

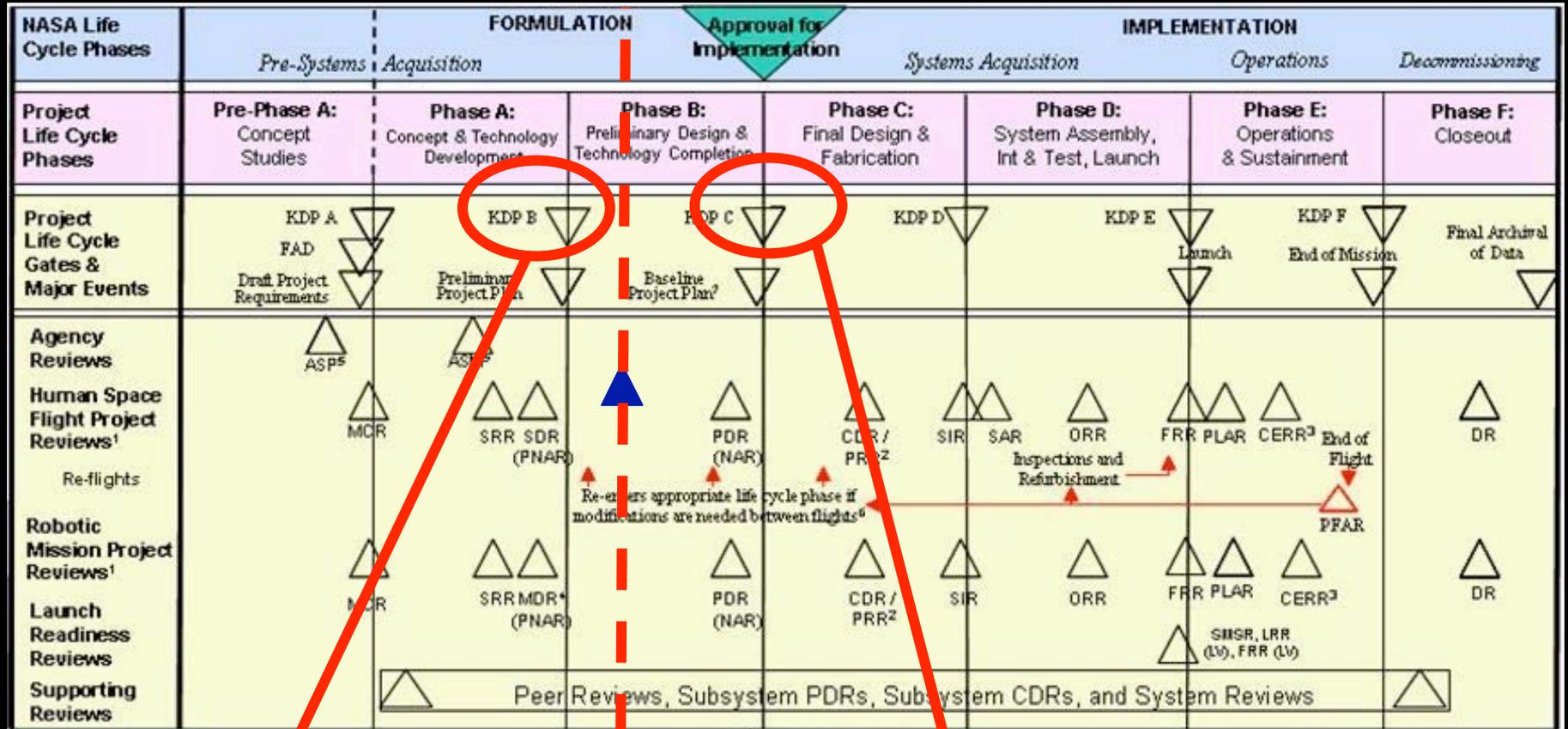
A detailed 3D rendering of the Orion Crew Exploration Vehicle (CEV) in space. The CEV is a white, conical spacecraft with a large, circular window at the front. It is attached to a Service Module (SM) and a Launch Abort Vehicle (LAV). The SM has a large, orange, cylindrical nose cone. The LAV is a small, white, cylindrical vehicle with a green, rectangular panel on its side. The CEV is surrounded by two large, octagonal solar panel arrays, each with a central hub and eight radial panels. The background is a dark, star-filled space. The text "Orion Crew Exploration Vehicle Overview" is overlaid on the image in a yellow, sans-serif font.

