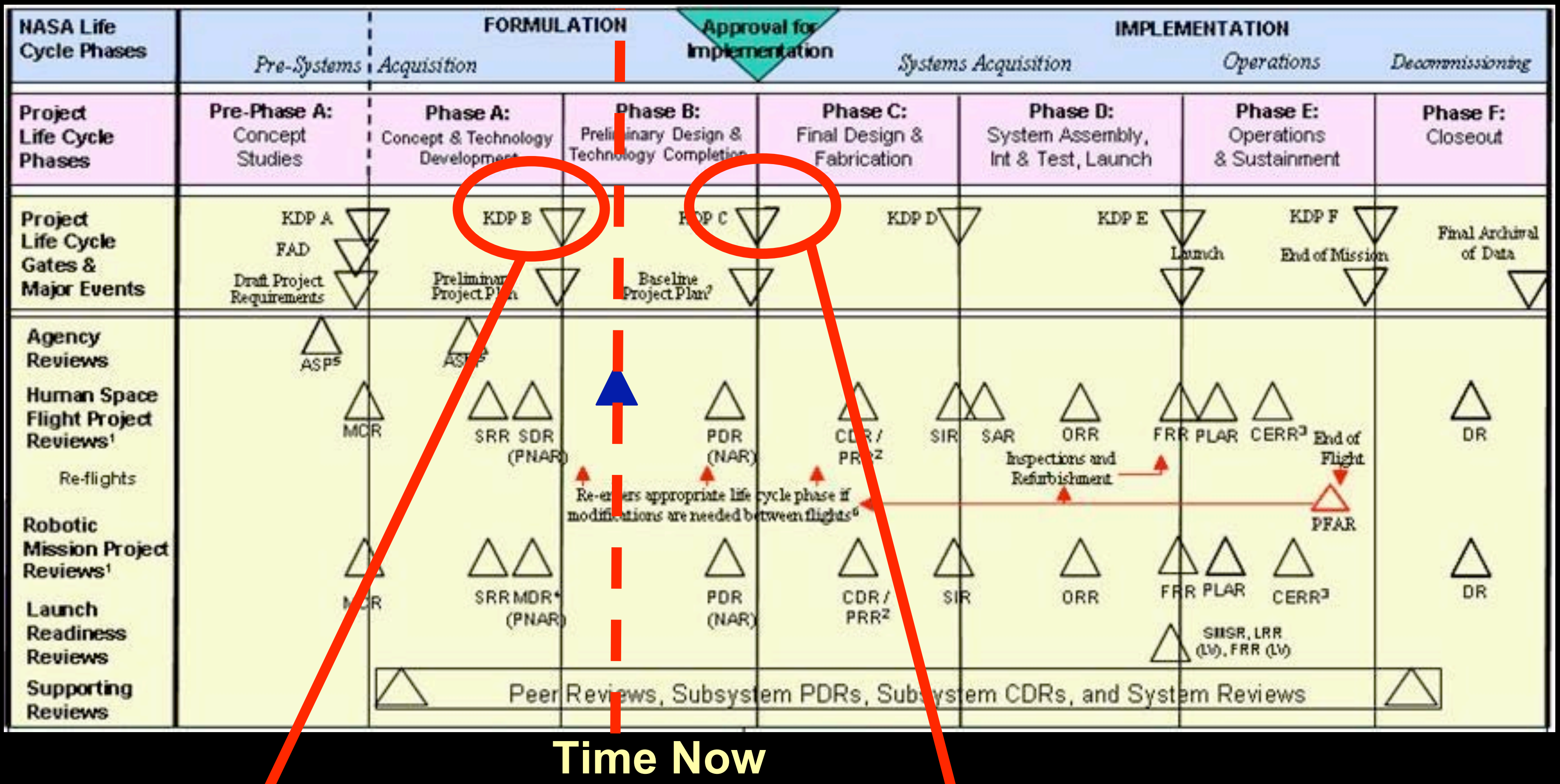
Orion Crew Exploration Vehicle
Overview

Masters Forum
Fred Ouellette
May 2009

NASA Program Life Cycle from 7120.5D



Completed: April 2008

Projected: 2Q FY10

NASA Orion Project Organization

Manager: Mark Geyer (ZV-111)
Deputy: Mark Kirasich
Assistant Manager, Technical Resources, Fred Ouellette
Assistant Manager, Management Integration, Paul Marshall
Assistant for Communication Integration, Barbara Zelon
Secretary, Karen Magram

Chief Engineer (EA): Julie Kramer White
Safety TA: John Trainor
Health & Medical TA: Mihriban Whitmore

DCMA Orion Program Integrator: Dural Horton

MOD: Robert Armstrong

KSC: Kelvin Manning

Flight Crew: Marsha Ivins

AMES Project Lead: George Sarver

DFRC Project Lead: Brent Cobleigh

GRC Project Lead: Eli Naffah (A)

LaRC Project Lead: Todd Denkins

MSFC Project Lead: Larry Gagliano

Project Planning & Control Office (ZV-211)
Manager: Bob Floyd
Deputy: Karen Schmalz

Vehicle Integration & Design (ZV-311)
Manager: John Curry
Dep Mgr, S/C Design: Chuck Dingell
Dep. Mgr, SE&I: Wayne Peterson
PLE (Design): Mike Brieden
PLE (SE&I): Brian Maynard

Safety & Mission Assurance (NC)
Manager: John Trainor

Production Operations (KSC & MAF)
Manager: Scott Wilson
Deputy: Glenn Chin

Crew Module (ZV-411)
Manager: Charlie Lundquist
Deputy: Jim Scheib
PLE: John Applewhite

Service Module (GRC-MX00)
Manager: Kathy Schubert (A)
Deputy: Kathy Schubert
PLE: Frank Gati

Launch Abort System (LaRC-E508)
Manager: Barry Meredith
Deputy: Steve Gaddis
PLE: John Stadler

Test & Verification (ZV-511)
Manager: Jim Free
Deputy: Mike See
PLE (EA): Michelle Rucker

Orion Government Project Team

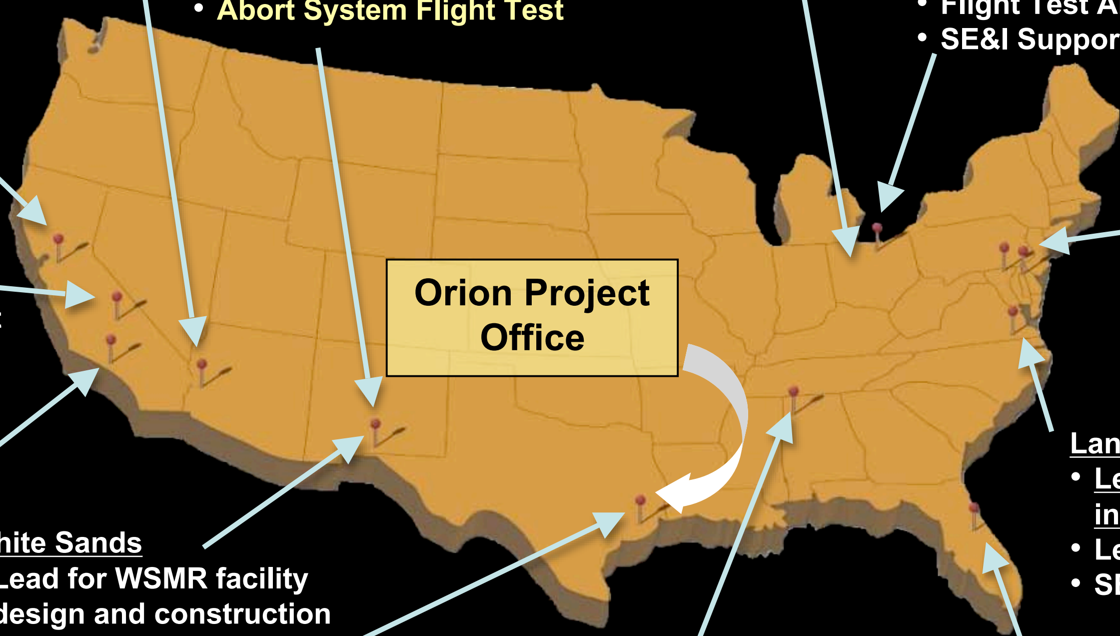
Ames
- Lead Thermal Protection System ADP
- Aero-Aerothermal database
- Software and GN&C support

Yuma Proving Grounds (U.S. Army)
- Parachute Testing

White Sands Missile Range (U.S. Army)
- Abort System Flight Test

Plum Brook Station
- Environmental Qualification test

Glenn
- Lead Service Module and Spacecraft Adapter integration
- Flight Test Article "Pathfinder" fabrication
- SE&I Support



Goddard
- Communications Support

Dryden
- Lead Abort Flight Test Integ/Ops
- Abort Test Booster procurement
- Flight Test Article Devt/Integ

White Sands
- Lead for WSMR facility design and construction management

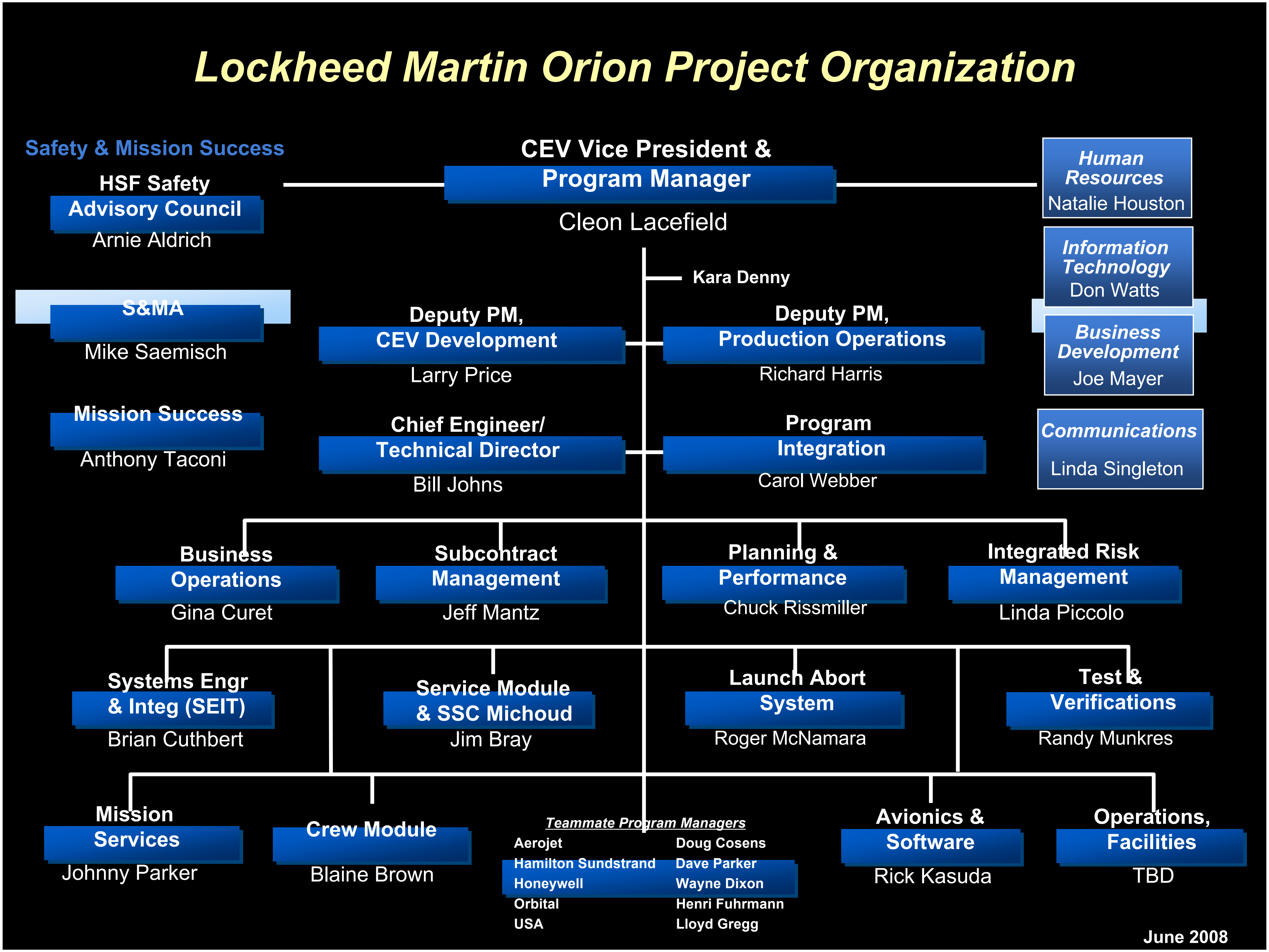
JPL
- Thermal Protection System support

Langley
- Lead Launch Abort System integration
- Lead landing system ADP
- SE&I Support

Kennedy
- Ground processing
- Launch operations
- Recovery operations

Johnson
- Lead Crew Module integration
- Orion Spacecraft Integration
- GFE projects management
- Flight Test Program

Marshall
- LAS and SM SE&I Support


Lockheed Martin Orion Project Organization
Safety & Mission Success
HSF Safety Advisory Council
Arnie Aldrich
S&MA
Mike Saemisch
Mission Success
Anthony Taconi
CEV Vice President & Program Manager
Cleon Lacefield
Kara Denny
Human Resources
Natalie Houston
Information Technology
Don Watts
Business Development
Joe Mayer
Communications
Linda Singleton
Deputy PM, CEV Development
Larry Price
Deputy PM, Production Operations
Richard Harris
Chief Engineer/ Technical Director
Bill Johns
Program Integration
Carol Webber
Business Operations
Gina Curet
Subcontract Management
Jeff Mantz
Planning & Performance
Chuck Rissmiller
Integrated Risk Management
Linda Piccolo
Systems Engr & Integ (SEIT)
Brian Cuthbert
Service Module & SSC Michoud
Jim Bray
Launch Abort System
Roger McNamara
Test & Verifications
Randy Munkres
Mission Services
Johnny Parker
Crew Module
Blaine Brown
Teammate Program Managers
Aerojet Doug Cosens
Hamilton Sundstrand Dave Parker
Honeywell Wayne Dixon
Orbital Henri Fuhrmann
USA Lloyd Gregg
Avionics & Software
Rick Kasuda
Operations, Facilities
TBD
June 2008

