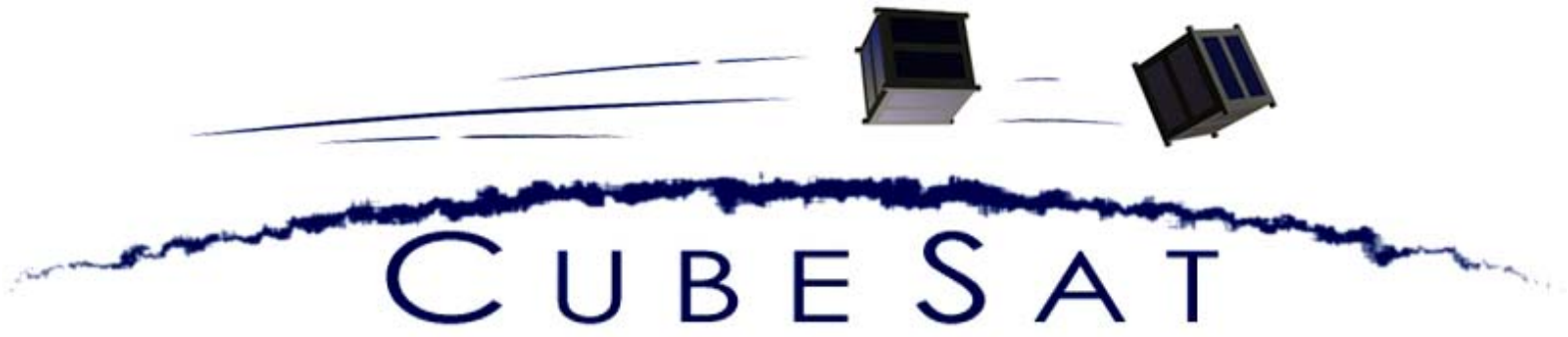


The Future for CubeSats
Present and Coming Launch Opportunities

18th Annual AIAA / USU Conference on Small Satellites
CubeSat Workshop

Presented By: Armen Toorian
California Polytechnic State University
August 8th 2004

Current Activities

- DNEPR Launch
- Schedule
- Pre–Flight Operations
- Requirements from Developers

DNEPR Spring 2004 Launch

- 4th successful mission of converted SS-18.
- Cluster launch with 9 satellites.
- High accuracy orbit insertion.

DNEPR Fall 2004 Milestones

1. September 1st
   Developer Documents due to Cal Poly
2. September 8th
   Qualification Testing of Flight P-PODs
3. September 16th
   Kosmotras Fit Check / Testing
4. October 1st
   Beginning of Integration at Cal Poly
5. October 7th
   Acceptance Testing of Flight P-PODs
6. October 14th
   Delivery of P-PODs to Kosmotras
7. October 30th

Fit Check with Kosmotras

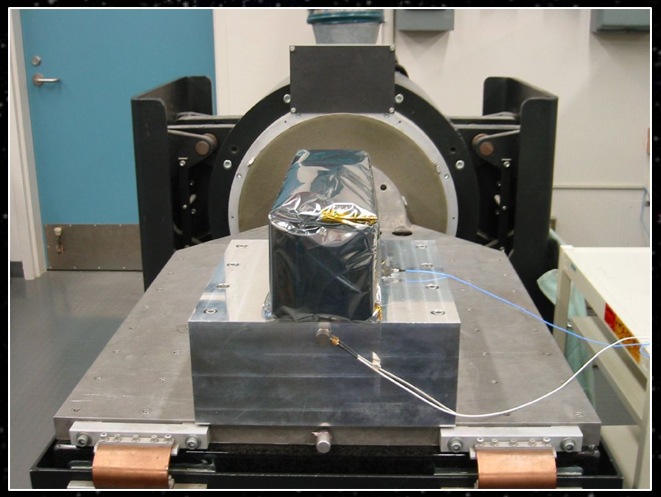
- Fit Check
  - All satellites mounted to LV together for first time.
  - Physical check of SHM layout.

- Vibration
  - Testing with fully integrated SHM.
  - P-POD mass models.

- Separation
  - Test deployment sequence and electronics.
  - Trajectory analysis.

