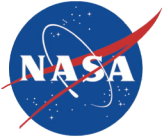




Launch Abort System Flight Test Overview
AIAA Guidance, Navigation & Control Conference



Peggy Williams Hayes
NASA Dryden Flight Research Center
August 21, 2007



Outline



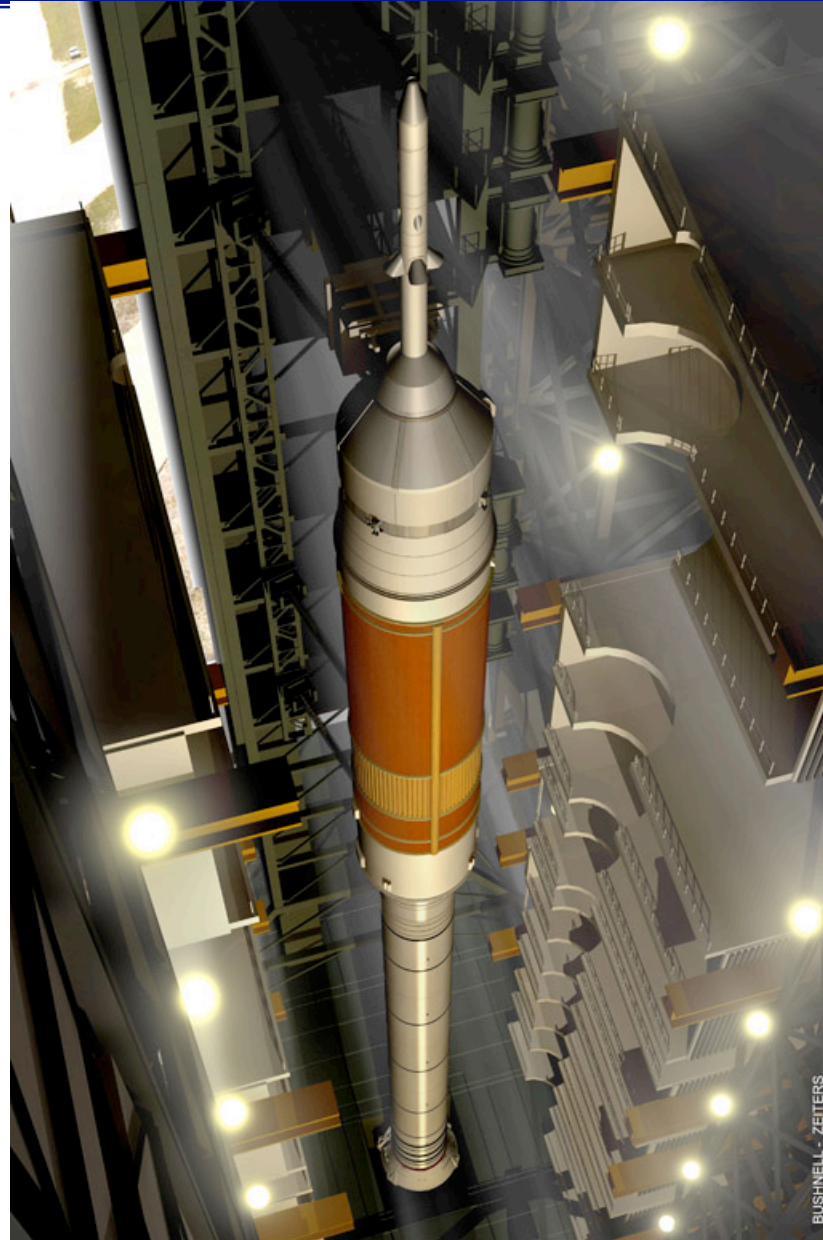
- Constellation Program
- Abort Flight Tests
 - Purpose of Flight Tests
 - Flight Test dates & fabrication plans
 - Flight Test Flight Dynamics working group
- PA-1 Information
 - Flight Test Objectives
 - Launch Site
 - Nominal trajectory animation & data
 - Day of Launch activities
 - Boilerplate photos
- Acknowledgements



Constellation Program Flight Vehicle



Project Orion: Flight Test Office



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Purpose of the Launch Abort System Flight Tests



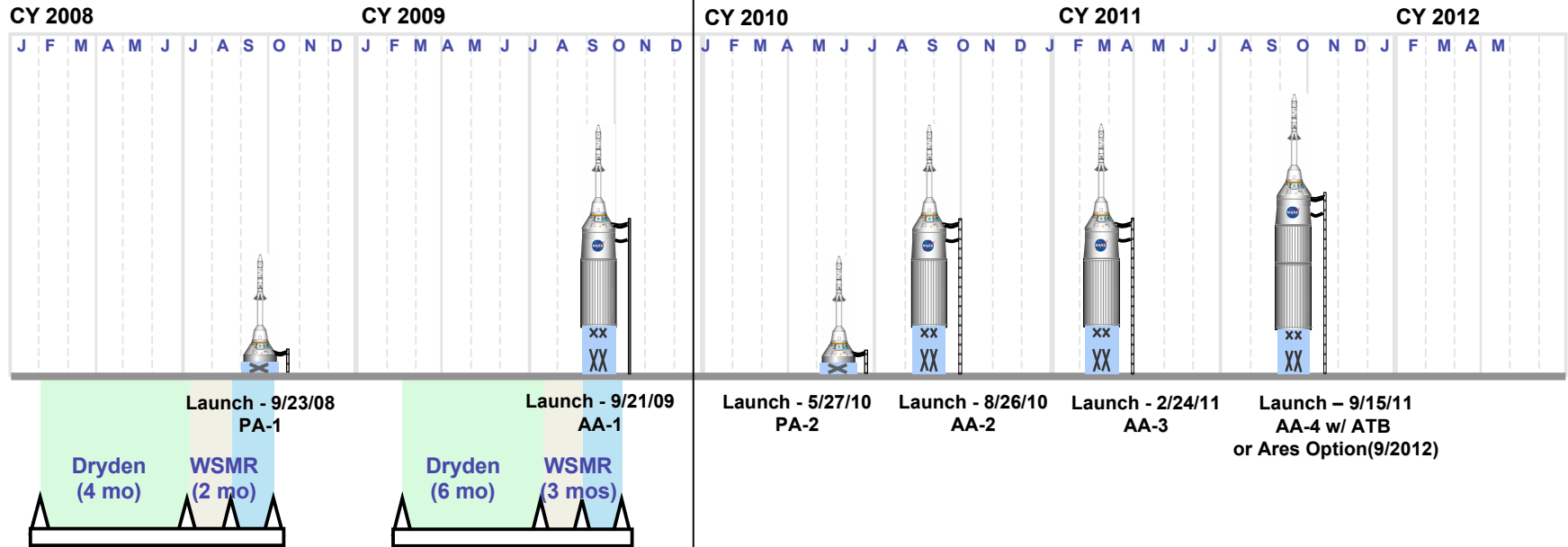
- Evaluate the performance of the crew escape functions of the Launch Abort System (LAS)
 - Ability of the LAS to separate from the crew module
 - Gather flight test data for future design & implementation
 - Reduce system development risks



