

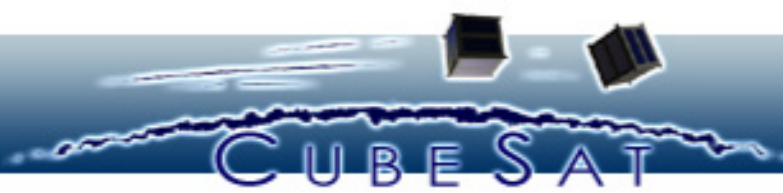


Dnepr 2 Satellite Identification and the Mk.III P-POD

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CubeSat Developers' Workshop



Dnepr Launch 2

- April 17, 2007, 6:46:35 UTC
- 7 CubeSats in 3 P-PODs
- P-POD A: CSTB1, AeroCube2, CP4
- P-POD B: MAST
- P-POD C: Libertad-1, CAPE1, CP3
- CP4, Libertad-1, and CAPE1 had beacons



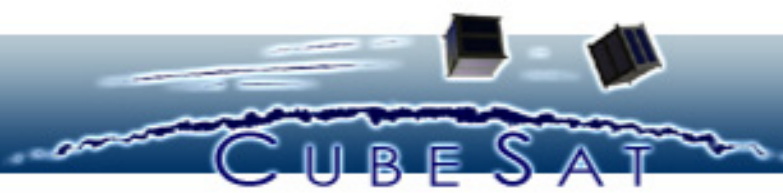
Integration Timeline

- 2 months: CubeSats delivered to Cal Poly for integration and acceptance
- 6 weeks: Ship P-PODs to launch site
- 3 weeks: Arrive at launch site, inspect P-PODs, integrate with LV
- Launch!



Integration Timeline

- Early Dec. – CubeSats shipped to Cal Poly
 - P-POD A integrated and accepted
- Mid Dec. – Launch delay
- Early Mar. – Libertad-1 arrives at Cal Poly
- Mid Mar. – P-PODs hand-carried to Baikonur
- End Mar. – Launch delay
- Mid Apr. – Launch (finally!)