Orion Crew Exploration Vehicle Overview

Masters Forum
Fred Ouellette
May 2009



NASA Program Life Cycle from 7120.5D



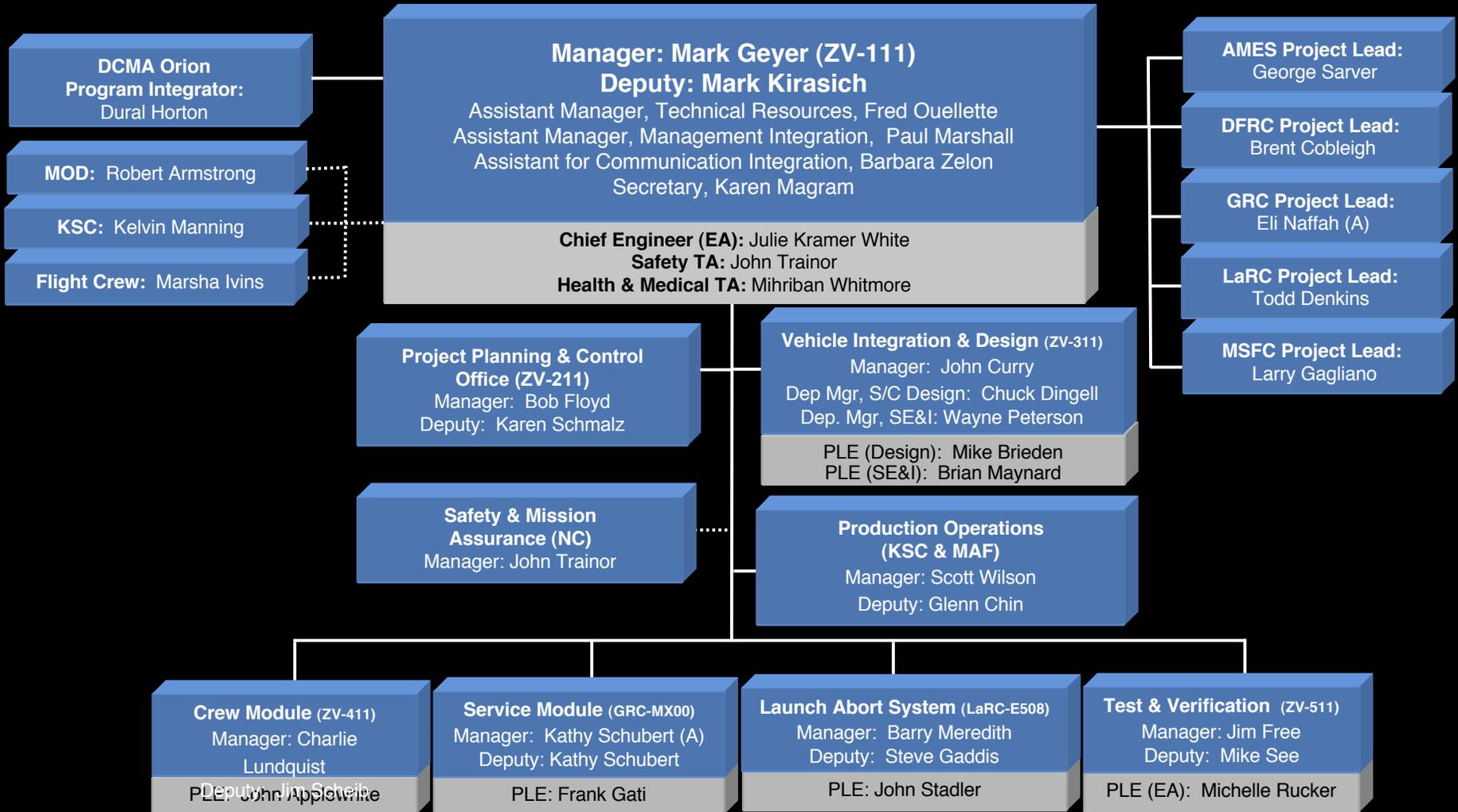
Time Now

Completed: April 2008

Projected: 2Q FY10

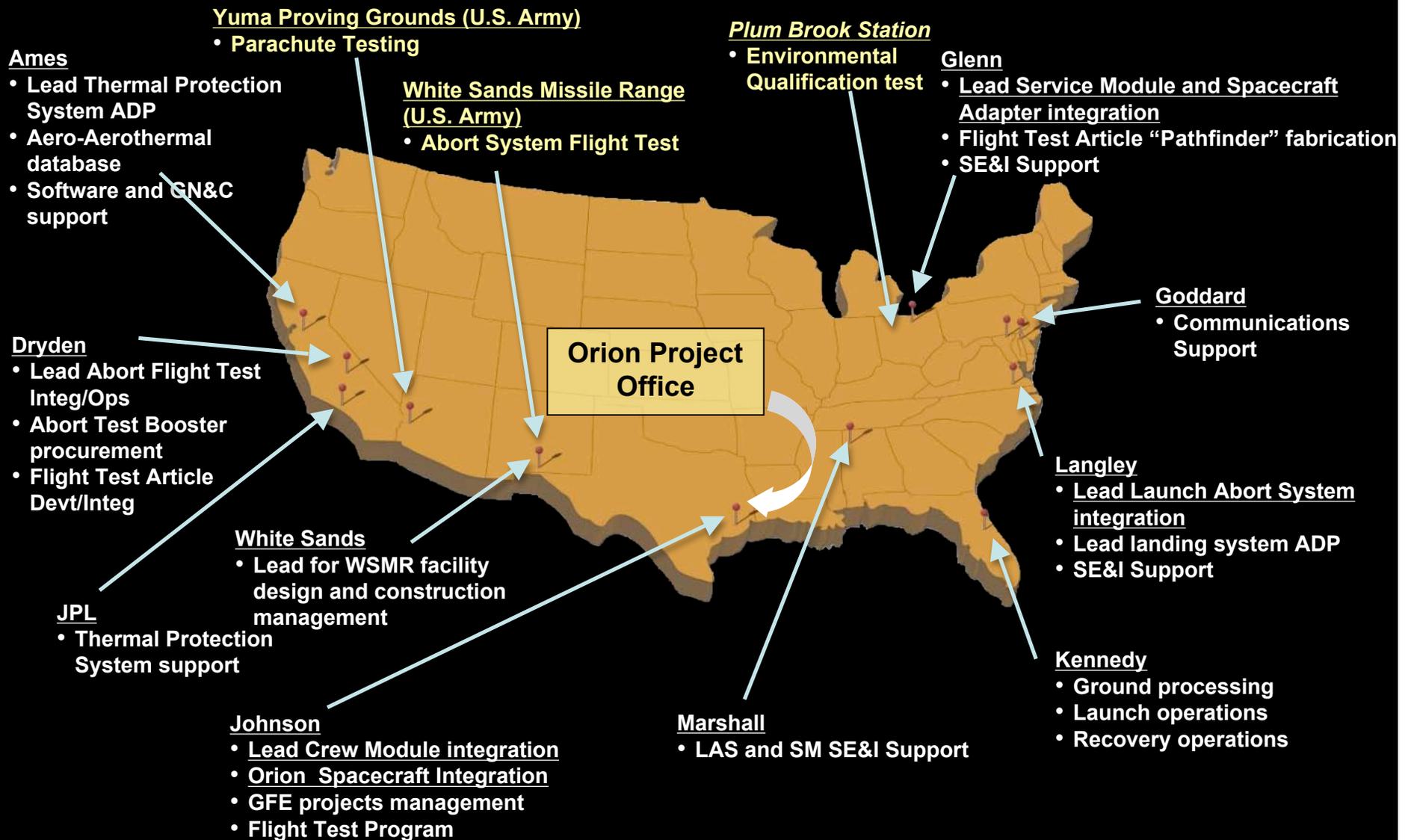


NASA Orion Project Organization



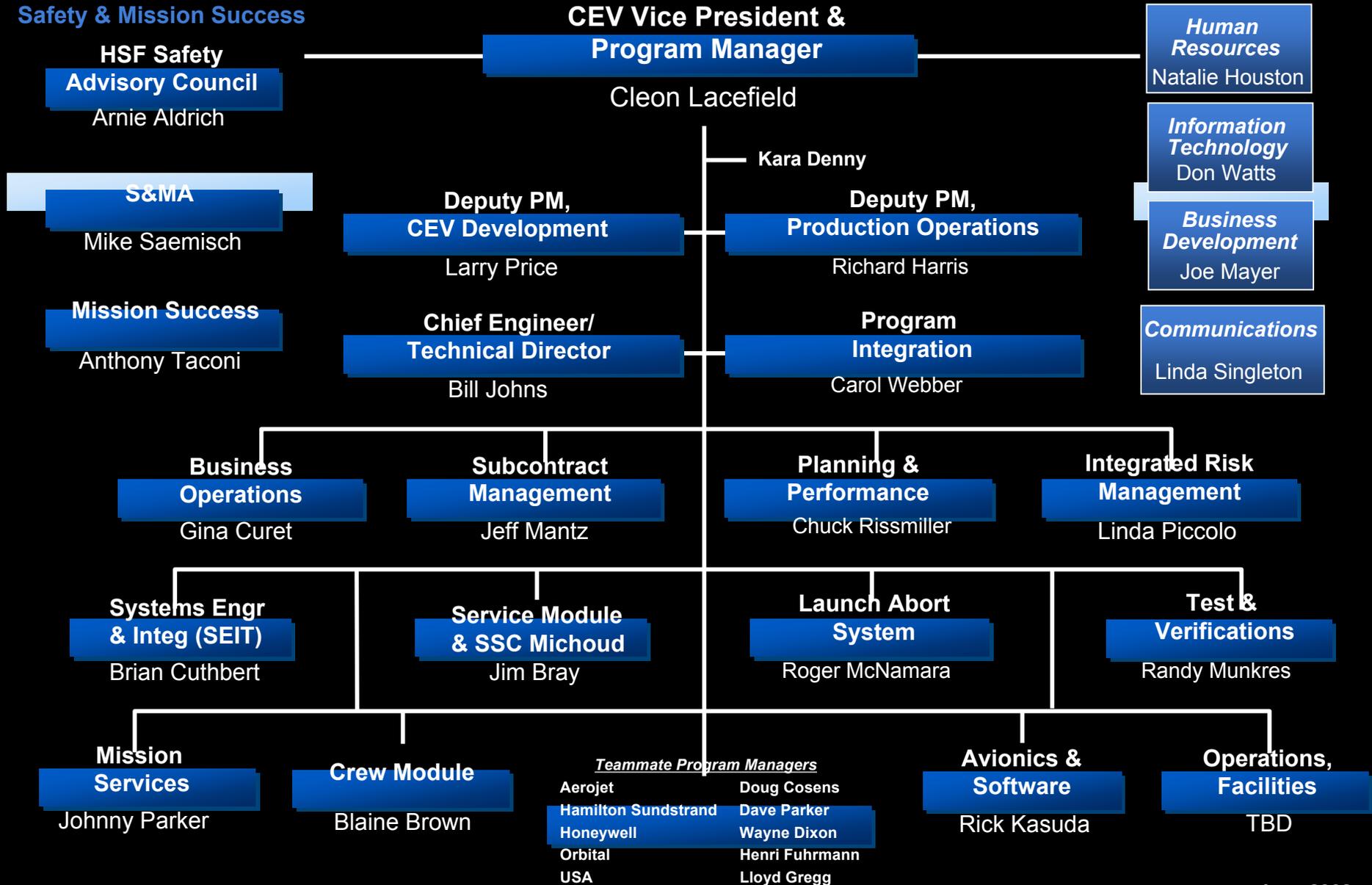


Orion Government Project Team



Lockheed Martin Orion Project Organization

Safety & Mission Success





Orion Lockheed Martin Industry Team



LOCKHEED MARTIN

- Systems & Design Engineering Support