Abort Flight Tests



Increasing Maturity of Crew Module and Launch Abort System



Inform the Design

Gov't Provided Test Article
 Integrate and Test at DFRC
 Launch at WSMR

Flight Certify the LAS

Prime Provided Test Article
 Integrate and Test at KSC (O&C)
 Launch at WSMR



Abort Flight Test Fabrication Plan

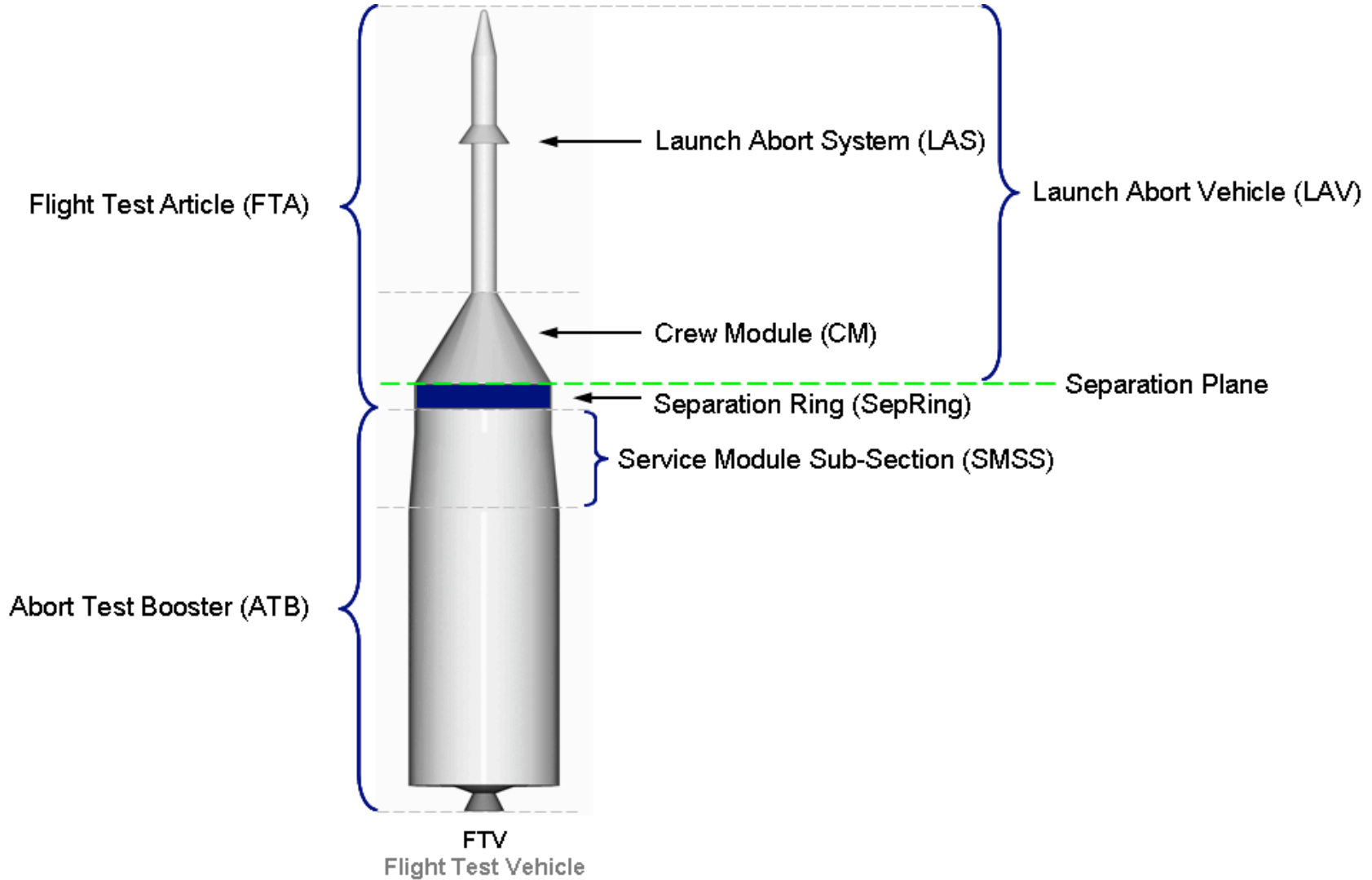


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	<u>Flight</u> <u>Flight Date</u>	<u>PA 1</u> 9/2008	<u>AA 1</u> 9/2009	<u>PA 2</u> 5/2010	<u>AA 2</u> 8/2010	<u>AA 3</u> 2/2011	<u>AA 4 (ATB or Ares)</u> 7/2011 or 9/2012	<u>Pathfinders</u>	<u>Totals</u>
LAS Fabrication (Lockheed Martin / Orbital)		LAS1	LAS2	LAS3	LAS4	LAS5	LAS6	To WSMR	6 Flight 1 PF
CM Fabrication (NASA LaRC)		CM1 BP	CM2 BP					CM3 To WSMR	2 Flight 1 PF
CM Fabrication (Lockheed Martin)				CM4 Prototype	CM5 Prototype	CM6 Prototype	CM7 Production		4 Flight
SepRing Fabrication (NASA LaRC with LM Sep System)		SR2	SR4	Reuse PA1	SR5	SR6	SR7	SM SR1 Qual SR3 To WSMR	5 Flight 2 PF/Qual
ATB (NASA Procured – Orbital-Chandler)			ATB1		ATB2	ATB3	ATB4	ARES Booster To WSMR	4 Flight 2 PF
	DFI Avionics AI&T	NASA LM DFRC	NASA LM DFRC	NASA LM O&C	NASA LM O&C	NASA LM O&C	NASA LM O&C		