Testing for the DNEPR Vehicle

- Qualification Requirements
  - Flight P-PODs qualified to DNEPR requirements.
    - 150% of launch levels.
    - Functional Testing and post-vibration inspection.
  - Developers must perform:
    - Vibration testing to 150% of launch levels.
    - Thermal Vacuum Bakeout.
    - Qualification MUST be done with flight hardware!
- Acceptance Testing
  - 100% of launch levels.
  - Vibration testing on integrated P-PODs.



DNEPR Fall 2004 Launch

- Developers can send 1 – 2 people to the launch.
- Trying to arrange a webcast of the launch.
- 14 CubeSats + 11 other satellites.

25 Satellites will be Deployed!

Expected Insertion Properties

- Altitude:
  650 km +/- 500 m
- Inclination:
  Within 0.01 degree
- Spin rates:
  Maximum 3 deg/sec.
- Position:
  Within 0.01 degree of ascending node.
- Redundant signals to P-POD.
- Redundant telemetry upon door opening.

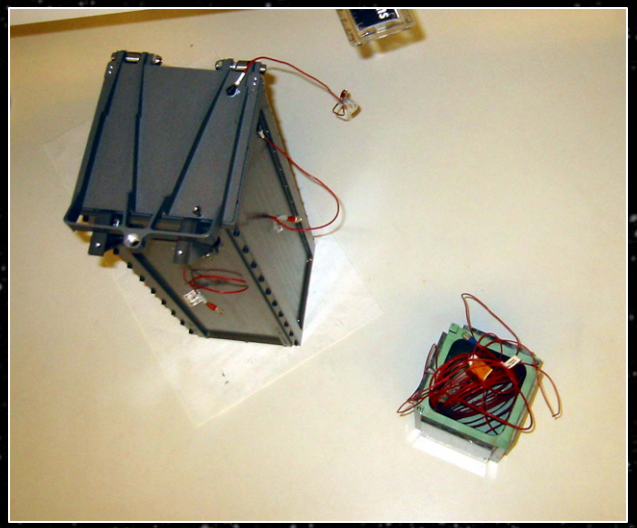
P-POD Status

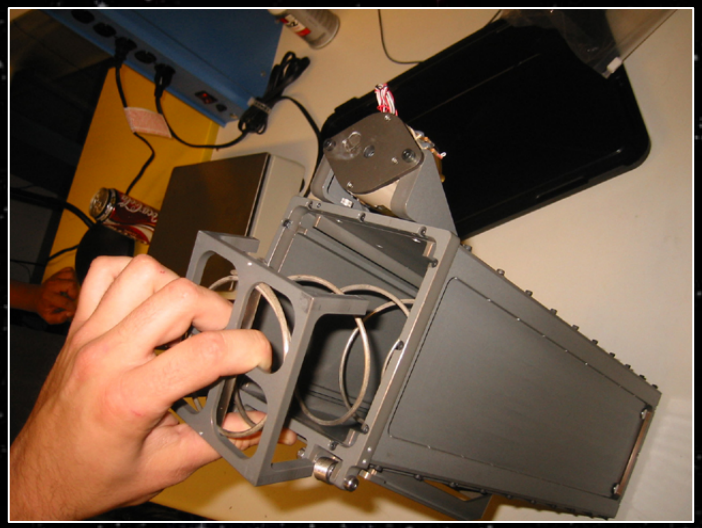
- Manufacturing Complete
- Vibration Testing
- Functional Testing
- Future Testing

