Minotaur V LADEE Mission Overview

September 2013

LADEE Launch Vehicle Highlights

- **Launch Vehicle: Minotaur V**
- **Launch Site: Wallops Flight Facility, VA**
- **Orbital Injection Requirements**
  - Characteristic Energy (C3) -2.75 km^2/sec^2
  - Inclination: 37.65^0
  - Argument Of Perigee (AOP): 155^0
  - Perigee: 200 km
- **Primary Objective**
  - The primary goal of the Minotaur V Launch Vehicle is to deliver the LADEE Space Vehicle into a lunar transfer orbit. The LADEE SV will then maneuver as necessary to enter Lunar orbit and perform studies of the Lunar dust and atmosphere.
- **Minotaur Launch Vehicle Background**
  - 24th Minotaur Launch Overall
  - 5th Minotaur Launch From Wallops
  - 1st Launch of Minotaur V Configuration
  - 6th Minotaur IV Based Vehicle

Minotaur V Vehicle Configuration Overview

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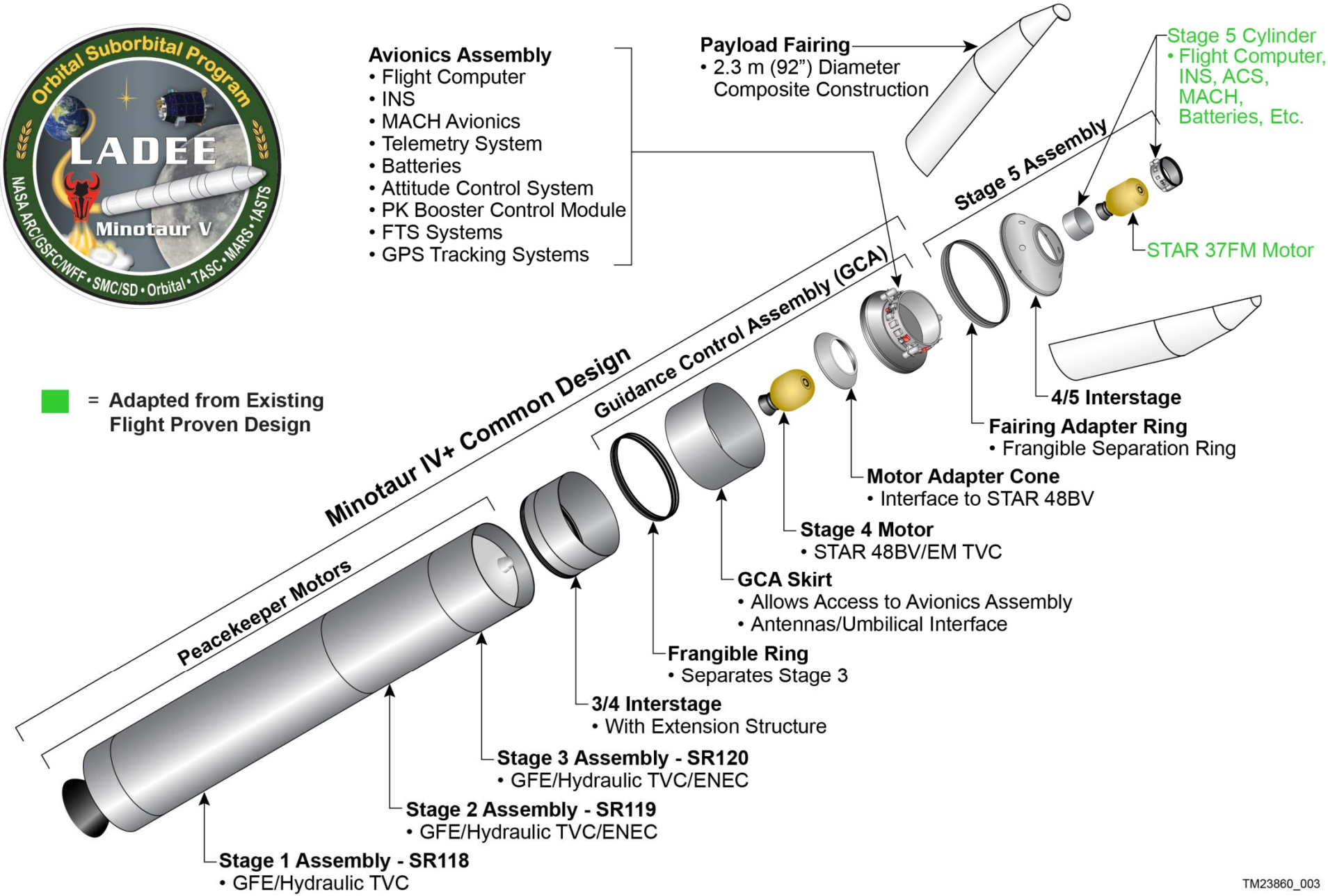
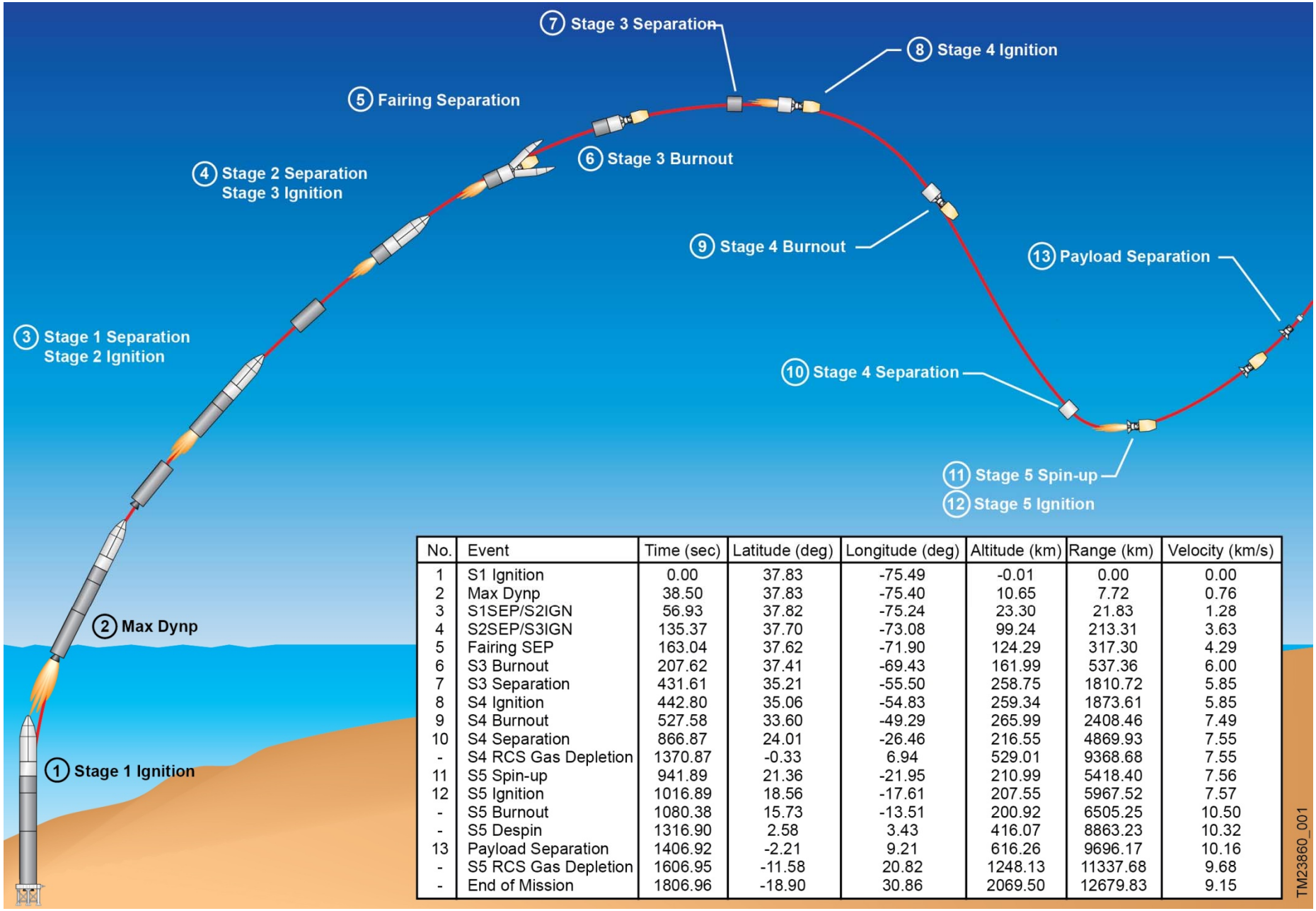
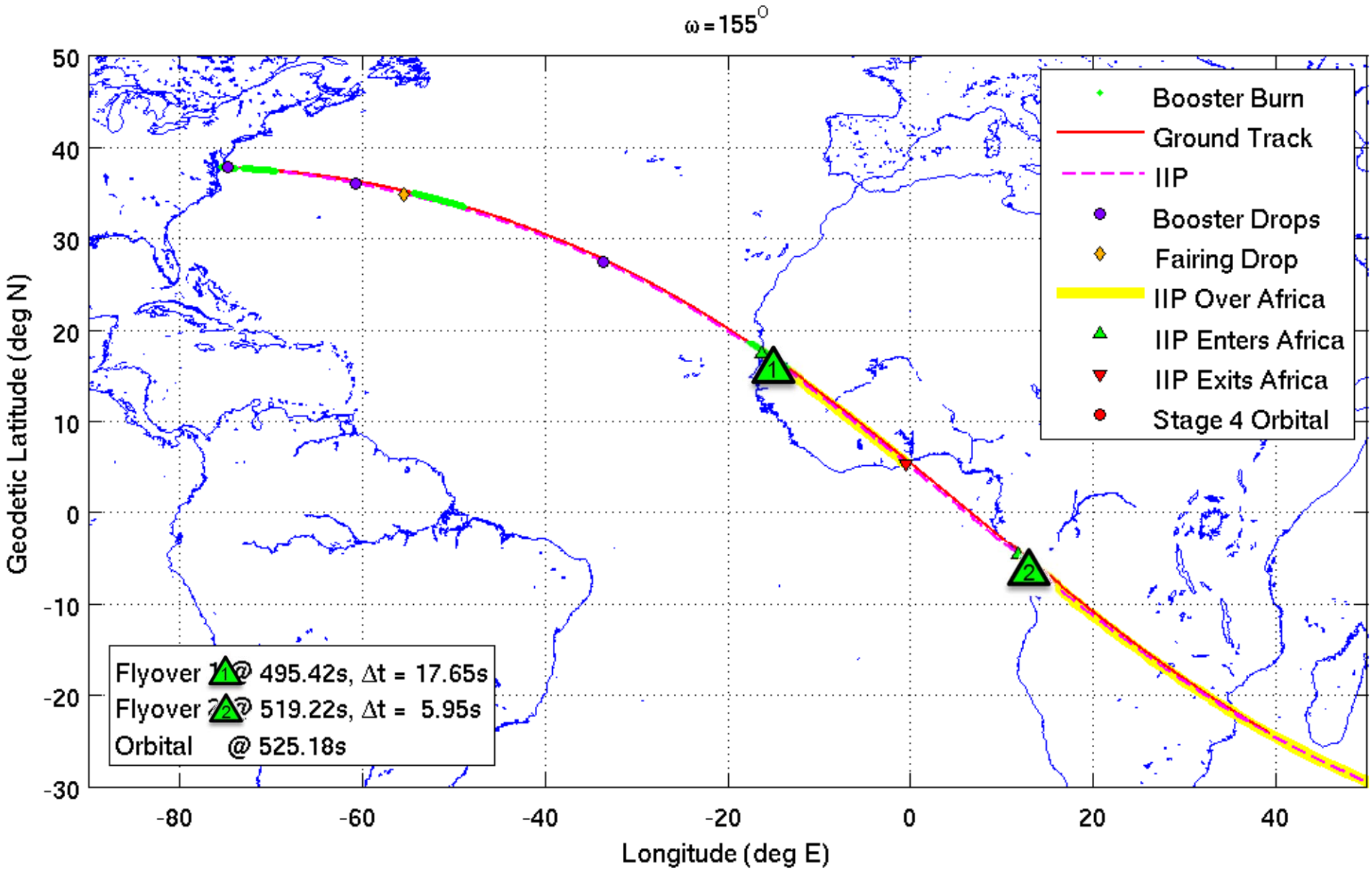


