



CubeSat Mission Integration: A Launch Vehicle Perspective

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Minotaur Launch Vehicles

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Innovation You Can Count On™

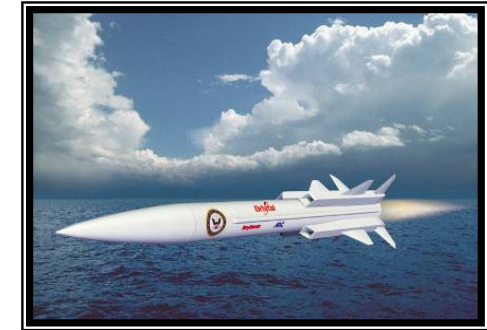


Agenda



- Orbital's Historical Perspective
- Recent and Current CubeSat Missions
- Sage Advice from the Rocket Guys

Launch Vehicle Products



Space Launch Vehicles

Interceptor Launch Vehicles

Target Launch Vehicles

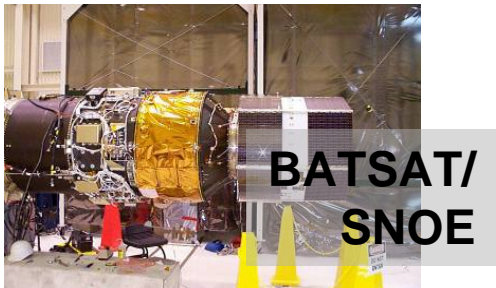
- In the Last 25 Years, the Company Has Developed and Built, or Is Now Under Contract to Produce, 610 Launch Vehicles
 - 433 Launch Vehicles Built and Delivered During 1982-2006
 - 177 Additional Vehicles Under Contract for 2007-2014 Deliveries
- Orbital's Main Launch Vehicles Are Fully Developed and In Production
 - 98% Full Mission Success Achieved Over Last 10 Years
 - 100% Full Mission Success Achieved Over Last 5 Years

Orbital's Multiple Payload Space Launch Experience



- Orbital Has Averaged >2 Spacecraft/Mission Across All Space Launch Missions
 - 37 Pegasus Missions, 81 Spacecraft: >2/Mission
 - 7 Taurus Missions, 11 Spacecraft: ~1.4/Mission
 - 7 Minotaur I Missions, 16 Spacecraft: ~2.3/Mission
 - 24 Spacecraft, 3.4/Mission if six picosats separated from OPAL spacecraft (JAWSAT mission) and two from MightySat are counted