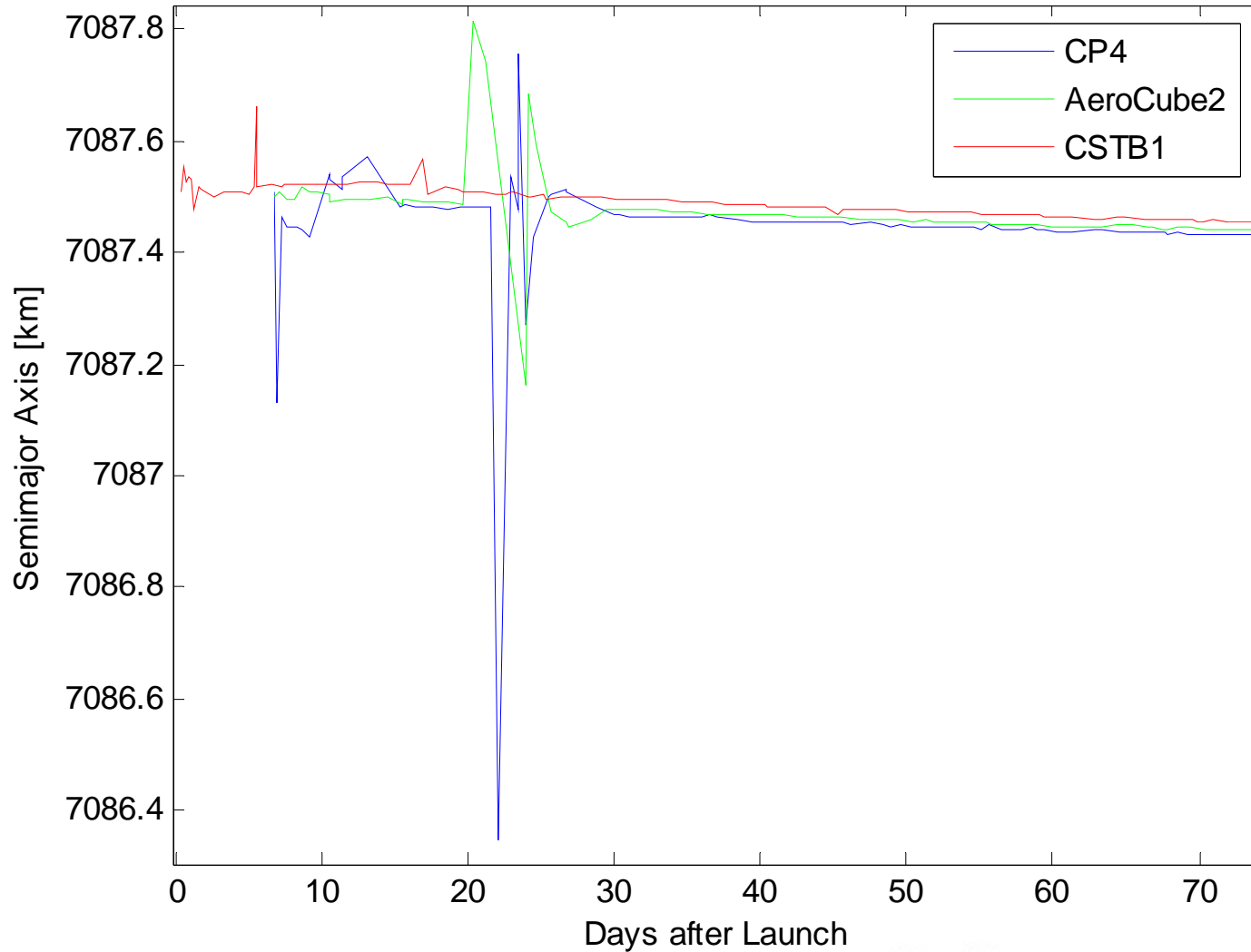


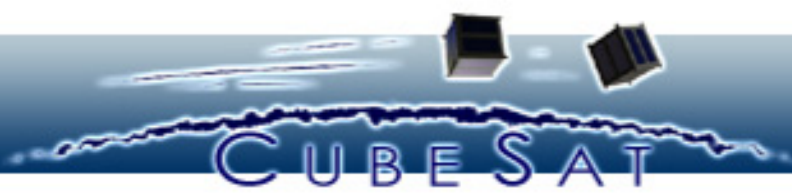
Tracking Data

- Preliminary TLEs were used to track first passes; heard all CubeSats with beacons
- First TLEs on Space Track available within 12 hours of launch
- All CubeSats independently identified after one week, most within 2 days
- Four weeks before data became consistent