Flight Test Article





Flight Test Flight Dynamics Working Group



- FTFDWG members from NASA centers (DFRC, JSC, LaRC, GRC, ARC), Lockheed Martin Space Systems, Orbital Sciences -Dulles, & Orbital Sciences –Chandler
- Working group includes Guidance, Navigation & Control (GN&C), Mission Analysis, Aerodynamics, and Simulation disciplines
 - GN&C
 - LAS controller (Orbital-Dulles)
 - LM responsible for avionics, vehicle hardware & flight software in crew module
 - Mission Analysis
 - LM responsible for nominal trajectory definitions for LAS aborts
 - LM compiles vehicle mass properties
 - Working group defines the targets for each flight test
 - » PA-1 CM under drogue chute mass of 17,167 lbm
 - » PA-1 Flight Test LAS mass of 14,632 lbm
 - » PA-1 LAV cg is 14” in front of operational cg (ballasted)



Aerodynamics and Simulation



- Aerodynamics are provided by Orion team of Johnson Space Center
 - JSC is responsible for aero for CEV vehicle (flight test & operational)
 - Wind tunnel testing
 - Analyses
 - Database development
 - Working group members coordinate with JSC aero team to determine developmental flight instrumentation present on vehicle
 - 550 sensors currently on PA-1 vehicle
 - Flush Air Data System (FADS) in nose of LAS

- Several simulations currently being developed/used by the various groups
 - Osiris (LM 6 DOF simulation)
 - ANTARES (NASA JSC 6 DOF simulation)
 - StepX (Orbital-Dulles LAS simulation)
 - LaRC GNC simulation
 - Abort Test Booster simulation (Orbital-Chandler)
 - Dryden Flight Test simulation (6 DOF for use in AA-1)



Flight Test Objectives for PA-1



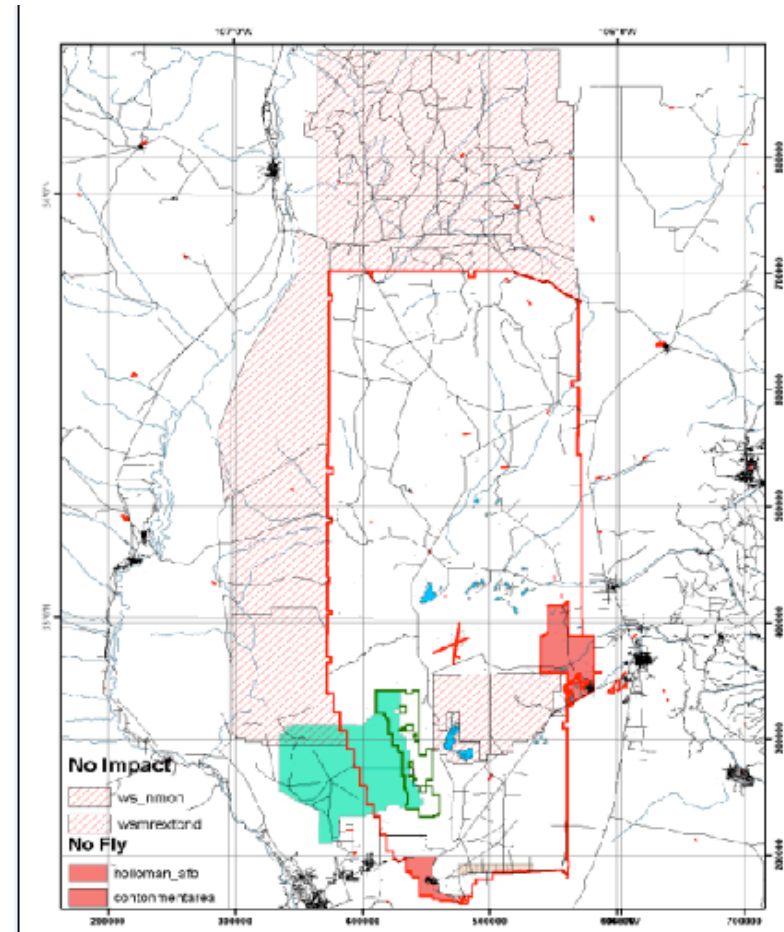
- LAV
 - Demonstrate stability & control of the LAV during ascent
- LAS
 - Determine abort motor performance
 - Determine attitude control motor performance
 - Demonstrate ability of LAS to jettison from CM
- Separation Events
 - Demonstrate abort events sequencing
 - Obtain data on ground impact locations for the LAV modules
- Parachute
 - demonstrate deployment of drogue & main parachute pilot chute
 - Demonstrate performance of main parachute system
- Environmental
 - Determine acoustics environment during ascent (before LAS jettison)
 - Determine telemetry transmission of the CM through the BPC
- Ground Support