Orion Lockheed Martin Industry Team

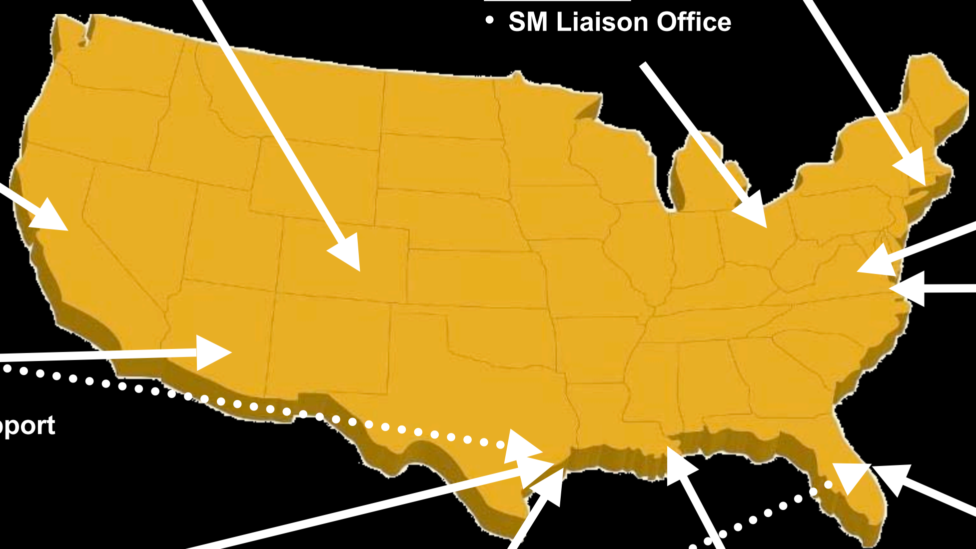
LOCKHEED MARTIN
- Systems & Design Engineering Support

Hamilton Sundstrand
A United Technologies Company
- Environmental Control & Life Support
- Active Thermal Control
- System Power Management

AEROJET
- Propulsion

LM GRC
- SM Liaison Office

Orbital
- Launch Abort System
- Safety & Mission Assurance



Honeywell
- Avionics
- Integrated System Health Management
- Crew Interface
- Mission Ground Ops Support

LM LaRC
- LAS Liaison Office

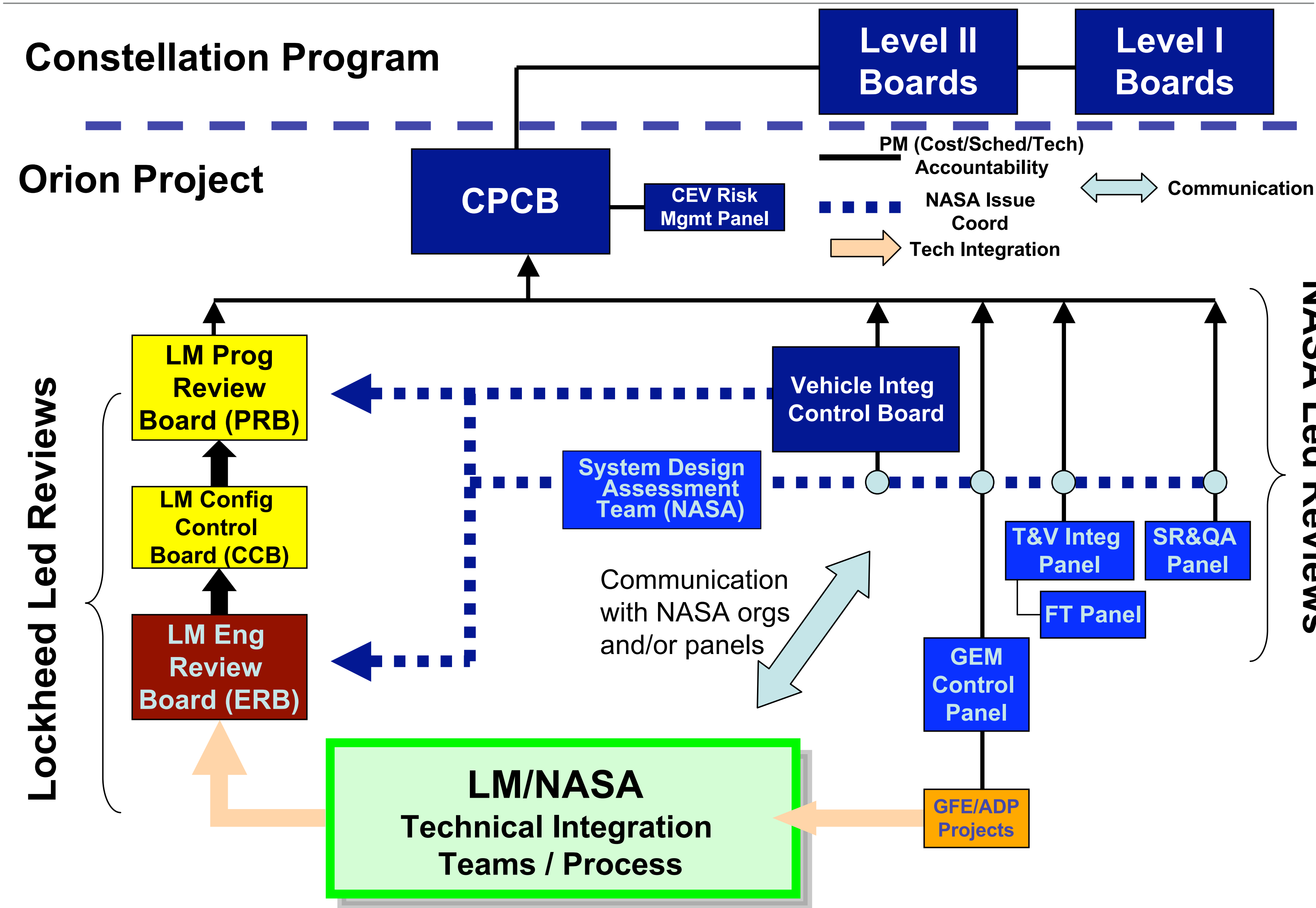
LOCKHEED MARTIN
KSC
- Final Assembly
- Checkout
- Acceptance Test
- Sustaining Engineering
- Spacecraft Refurbishment

LOCKHEED MARTIN
- Program Management
- Systems Integration
- Crew Module Development
- Service Module Development
- Qualification Test
- Software Development

USA
United Space Alliance
- Operator Interfaces
- Ground Processing
- Mission Flight Planning
- Software Development

LOCKHEED MARTIN
Michoud
- CM and SM Structures

CEV Project Boards and Panels Structure



Government Furnished Equipment (GFE) and Advanced Development Projects (ADP) Roles

- Several Non-Prime efforts are managed out of Orion project office
  - GFE projects (LIDS, ATLAS, CPAS, ICCA)
  - Advanced Development Projects (TPS ADP, Landing Systems ADP)
  - Test Facilities (IET@GRC, CAIL, EEST)
  - Abort Flight Test Projects (PA-x, AA-x, facilities)
  - Aerodynamics/Aerothermal Testing/Analysis/Database & Model Development (CAP)
- Management Processes
  - Leadership: NASA Project managers report to respective Orion Managers
    - Teams utilize resources across multiple centers
  - Interaction with Prime
    - Requirements trace/flow from prime (thru NASA) to GFE and ADP projects
    - GFE/ADP design data and PDR/CDR products flows to prime (thru NASA)
    - Both flows utilize Orion Config Management processes & databases
  - PP&C control: follows similar processes as Prime-led efforts
    - Integrated Budget & schedule accounting/databases
    - Status Reviews (TCSRs, PMRs, etc.)
    - Budget planning/formulation (PMR08r1, PMR09, etc)
    - Funding issues utilize Orion IRMA and risk review processes

Governance, Technical Authority, and Independent Assessment in Constellation

The NASA Governance Model

(NASA Policy Directive (NPD) 1000.0, NASA Strategic Management and Governance Handbook)

- Separates Programmatic and Institutional Authorities
- Describes Governing Councils
- Articulates Strategic Management Principles
- Establishes Technical Authority

NPD 1000.0

→ **NASA Space Flight Program and Project Management Requirements**

NPR 7120.5D (Section 3.4)

→ **Constellation Program Plan**

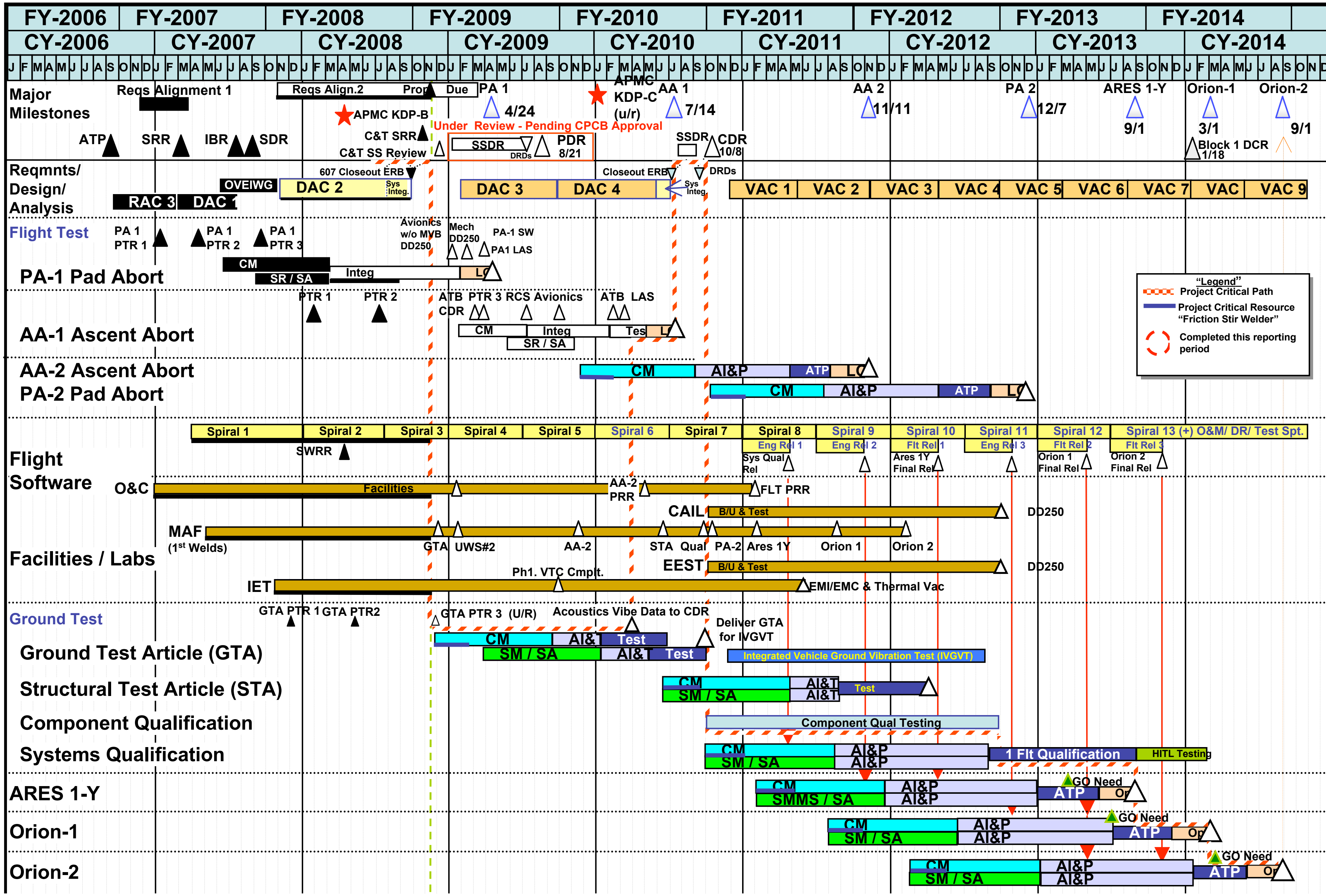
CxP 70003 (Section 4.4)

Technical Authority and Independent Assessment

- Technical Authority (TA) is the institutional expertise required in the Engineering, S&MA, and medical fields in order to make sound technical engineering decisions.
- For Constellation (Cx), technical authority consists of the Office of Chief Engineer (OCE), Office of Safety and Mission Assurance (OSMA), and Office of the Chief Health and Medical Officer (OCHMO) and their respective institutional support across the Agency. Implemented at Program and Projects level.
- Independent Assessment performed through HQ chartered Standing Review Boards