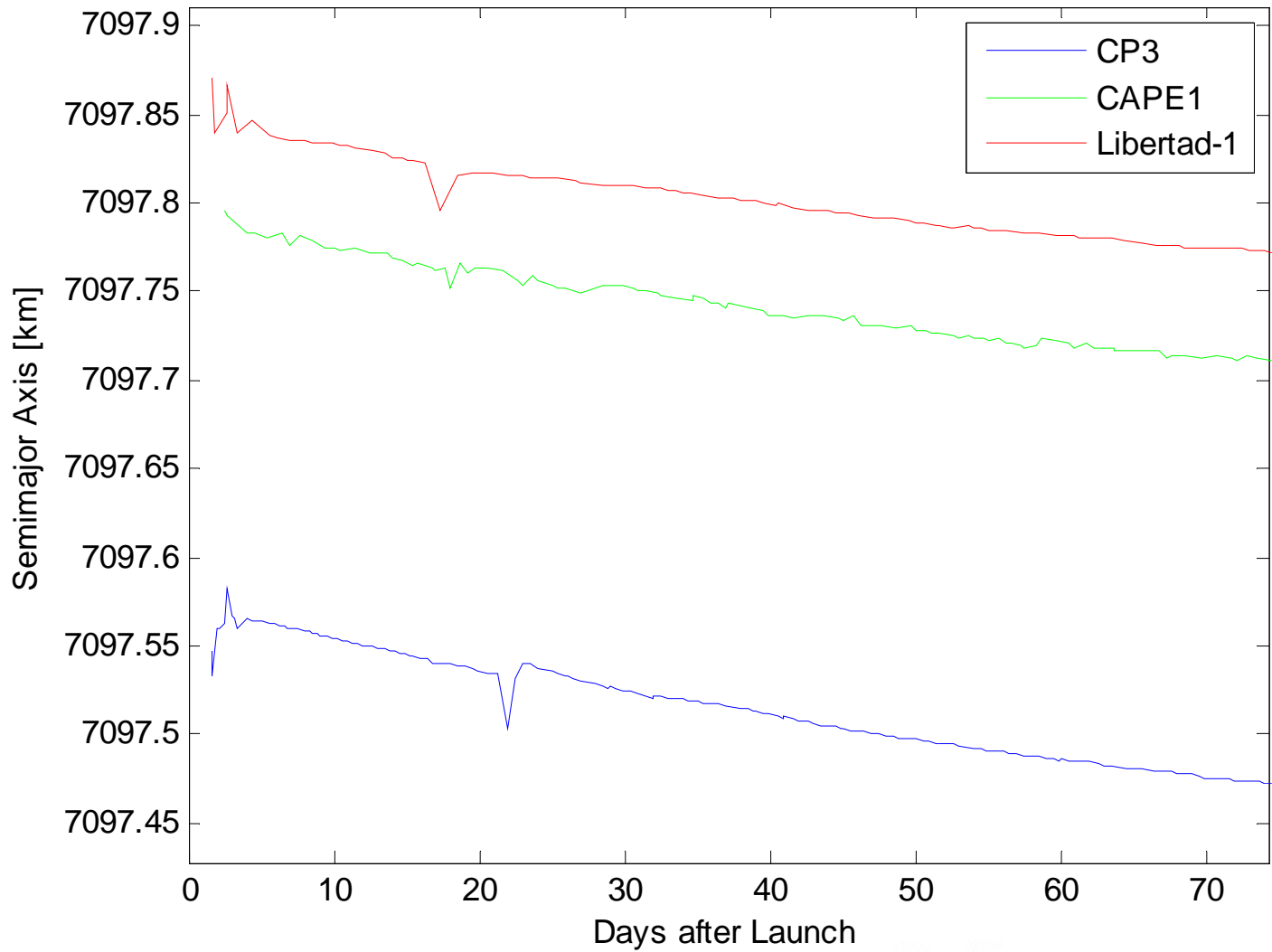


P-POD A





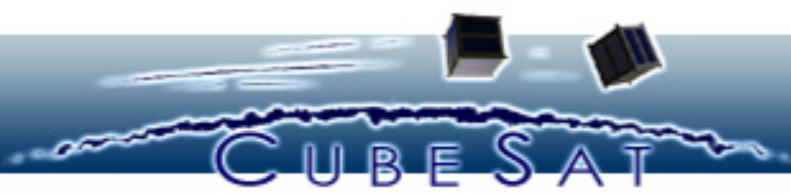
P-POD C



Separation Rates

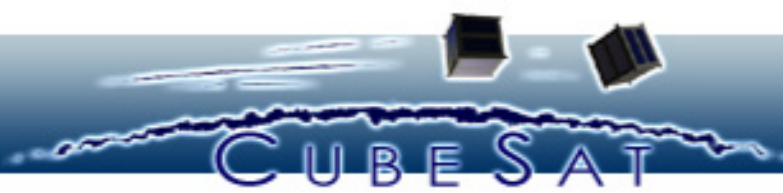
Between CubeSats	Observed Relative Speed [cm/s]
CP4/ AeroCube2	0.3
AeroCube2/ CSTB1	1.5
CP3/ CAPE1	4.9
CAPE1/ Libertad-1	2.2

- Analytical separation rates ~5 cm/s between CubeSats
- Reasons for discrepancies:
 - Friction
 - Different strength springs on CubeSats
 - Separation springs in P-POD A likely not fully compressed



Satellite Misidentification

- Order of CubeSats in cluster was still unclear after a month
- First and last CubeSats in each P-POD were interchanged when names were assigned to objects
- Problem not discovered for two months, when CP3 was contacted for the first time



Recommendations for Improvement

- Stronger separation springs to disperse CubeSats faster
- P-POD redesign allows for visual confirmation of total spring compression
- Beacons!