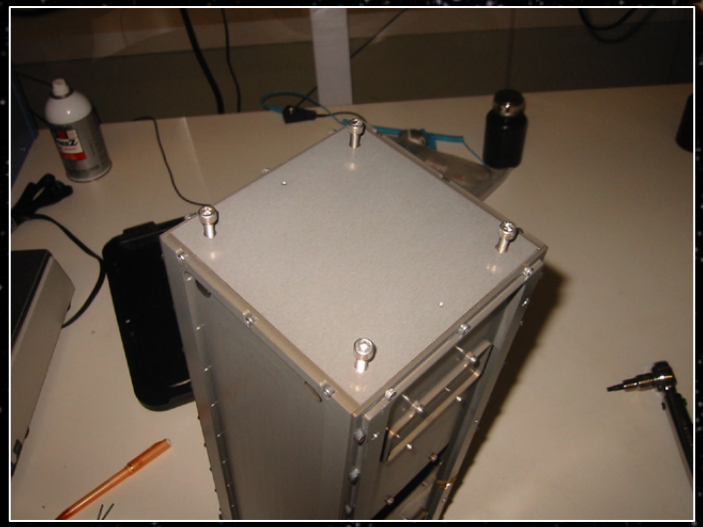
P-POD Redesign Qualification

- Testing on Engineering Unit.
  - Verification of assembly procedure.
  - Vibration Testing in June 2004 at Raytheon Facility.
    - **University of Hawaii**
    - **Montana State University**
    - **Pumpkin Inc.**
  - Functional Testing.

Vibration Testing Pictures







P-POD Mk. II

Future Plans

- Domestic Launch Capability
- Overseas Launches
- Overview of current work

Domestic Launches

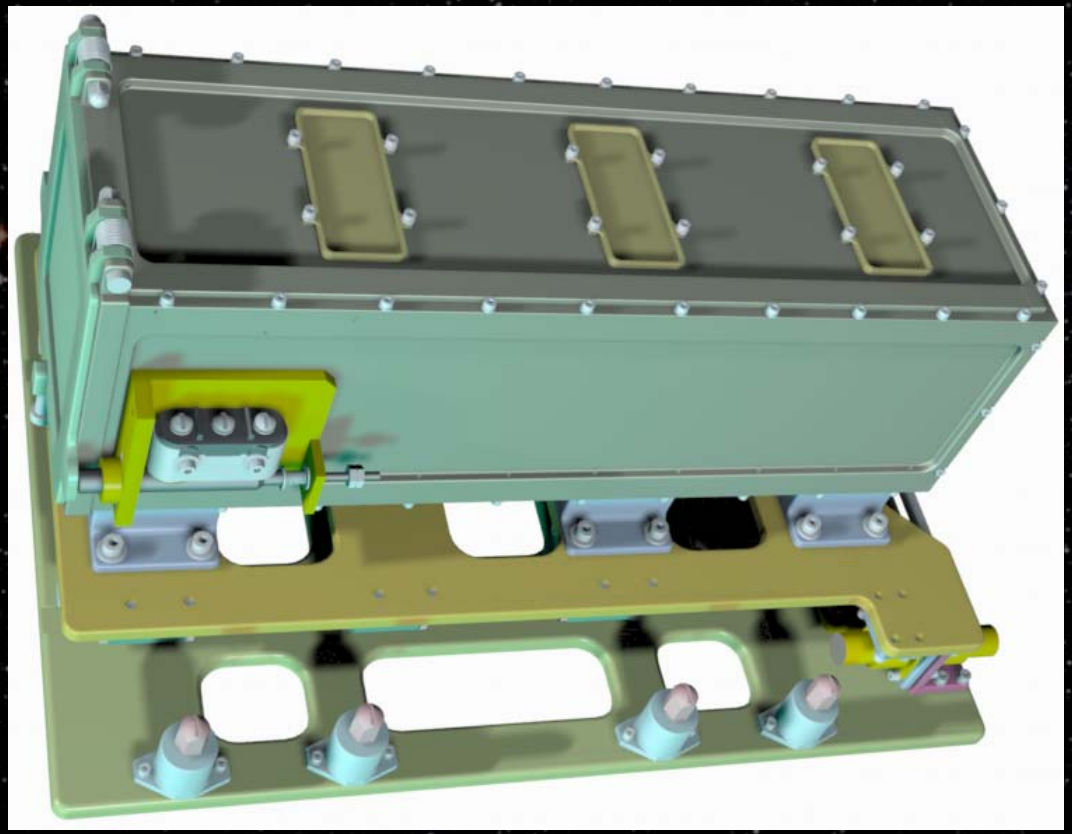
- Developing capability to launch on US vehicles.
  - Eliminate travel and export issues.
  - More students can be involved.
  - Great experience for graduating engineers.
  - Resistance from US Launch Providers / Payloads
  - Initial (NRE) Cost Barrier

DNEPR 2005 Launch

- Will continue with DNEPR Launches for now.
  - Much lower cost (NRE *and* per kilogram).
  - Access to hardware up to 7 days before launch.
  - Baikonur's beautiful scenery.