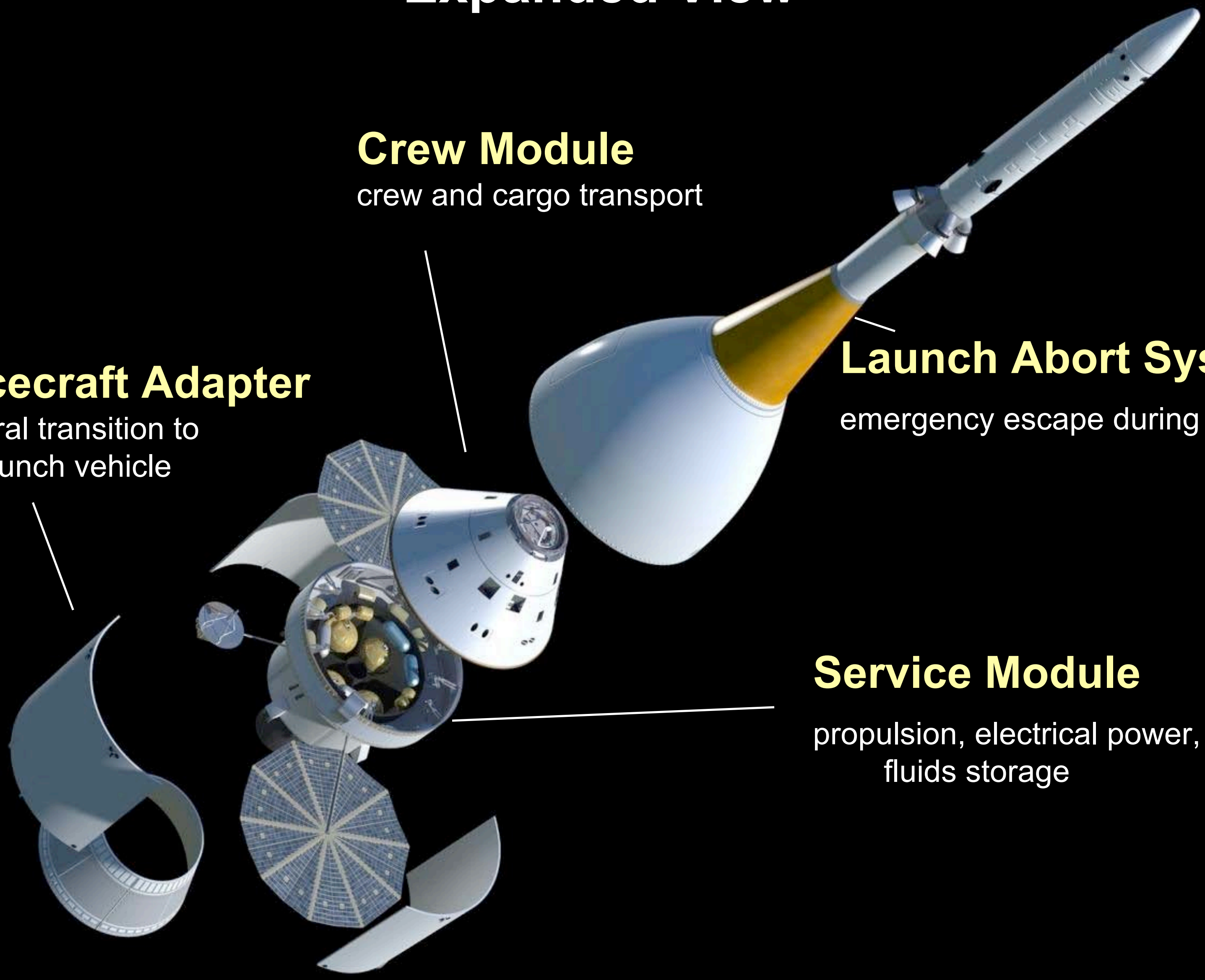
Orion Master Summary Schedule

Status as of 11/21/08



Orion Crew Exploration Vehicle

Expanded View



Apollo/Orion Comparison

5 meter diameter capsule – Apollo shape

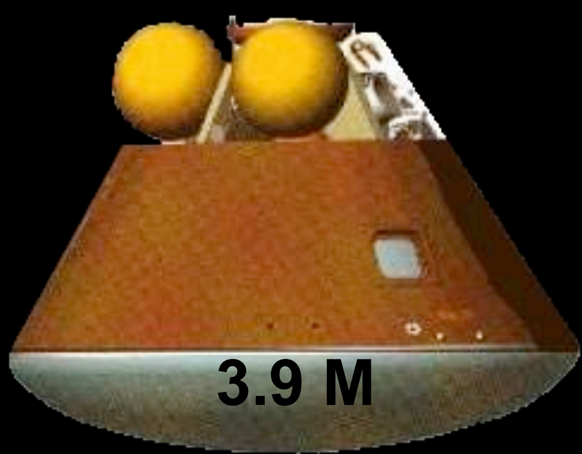
- Significant increase in volume from Apollo (3.9 meter)
- Reduced development time and risk

Larger Crew Accommodations

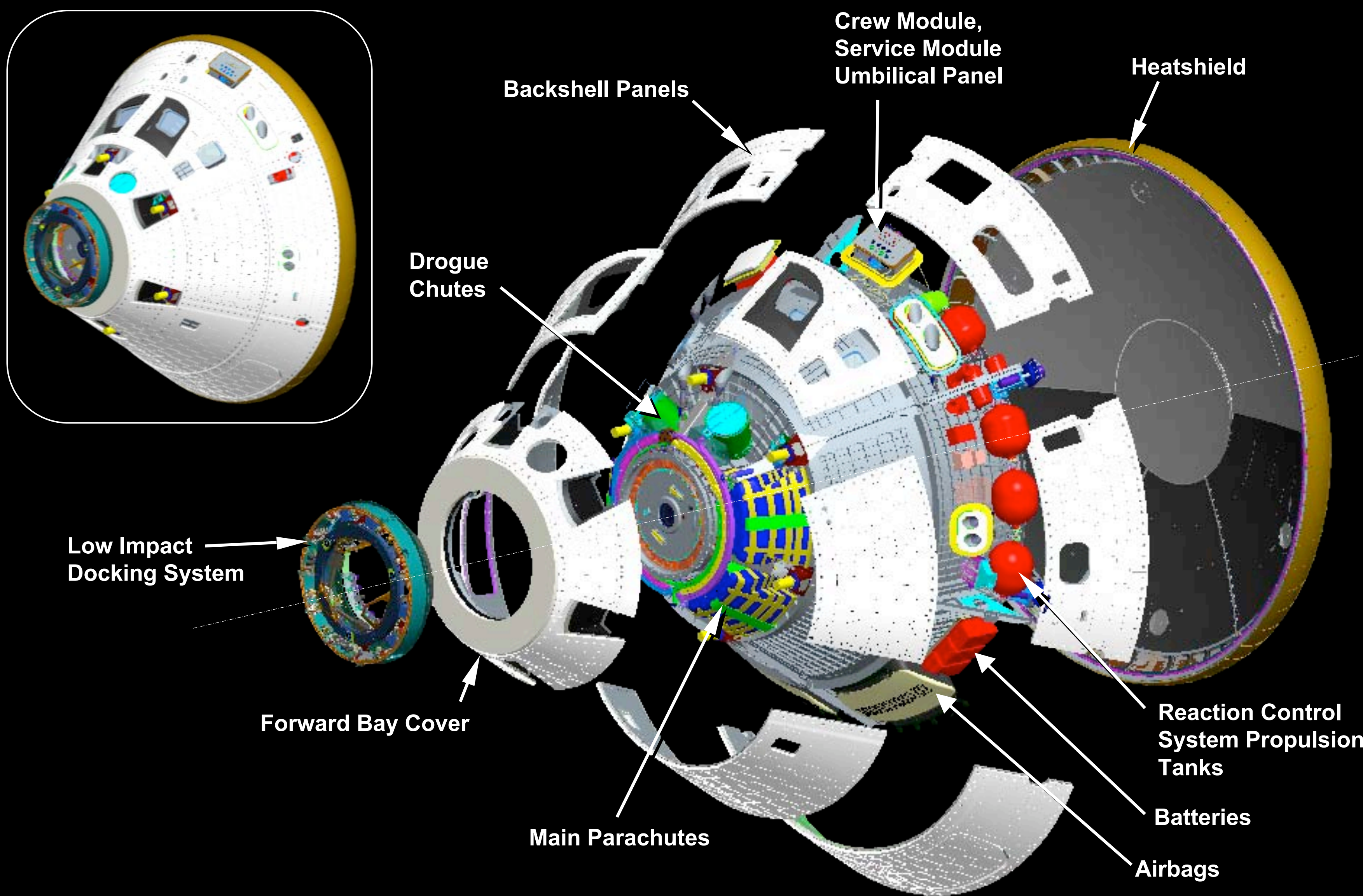
- Lunar missions: 4 crew
- Space Station missions: 6 crew

Expanded Mission Capabilities

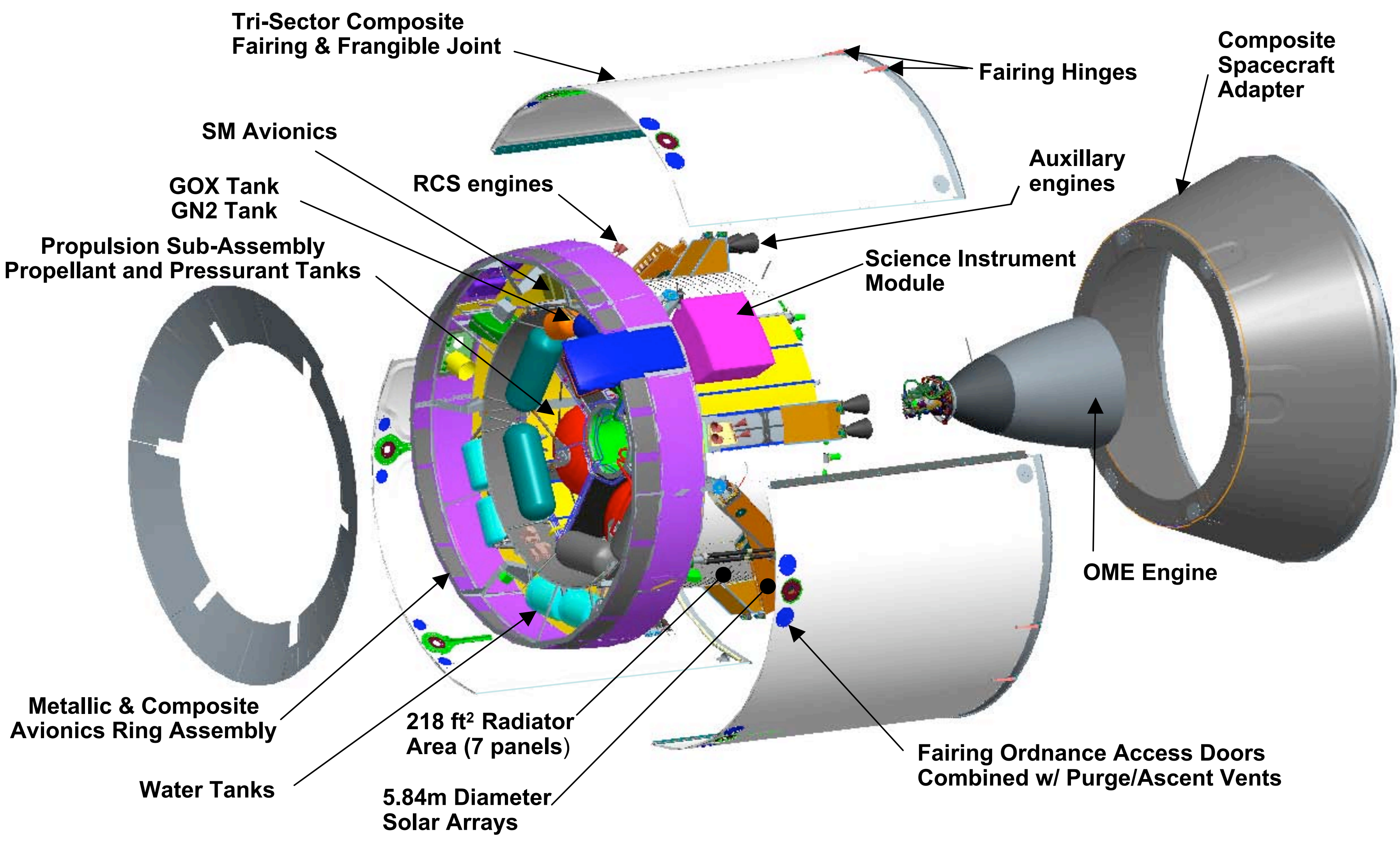
- Long Duration (6 months)
- State-of-the-Art Materials, Systems