- Environmental Control & Life Support
- Active Thermal Control
- System Power Management



- Propulsion

LM GRC

- SM Liaison Office



- 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



- Operator Interfaces
- Ground Processing
- Mission Flight Planning
- Software Development

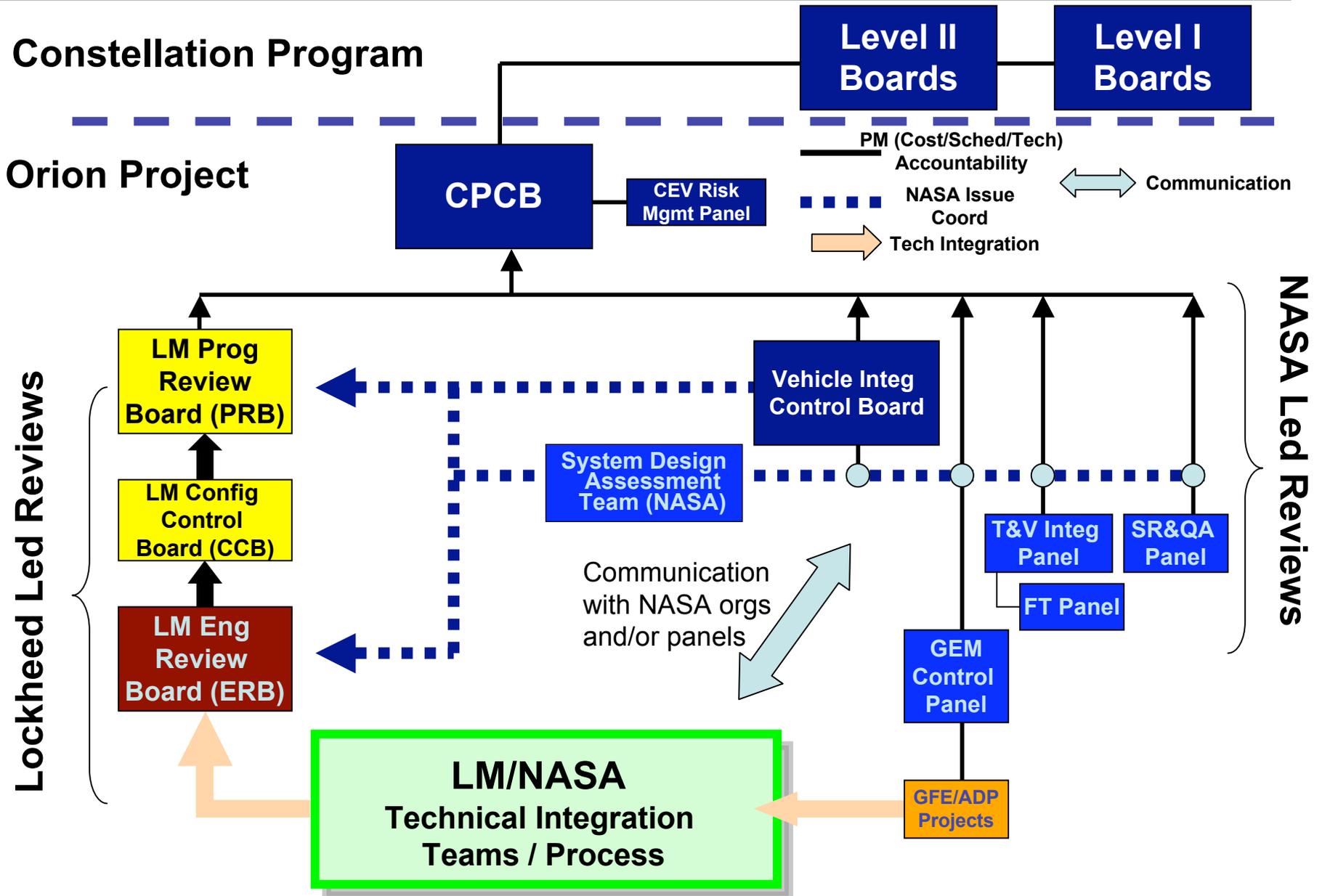
LOCKHEED MARTIN

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



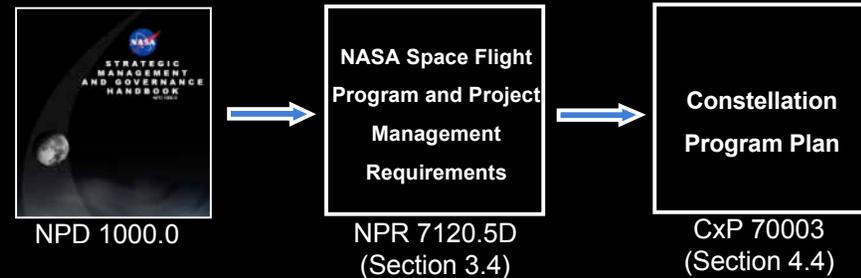
Governance, Technical Authority, and Independent Assessment in Constellation



