

MSFC-776

NanoSail-D

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The "NanoSail-D" mission is currently scheduled for launch onboard a Falcon-1 Launch Vehicle in the early June 2008 timeframe. The NanoSail-D spacecraft will consist of a solar sail subsystem stowed in a 2U volume and a 1U spacecraft bus, provided by Ames Research Center. The primary objectives of the NanoSail-D technology demonstration mission are to fabricate, stow and deploy on-orbit a solar sail and perform a de-orbit maneuver to demonstrate a potential orbital debris mitigation technology. The NanoSail-D mission is being developed through a collaborative effort between the NASA Marshall Space Flight Center and the NASA Ames Research Center Small Spacecraft Office.

Details of the NanoSail-D system will be presented, including: 1) design details of the solar sail reflective membrane quadrants, gossamer booms, deployment system and passive attitude control system, 2) design analysis results including structural, thermal, environmental, orbital debris and safety, and 3) test results including deployment, ascent venting, launch vibration and PPOD integration verification.

NanoSail-D



SCIENCE & MISSION SYSTEMS



**CubeSat Developers' Workshop
California Polytechnic State University
San Luis Obispo, CA**

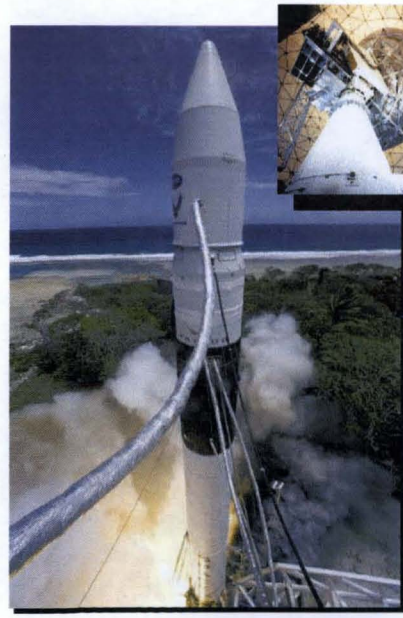
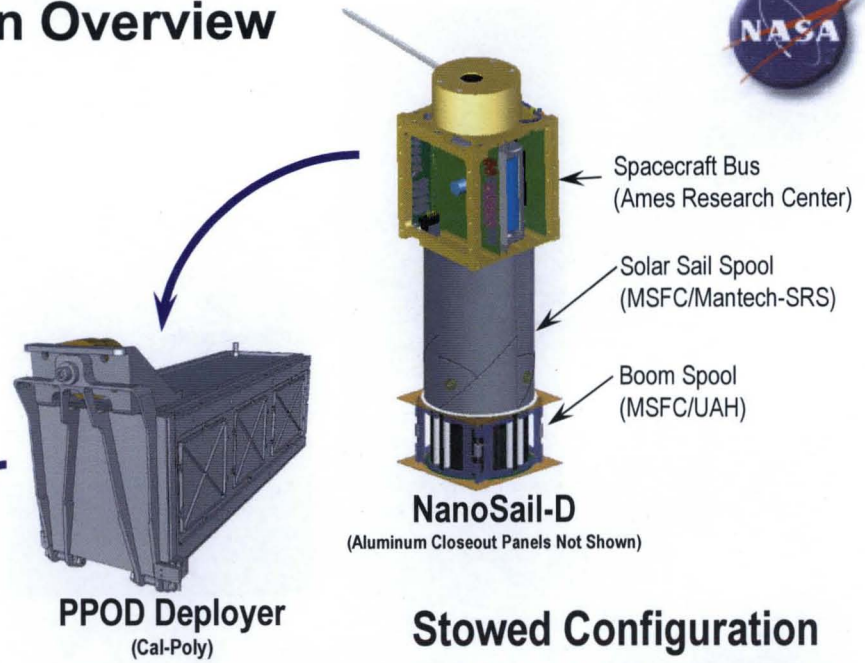
**Edward E. (Sandy) Montgomery IV
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**Charles L. Adams
Jacobs/ Gray Research, Inc.**

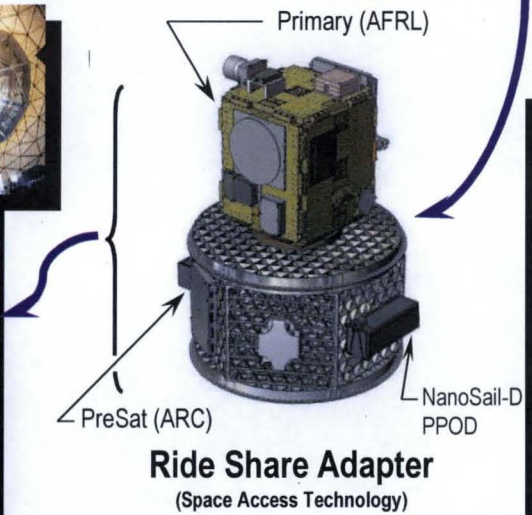
NanoSail-D Mission Overview



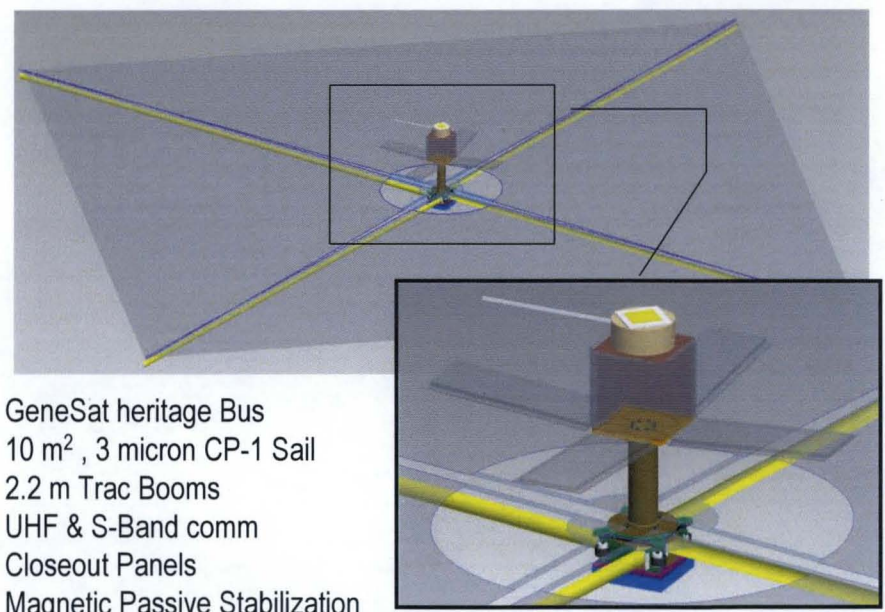
- Objectives
 - Primary
 - Establish ARC-MSFC collaborative relationship for small satellite initiatives
 - Deploy solar sail leveraging directed work performed by MSFC in prior years under the SMD In-Space Propulsion Program
 - Secondary/Opportunity
 - Demo Orbital Debris Mitigation technology – drag sail
 - Ground Imaging to reduce spacecraft instrumentation
 - Add to flight experience - ARC Bus “light” experience
- Relevance
 - Planetary & Heliophysics Science missions
 - Most smallsats orbiting above 450 km struggle to meet <25 year life MOD requirement



Falcon-1 Third Launch
(SpaceX)