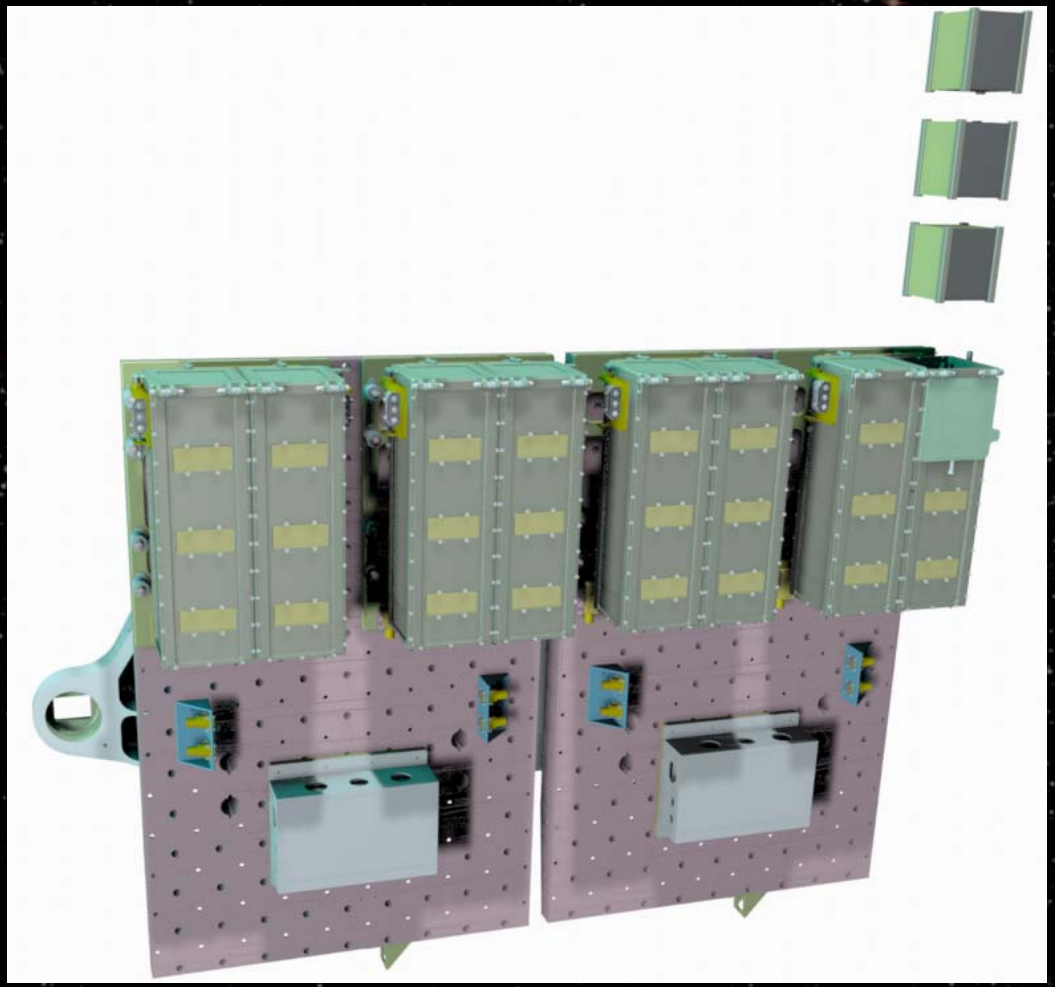
Long term opportunities.

- Space Shuttle
  - NASA contracted Swales Aerospace to do a study.