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



Technical Authority and Independent Assessment

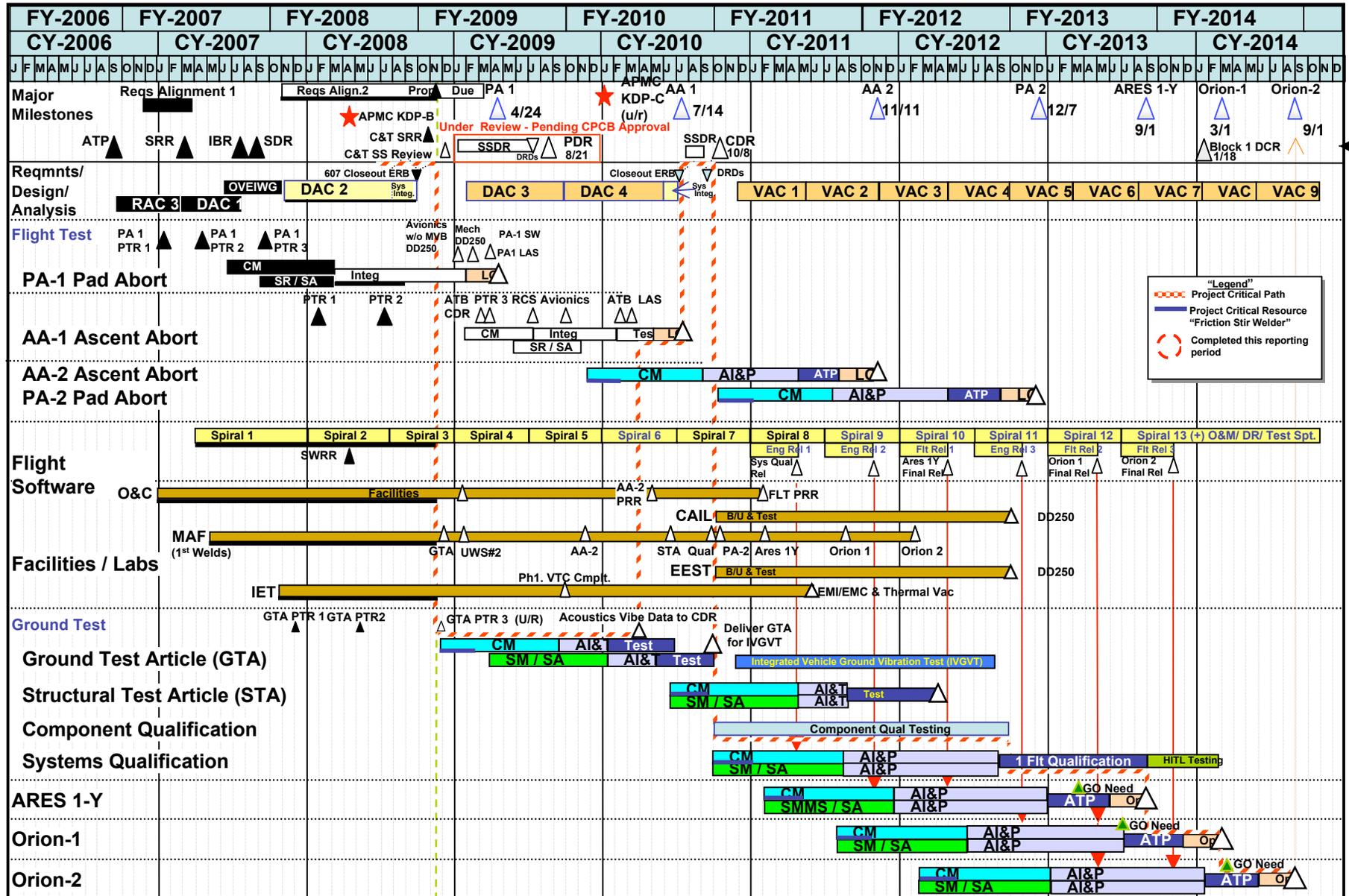
- Technical Authority (TA) is the institutional expertise required in the Engineering, S&MA, and medical fields in order to make sound technical engineering decisions.
- For Constellation (Cx), technical authority consists of the Office of Chief Engineer (OCE), Office of Safety and Mission Assurance (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