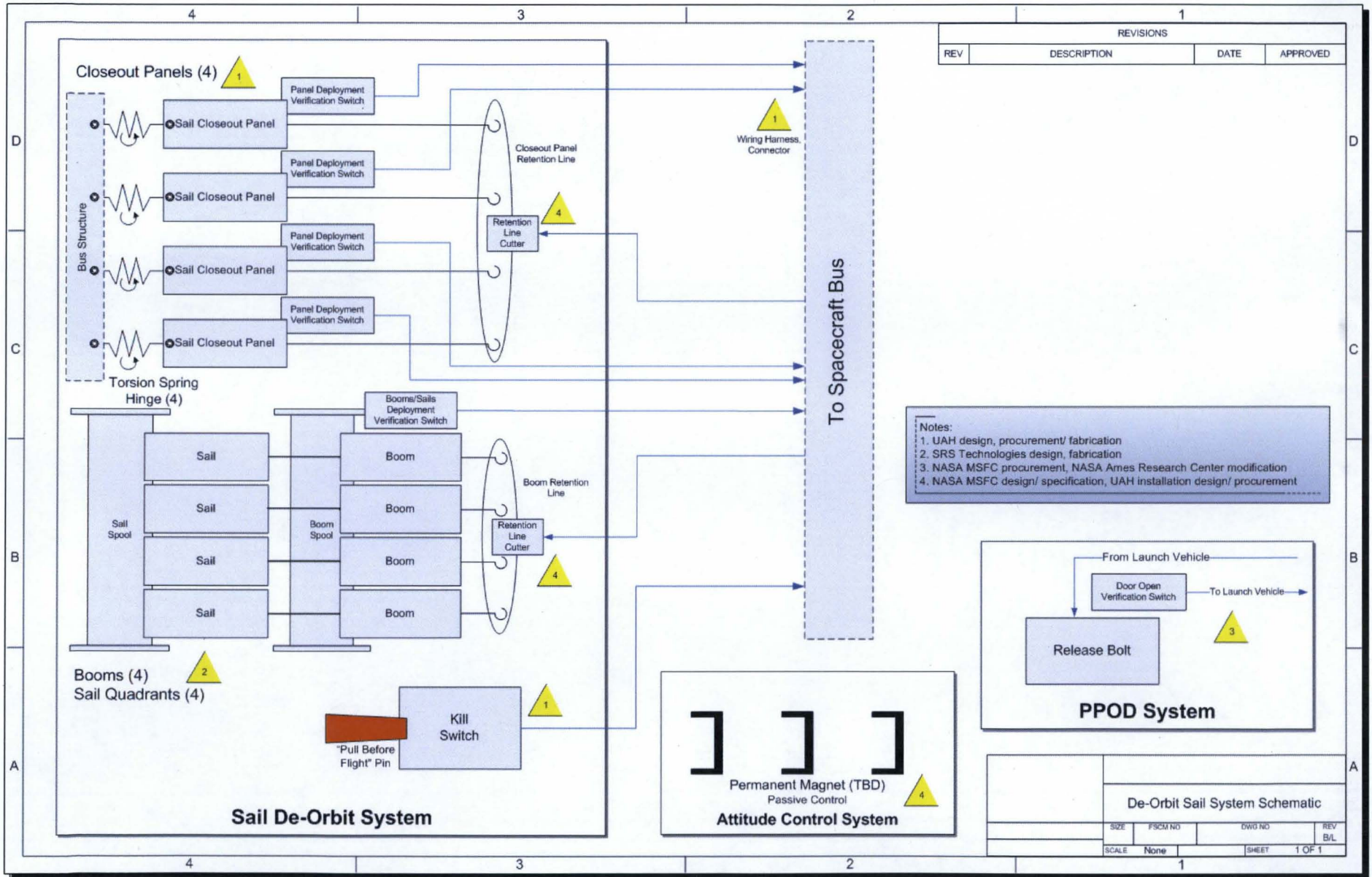


Launch Date: June, 2008
 Launch site: Omelek Island, RTS (Kwaj)
 Orbit: 685 X 330 km, 9° inclination
 De-Orbit Period: Approximately 14 days



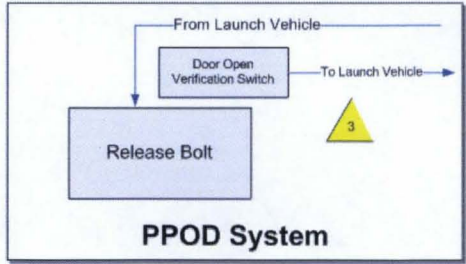


System Schematic



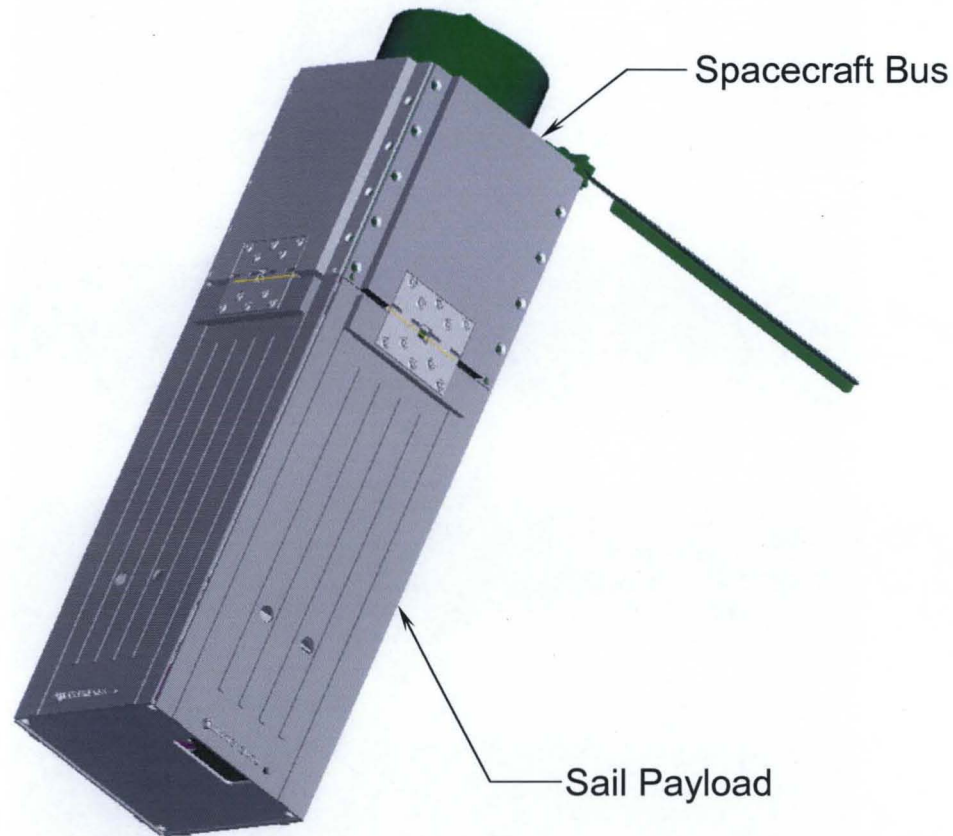
REVISIONS			
REV	DESCRIPTION	DATE	APPROVED

- Notes:
- 1. UAH design, procurement/ fabrication
 - 2. SRS Technologies design, fabrication
 - 3. NASA MSFC procurement, NASA Ames Research Center modification
 - 4. NASA MSFC design/ specification, UAH installation design/ procurement