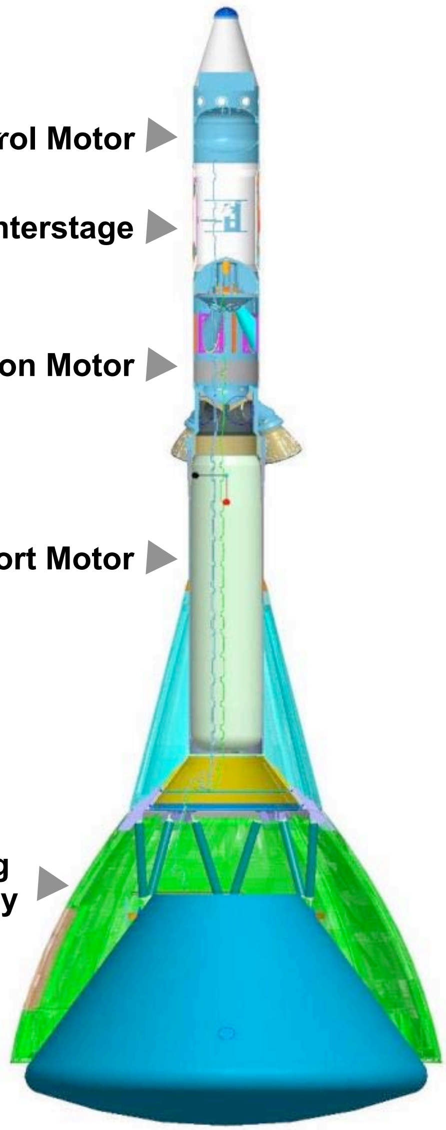
Orion External Configuration



Orion Service Module

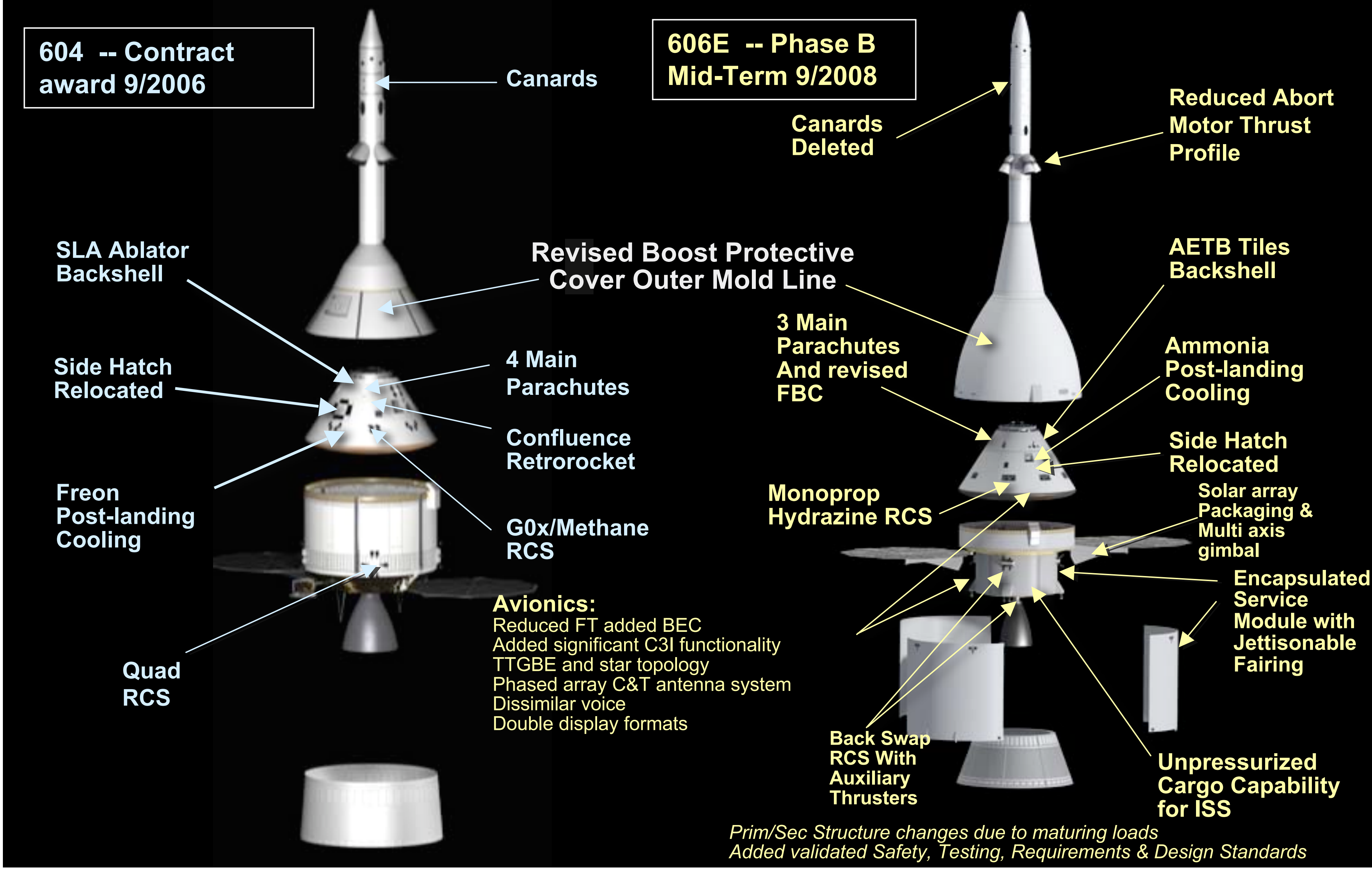


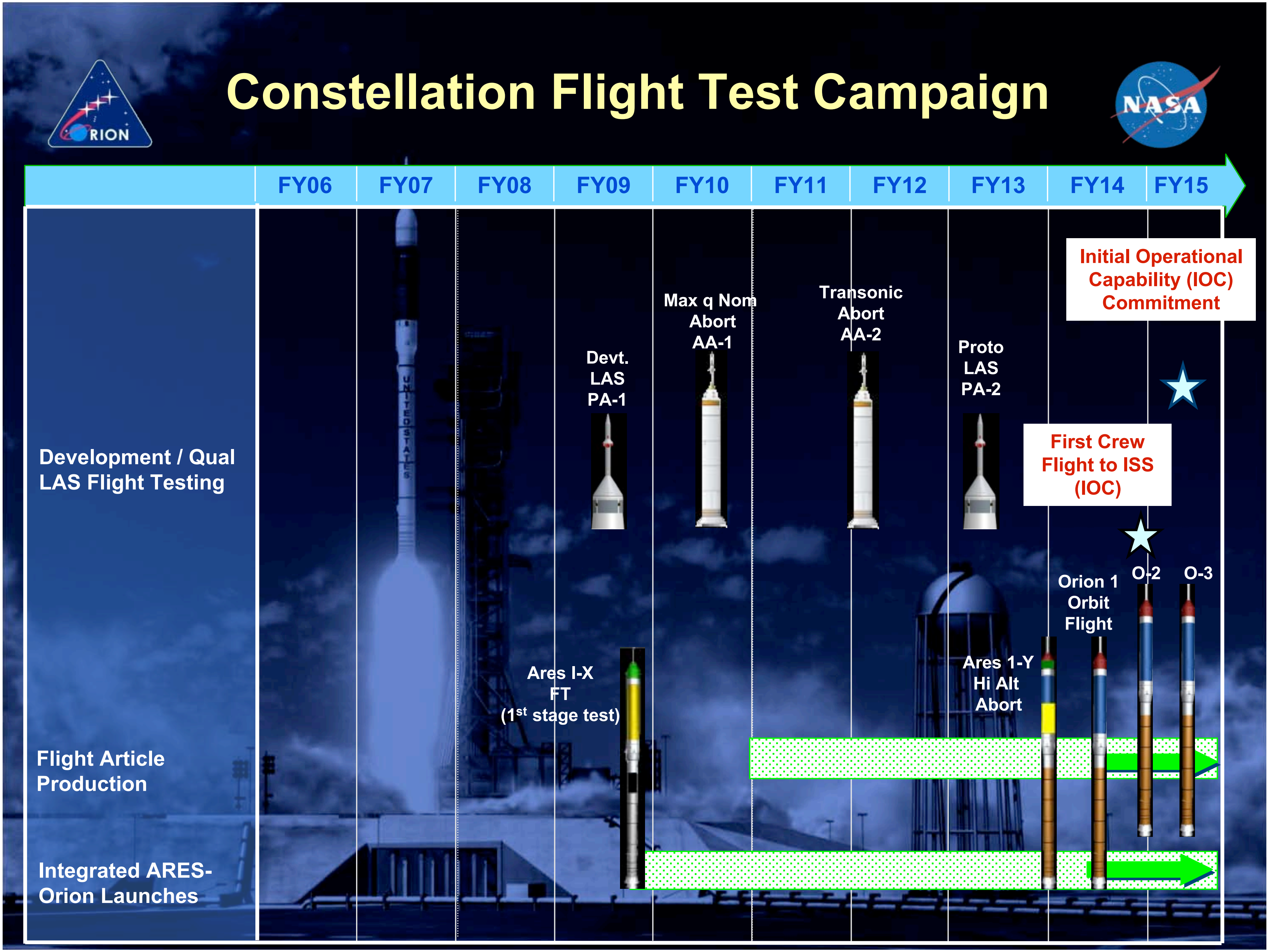
Orion Launch Abort System



Capability	All Versions
Control Mass	15598 lbm
Abort Range	0 – 300,000 ft
Power Storage	Li-ion 140 V & 28 V Batteries
GN&C	Closed loop control provided by CM
Communications	S- Band for CM mounted on Fillet
Propulsion	<u>Abort Motor</u> No. of Nozzles: 4 reverse flow Nozzle Cant Angle (to CL): 25º Isp (sea level): 245s Thr (Total in Vehicle Axis): 395,000 lbs (Reduced AMTP) Burn Time: 4.4 s Wagon wheel grain design <u>Attitude Control Motor</u> No. of Nozzles: 8 Nozzle Cant Angle (to CL): 90º Isp (vac): 227s Thr (per Nozzle): 4101 lbs max Burn Time: 30s <u>Jettison Motor</u> No. of Nozzles: 4 Nozzle Cant Angle (to CL): 35º Isp (vac.): 221s Thrust axial vac: 32.9k lbs Burn Time: 1.55s

Major Configuration Changes Since Contract Award




Constellation Flight Test Campaign
RION
NASA
FY06
FY07
FY08
FY09
FY10
FY11
FY12
FY13
FY14
FY15
Development / Qual LAS Flight Testing
Flight Article Production
Integrated ARES-Orion Launches
Devt. LAS PA-1
Max q Nom Abort AA-1
Transonic Abort AA-2
Proto LAS PA-2
Initial Operational Capability (IOC) Commitment
First Crew Flight to ISS (IOC)
Ares I-X FT (1st stage test)
Ares 1-Y Hi Alt Abort
Orion 1 Orbit Flight
O-2
O-3

Orion **Accomplishments**

May 2009

Orion Challenges and Opportunities

- Technical
- Non-Technical
- Personnel

Technical Challenges

- **Extending capability of current design heritage**
  - **LAS Attitude Control Motor**
    - Test anomalies: i.e. ACM HT-7 followed by successful HT-6 and HT-8 after investigation and design modifications
  - **Parachutes – limiting capability during landing**
  - **Command/Crew Module – even though using heritage shape, increase in capability still driving extensive testing and validation**

- **Mass (in 2007, reduced ~ 7000 lbs and 300 lbs of risk**
  - **Always a challenge no matter how much capability you have**
  - **Mass affected by meeting other requirements; acoustics (LAS O-Jive Fairing), loads, LOC/LOM improvements**

- **Program requirement maturation in parallel to Orion concept and architecture development – SE&I challenges**
  - **Communication system**
  - **Landing (primary water with contingency land landing)**

Technical Opportunities

- **Risk Informed Design**
  incorporating PRA into architecture studies and preliminary design integration

- **Imbed Technical Authority**
  Engineering, SRQA and H&M, and use them

- **Implementation of the technical oversight team across agency**

- **Strong requirement push/pull**
  - Contractor ⟷ NASA CEV
  - NASA CEV ⟷ CxP and other elements

- **Use NESC for specific support tasks and analysis**

Non-Technical Challenges

- Level of independent oversight activities due to size of project
  - External – IG and GAO (continuous), OMB (periodic, as needed)
  - Internal – SRB (Cx and Orion), ASAP, NAC, PA&E, OCE
- Keeping the contract aligned with the changing requirements and budget
- Projects need to consider the “illogical” political ramifications of actions internal and external to the project
- “Death by Meetings”
  - What is the right balance in phase B of a major DDTE effort? Due to so many levels of boards/panels, authority gets confused
- Tracking and maintaining risks (technical, cost and schedule)

Non-Technical Opportunities

- **Plan on change**
  Project needs budget, schedule and technical flexibility to handle change
- **Engage procurement personnel the same way you would technical folks**
  Fold them into the team
- **Don't get fixed on organization and board structure**
  These are tools and need to be changed to maximize performance.
- **Use independent review outputs**
  Investigate and learn from independent reviews (also review other relevant reviews)
- **Use previous lessons learned**
  Most of the time, something you are seeing for the first time has probably happened before

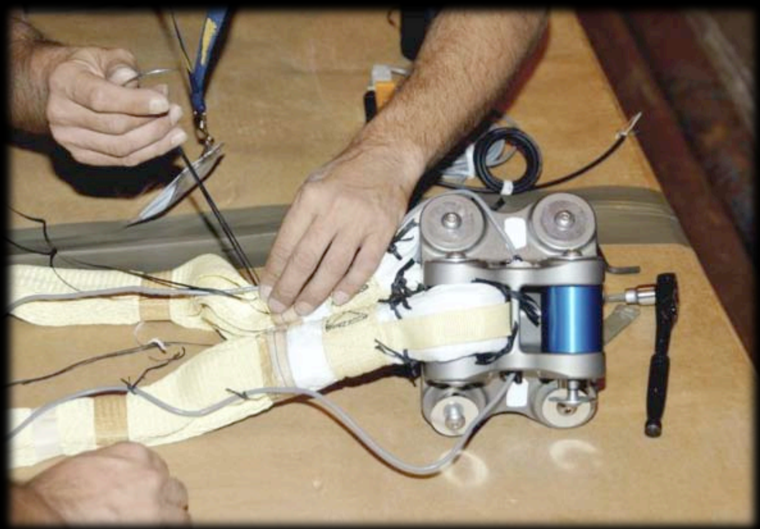
Personnel Challenges

- **Working with a dispersed team**
  Even though we have a lot of remote support capability, it still is not as effective as it could be. Also, appreciation isn't as strong at dispersed centers
- **Communication, no matter how good, is not satisfactory to all**
  Some want more, some want less. Also, communication is probably one of our biggest hurdles to being more effective and efficient. If there are 10 people, there are 10 different interpretations
- **Work load!**
  With the IT infrastructure we use, information travels faster and constantly.   Always in a race to keep in front of the "bad news" before it reaches higher management. With blackberries, everyone works at some level 16 hours a day, only time we don't, it seems, is when we sleep (which is another thing we sacrifice in a project)
- **Relationships**
  Constant reassuring and "massaging" of relationships between NASA and with the contractor