PA-1 Launch Site

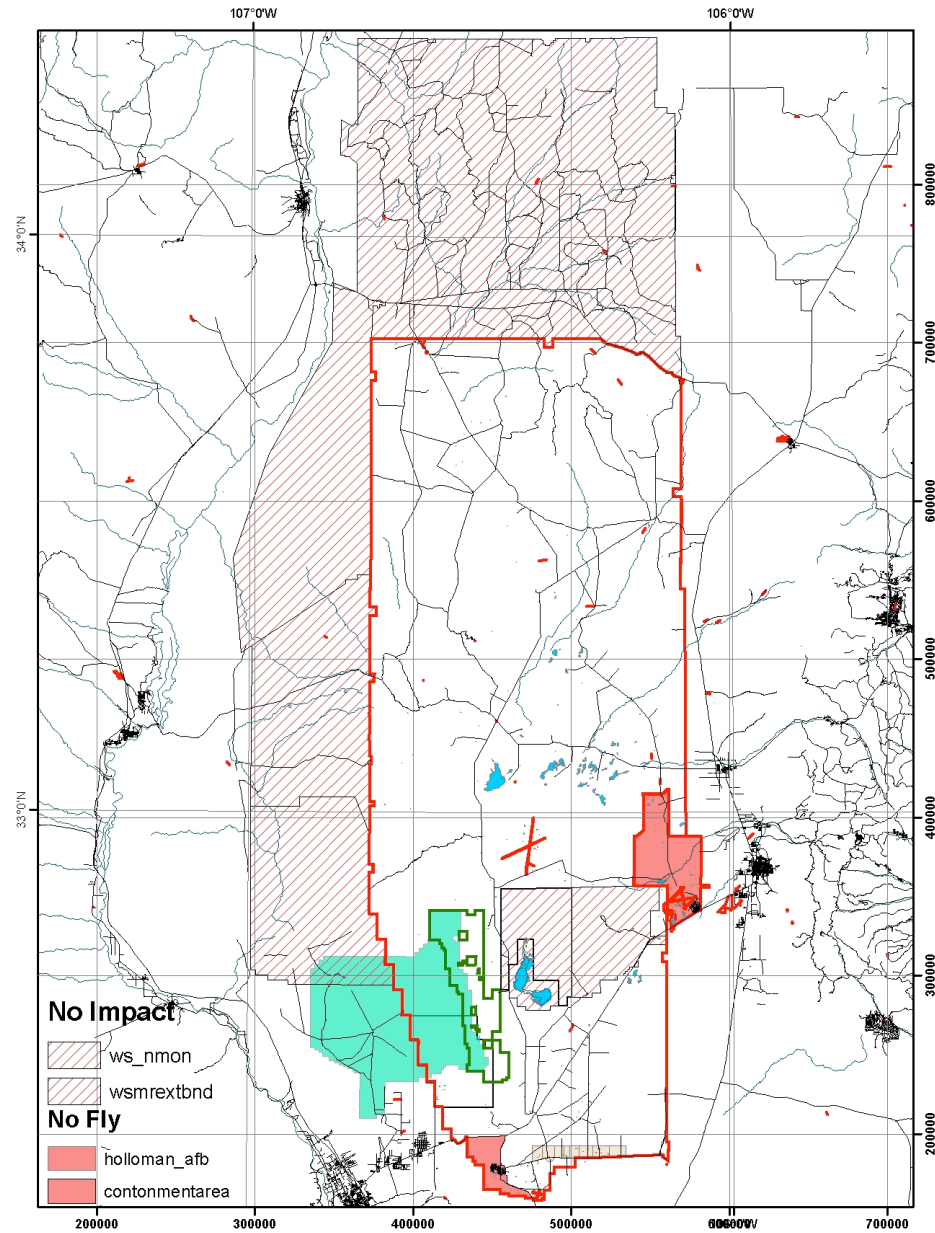


- Launch Site
 - near WSMR LC-32
 - Geodetic Latitude: 32.408 deg
 - Longitude: -106.401 deg
 - Altitude: ~ 4000 ft





White Sands Missile Range



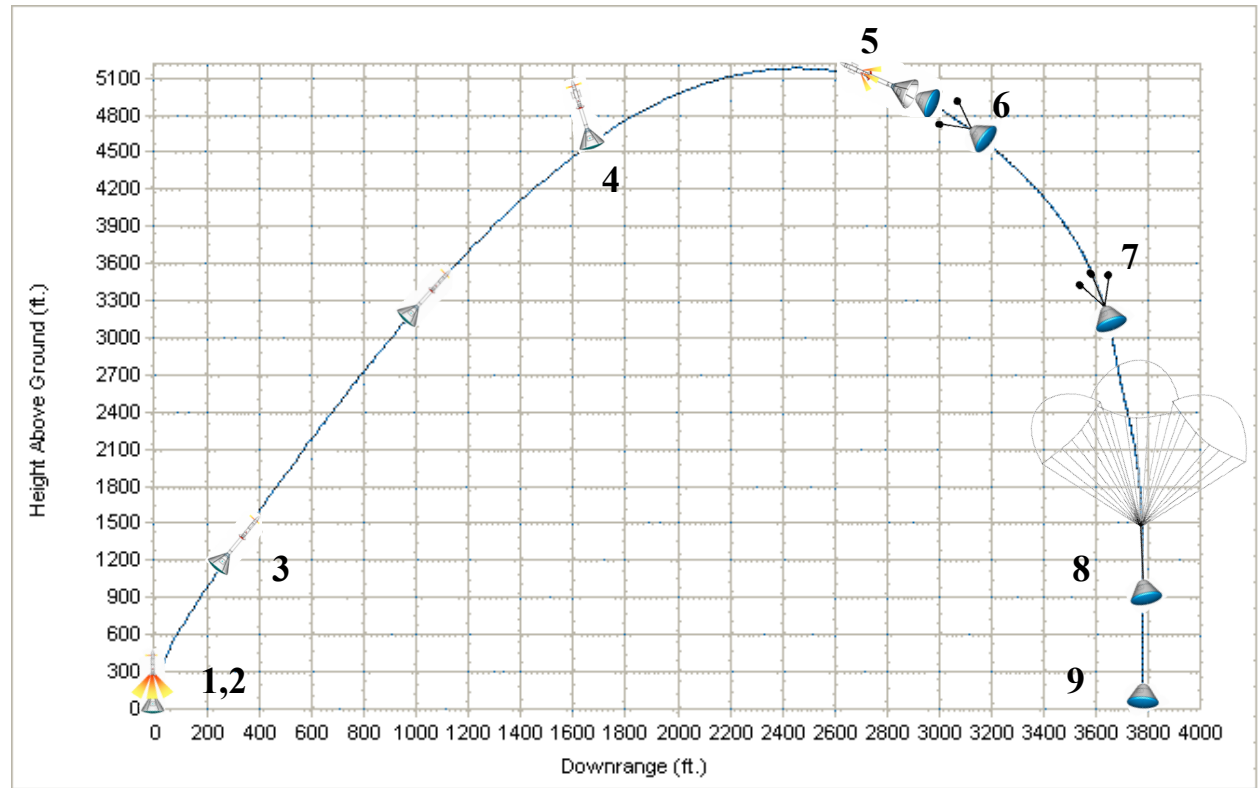


PA-1 Nominal Trajectory Timeline



- Nominal trajectory: 15° max α and 7 seconds on drogue

Event	Time Since Ignition (sec)	Event
1	0.0	Ignition of abort and pitch motors
2	0.02	Liftoff and pitch-over
3	2.6	Abort motor Tail Off
4	11.0	Deploy canards begin reorientation
5	21.0	Jettison tower
6	24.0	Deploy drogues
7	31.0	Deploy mains
8	52.1	Mains full open
9	89.2	CM touchdown