LADEE Mission Trajectory and Timeline



No.	Event	Time (sec)	Latitude (deg)	Longitude (deg)	Altitude (km)	Range (km)	Velocity (km/s)
1	S1 Ignition	0.00	37.83	-75.49	-0.01	0.00	0.00
2	Max Dynp	38.50	37.83	-75.40	10.65	7.72	0.76
3	S1SEP/S2IGN	56.93	37.82	-75.24	23.30	21.83	1.28
4	S2SEP/S3IGN	135.37	37.70	-73.08	99.24	213.31	3.63
5	Fairing SEP	163.04	37.62	-71.90	124.29	317.30	4.29
6	S3 Burnout	207.62	37.41	-69.43	161.99	537.36	6.00
7	S3 Separation	431.61	35.21	-55.50	258.75	1810.72	5.85
8	S4 Ignition	442.80	35.06	-54.83	259.34	1873.61	5.85
9	S4 Burnout	527.58	33.60	-49.29	265.99	2408.46	7.49
10	S4 Separation	866.87	24.01	-26.46	216.55	4869.93	7.55
-	S4 RCS Gas Depletion	1370.87	-0.33	6.94	529.01	9368.68	7.55
11	S5 Spin-up	941.89	21.36	-21.95	210.99	5418.40	7.56
12	S5 Ignition	1016.89	18.56	-17.61	207.55	5967.52	7.57
-	S5 Burnout	1080.38	15.73	-13.51	200.92	6505.25	10.50
-	S5 Despin	1316.90	2.58	3.43	416.07	8863.23	10.32
13	Payload Separation	1406.92	-2.21	9.21	616.26	9696.17	10.16
-	S5 RCS Gas Depletion	1606.95	-11.58	20.82	1248.13	11337.68	9.68
-	End of Mission	1806.96	-18.90	30.86	2069.50	12679.83	9.15

Nominal Trajectory – Ground Track



Minotaur Family of Space Launch Vehicles Configuration and Performance Overview

Minotaur Space Launch Vehicles Overview

Designed to provide reliability, flexibility and cost-effective access to space for government sponsored payloads

Minotaur Family of Launch Vehicles

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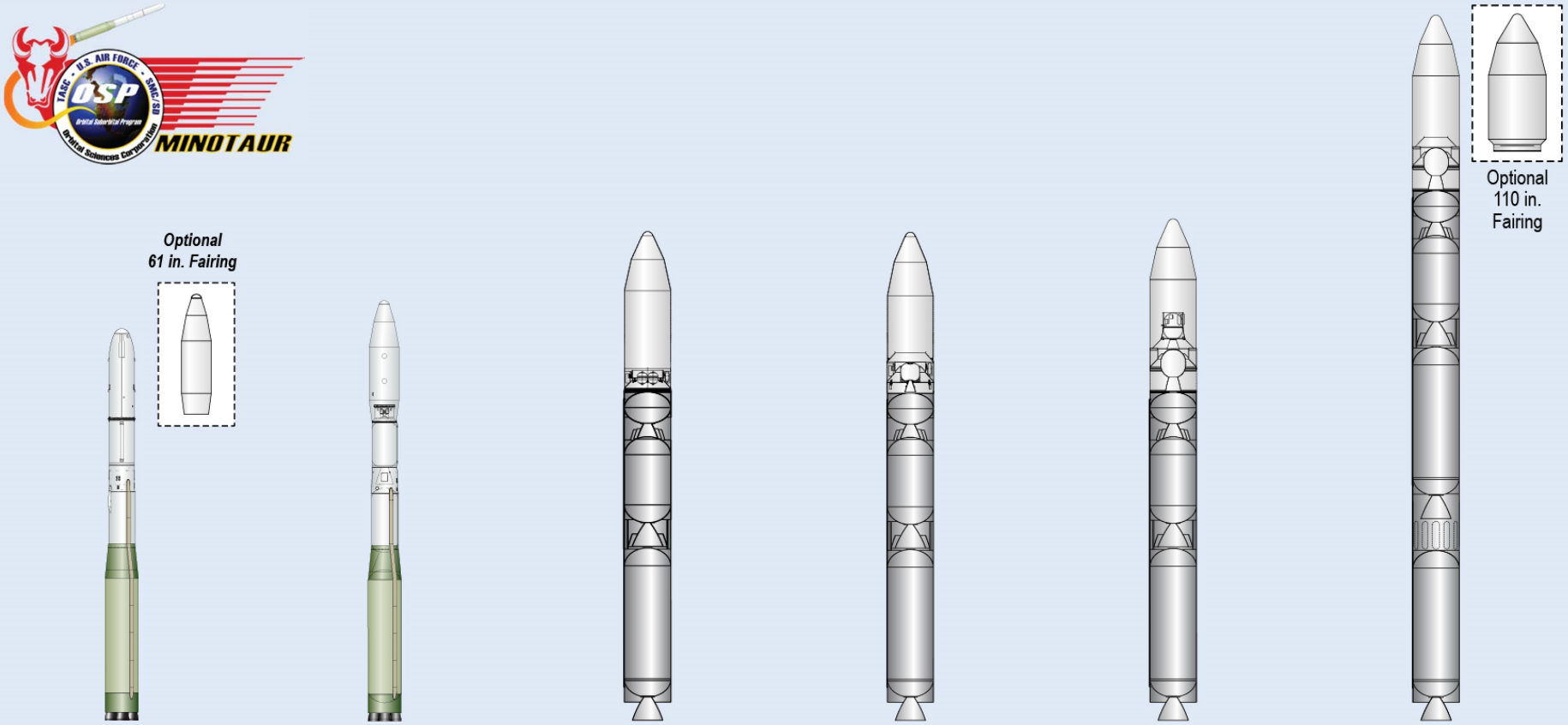