Personnel Opportunities

- Push to use the best personnel in the agency, no matter which center they are located
- There are many tools out there to gauge personnel /team performance and perceptions, USE THEM!
- Take the time for training, whether individually or as a project
- Recognize your project team's effort, even in difficult times
- "…Marathon, not a sprint", constantly look for ways to reduce stress and workload (9/80 work weeks, holiday shut down)
- Provide personnel the best tools for their work. The intangible efficiency gained by this significantly outweighs the costs

Parachute Integration

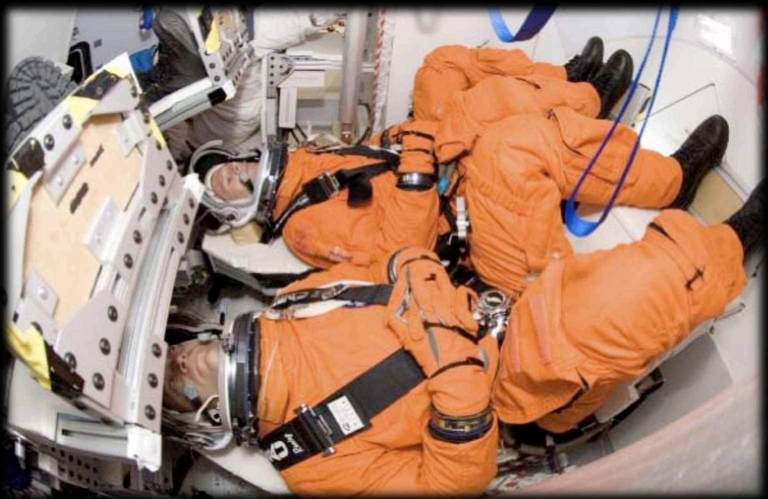


Parachute Test Vehicle

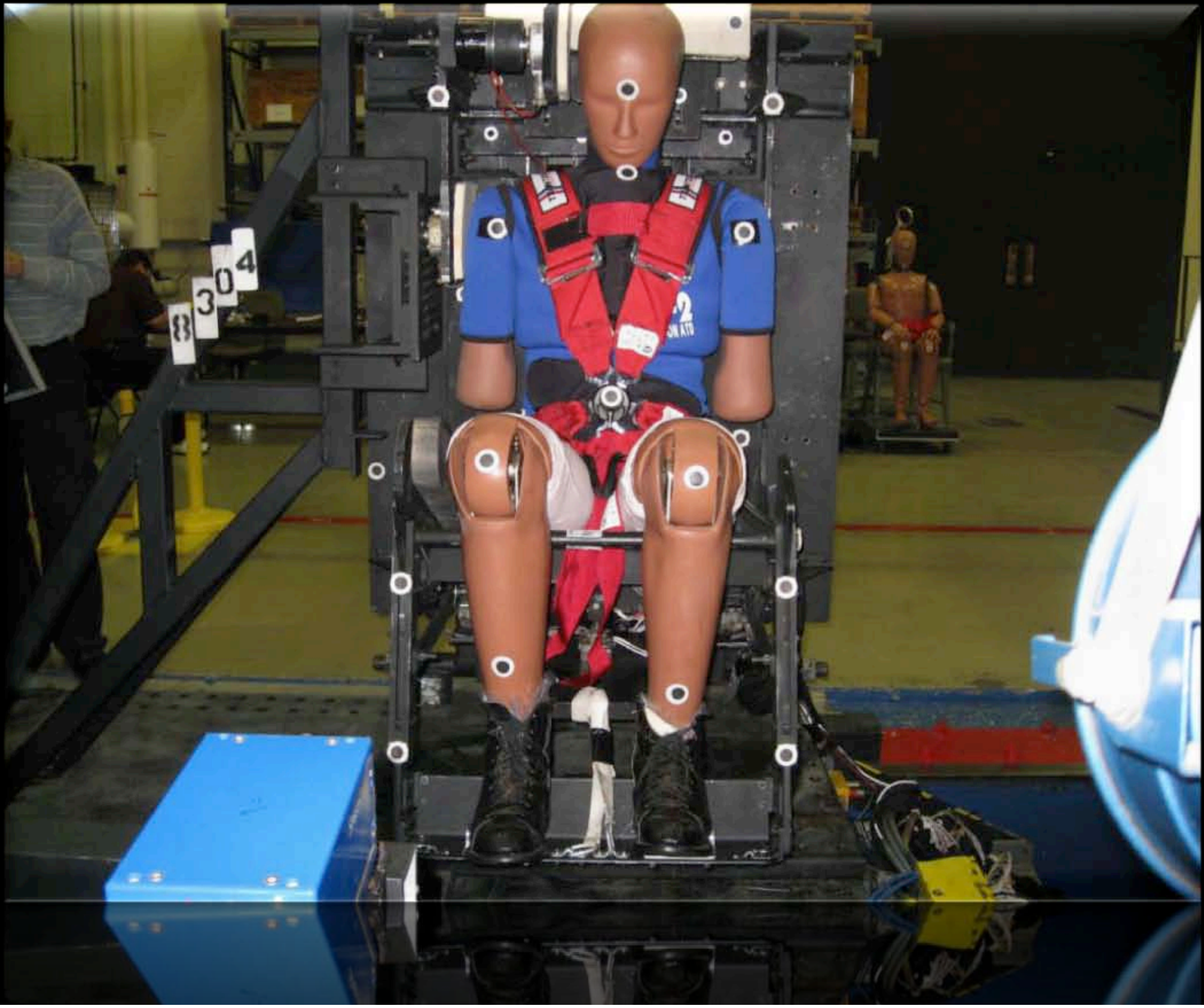
Parachute Tests

Crew Impact Attenuation System **Test Fixture**

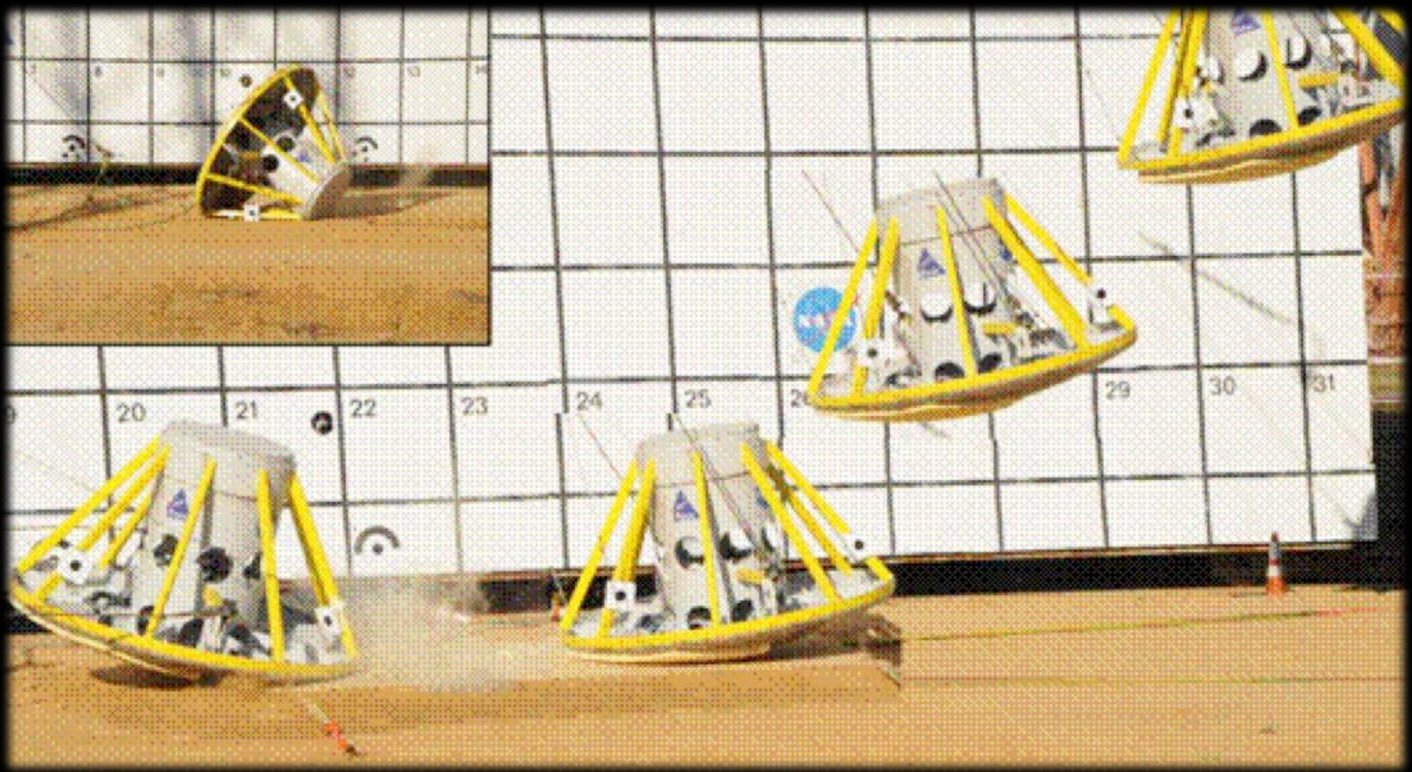
Orion Seat Evaluations



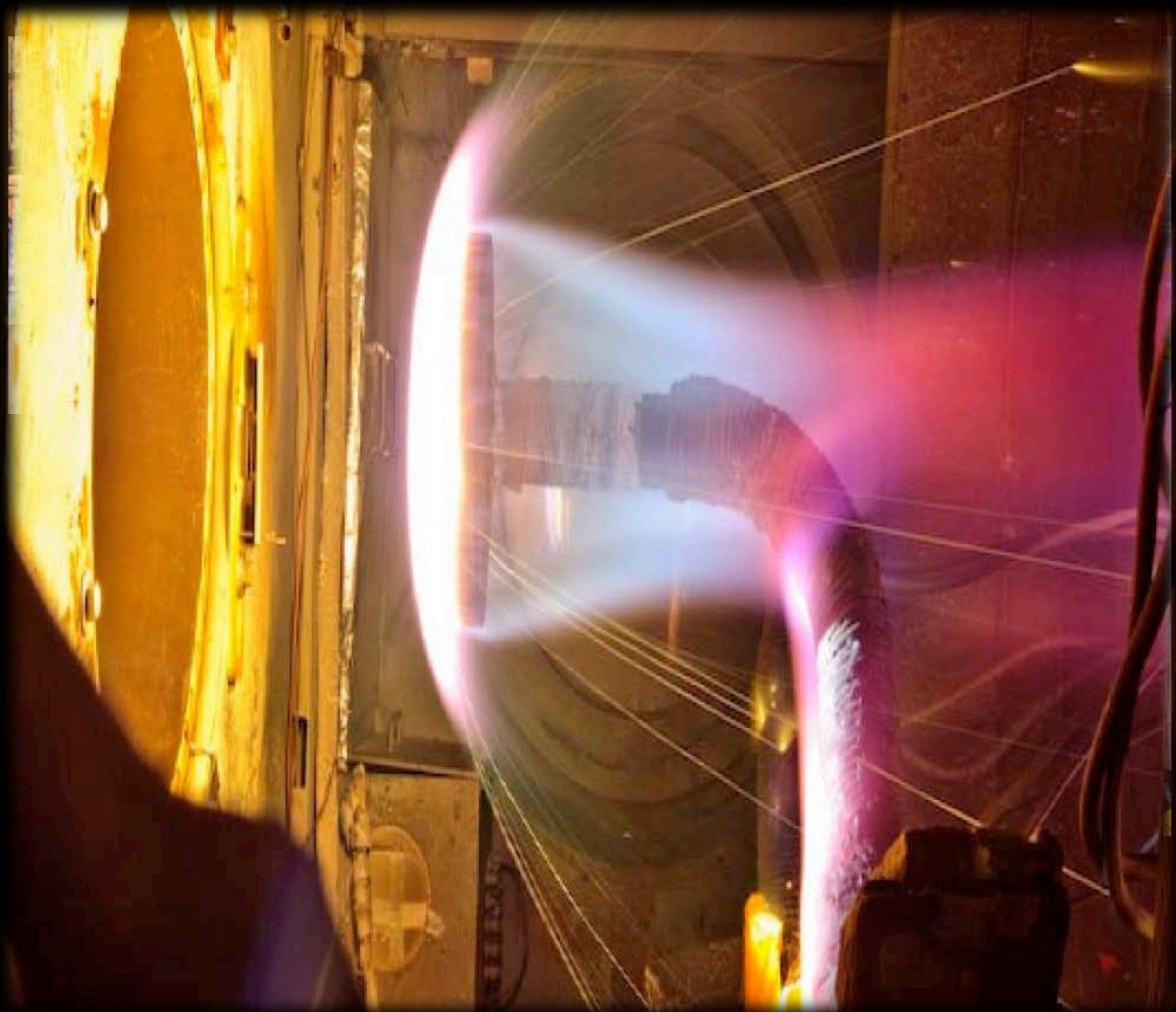
Crew Systems Lateral Restraint Sled Testing