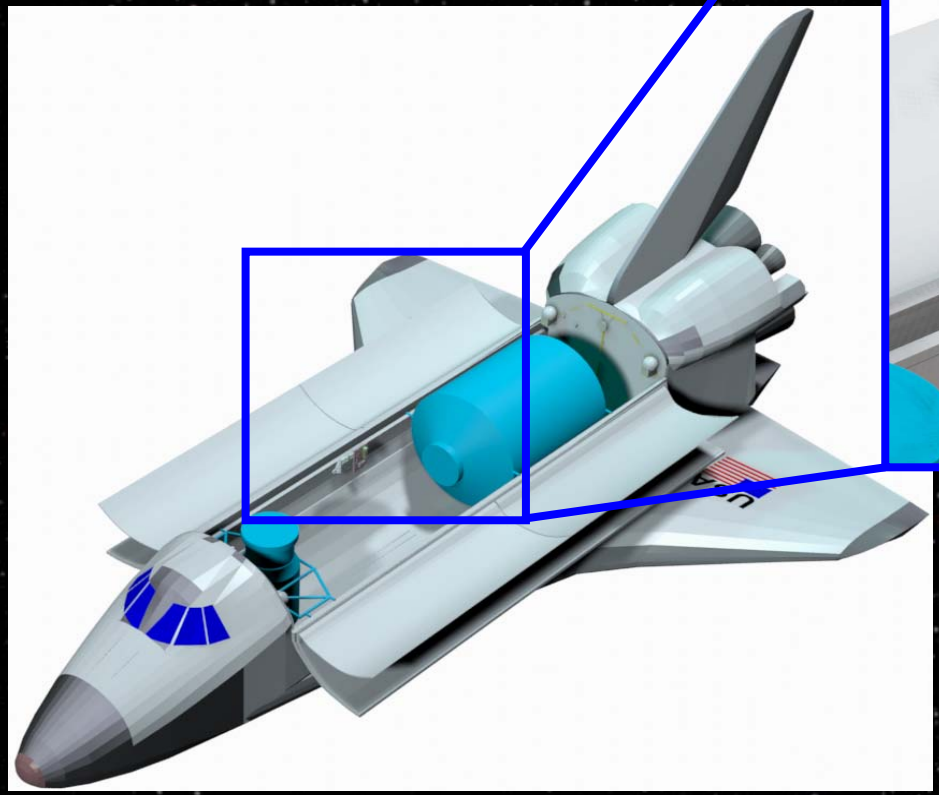
Swales P-POD Study

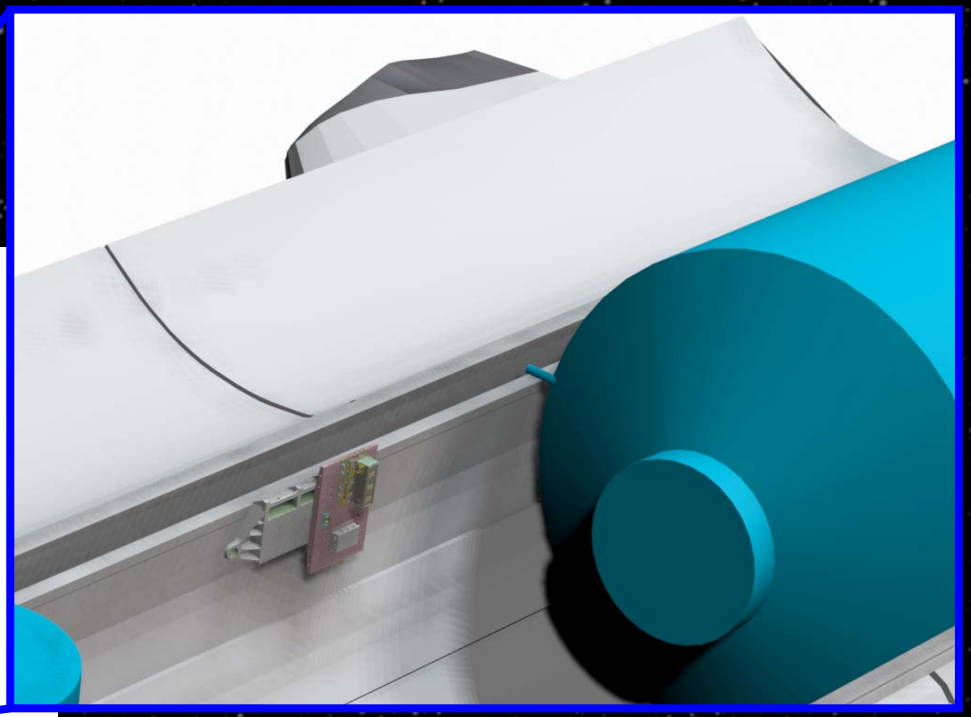
- Possible mounting scheme and payload capability.