Poly Picosatellite Orbital Deployer

- Standard deployment system
 - Tubular frame
 - Spring assisted ejection
 - Payload of 3 single CubeSats
- P-POD mission objectives
 - Protect LV and primary payload
 - Safe/reliable deployment
 - Compatibility with many LV

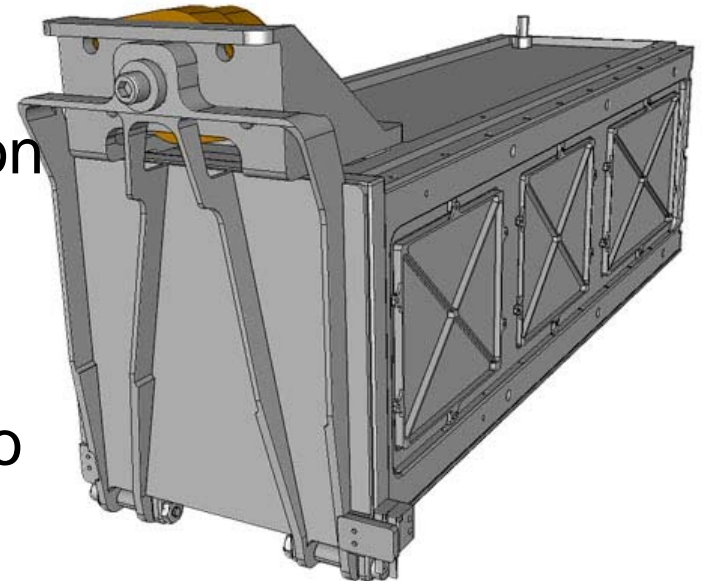




P-POD Mark III Structure

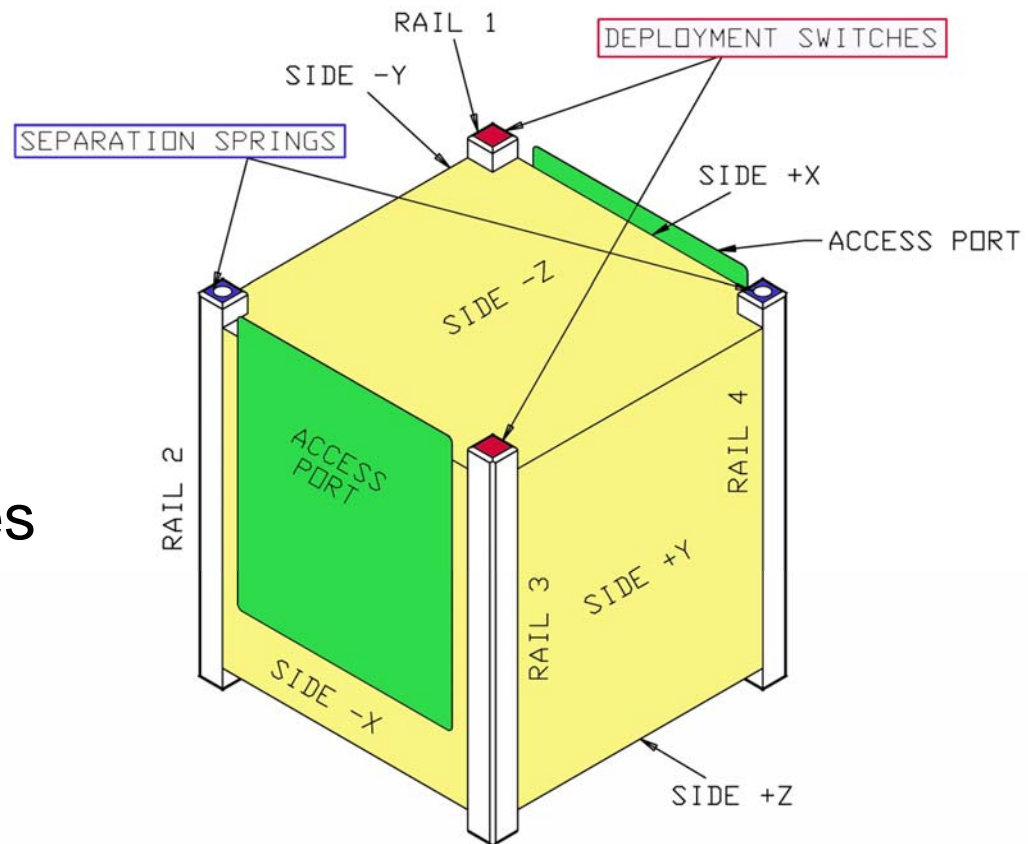
- **Mark III P-POD**

- Increased Side Panel Access to facilitate CubeSat integration process