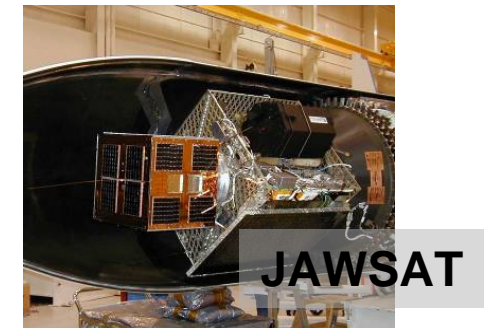
Pegasus



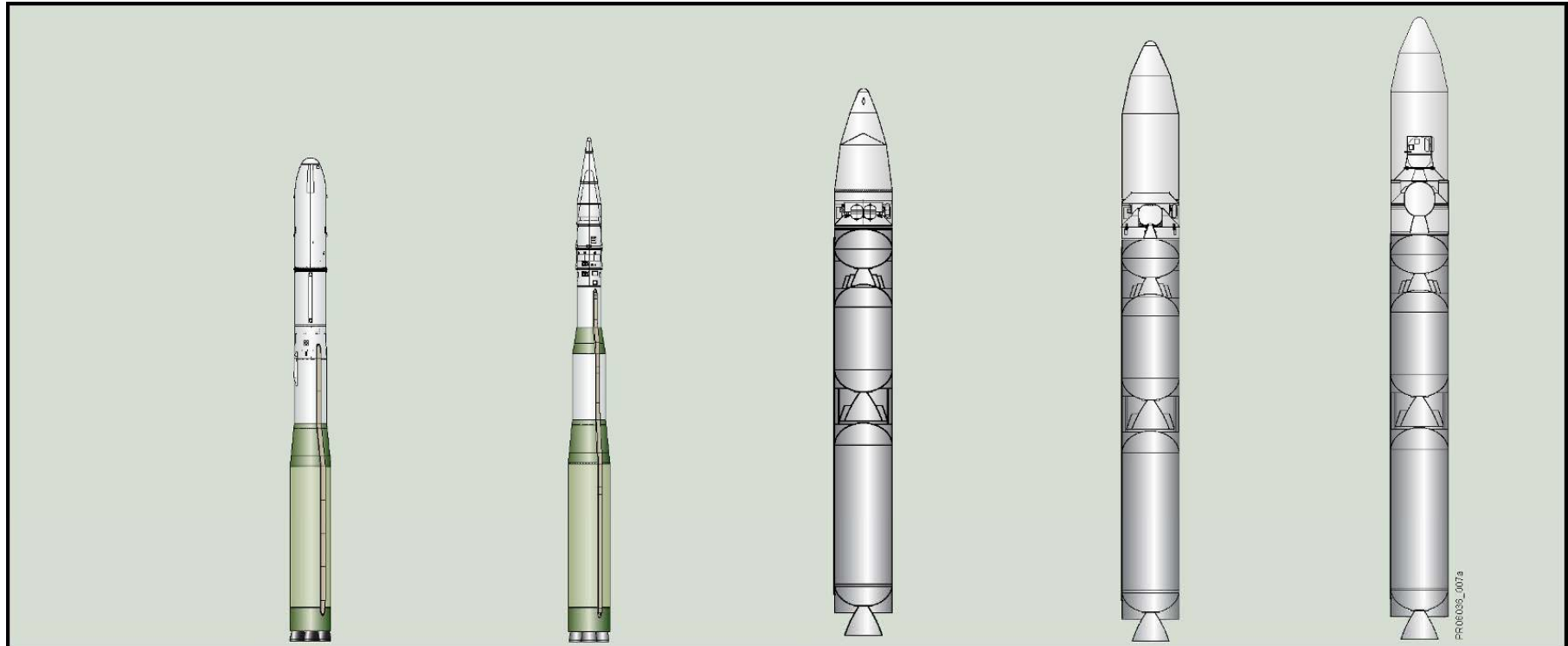
Taurus



Minotaur I



Minotaur Family of Launch Vehicles



	Minotaur I	Minotaur II	Minotaur III	Minotaur IV	Minotaur V
S1	M55A1 (GFE)	M55A1 (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)
S3	Orion 50XL	M57 (GFE) (Orion 50XL Optional)	SR-120 S3 (GFE)	SR-120 S3 (GFE)	SR-120 S3 (GFE)
S4	Orion 38	(N/A)	Super HAPS	Orion 38 (Star 48V Optional)	Star 48V
S5	HAPS (Optional)	(N/A)	(N/A)	HAPS (Optional)	Star 37FMV
Application	Spacelift	Suborbital/Target	Suborbital/Target	Spacelift	MTO/GTO/Lunar
Performance:					
	581 kg to LEO Larger Fairing Optional	441 kg Ballistic (524 kg w/Orion 50XL) Larger Front End Optional	3064 kg Ballistic Larger Fairing Optional	1724 kg to LEO (2002 kg w/Star 48V)	700 kg to MTO (GPS) 627 kg to GTO 415 kg to TLI
LEO = 185 km, 28.5° Ballistic = VAFB to RTS					

Minotaur Family Flight History and Firm Manifest

13 Missions Successfully Launched in 2000-2007

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
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