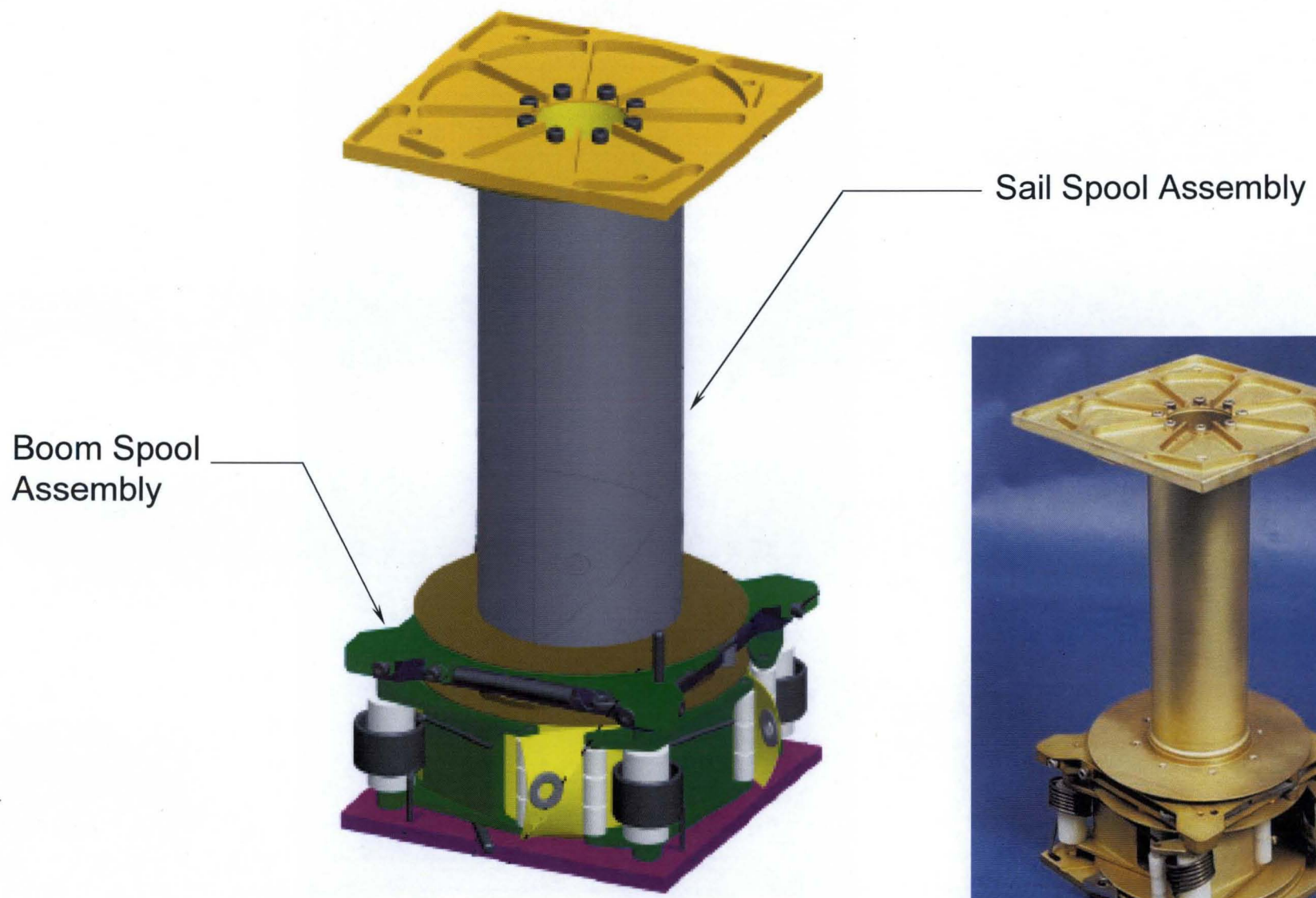
De-Orbit Sail System Schematic			
SIZE	PSCM NO	DWG NO	REV B/L
SCALE	None	SHEET	1 OF 1

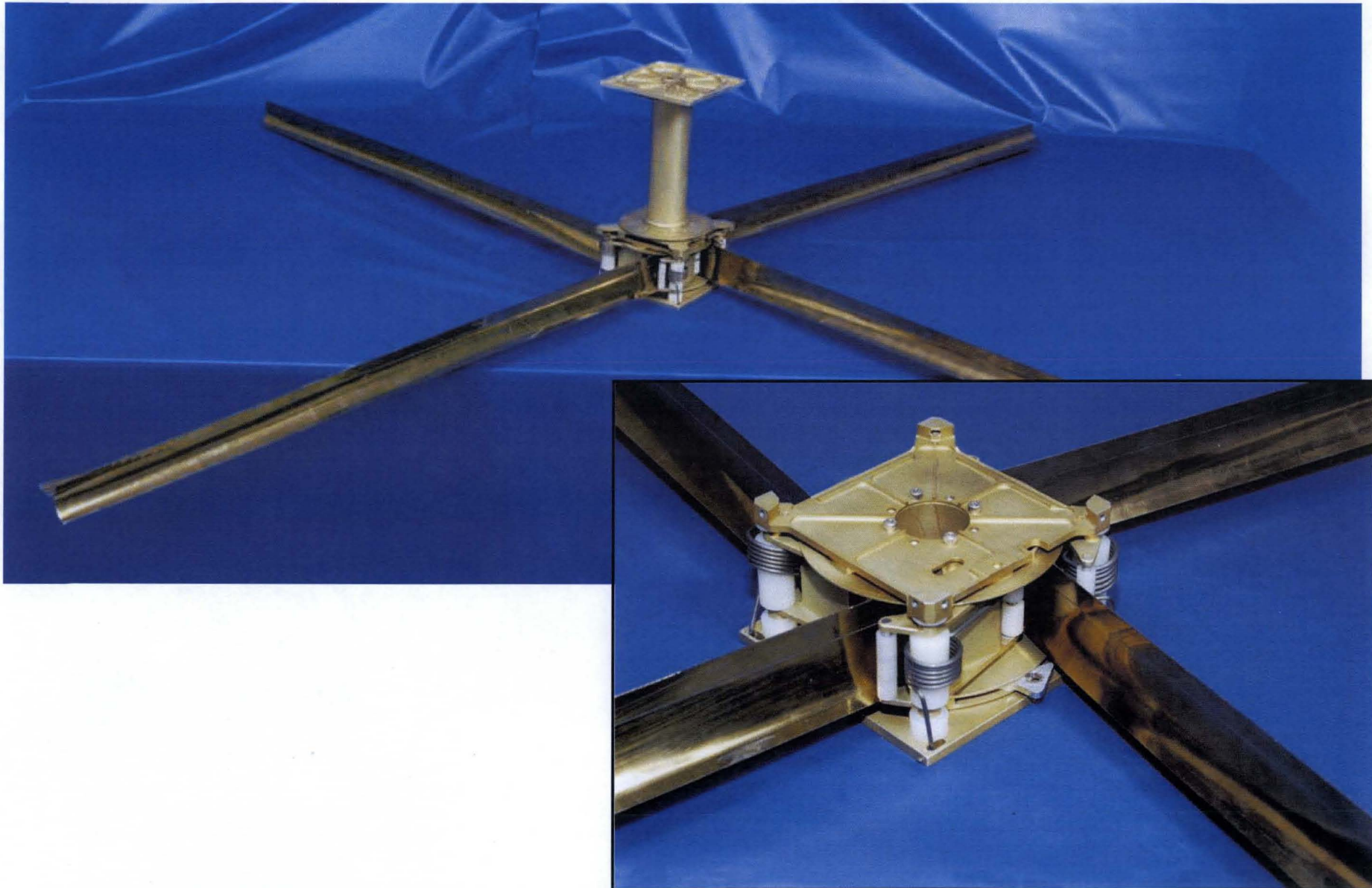
- Sail Quadrants
- Booms (Trac and Tape Spring Booms)
- Deployment System (Spools, Governor System Details)
- Bus/Passive ACS