Spacecraft Adapter

structural transition to
Ares launch vehicle

Crew Module

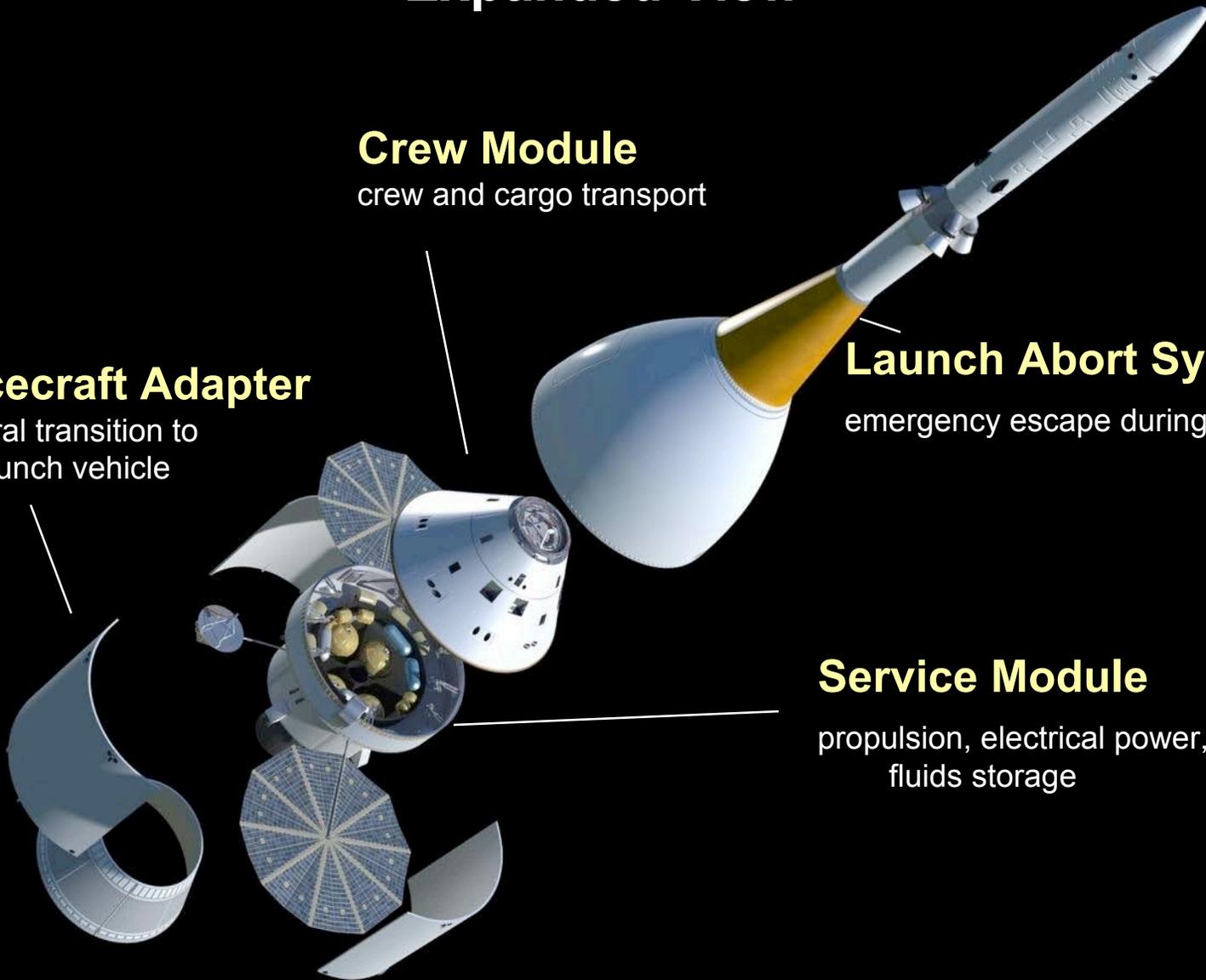
crew and cargo transport

Launch Abort System

emergency escape during launch

Service Module

propulsion, electrical power,
fluids storage





Apollo/Orion Comparison



5 meter diameter capsule – Apollo shape

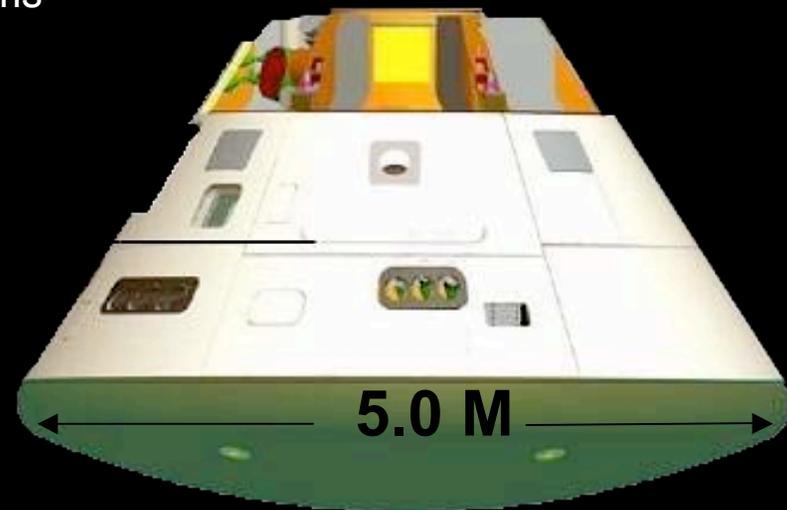
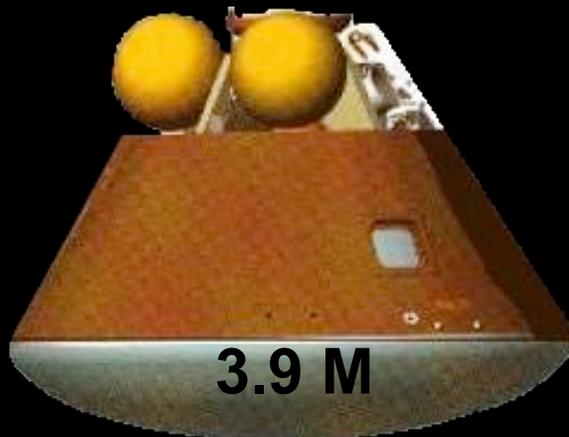
- Significant increase in volume from Apollo (3.9 meter)
- Reduced development time and risk

Larger Crew Accommodations

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

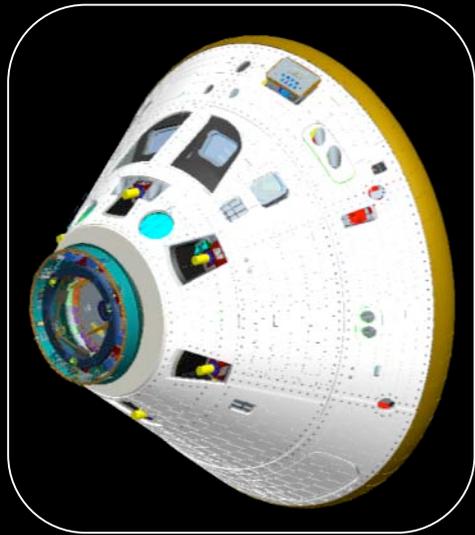
Expanded Mission Capabilities

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





Orion External Configuration



Low Impact Docking System

Forward Bay Cover

Drogue Chutes

Backshell Panels

Main Parachutes

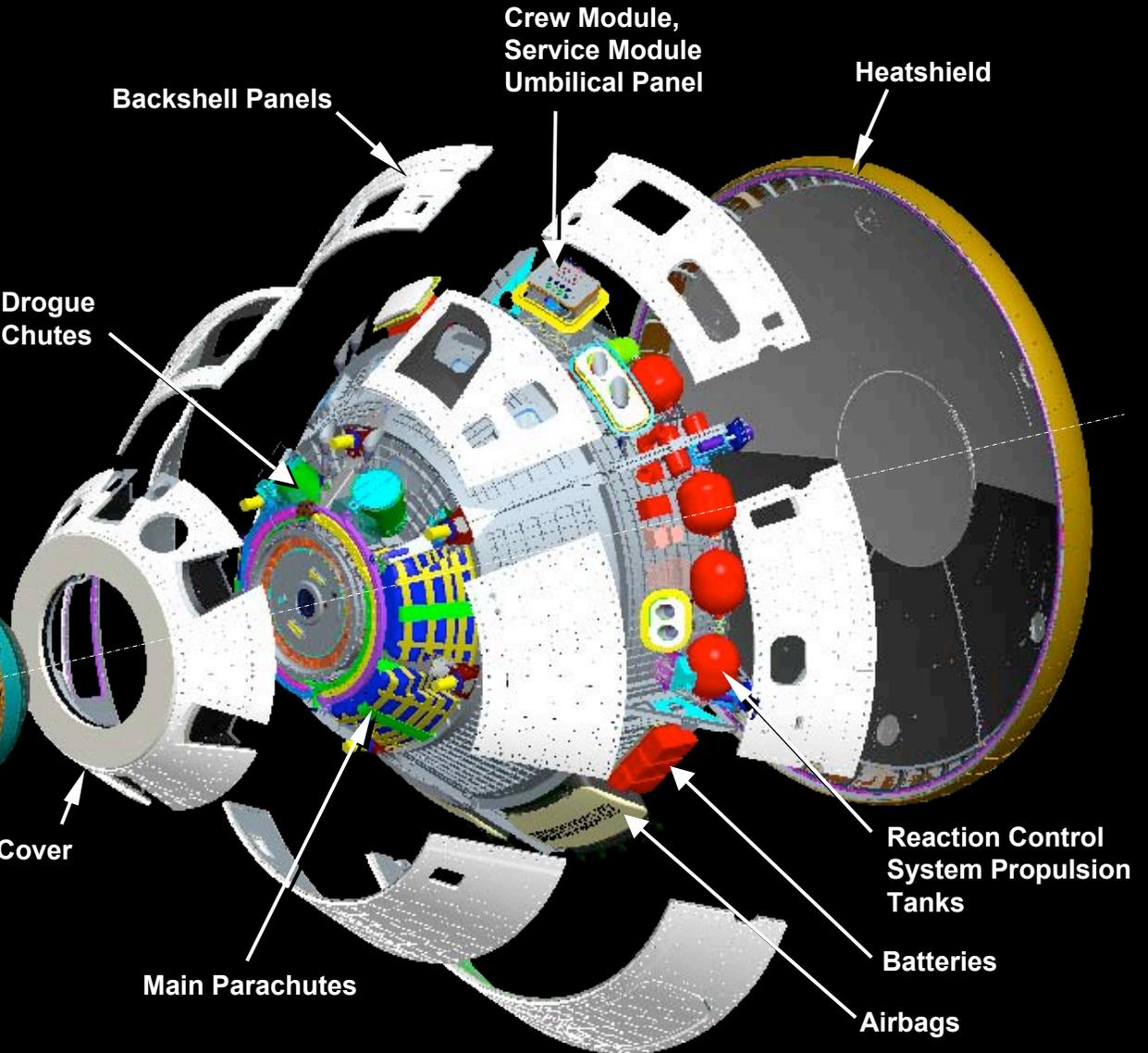
Crew Module,
Service Module
Umbilical Panel