	Minotaur I	Minotaur I Lite	Minotaur IV Lite	Minotaur IV	Minotaur V	Minotaur VI
S1	M55A1 (GFE)	M55A1 (GFE)	SR-118 S1 (GFE)	SR-118 S1 (GFE)	SR-118 S1 (GFE)	SR-118 S1 (GFE)
S2	SR 19 (GFE)	SR 19 (GFE)	SR-119 S2 (GFE)	SR-119 S2 (GFE)	SR-119 S2 (GFE)	SR-118 S2 (GFE)
S3	Orion 50XL	Orion 50XL	SR-120 S3 (GFE)	SR-120 S3 (GFE)	SR-120 S3 (GFE)	SR-119 S3 (GFE)
S4	Orion 38	(N/A)	Super HAPS	Orion 38 (STAR 48BV Optional)	STAR 48BV	SR-120 S4 (GFE)
S5	HAPS (Optional)	(N/A)	(N/A)	HAPS (Optional)	STAR 37	STAR 48BV
S6	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	STAR 37 (Optional)*
Application	***Spacelift***	***Suborbital/Target***	***Suborbital/Target***	***Spacelift***	***MTO/GTO/Lunar***	***LEO/MTO/GTO/Lunar***
Performance:						
	584 kg to LEO	680 kg Ballistic	3000 kg Ballistic	1591 kg to LEO (1837 kg w/Star 48BV)	650 kg to MTO 532 kg to GTO 342 kg to TLI	3144 kg to LEO 1025 kg to MTO* 866 kg to GTO* 560 kg to TLI*

LEO = 200 km, 28.5°
Ballistic = VAFB to RTS (6,600 km, 20° Reentry Angle)

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Orbital Suborbital Program (OSP) Organization

US Government Customer/ Sponsored Spacecraft

USAF SMC SD
Launch Systems Division (SMC/SDL)

SMC/SDL Technical and Ops Support

Minotaur I Family
Minuteman - based
Launch Vehicles

Commonality

- *Avionics*
- *Subsystems*
- *GSE*
- *Processes*

Minotaur IV, V, and VI
Peacekeeper - based
Launch Vehicles

Minotaur Launch Vehicle System Features

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- Provides substantial payload performance into a variety of low inclination low-Earth orbits (LEO), sun-synchronous, and intermediate transfer orbits
- 1.27 to 2.3 meter fairings accommodate a range of payloads
- Streamlined vehicle/payload integration and testing via simplified avionics interfaces and payload encapsulation
- Incorporates proven government and commercial solid propulsion systems
- 23 successful missions with multiple configurations from 2000 through 2011
- Launch availability from existing ranges or austere sites accommodates low or high inclination orbits