Stowed Configuration

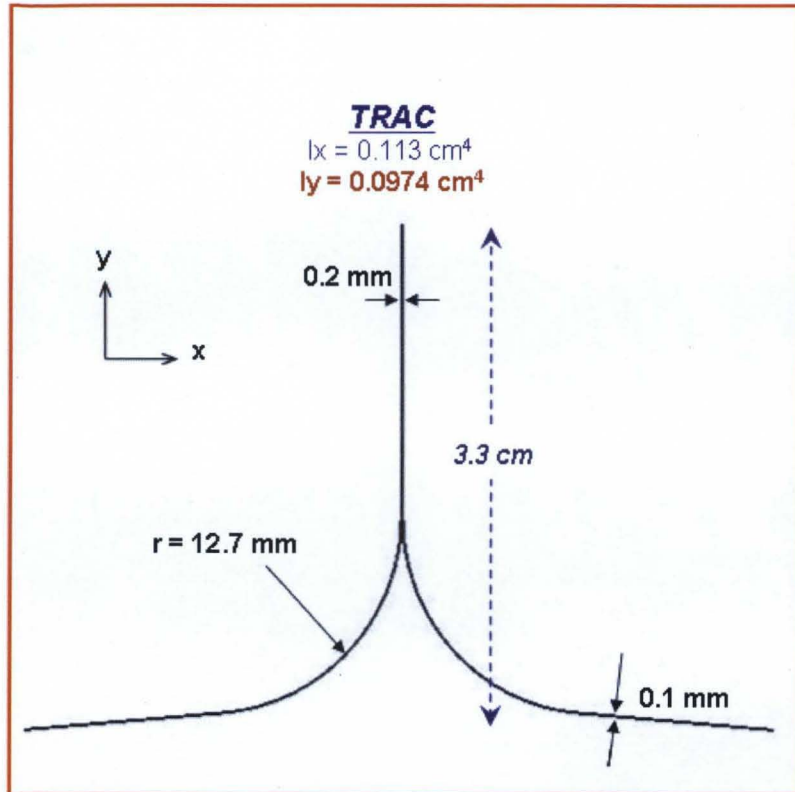
Sail Subsystem Design Details



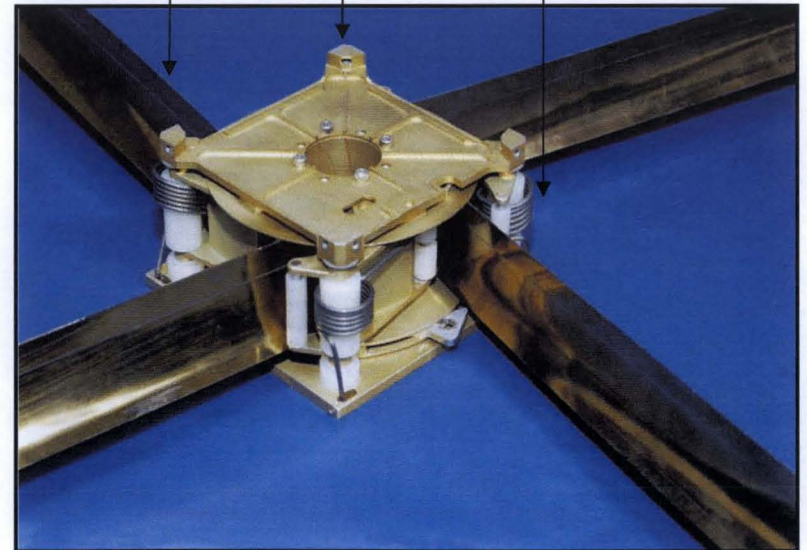




Boom Subsystem Details

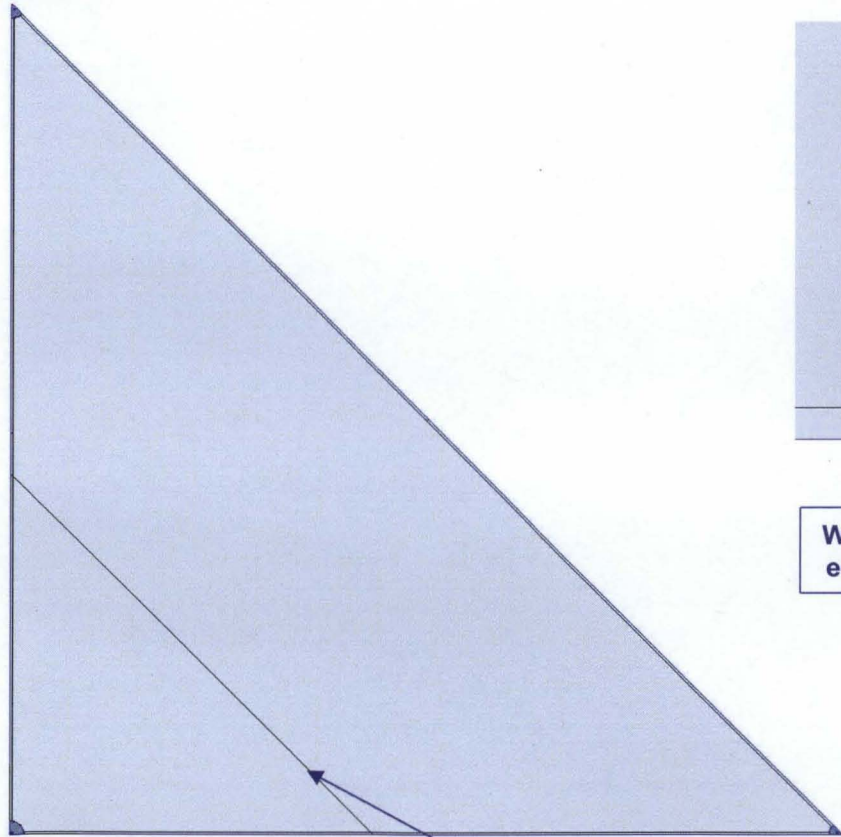


Elgiloy "Trac" Booms
Boom Housing
Retaining Springs/Guides



Sail Quadrant Design

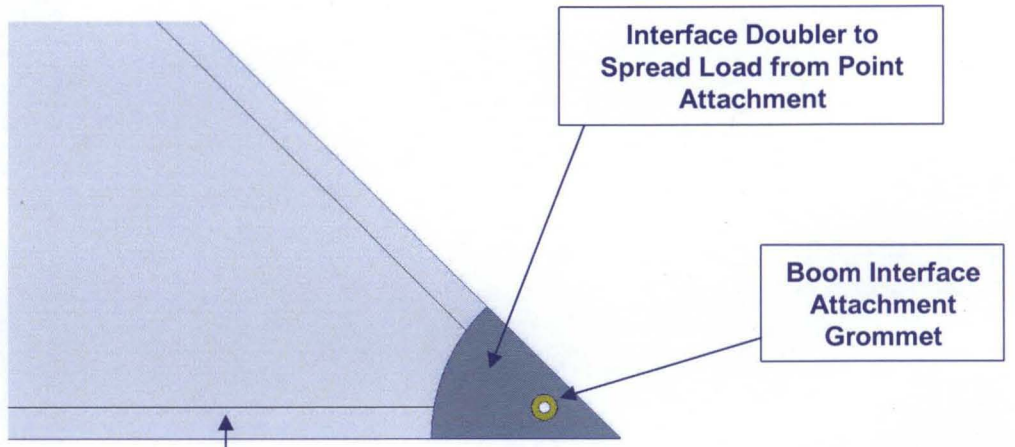
Corner 2.



Corner 1.

Corner 3.