Heatshield

Reaction Control
System Propulsion
Tanks

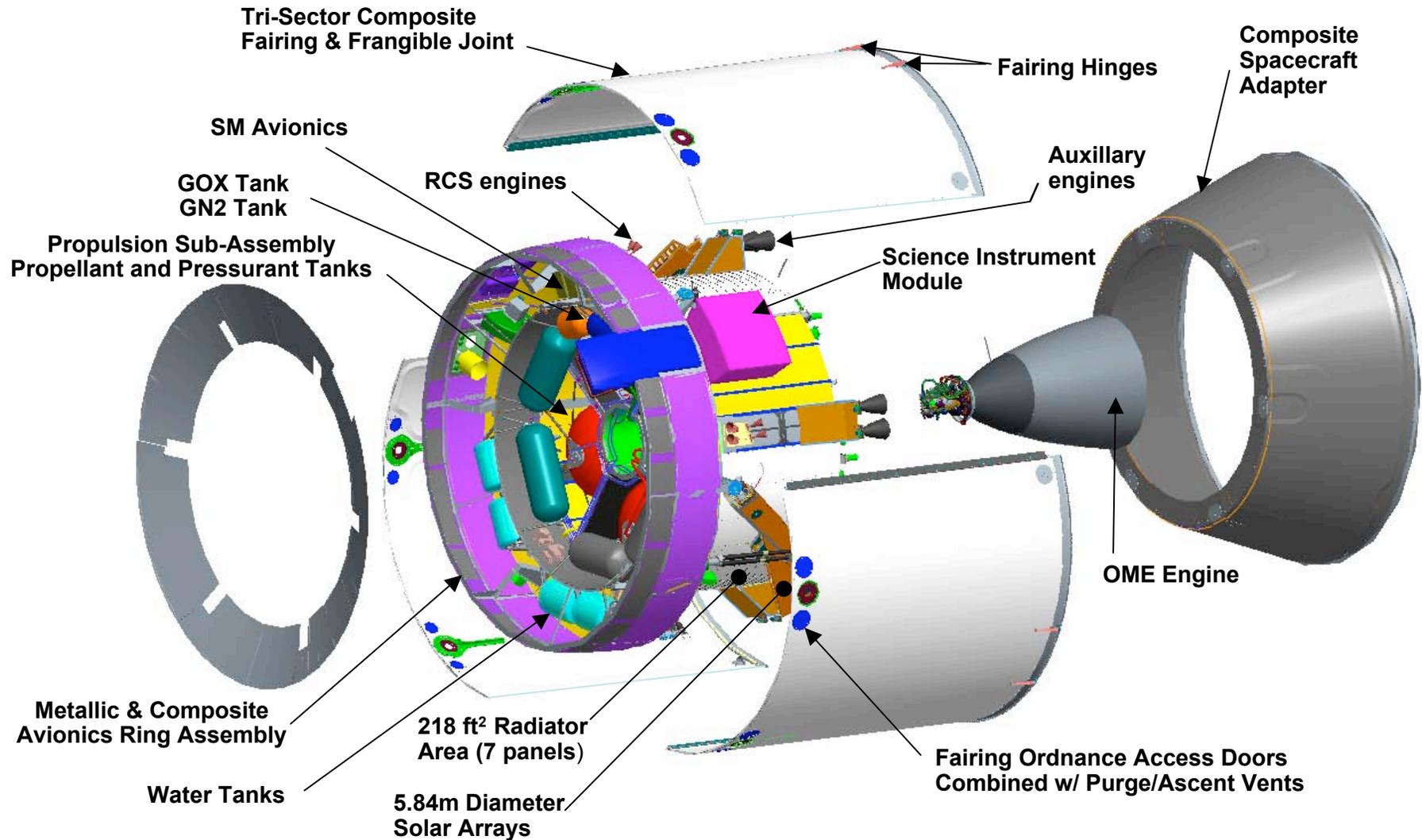
Batteries

Airbags



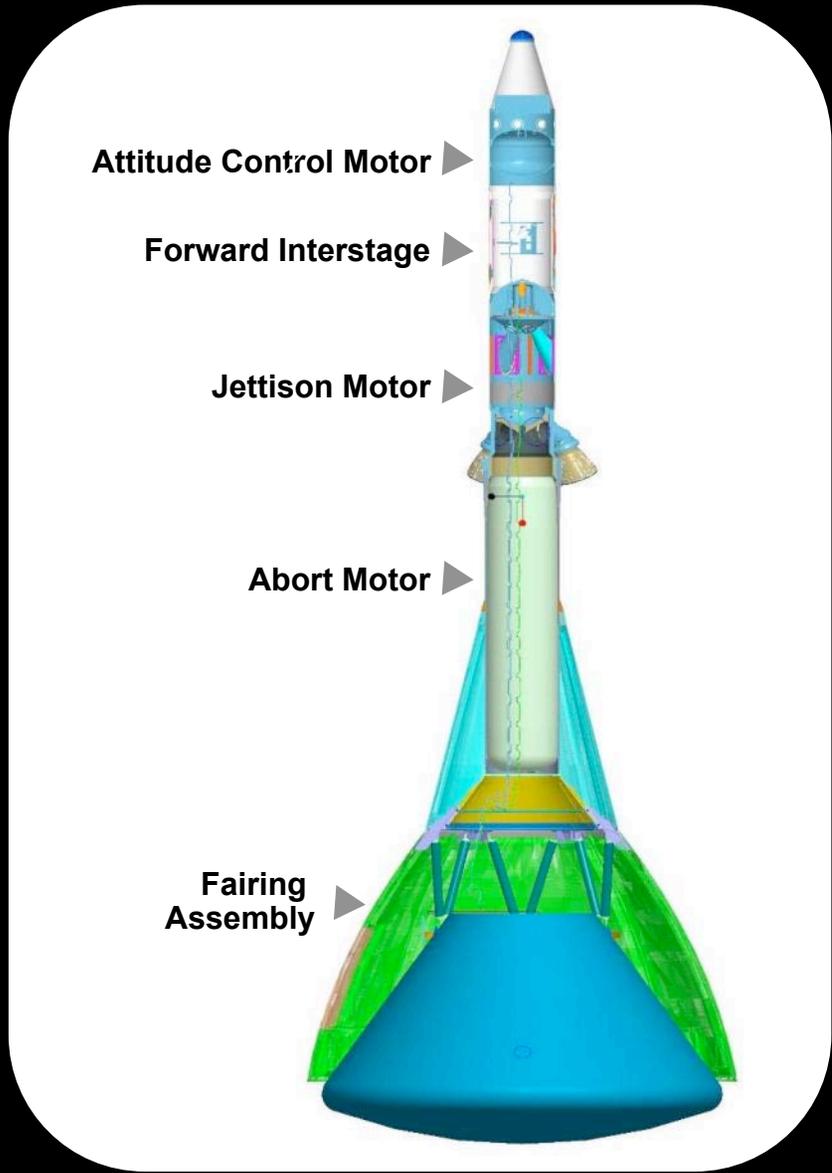


Orion Service Module





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): 25° 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): 90° 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): 35° Isp (vac.): 221s Thrust axial vac: 32.9k lbs Burn Time: 1.55s