Swales P-POD Study

Where did they go?!





Long Term Opportunities

- Orbital Sciences Pegasus
  - Good vehicle for small payloads.
  - “Dual Manifest”
  - Mostly NASA payloads.

  - Mostly NASA payloads!
  - Cost barrier.

Very Small Vehicles

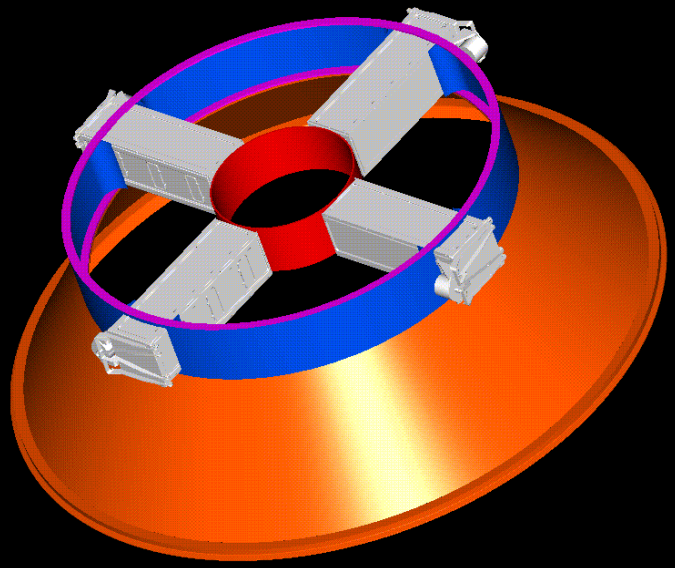
- Space Transport Company
- Nanosatellite Launch Vehicle
- SpaceDev

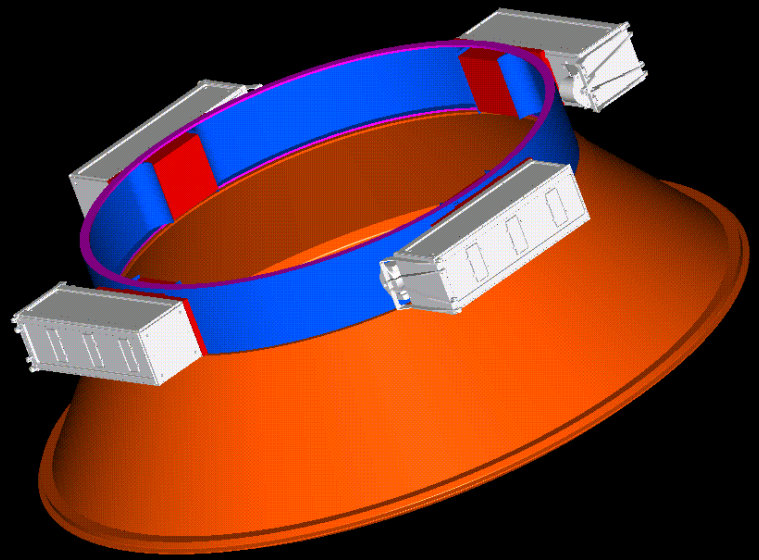
  - Very receptive to small payloads.
  - P-POD cluster can be the primary.
  - Flexible with schedule / operations.

  - Projects still in development phases.
  - Reliability not proven.

Space X Falcon I

- Working with Space X on an adapter design.
  - Four P-PODs fit on a Falcon I without infringing on primary payload volume.
  - P-POD mounts can be built into the payload adapter cone.