2.5 Micron CP1 Panel Seam



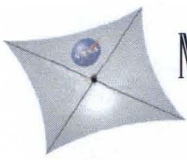
Wrap-around Edge (Folded edge around border cable)

Interface Doubler to Spread Load from Point Attachment

Boom Interface Attachment Grommet

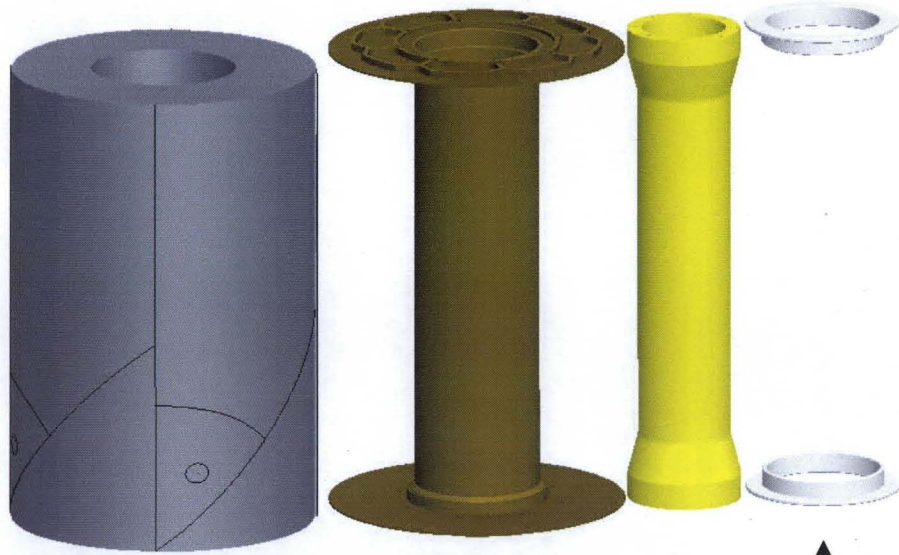


Spool Interface Attachment Grommet



NanoSail-D

Sail Stowage Configuration