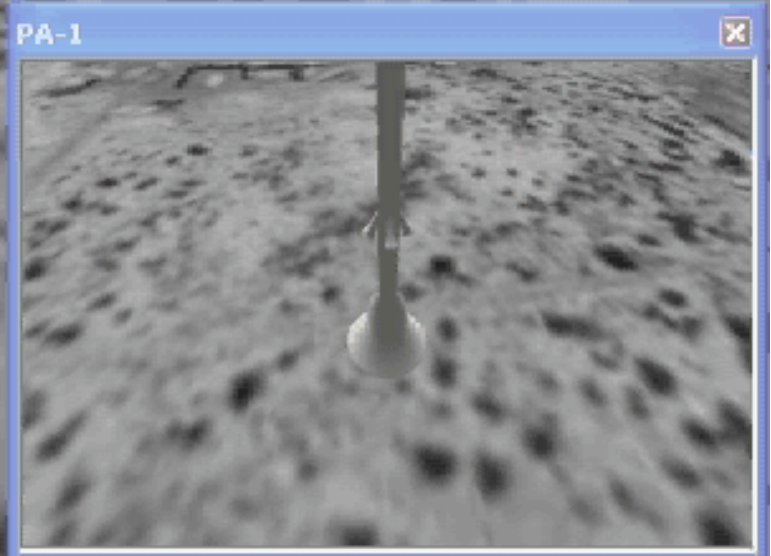
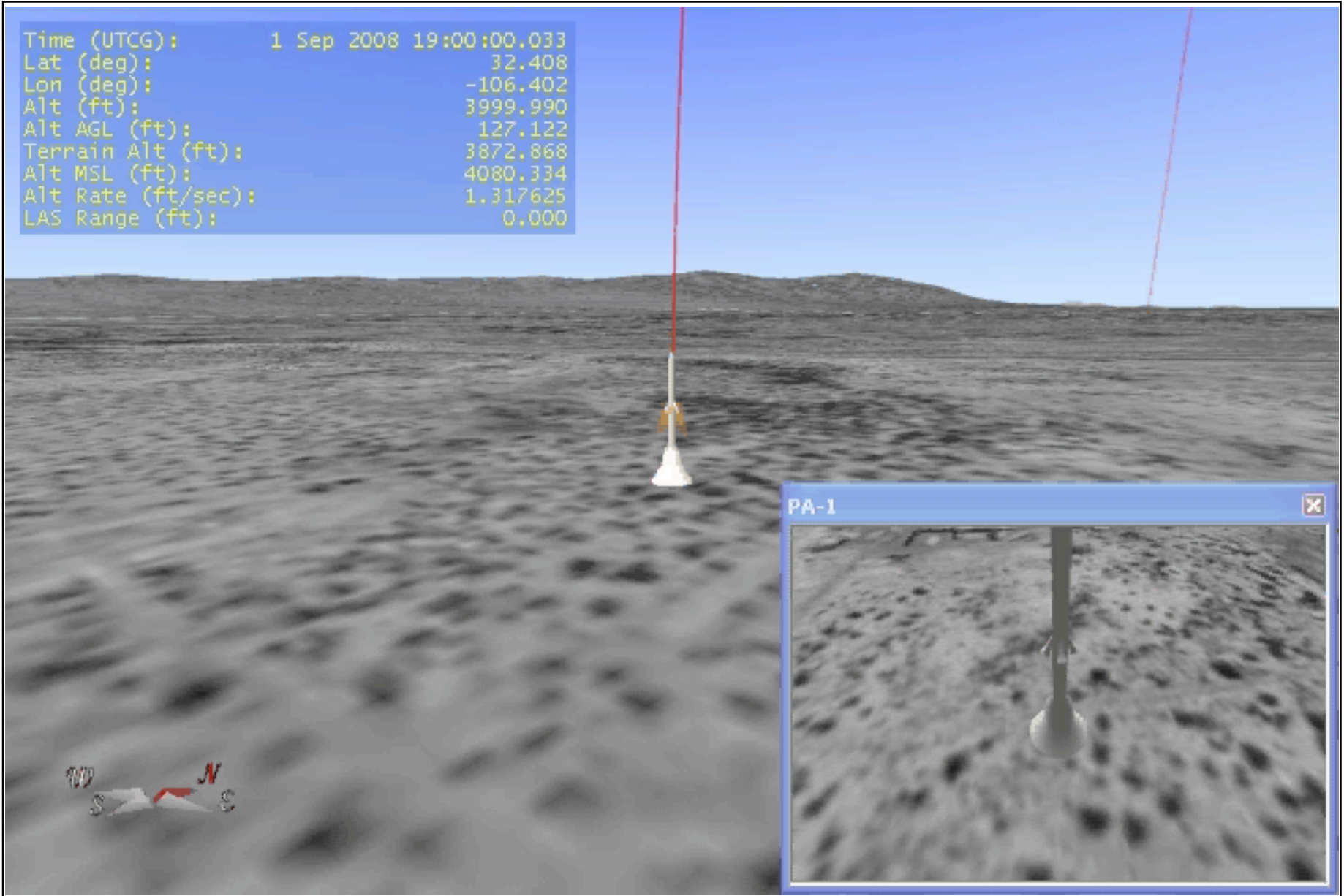