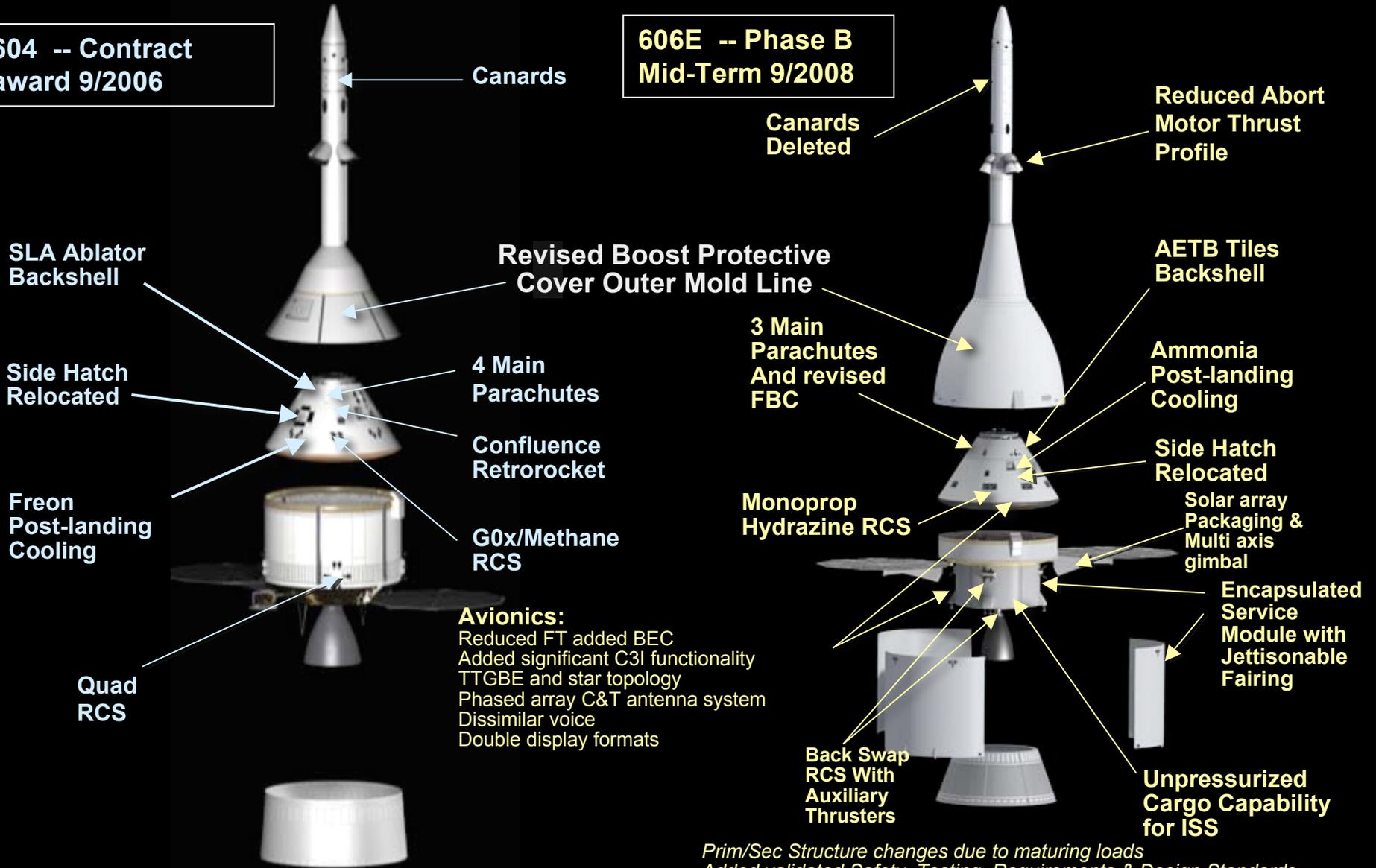


Major Configuration Changes Since Contract Award



604 -- Contract award 9/2006

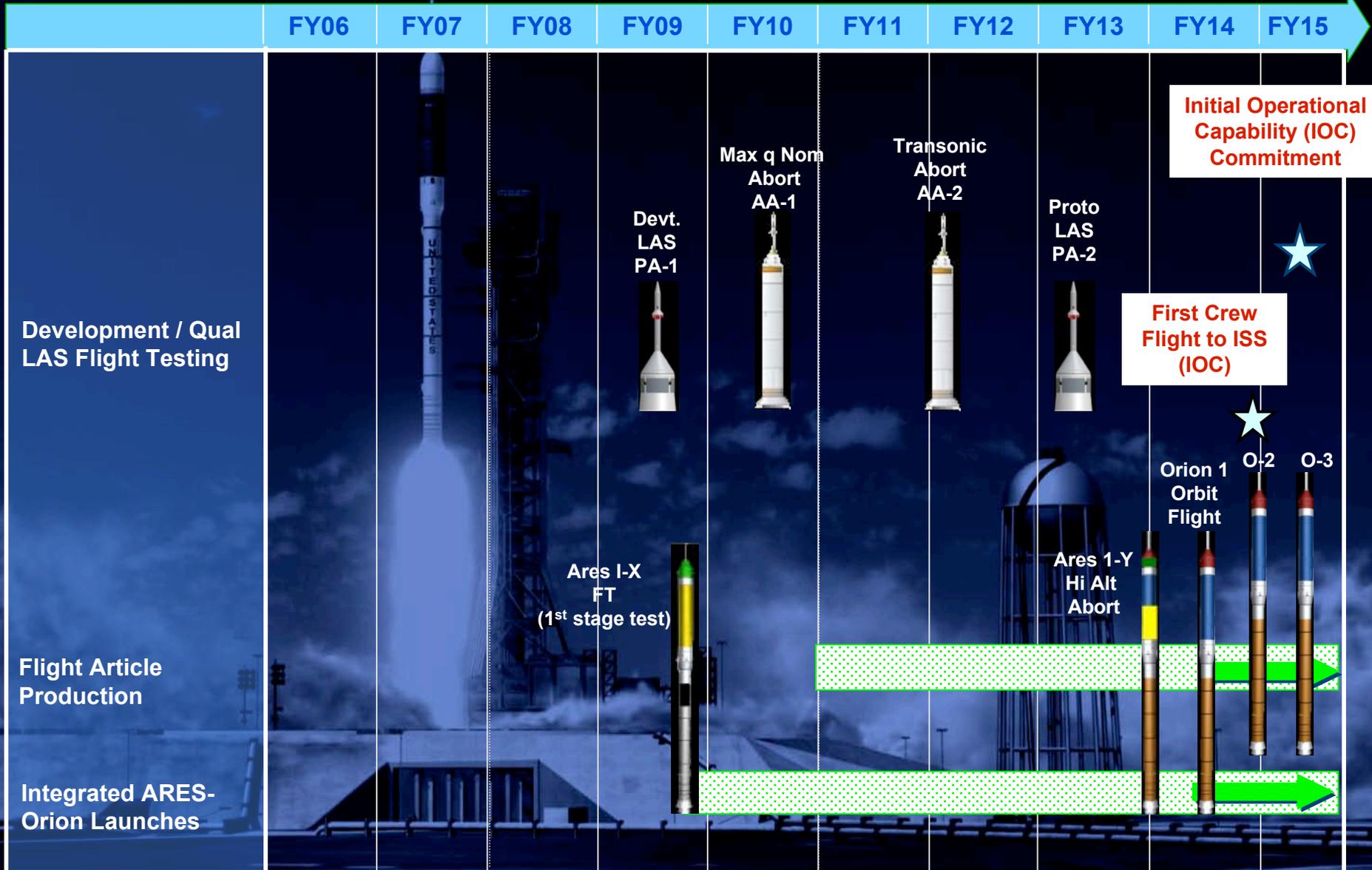
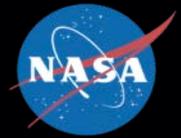
606E -- Phase B Mid-Term 9/2008



Prim/Sec Structure changes due to maturing loads
Added validated Safety, Testing, Requirements & Design Standards