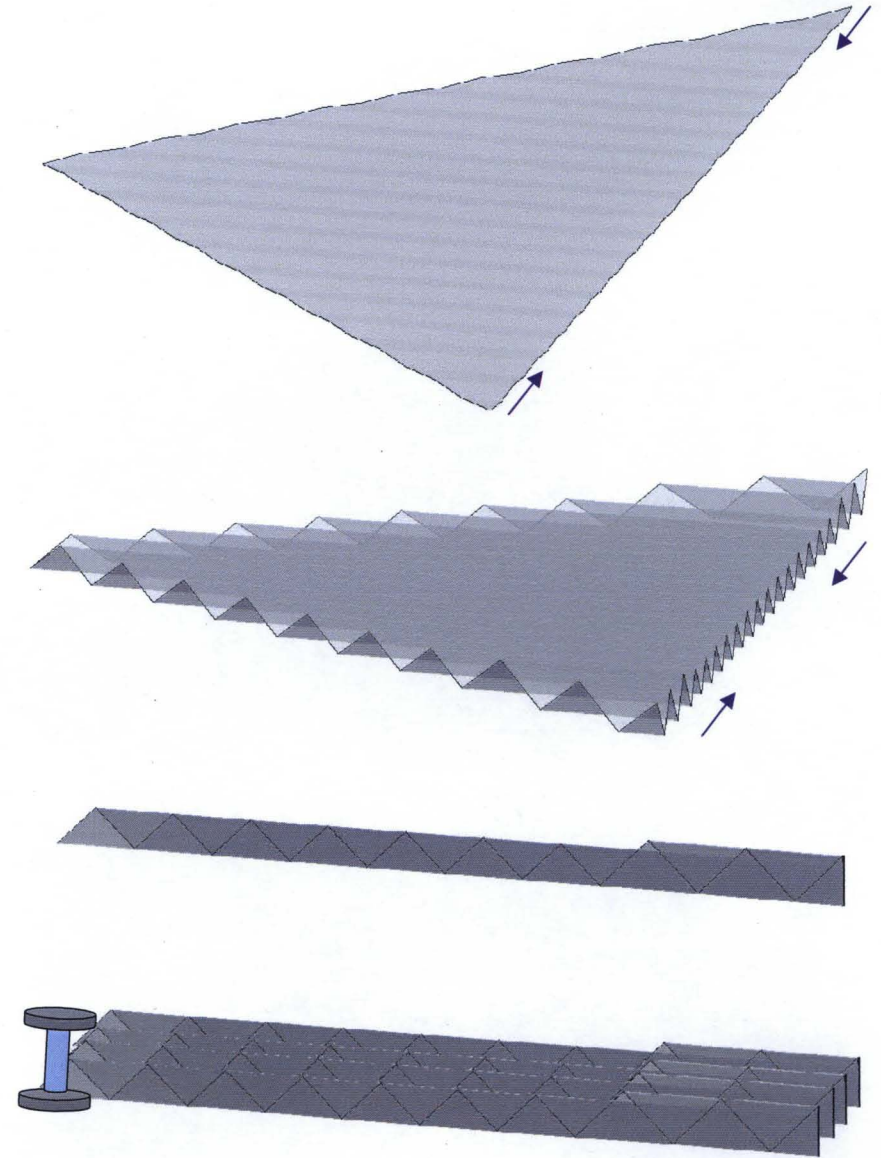


Z-Folded/Rolled Sail

Flanged Sail Spool

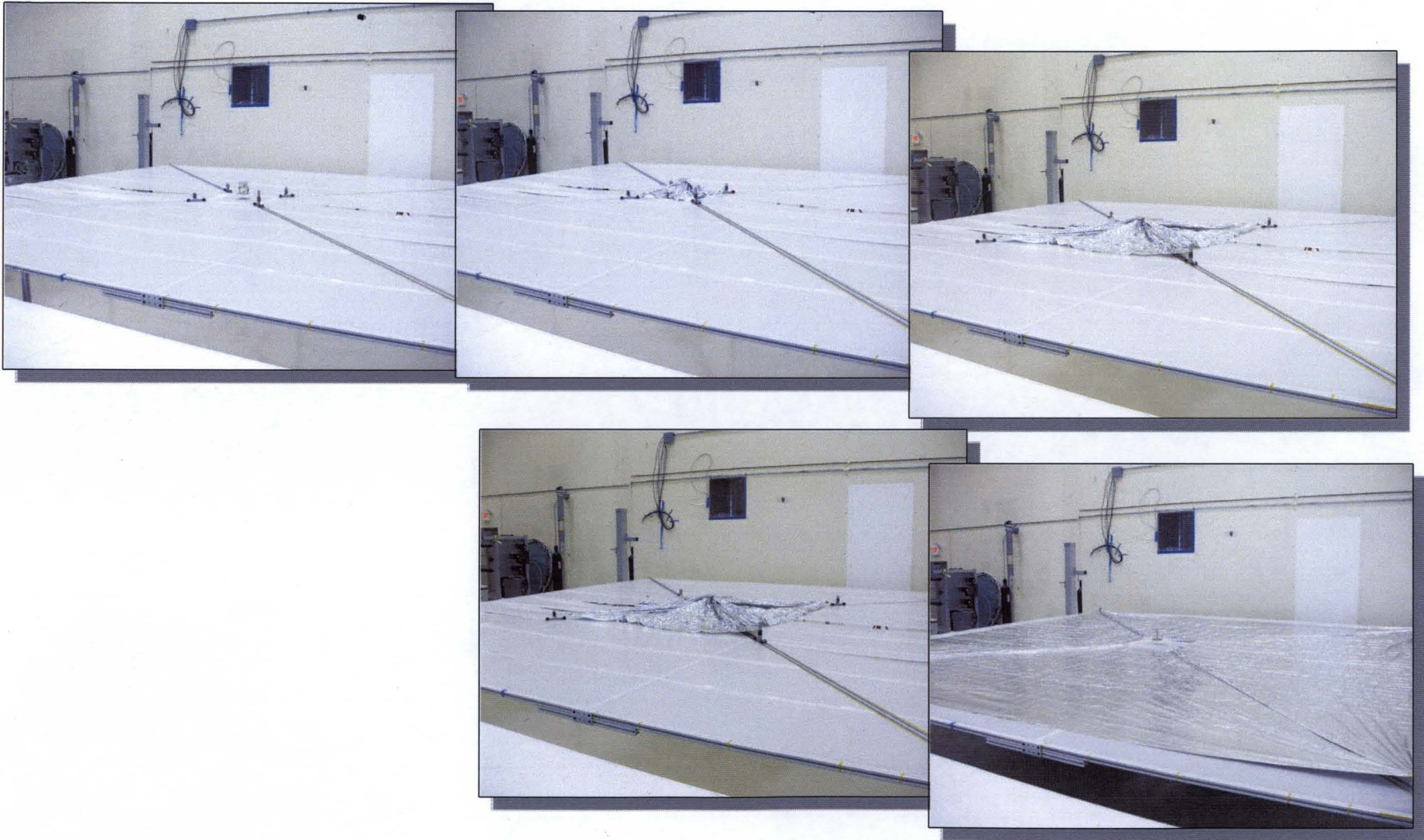
Central Structural Post

Bushings



Sail Quadrant Deployment Sequence

4 Quadrant Deployment Demonstration

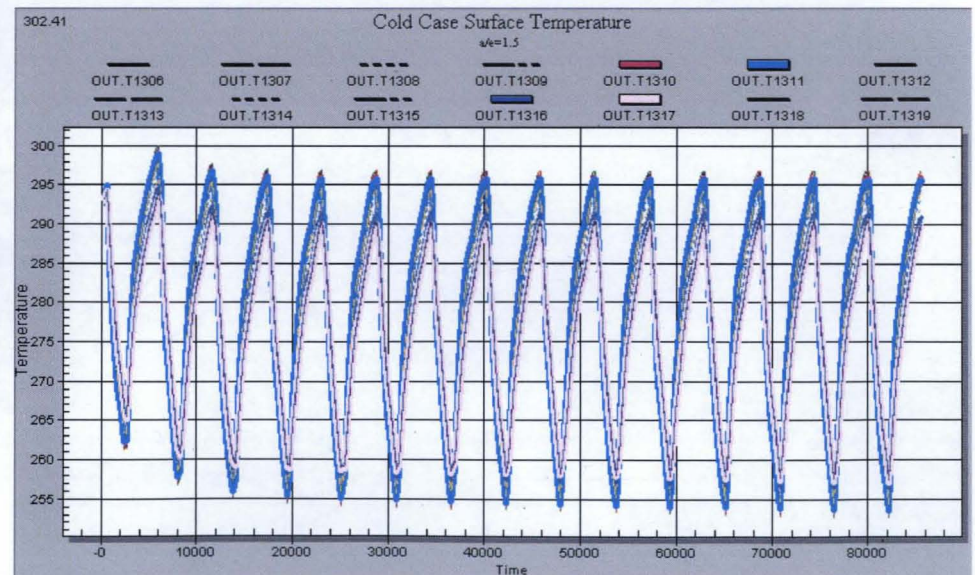
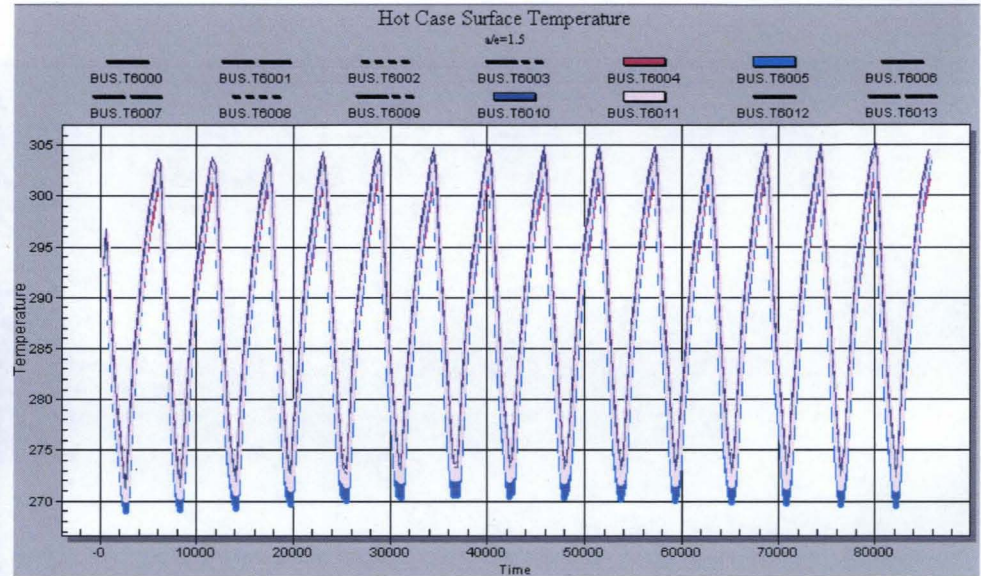
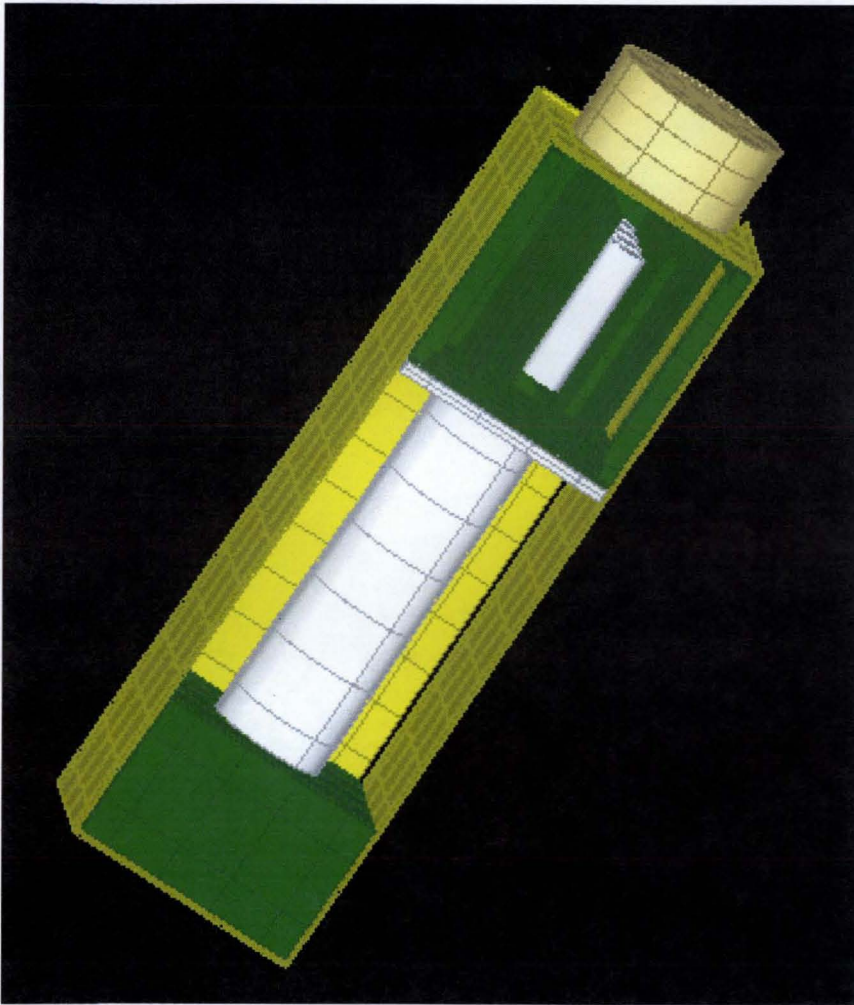