PA-1 Animation



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```
Time (UTCG):      1 Sep 2008 19:00:00.033
Lat (deg):        32.408
Lon (deg):        -106.402
Alt (ft):         3999.990
Alt AGL (ft):     127.122
Terrain Alt (ft): 3872.868
Alt MSL (ft):     4080.334
Alt Rate (ft/sec): 1.317625
LAS Range (ft):   0.000
```

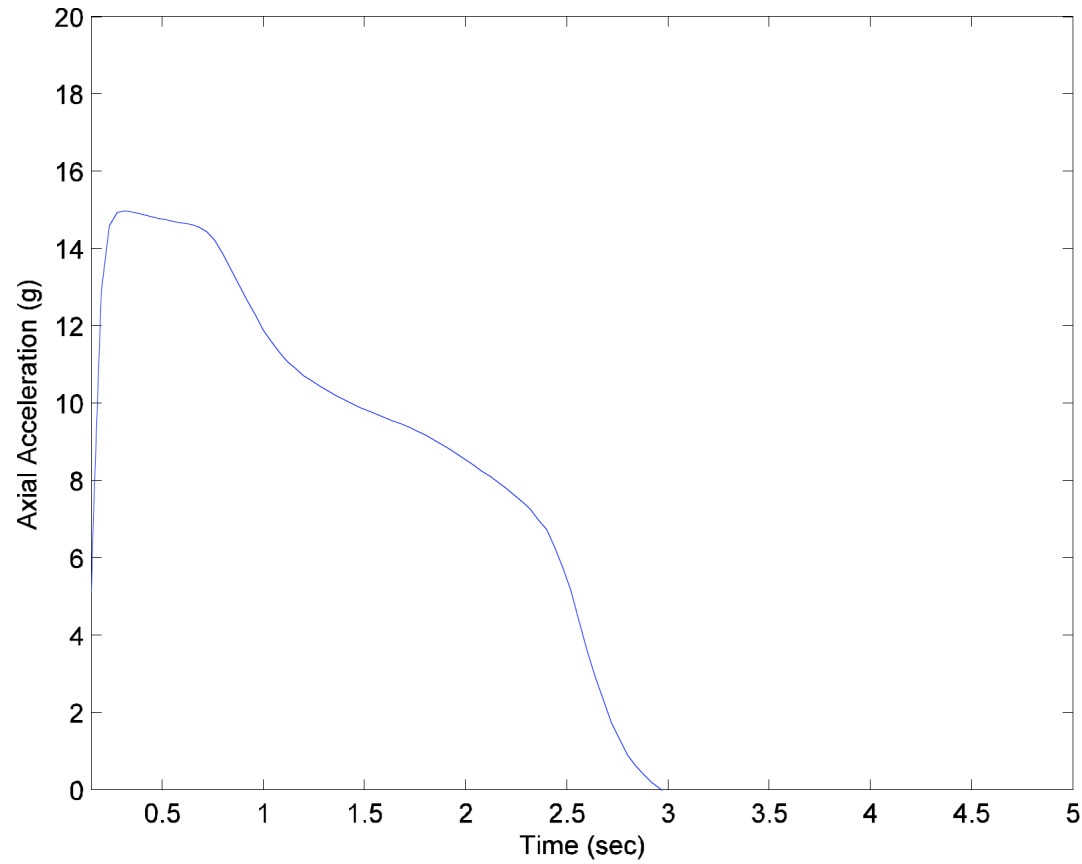




LAS Abort Motor Thrust for PA-1 Nominal Trajectory

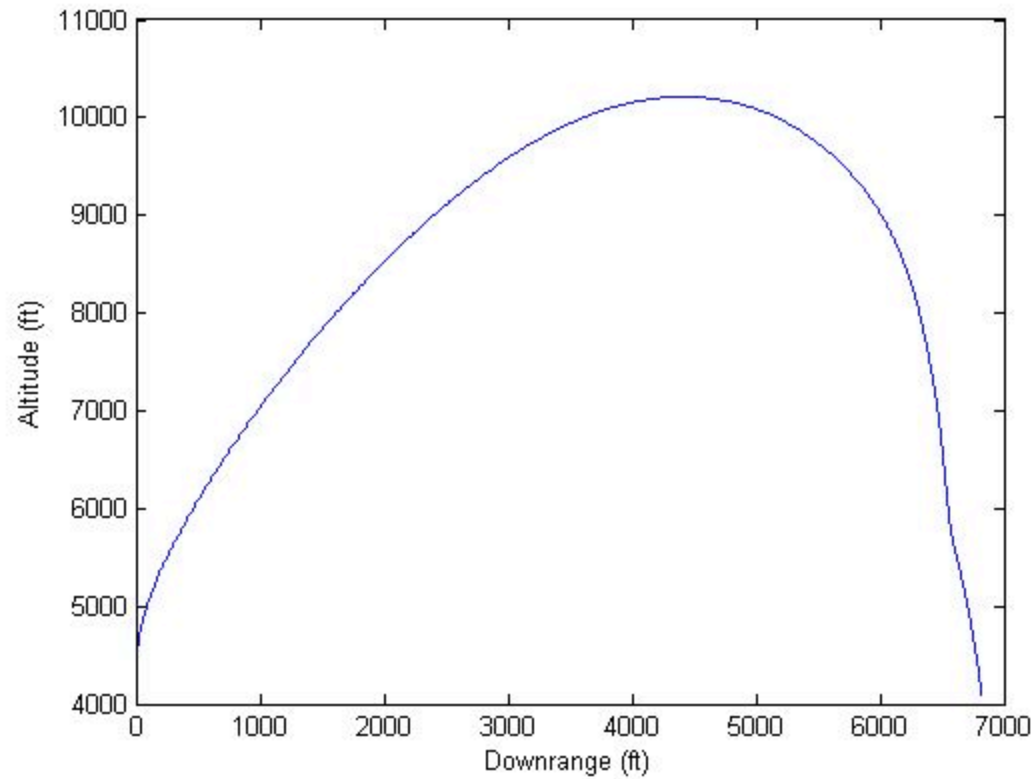


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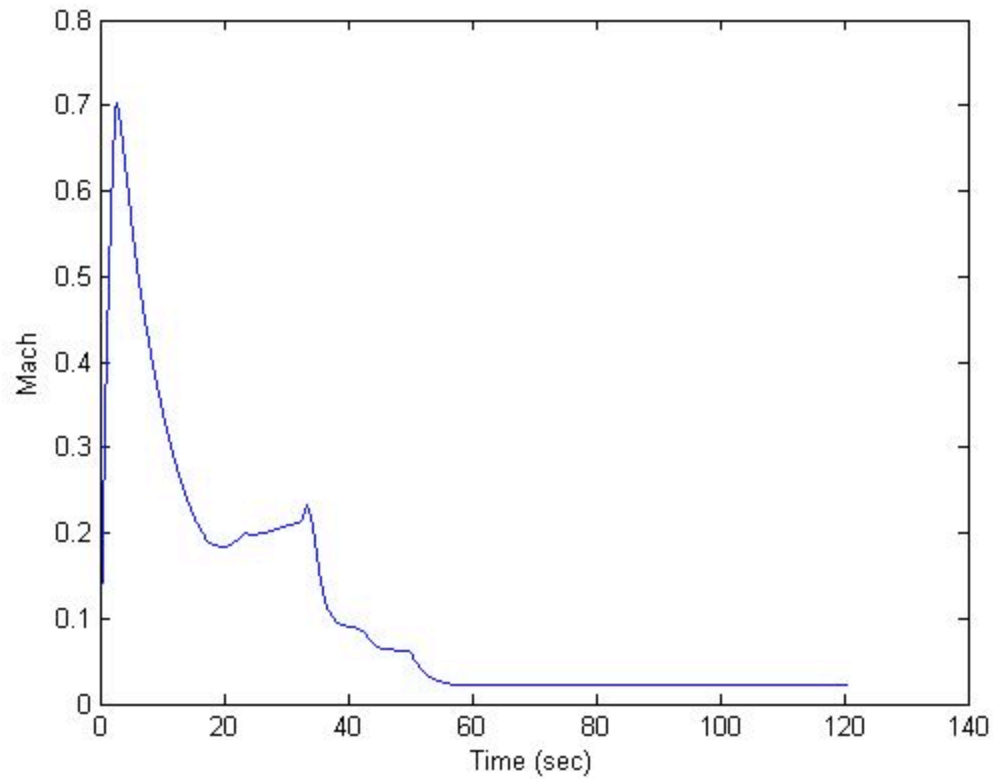


Altitude & Downrange for PA-1 nominal trajectory (with ~20 degree pitch profile)



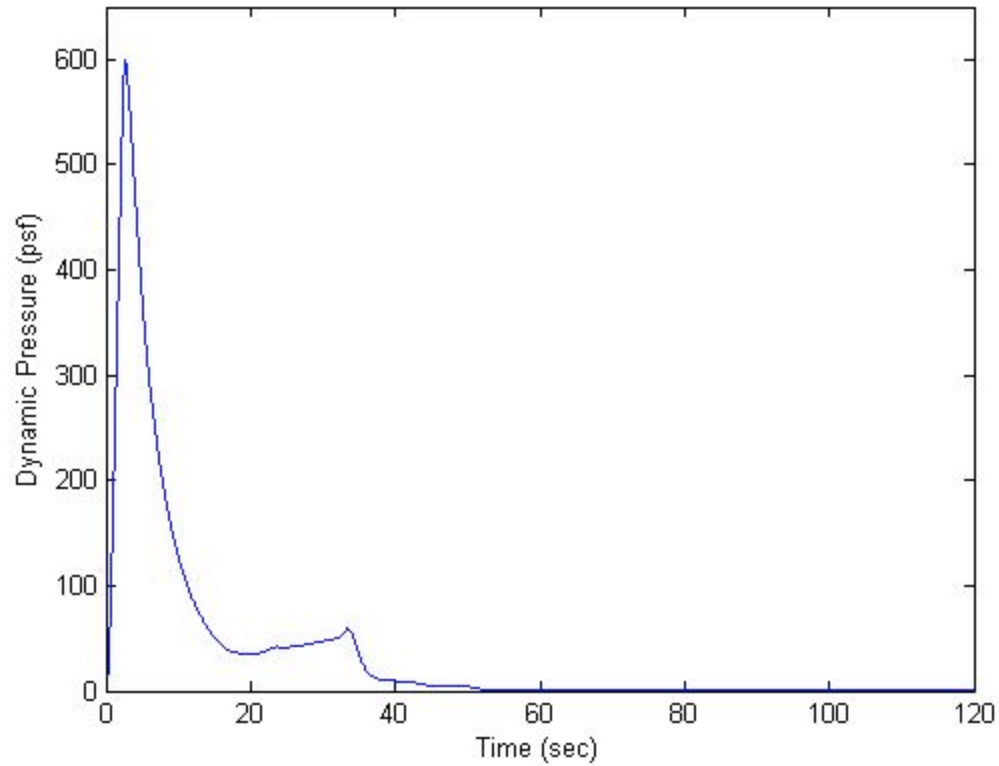


Mach for PA-1 nominal trajectory (with ~20 degree pitch profile)





Dynamic Pressure for PA-1 nominal trajectory (with ~20 degree pitch profile)