7 Missions for 2007-2009 Launches

Minotaur I TACSAT-2	Minotaur II TLV-5	Minotaur I NFIRE	Minotaur II+ TLV-7	Minotaur II+ TLV-8	Minotaur I TacSat-3	Minotaur II TLV-6	Minotaur IV SBSS	Minotaur IV Lite - HTV-2	Minotaur IV Lite - HTV-2
16 Dec 2006	20 Mar 2007	24 Apr 2007	3rdQ 2007	4thQ 2007	4thQ 2007	TBS	4thQ 2008	4thQ 2008	2ndQ 2009

TBS = To Be Scheduled

Minotaur I TacSat-2 ORS Demonstration

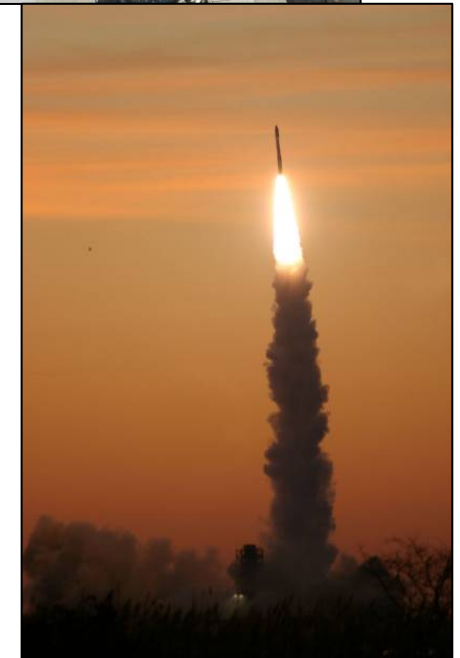


- **Operationally Responsive Space (ORS) Demonstration**

- Rapid Launch Vehicle Build and Call-up (<7 Months)
 - Utilized Existing Long-Lead Hardware
- Timed Critical Operations for ORS Baseline
 - Demonstrated 6 Day Integration (24/7)
- Stood-by “On Alert” for 5 Days While Spacecraft Issues Were Resolved and Launched When Called-up

- **Multiple “Firsts” Demonstrated While Meeting Compressed Launch Integration Timeline**

- First Minotaur I Mission From Wallops
- First Flight Larger 61 Inch Diameter Minotaur I Fairing
- Four Month Integration of NASA Ames GeneSat-1 Secondary Pico-spacecraft:
- RocketCam™ Onboard Video
- Tightest Orbital Accuracy Requirement to Date for Minotaur I



Secondary Payload – NASA Ames GeneSat and Poly PicoSat Orbital Deployer (P-POD)



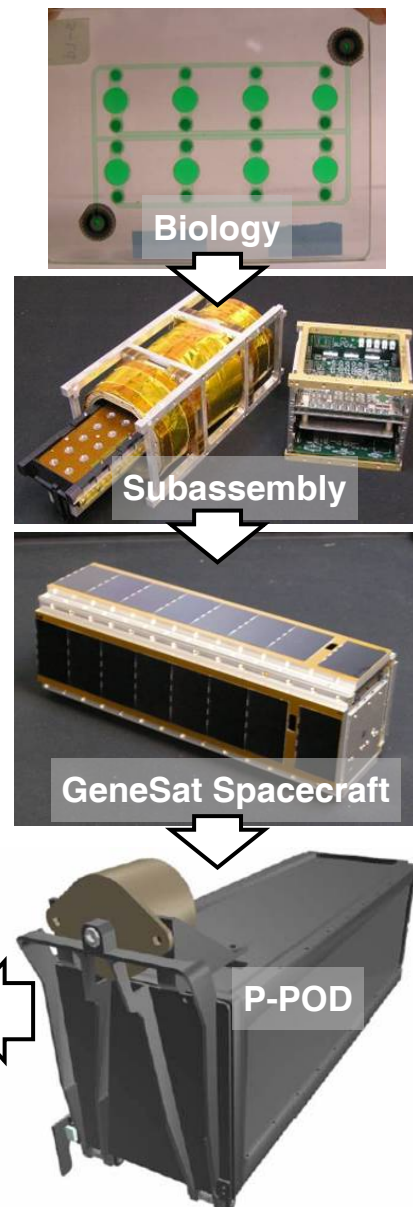
- **GeneSat-1/P-POD Integration Accomplished in Less Than 4 Months from Turn-On to Launch**
- **GeneSat-1/P-POD Sponsored by NASA Ames**
 - GeneSat-1 demonstrates the capability to conduct biologically-based investigations autonomously
 - Demonstrated P-POD integration to enable secondary payloads for future Minotaur missions
 - Established ICDs and Integration Processes
 - Support was “Best Effort Non-Interference”