- The Mk III can accommodate both the Qwknut and NEA 9102G release mechanisms to meet different launch vehicle requirements.
- Release door modified to account for shear relief from NEA



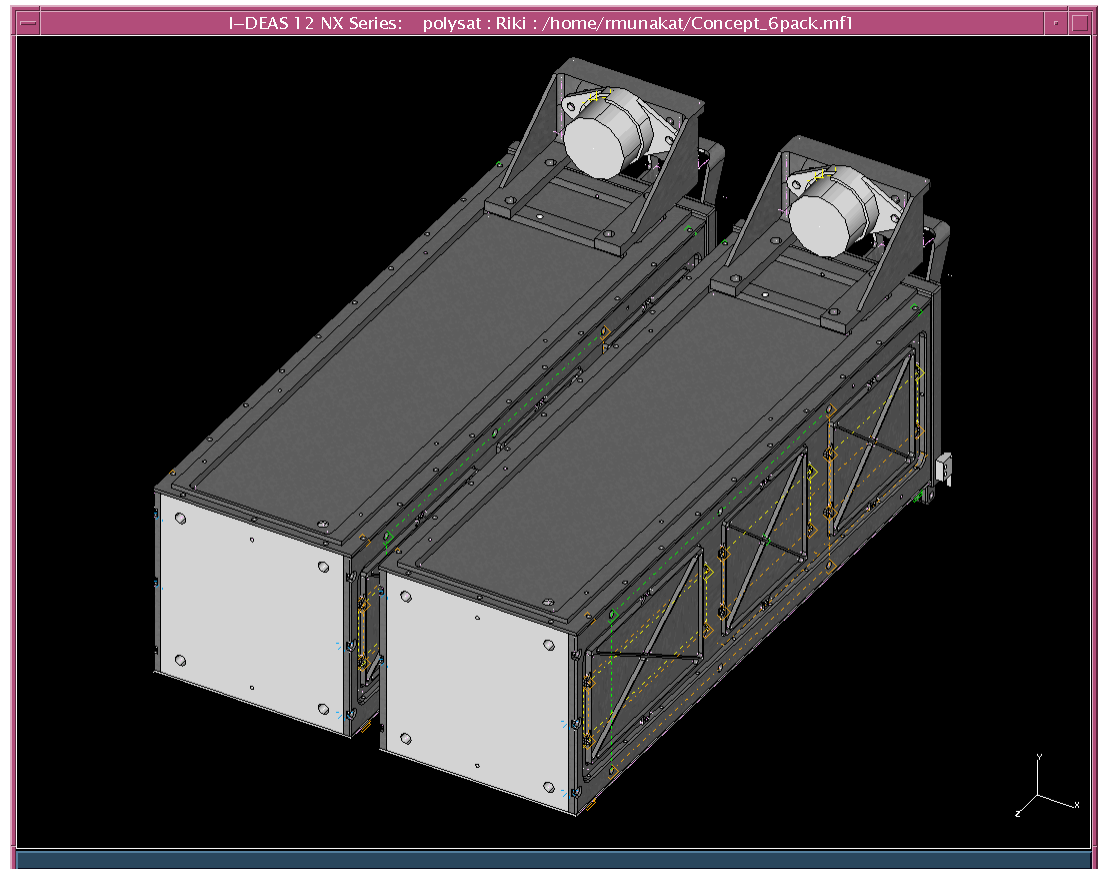
The CubeSat Standard

- Shape and size (10 cm cube)
- Mass (up to 1 kg)
- Interface to P-POD
 - Rails
 - Access ports
- Materials and tolerances
- Operations
 - Deployables
 - Communication
- Different configurations possible