Analysis Results

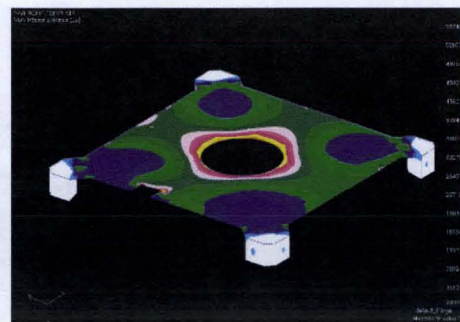
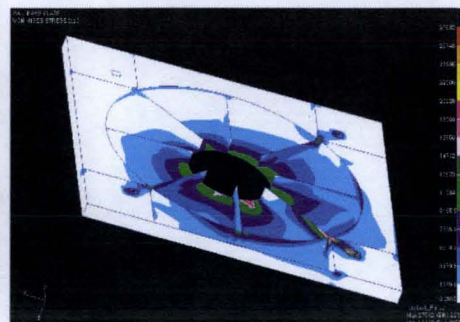
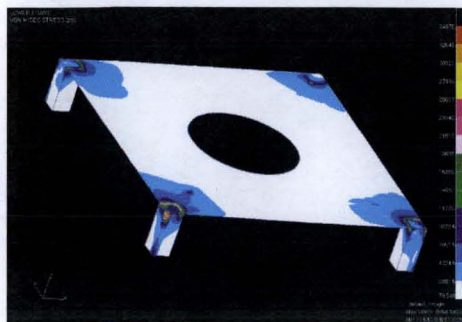


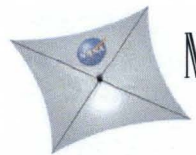
- Thermal Analysis
- Structural Analysis
- De-Orbit Predictions, Orbital Debris





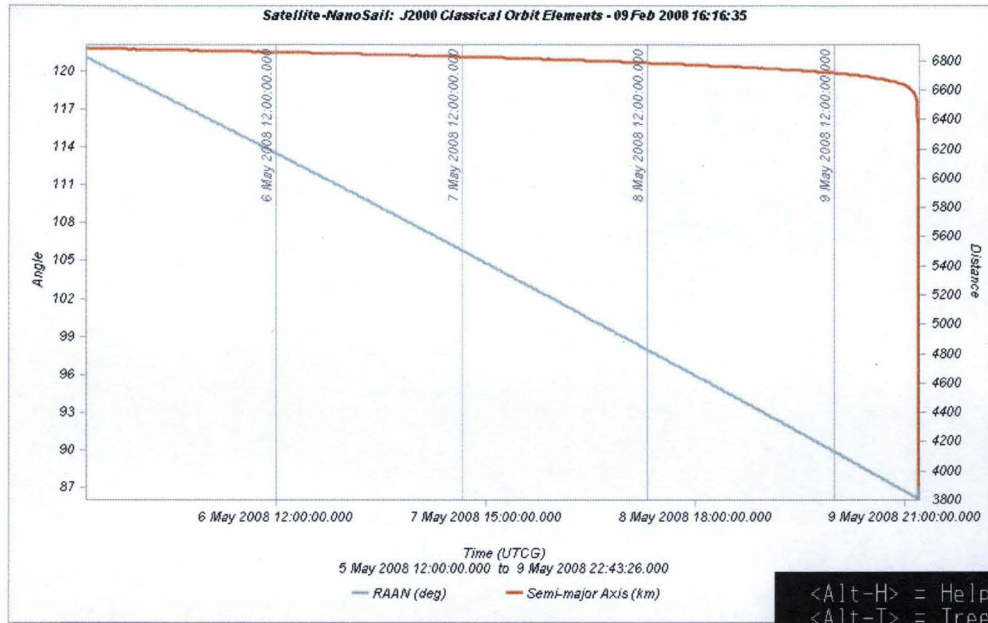
COMPONENT NAME	NANOSAIL ASSEMBLY MINIMUM MARGIN OF SAFETY SUMMARY TABLE		
	FAILURE MODE	CONDITION	MARGIN OF SAFETY
BOTTOM COVER PLATE	VON MISES	YIELD	+10.506
LOWER FRAME	VON MISES	YIELD	+0.058
SAIL BASEPLATE	VON MISES	YIELD	+0.341
SAIL BOOM TOP PLATE	COMBINED - MAX PRINCIPAL	ULTIMATE	+0.086
SAIL BOOM POST	VON MISES	YIELD	+8.519
SAIL BOTTOM PLATE	COMBINED - MAX PRINCIPAL	ULTIMATE	+0.019
SAIL POST	VON MISES	YIELD	+15.260
SAIL TOP PLATE	COMBINED - MAX PRINCIPAL	ULTIMATE	+0.012
BUS INTERFACE PLATE	COMBINED - MAX PRINCIPAL	ULTIMATE	+10.389
BUS FRAME	VON MISES	YIELD	+1.759
BUS FRAME LOWER PLATE	COMBINED - MAX PRINCIPAL	ULTIMATE	+9.197
BUS FRAME UPPER PLATE	VON MISES	YIELD	+10.075
COVER PLATES	VON MISES	YIELD	>+20.0





NanoSail-D

Deorbit Predictions



STK

<Alt-H> = Help
<Alt-T> = Tree

NASA DEBRIS ASSESSMENT SOFTWARE
VERSION 1.5.3

MENU NUMBER
6.1.1.2.1.x

```

Initial Orbit Data :
Apogee Altitude..... 685.00000000 km
Perigee Altitude..... 330.00000000 km
Other Data :
Area to Mass..... 1.19799995 m^2/kg
Solar Activity..... 130.00000000 sfu
Orbit Lifetime..... 0.00845622 yr
  