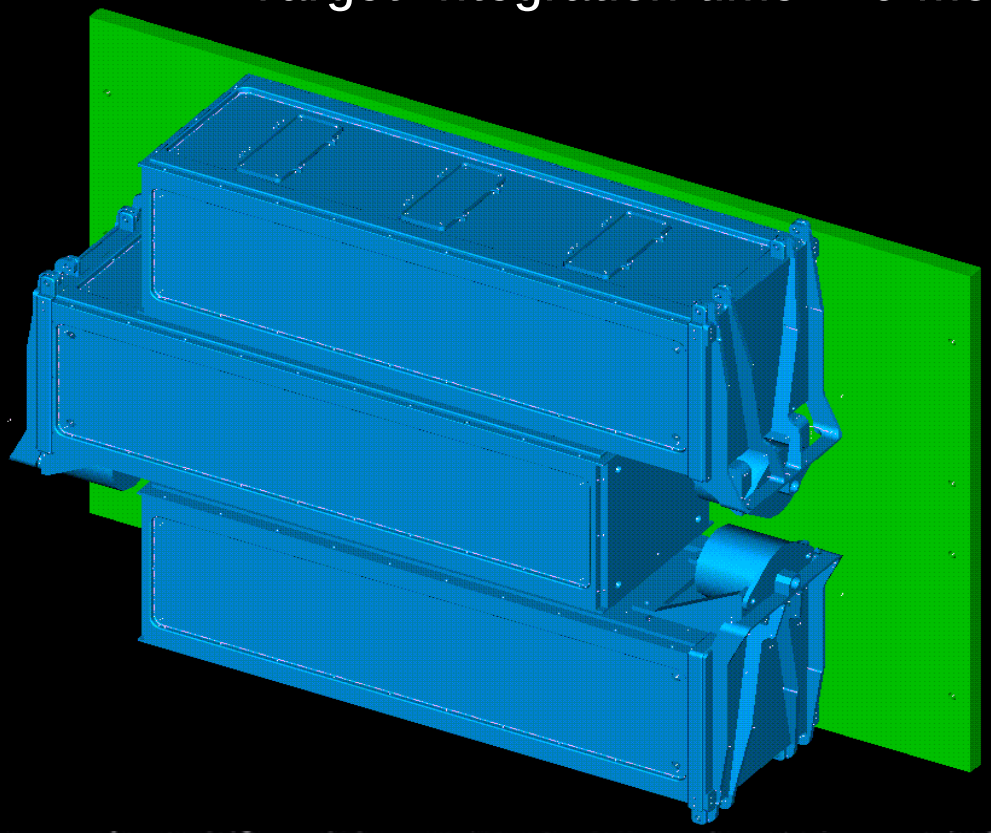


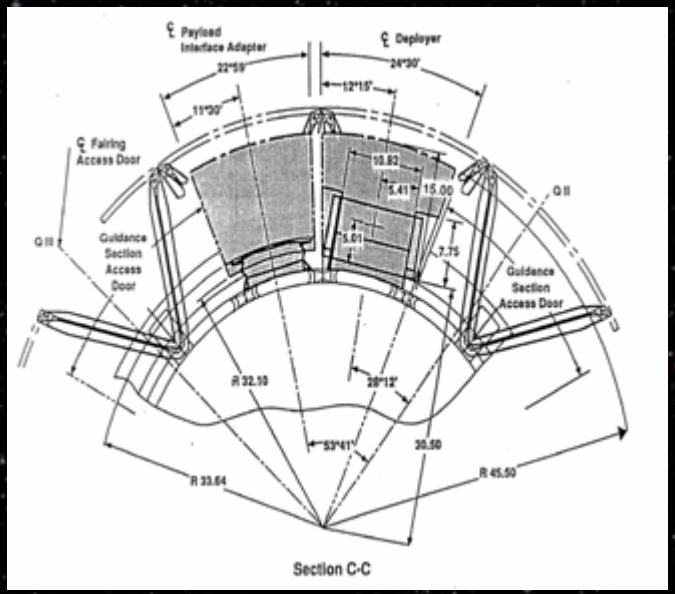


- First Space X launch scheduled for September 2004.

Boeing Delta II

- Standard Secondary Payload adapter available.
  - Have launched 26 secondary payloads to date.
  - Can fit 3 P-PODs in one secondary payload slot.
  - Target Integration time = 9 months.





Plus some interesting Delta II concepts in the works…

Support for Other Organizations

- Primary Objective: Find ways to launch CubeSats!

- Support organizations working to launch CubeSats.
  - Space Test Program
    - “the primary provider … for DoD’s most innovative space experiments…”
  - Ecliptic Enterprises
    - CubeSat deployer based on Rocket-Cam.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