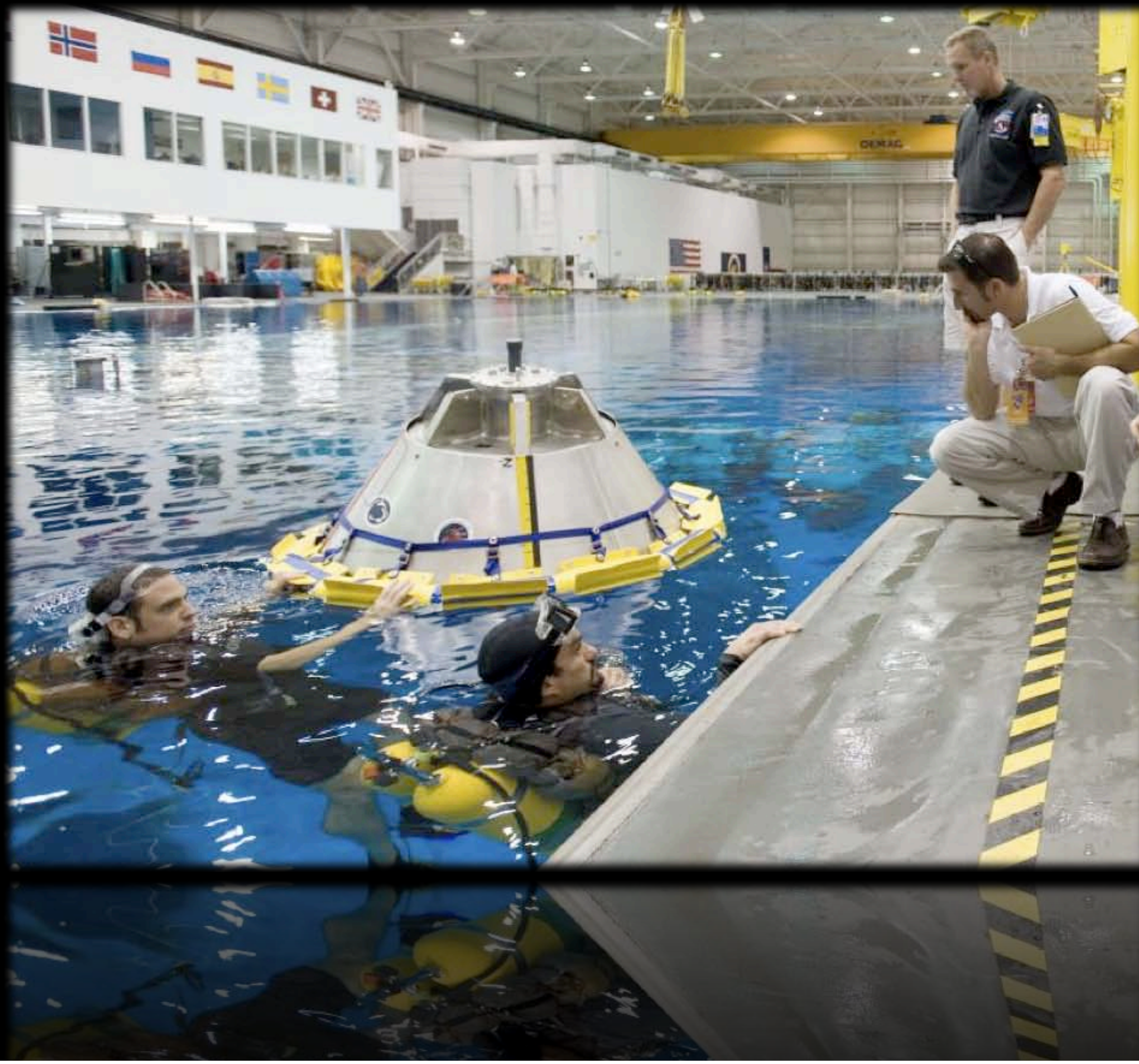
Avcoat Friction **Drop Tests**



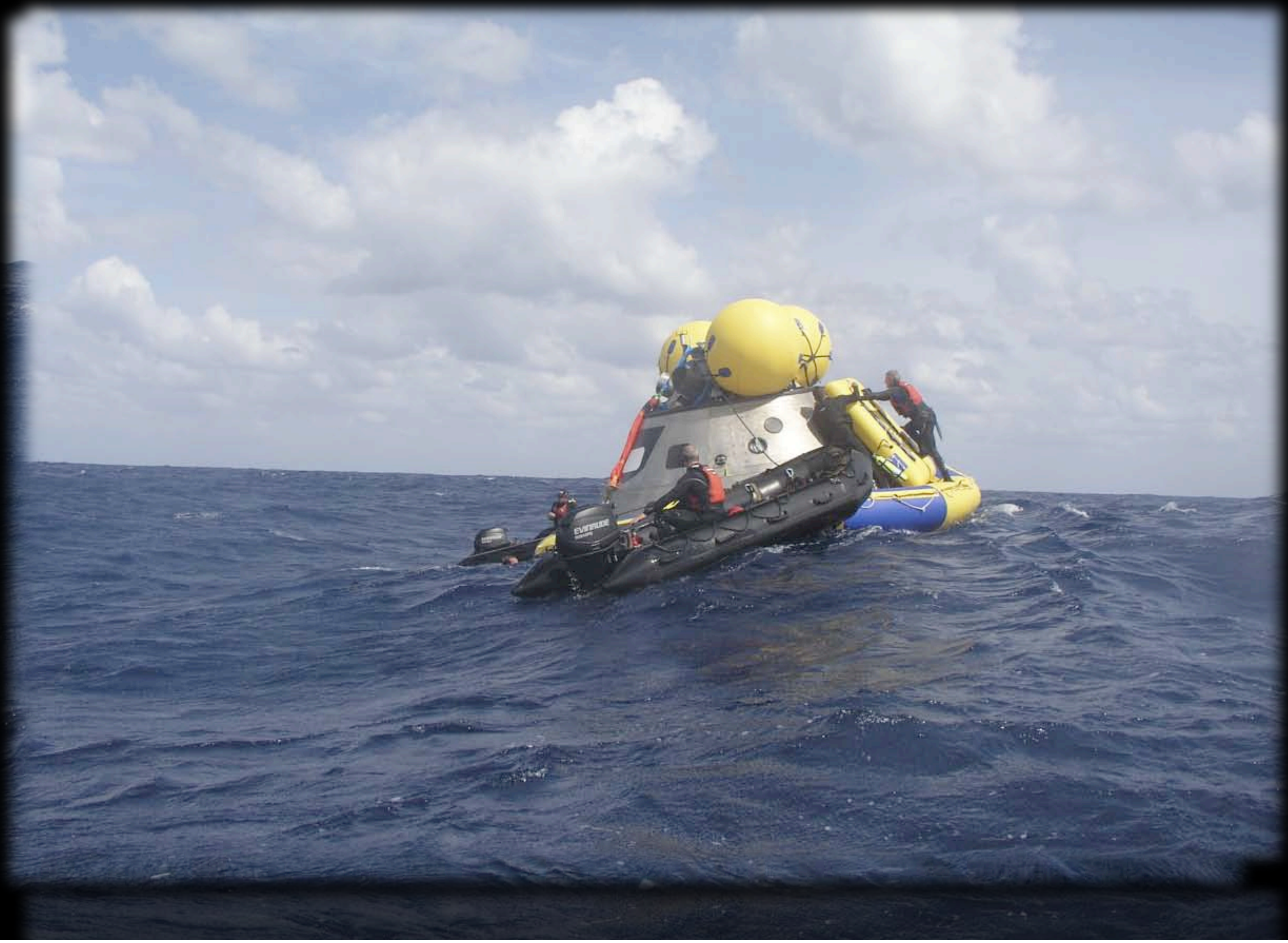
Downselect of Avcoat &
Thermal Protection System Transition



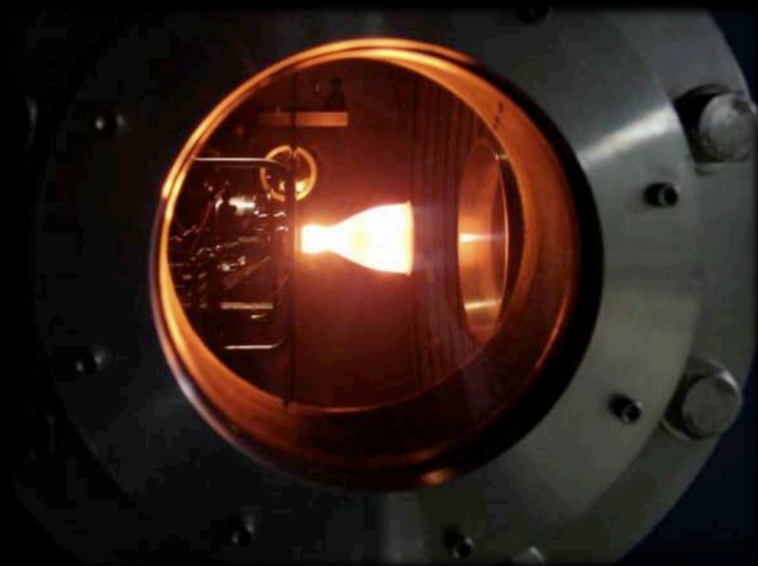
¼ Scale Crew Module Testing **Neutral Buoyancy Lab**