```

Debris Assessment Software

MESSAGES

Press any key to continue



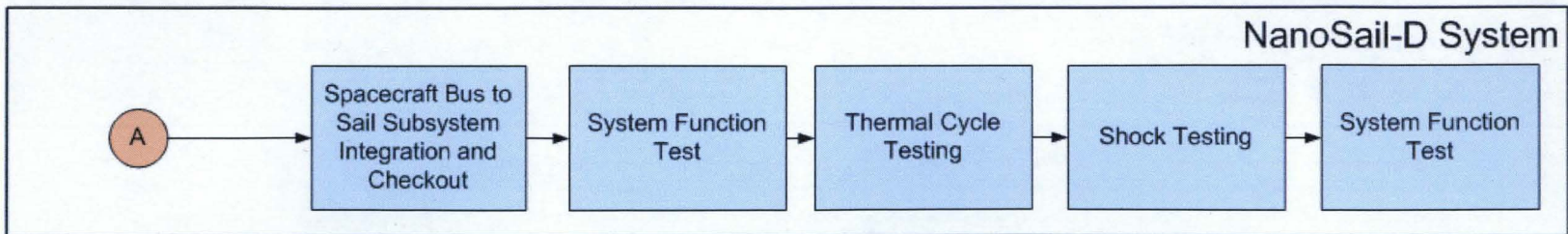
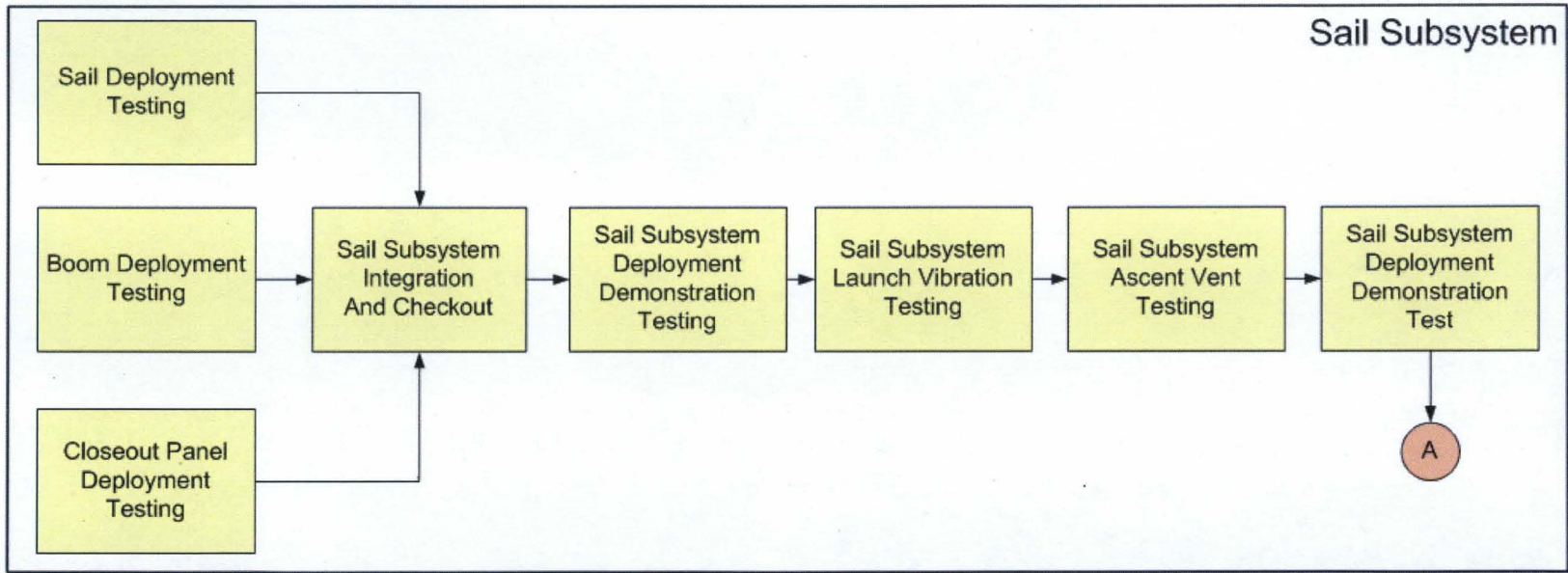
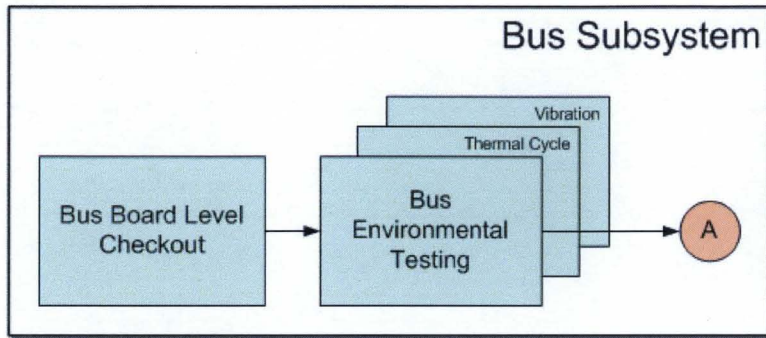
System Testing



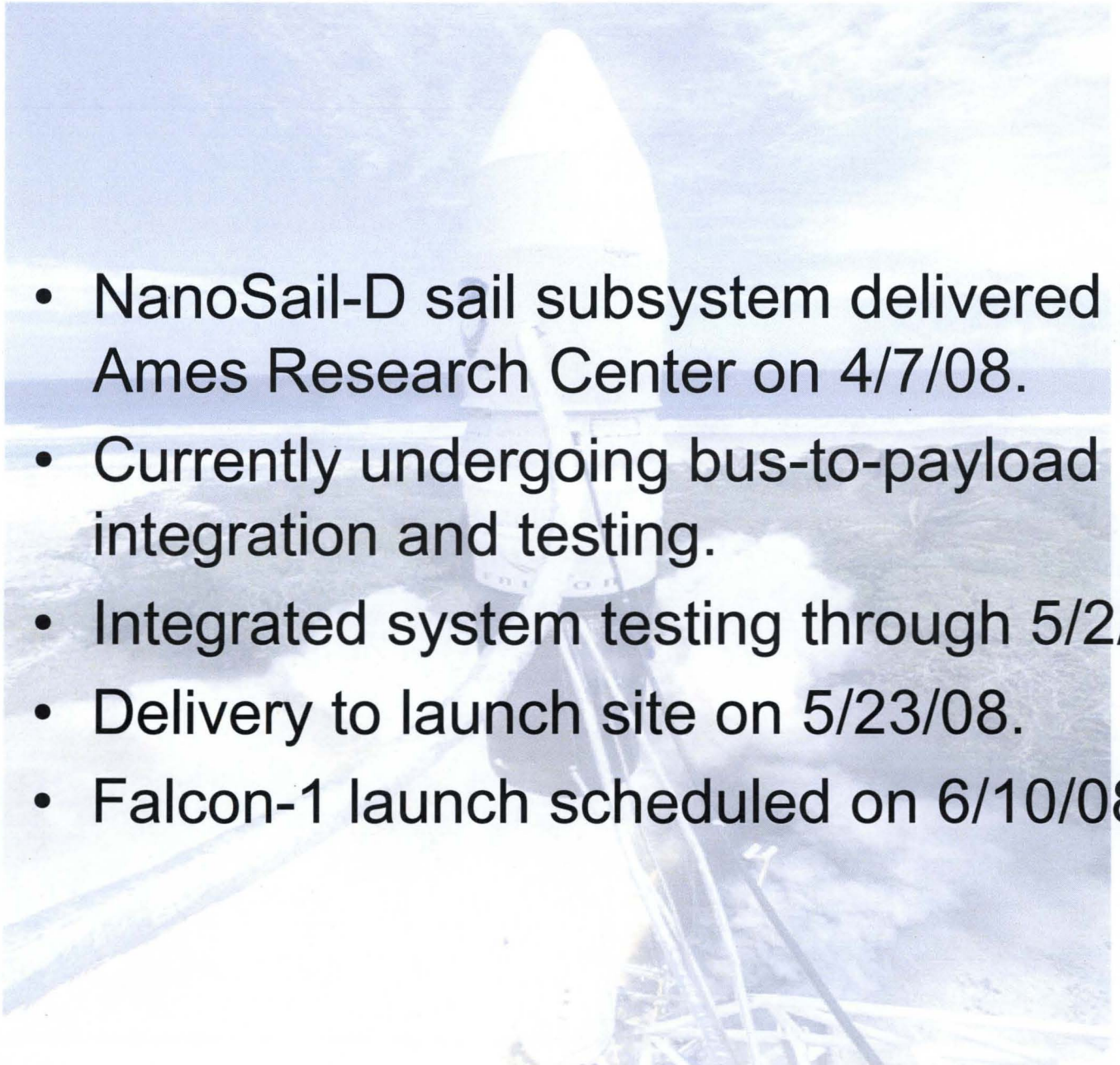
- System Functional Testing
- Deployment Test Results
- Launch Vibration Test Results
- Ascent Vent Test Results
- Testing planned for ARC



Test Sequence



Summary

- 
- NanoSail-D sail subsystem delivered to Ames Research Center on 4/7/08.
 - Currently undergoing bus-to-payload integration and testing.
 - Integrated system testing through 5/2/08.
 - Delivery to launch site on 5/23/08.
 - Falcon-1 launch scheduled on 6/10/08.