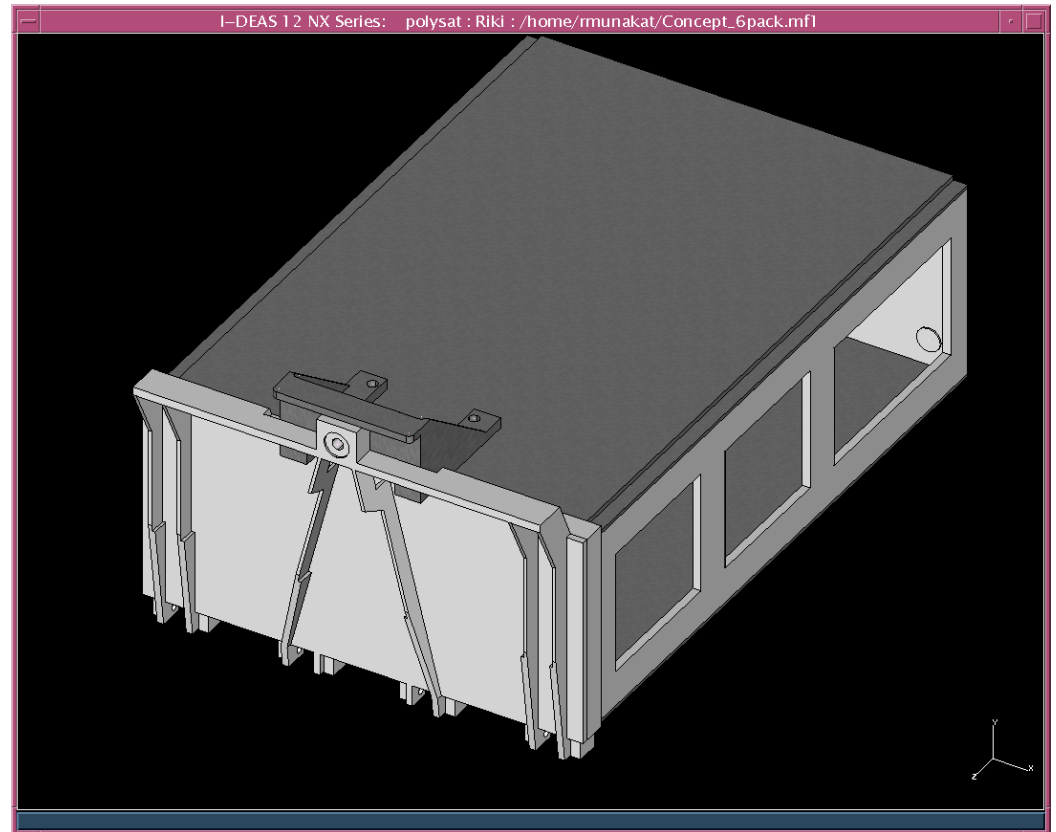
6-Pack Concept

- Larger form factor
- Fully enclosed deployer
- One NEA
- One satellite

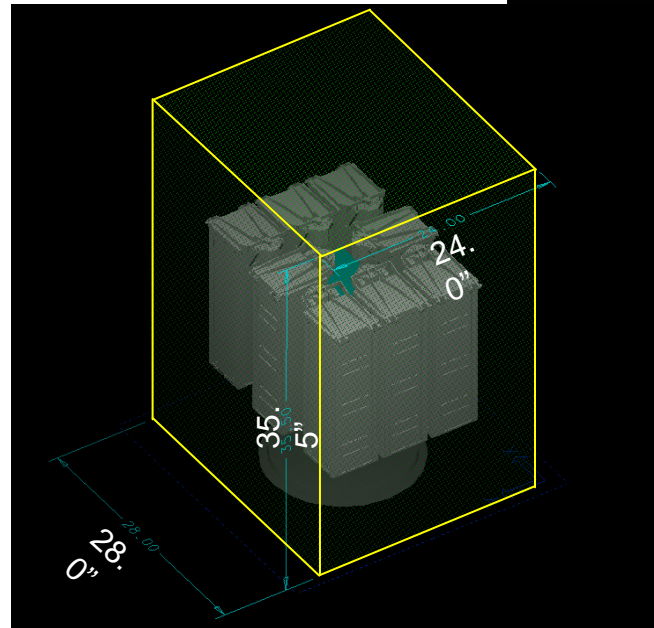
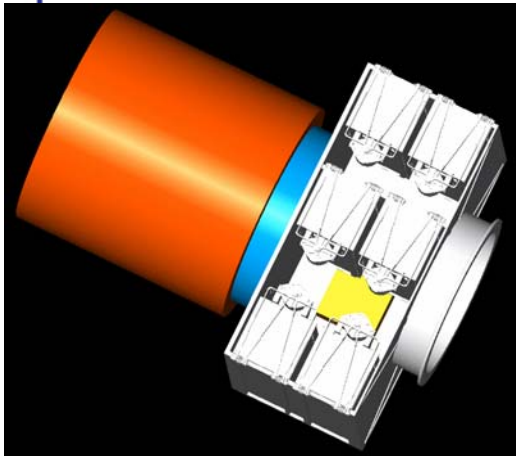
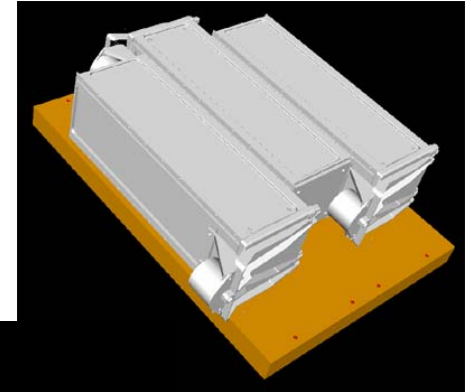
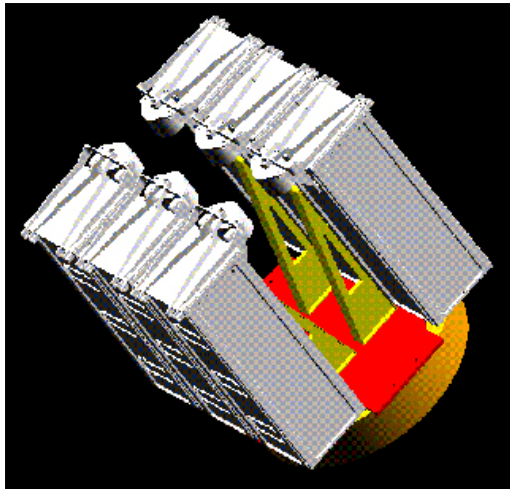


6-Pack

- Mass: +6kg
- Size: +6U

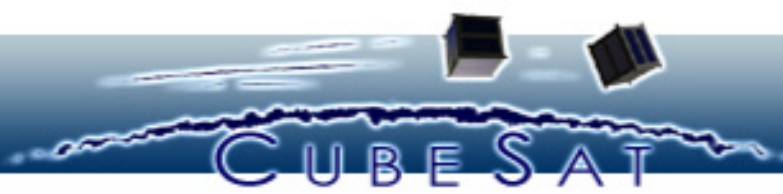


Major Domestic Launch Vehicles



Heritage

Launch	Number of P-PODS	CubeSat Missions
Eurokot	2	P-POD A: CanX-1, DTU Sat, AAU CubeSat P-POD B: QuakeSat
SSETI Express	1	CubeSat XI-V, NCUBE-2, UWE-1
Belka: Dnepr (Rocket Failure)	5	P-POD A: ION, Sacred P-POD B: KUTESat Pathfinder P-POD C: SEEDS, HAUSAT 1, Ncube 1 P-POD D: MEROPE, AeroCube-1, CP2 P-POD E: CP1, Ice Cube 2, Mea Huaka (Voyager)
TacSat-2: Minotaur	1	Modified P-POD: GeneSat-1
EgyptSat: Dnepr	3	P-POD A: CP4, AeroCube 2, CSTB 1 P-POD B: MAST P-POD C: CP3, CAPE 1, Libertad-1



Upcoming Launches

- Falcon-1 3rd flight
 - 2 P-PODs
 - NASA Ames 3U
 - NASA Marshall 3U
- Falcon-1 RazakSat
 - 2 P-PODs
- Minotaur-I TacSat 3
 - 2 P-PODs