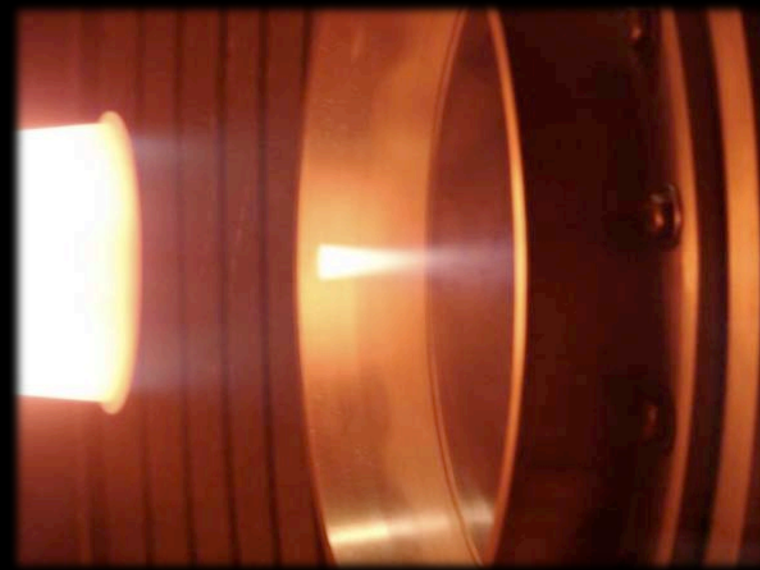


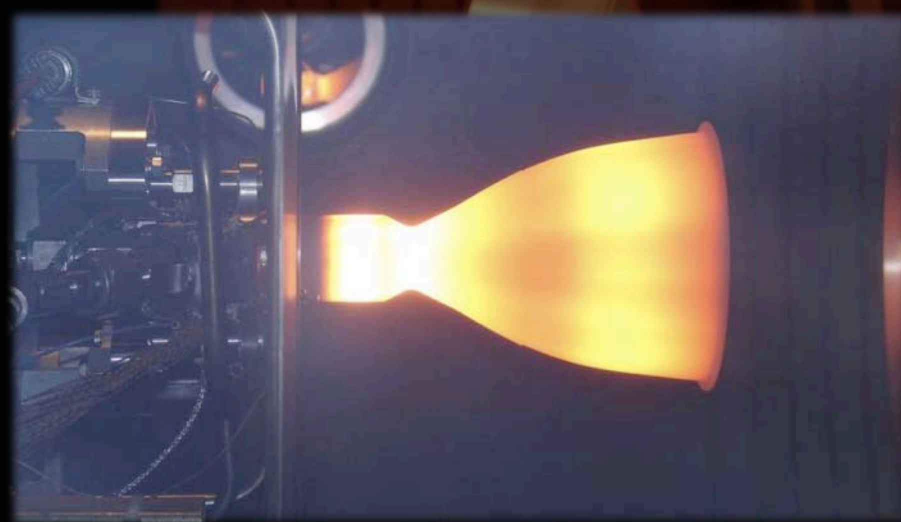
Orion PORT Sea State Testing



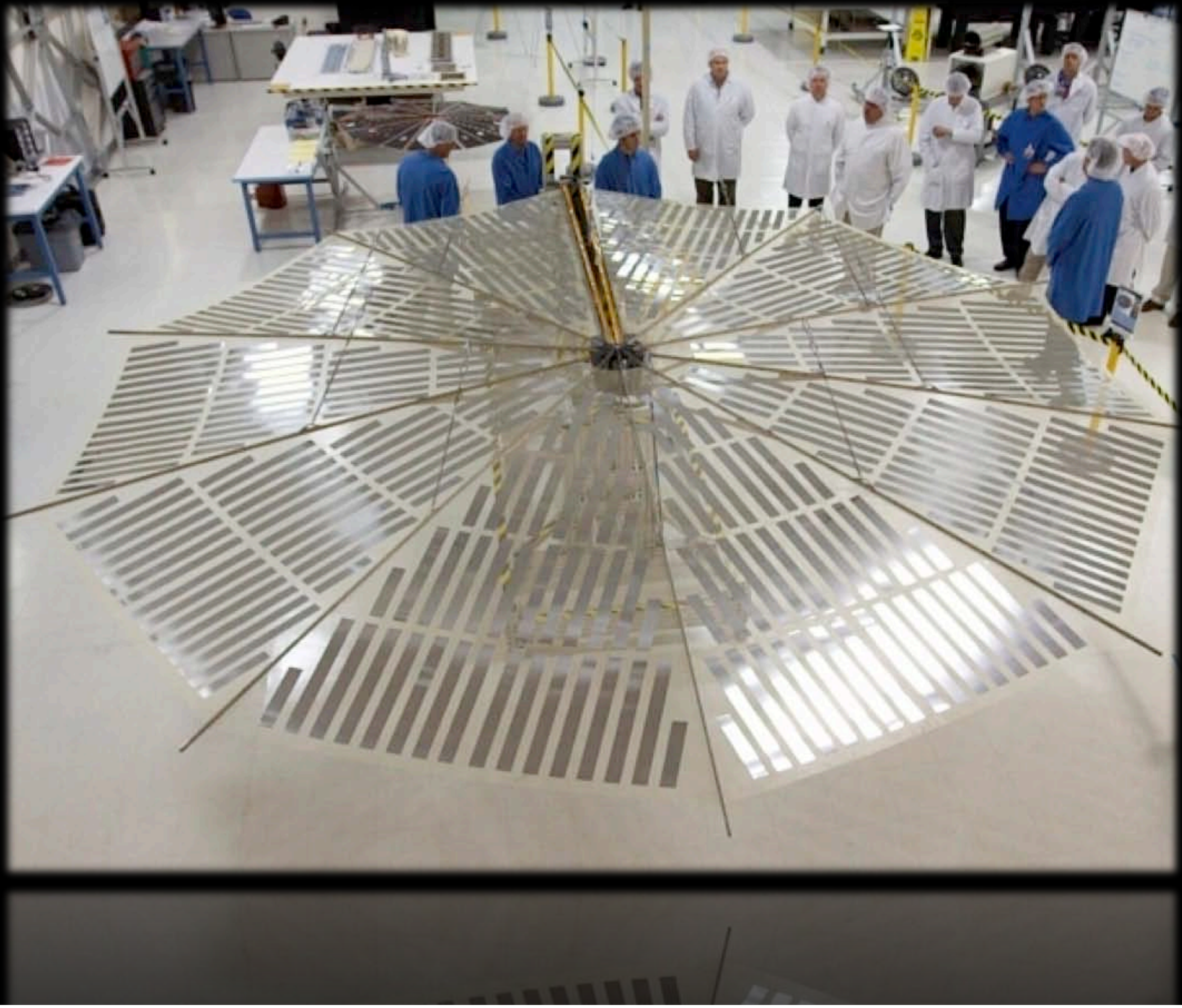
Service Module Auxiliary Propulsion







Solar Array Deployment Testing



Abort Motor **Static Test-1**

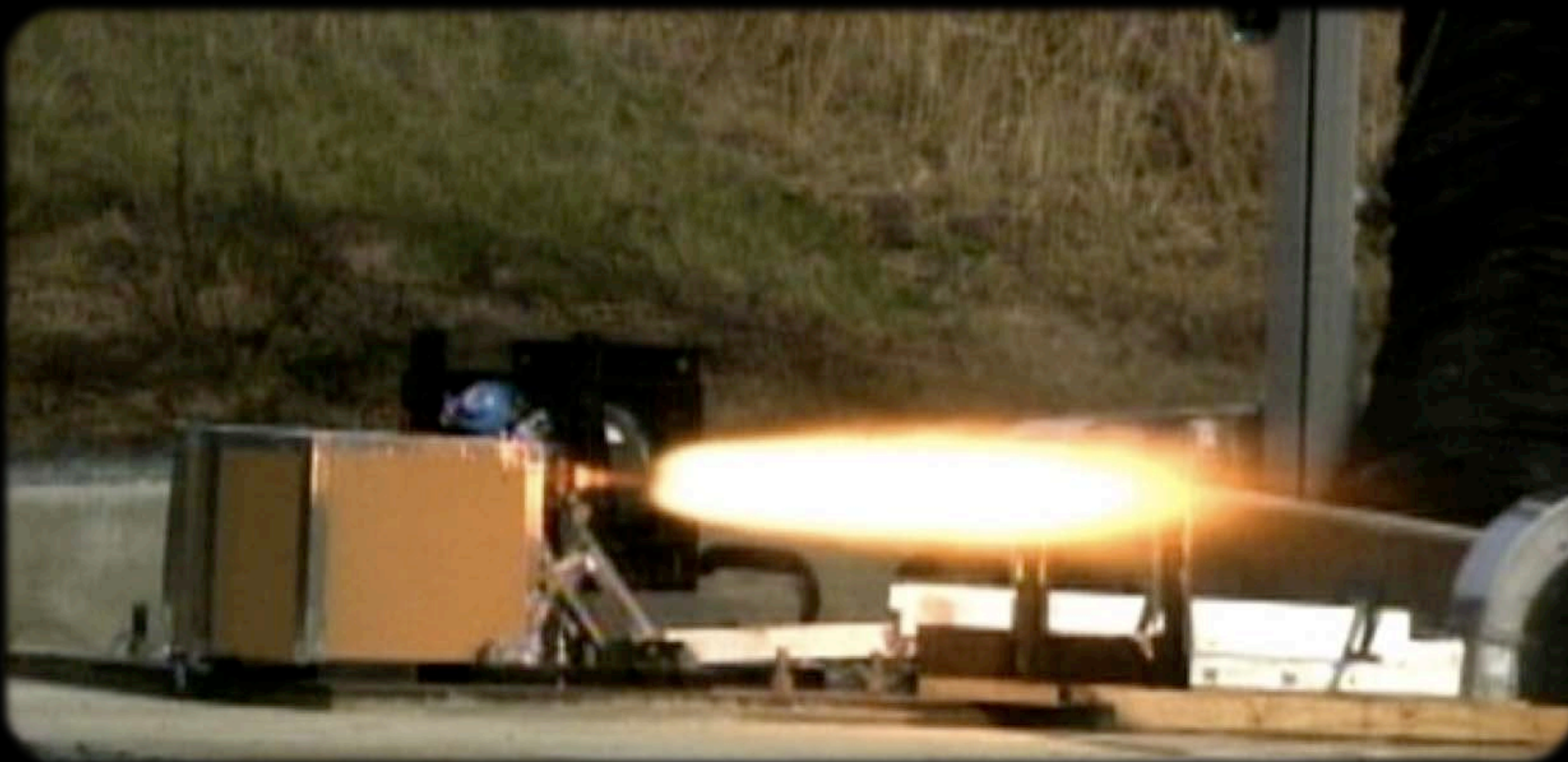
video

Launch Abort System Jettison Motor

SDU Case

SDU Core

Attitude Control Motor High Thrust 6



Attitude Control Motor **High Thrust 8**

Operations & Checkout Facility **High Bay Looking West**

Before

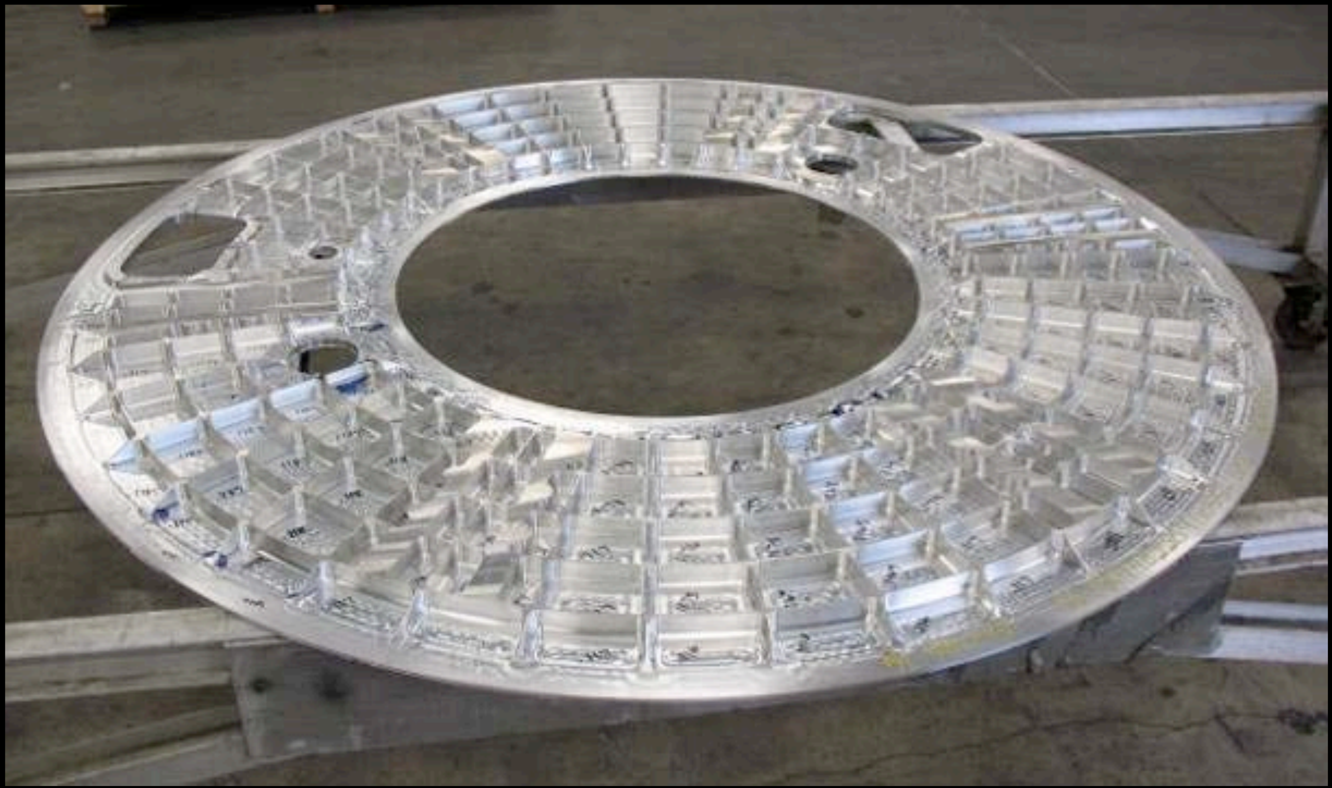
After

Operations & Checkout Facility **Basement**

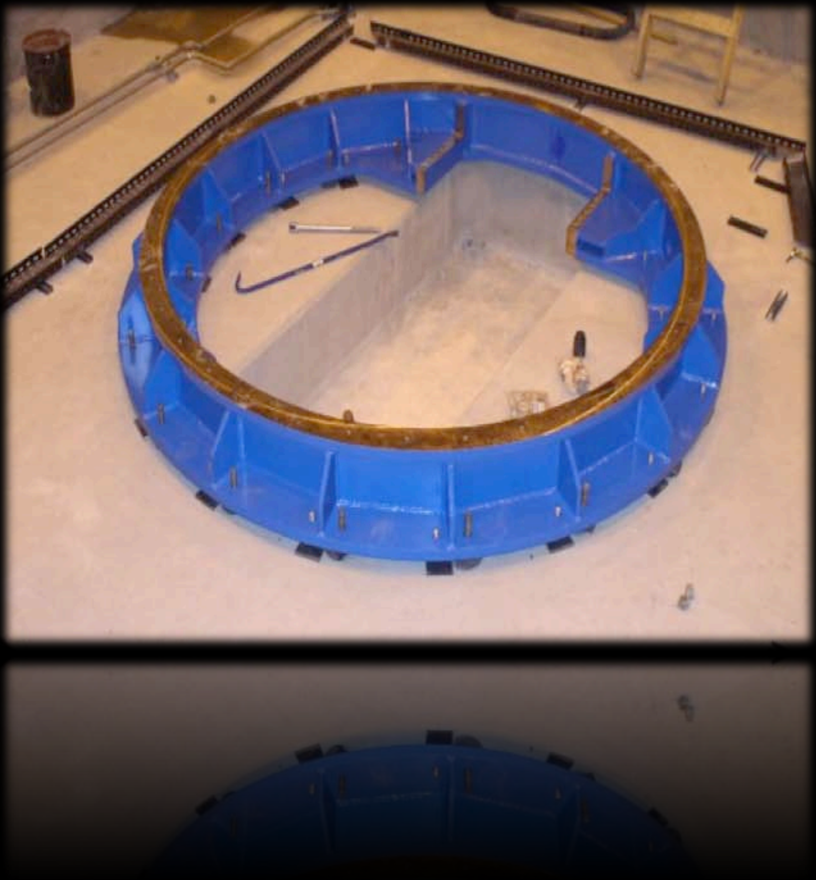
Before

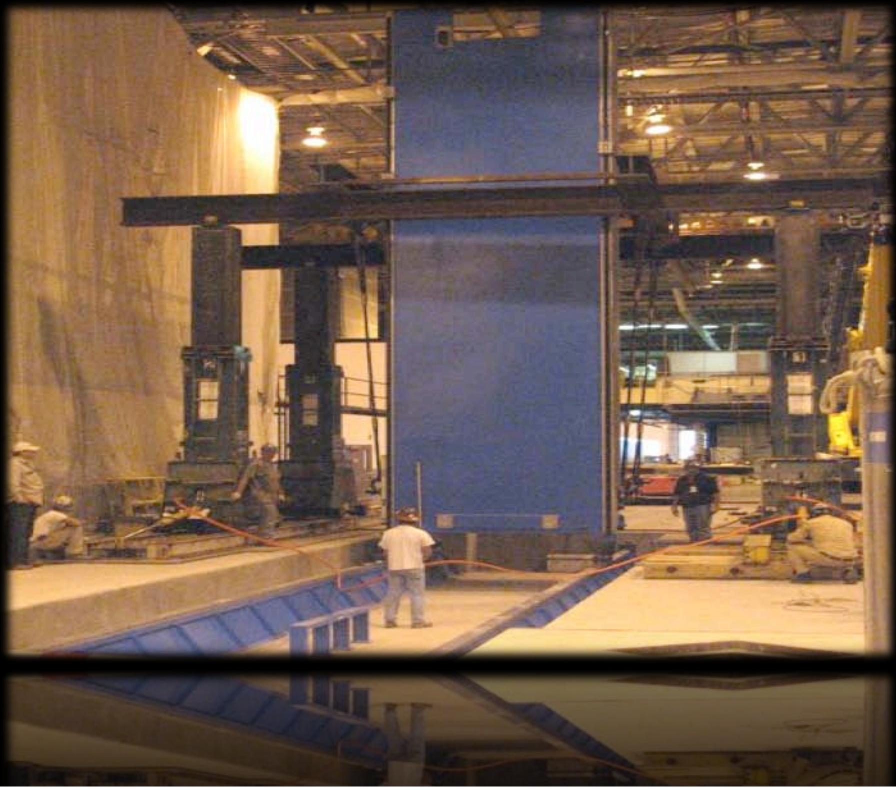
After

Michoud Assembly Facility Orion Structural Manufacturing