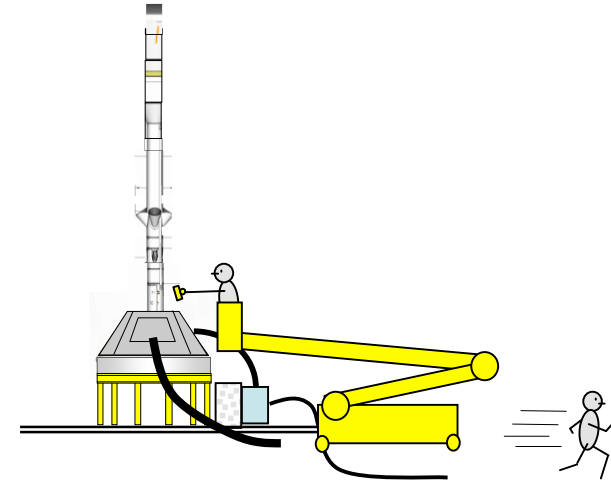
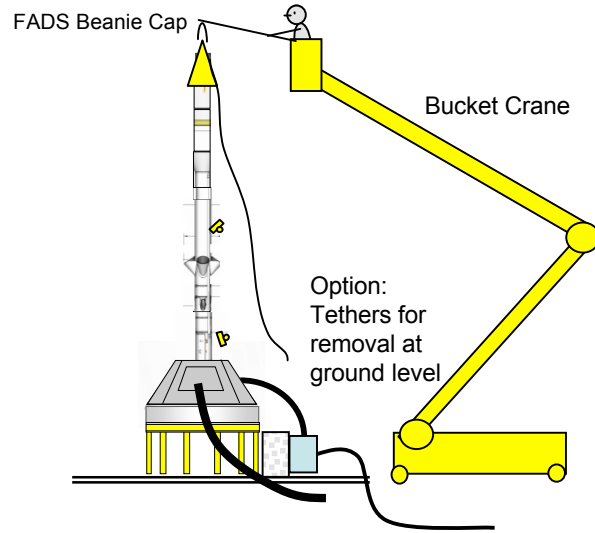
PA-1 dates & boilerplate photos



- PA-1 & AA-1 boilerplate construction currently in progress by LaRC
 - Boilerplate CM to ship to Dryden in February 2008
 - Flight Test LAS ships to White Sands in July 2008
 - LAV assembled & tested at White Sands July - September 2008
- PA-1 launch is set for September 23, 2008



Day-of-Launch Activities

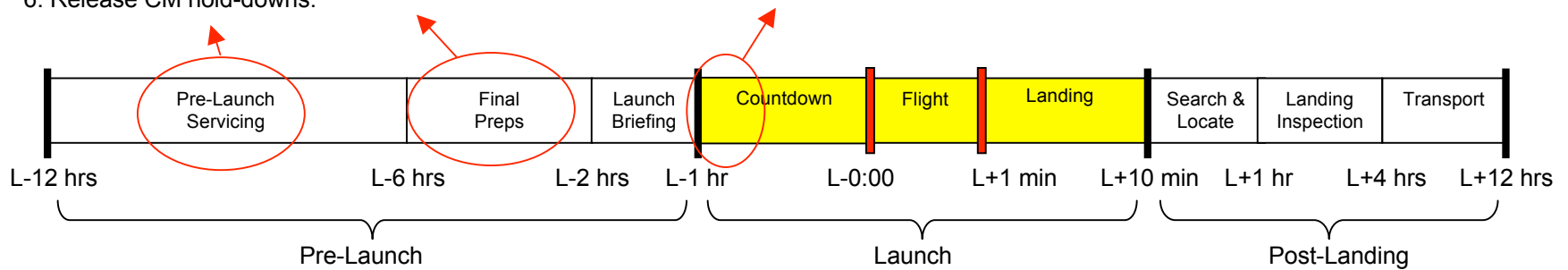


Pre-Launch Phase:

1. Remove LAS desiccant pack; replace hard cover with soft cover.
2. Secure CM hatch panel.
3. Remove FADS beanie cap.
4. Secure BPC Hatch Panel.
5. Remove CM hatch access platform.
6. Release CM hold-downs.

After Launch Briefing (L-1 hr) and with "go" for test:

7. Remove LAS safe and arm devices.
