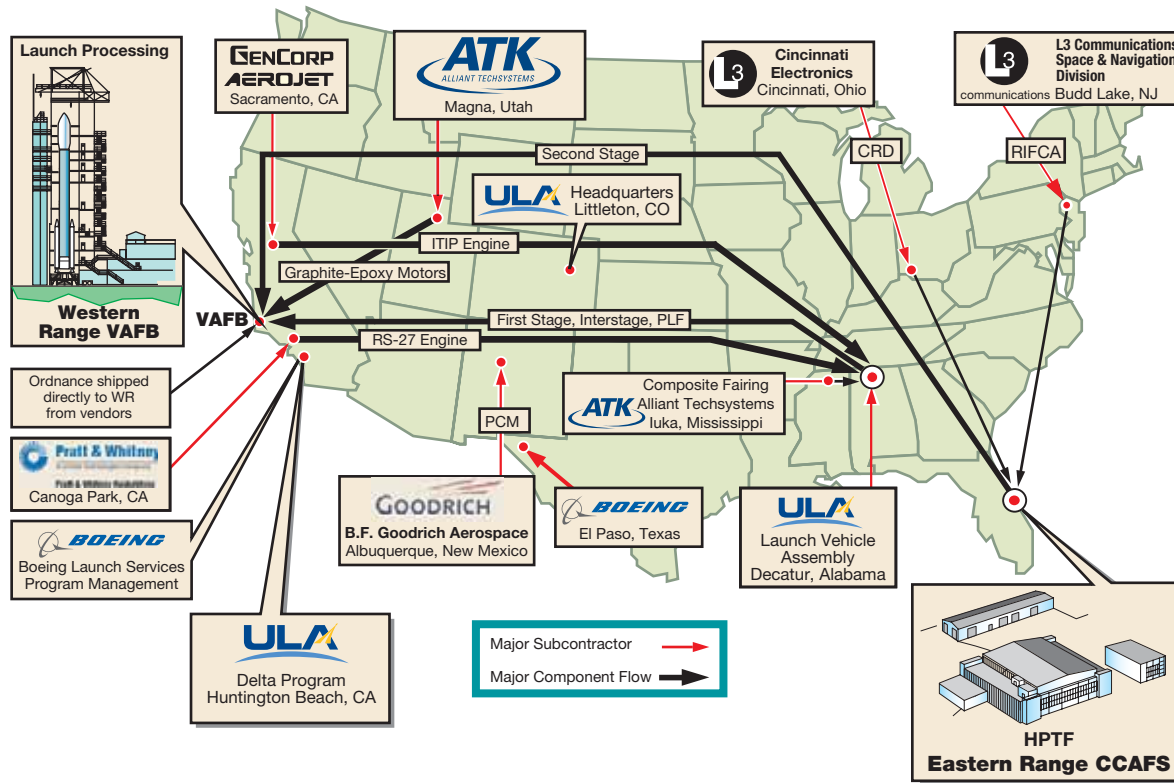


# COSMO-1 Terminal Count

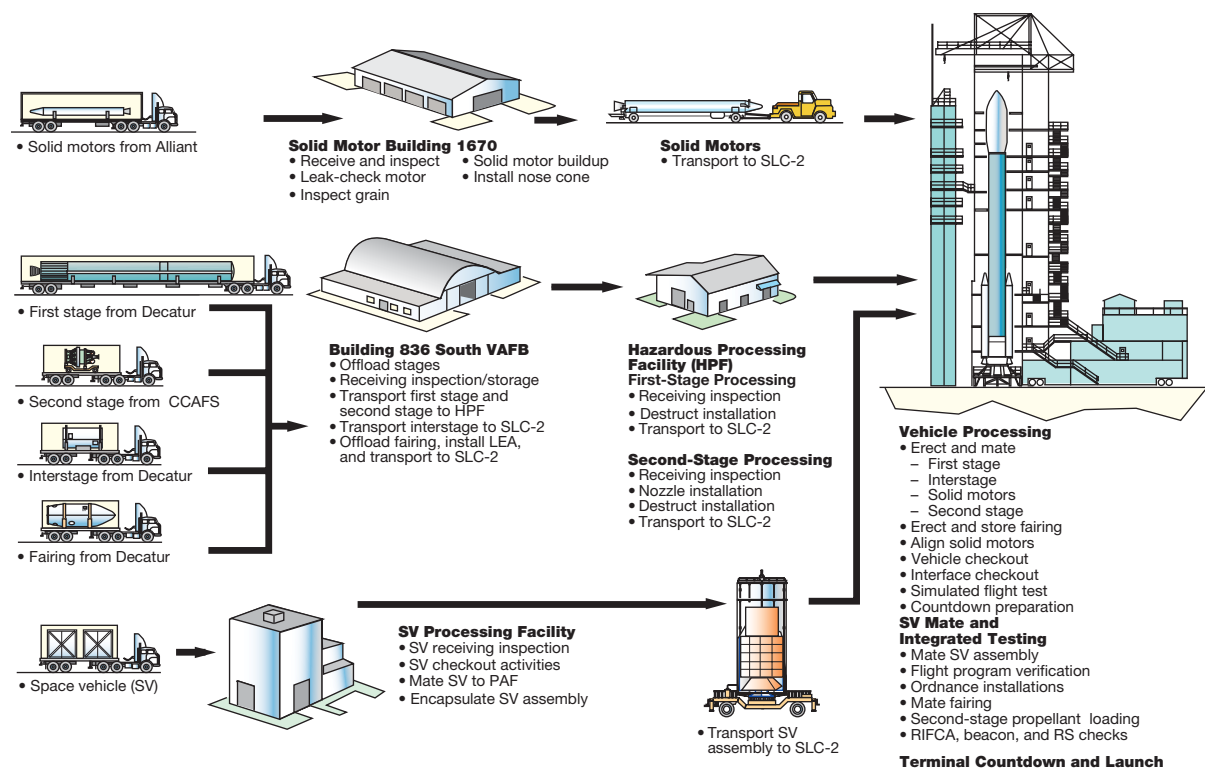
## T-0 Day



# Delta II Operational Flow at Western Range



# Delta II Hardware Flow at VAFB







*Delta Launch Vehicle Programs*

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