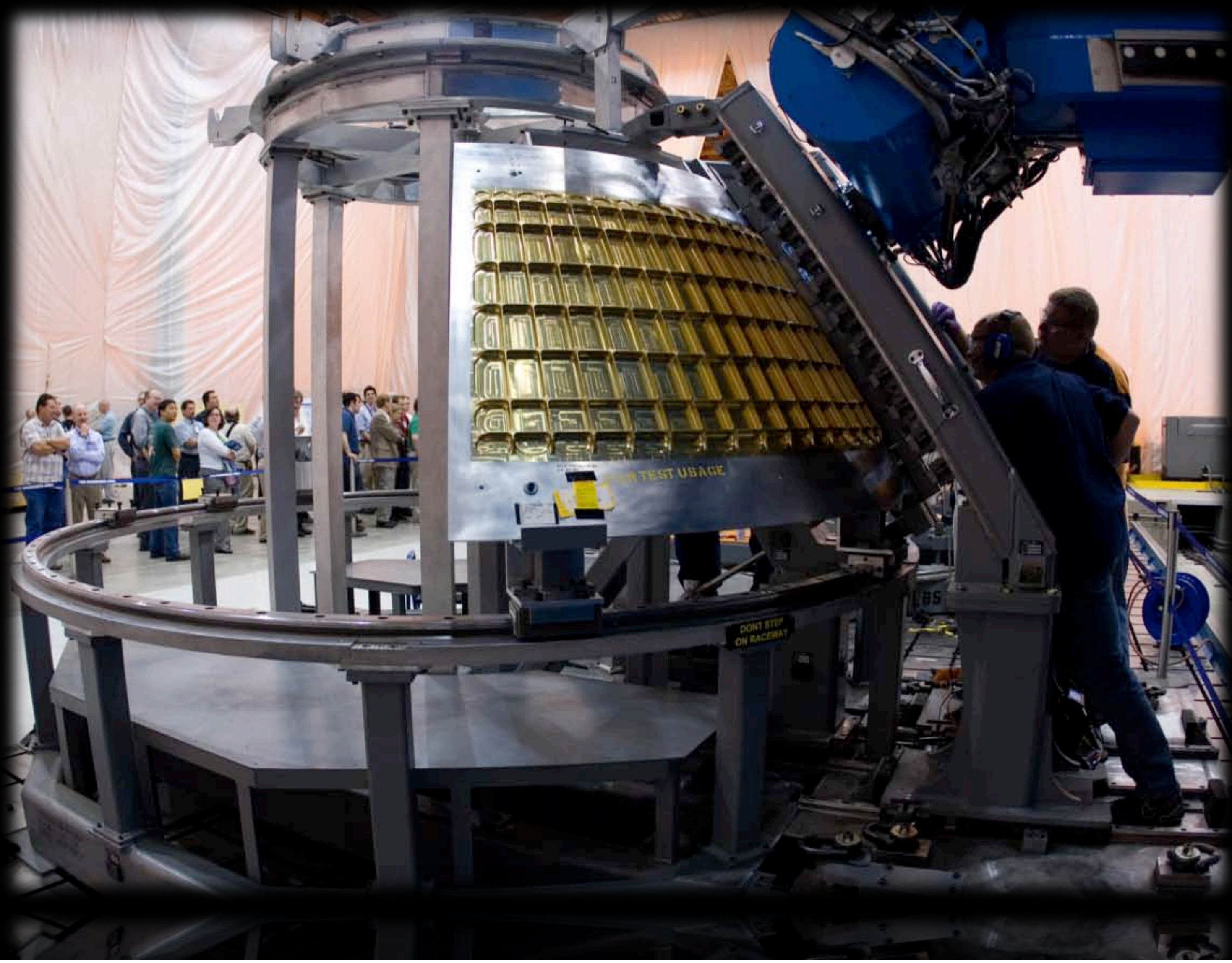
Michoud Assembly Facility Universal Weld System 2 turntable base and Y-Column X-Rails



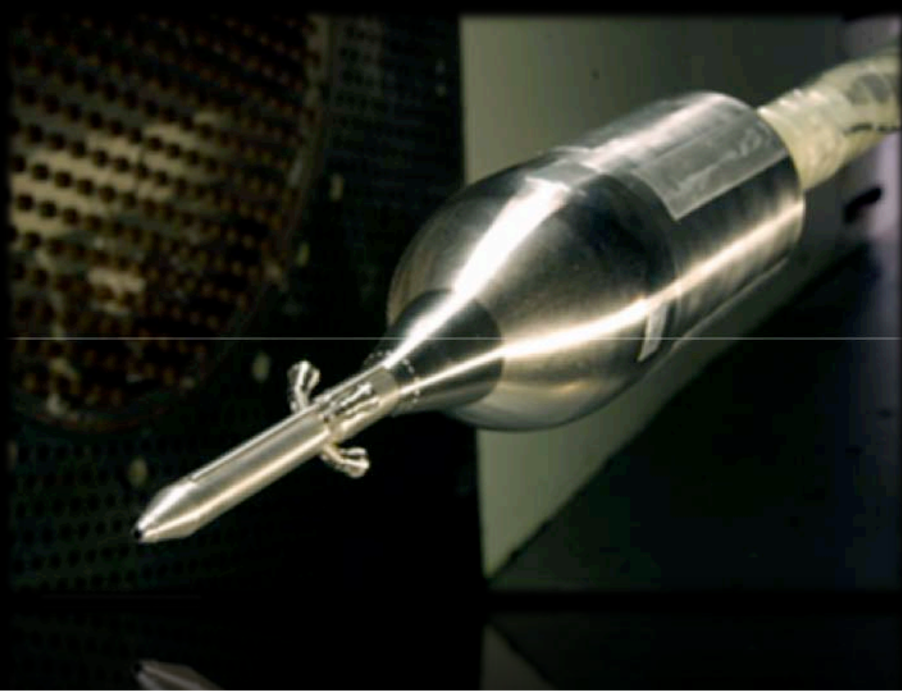


First friction stir weld

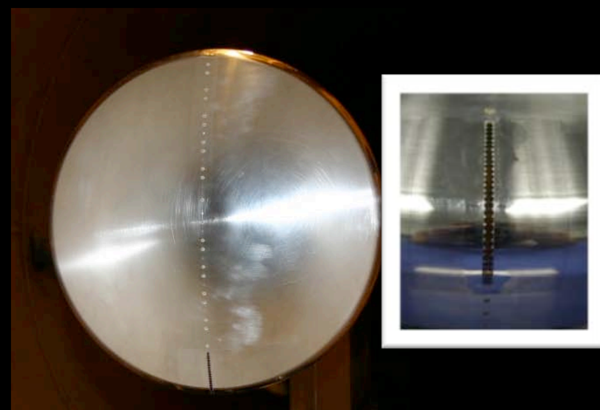
Orion crew module Ground Test Article Lite

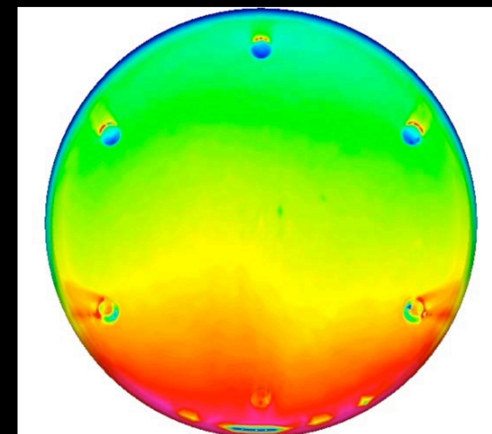


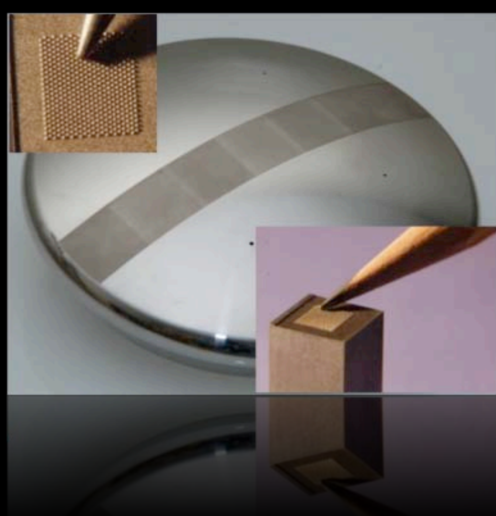
Wind Tunnel Testing

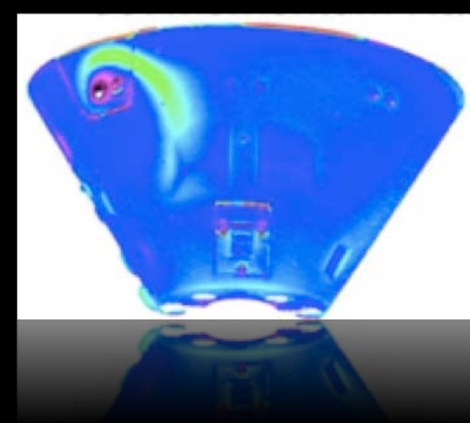


CAP Aerothermodynamic Testing







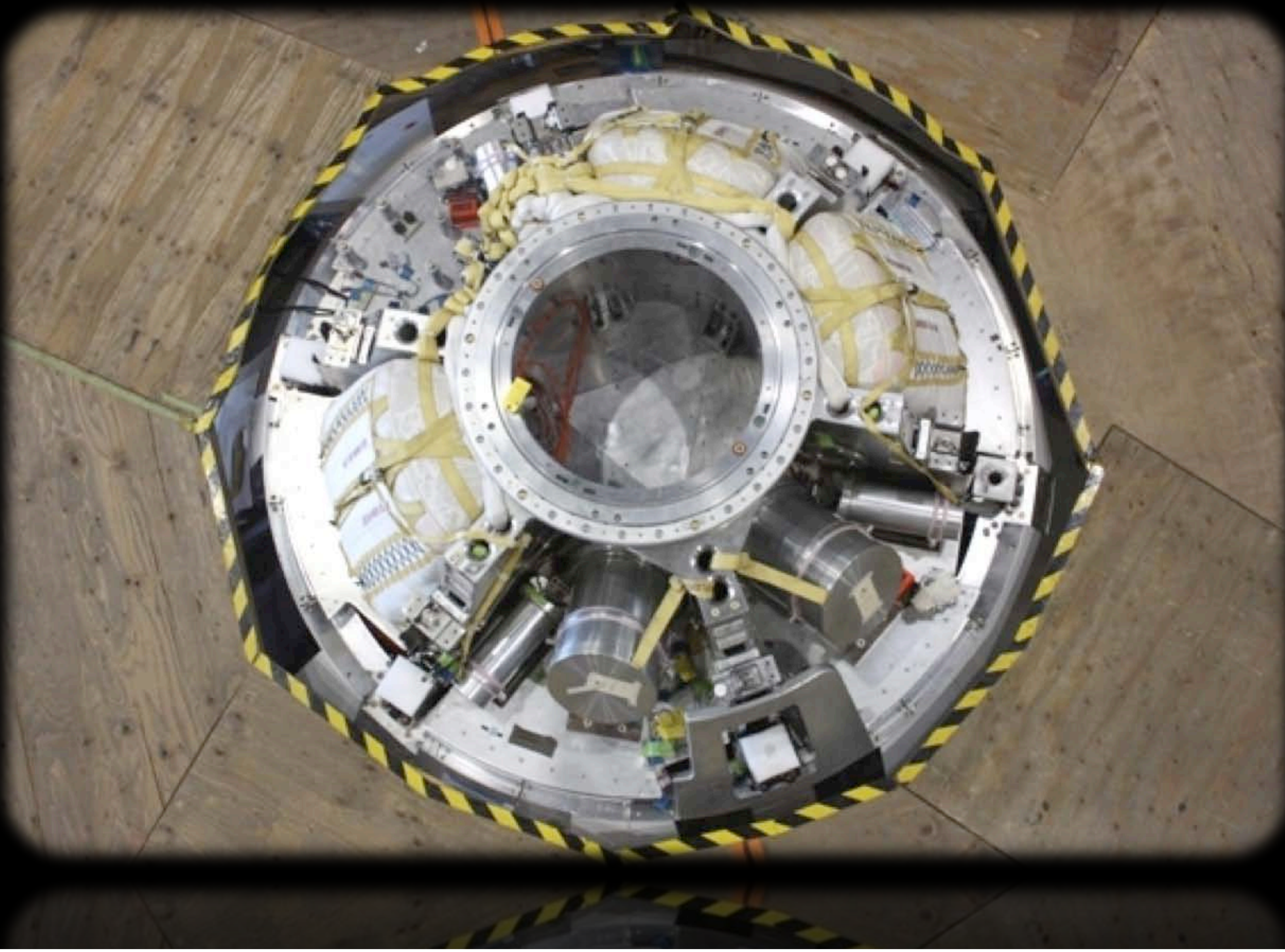


Pad Abort 1 Crew Module **Weight and balance testing**

Pad Abort 1 Launch Abort System **Jettison Motor Delivery**

Pad Abort 1 Adapter Cone to Crew Module Fit Check

CEV Parachute Assembly System Hardware
Installed on top of the Pad Abort 1 vehicle



Ascent Abort 1 **Gantry Construction**