- **GeneSat-1 Satellite Details**

- Deployment from P-POD after CCAM
- Size: 14 by 4 by 4 inches
- Total Mass: 4.4 kg



P-POD mounted on Stage 4



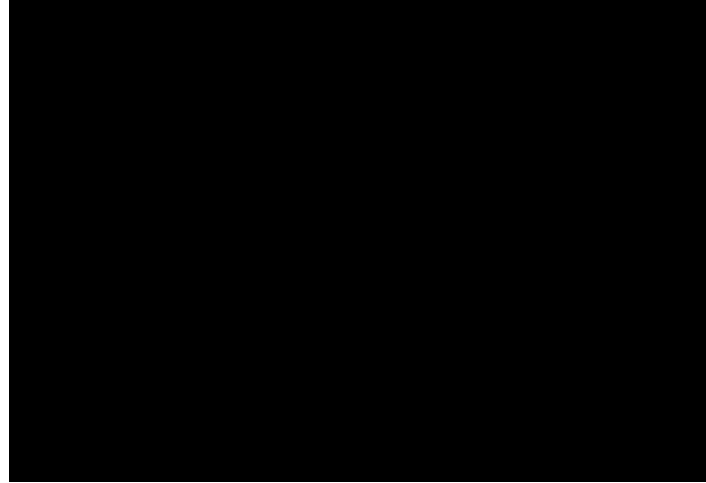
Biology

Subassembly

GeneSat Spacecraft

P-POD

TacSat-2 Launch Video



Been there, done that....what's next?



- Minotaur I TacSat-3 Mission – March 2008
 - Two P-PODS planned
 - PharmaSat (3U CubeSat for NASA Ames)
 - AFRL (3 Single CubeSats)
 - CP-X (Cal Poly)
 - AeroSat (Aerospace Corp.)
 - HawkSat
- NASA Launch Services Program Study
 - P-PODS on Taurus
- Future Opportunities...the Cat's Out of the Bag!
 - More Minotaur I and IV missions are being planned – stay tuned!
 - DoD and NASA See Value in CubeSats and are Supportive...but...
 - More Formal Manifest Process Will be Expected by Air Force and NASA
 - Air Force: Space Test Program (SDTW, Kirtland AFB, NM)
 - NASA: KSC Launch Services Program?

Advice from the (Flame) Trenches... or How to Appease Your Launch Provider



- **Four “Be P’s”:**

- 1) Be Professional**

- Biggest challenge: Convincing the primary mission/payload customer that CubeSats pose ZERO risk to their mission

- 2) Be Prepared**

- Firm ICD’s and Requirements
 - Don’t make late “tweaks”
 - Meet deadlines (documents, HW delivery, etc.)
 - Have spacecraft ready...early! (You CAN be replaced!)



- 3) Be Persistent**

- Keep trying – don’t give up if at first you don’t succeed.
 - But...see #1 above

- 4) Be Patient**

- Govm’t and Industry run at a slower clockspeed than college projects

Questions?



*Minotaur I TacSat-2 Launch
16 Dec 07
Wallops Island, VA*