Minotaur austere approach to operations requires minimal pad infrastructure and solid boosters significantly improve launch responsiveness and minimizes launch pad integration timelines

Minotaur Launch Vehicle Launch Sites

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Common Equipment
- Portable Control Consoles
- Demonstrate Emplacement
- Supports all Sites

Minotaur IV – 2 Missions

KODIAK LAUNCH COMPLEX
Kodiak Island, AK

Minotaur I – 4 Missions
Minotaur I Planned – 1 Mission
Minotaur V Planned – 1 Mission

VIRGINIA SPACE FLIGHT CENTER
Wallops Island, VA
- Commercial Launch Sites at NASA's Wallops Flight Facilities

WESTERN RANGE
Vandenberg AFB, CA
- Government Launch Sites
- California Spaceport SSI CLF

Pad infrastructure In Place to Support Minotaur Missions

EASTERN RANGE
Patrick AFB, FL
- Government Launch Sites
- Spaceport Florida

Minotaur I – 6 Missions
Minotaur II – 8 Missions
Minotaur IV – 3 Missions
Minotaur IV Planned – 1 Mission

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OSP Flight History and Firm Manifest

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23 Missions Successfully Launched in 2000-2011

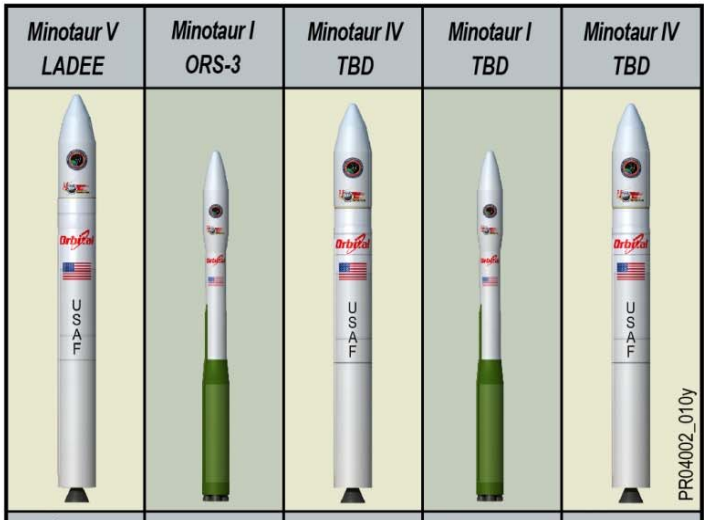
Minotaur I JAWSAT	Minotaur II TLV-Demo	Minotaur I MightySat	Minotaur II IFT-7/TLV-1	Minotaur II IFT-8/TLV-2	Minotaur II IFT-9/TLV-3	Minotaur II IFT-10/TLV-4	Minotaur I XSS-11	Minotaur I STP-R1	Minotaur I COSMIC	Minotaur I TacSat-2	Minotaur II TLV-5	Minotaur I NFIRE	Minotaur II+ TLV-7	Minotaur II+ TLV-8
26 Jan 2000	28 May 2000	19 July 2000	3 Dec 2001	15 Mar 2002	15 Oct 2002	11 Dec 2002	11 Apr 2005	22 Sep 2005	14 Apr 2006	16 Dec 2006	20 Mar 2007	24 Apr 2007	23 Aug 2007	23 Sep 2008

6 Launches In 1 Year

Minotaur I TacSat-3	Minotaur IV Lite - HTV-2A	Minotaur IV SBSS	Minotaur IV STP-S26	Minotaur I NROL-66	Minotaur I ORS-1	Minotaur IV Lite - HTV-2B	Minotaur IV+ TacSat-4
19 May 2009	22 Apr 2010	25 Sep 2010	19 Nov 2010	6 Feb 2011	29 Jun 2011	11 Aug 2011	27 Sep 2011

3 in <90 Days

5 Missions for 2012-2016 Launches



Minotaur V LADEE	Minotaur I ORS-3	Minotaur IV TBD	Minotaur I TBD	Minotaur IV TBD
3rdQ 2013	4thQ 2013	4thQ 2015	2ndQ 2016	4thQ 2016