8. Move bucket crane behind blast barrier.
9. Pad egress and relocate to safe zone.





Heat Shield Simulators



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Photo courtesy of Amanda Cutright, LaRC



Project Orion: Flight Test Office





Photo courtesy of J.K. Walters, LaRC



Project Orion: Flight Test Office





Photo courtesy of Amanda Cutright, LaRC



Project Orion: Flight Test Office

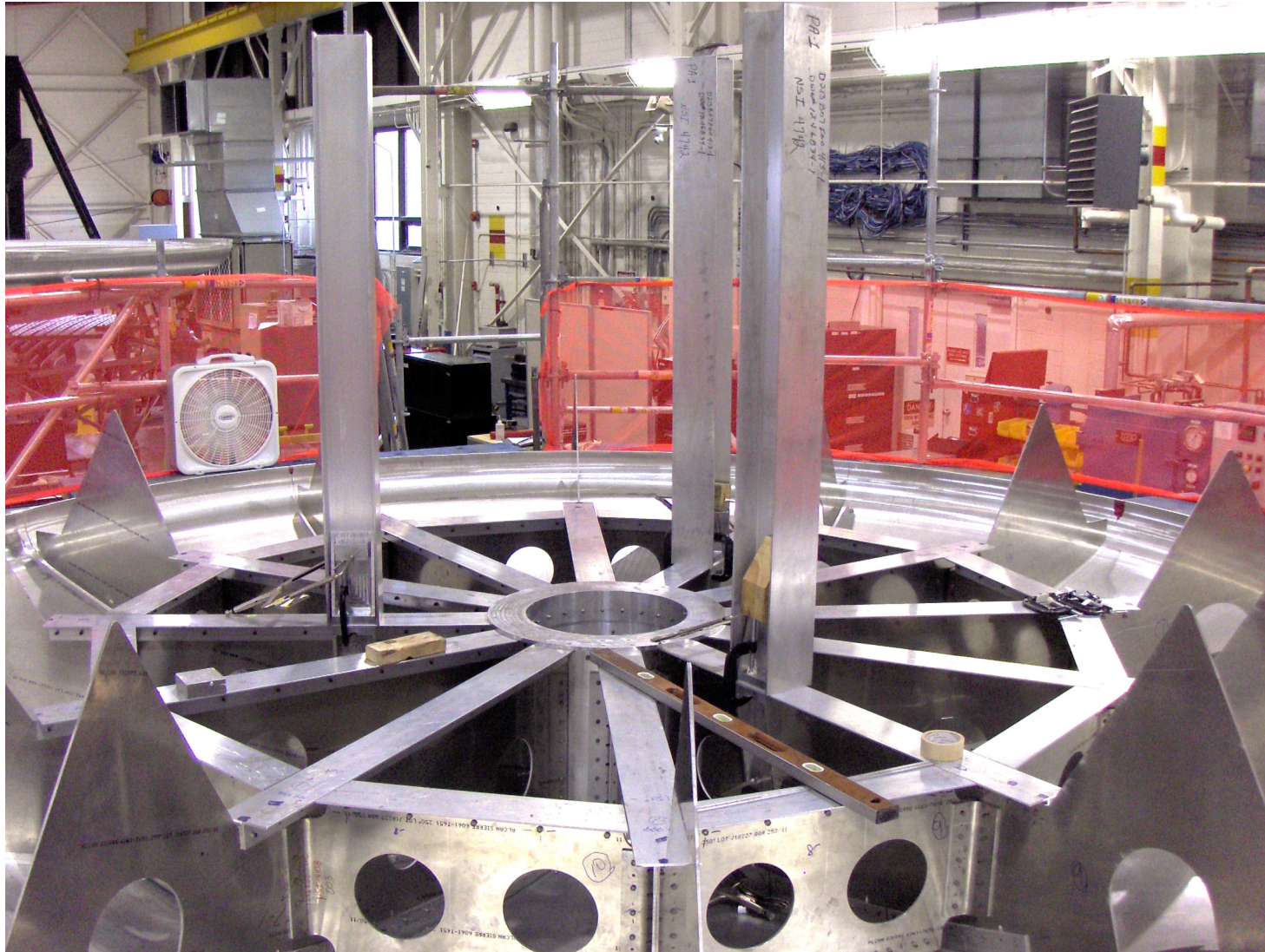


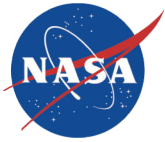


Photo courtesy of Amanda Cutright, LaRC



Project Orion: Flight Test Office





Acknowledgements



- Flight Test Flight Dynamics Working Group members
- Ascent Abort Mode Team of Johnson Space Center
- Amanda Cutright, Langley Research Center
- Kenny Walters, Langley Research Center
- Flight Test Office