Constellation Flight Test Campaign





Orion Accomplishments

May 2009

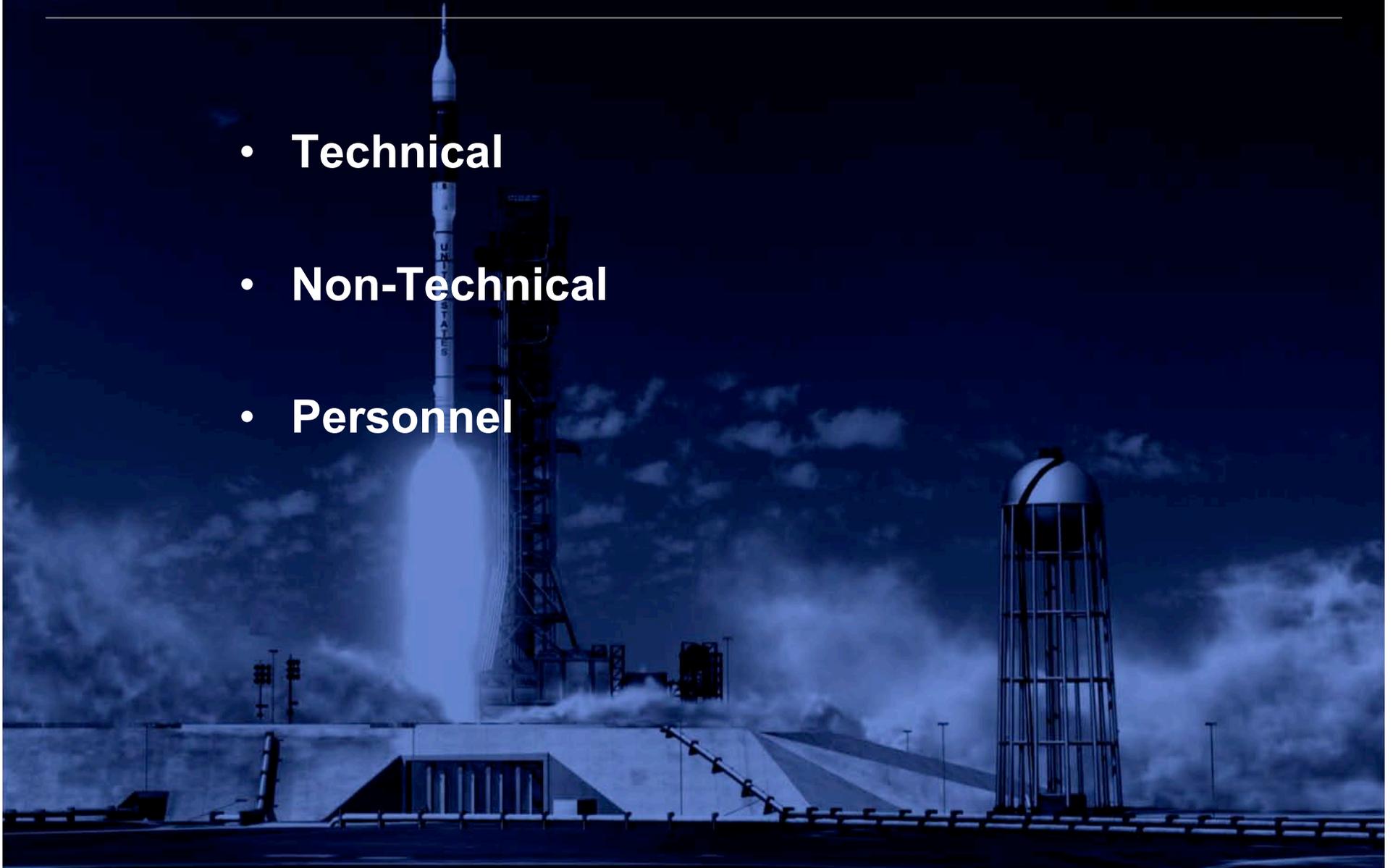




Orion Challenges and Opportunities



- **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 \longleftrightarrow NASA CEV
 - NASA CEV \longleftrightarrow CxP and other elements
- **Use NESAC 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

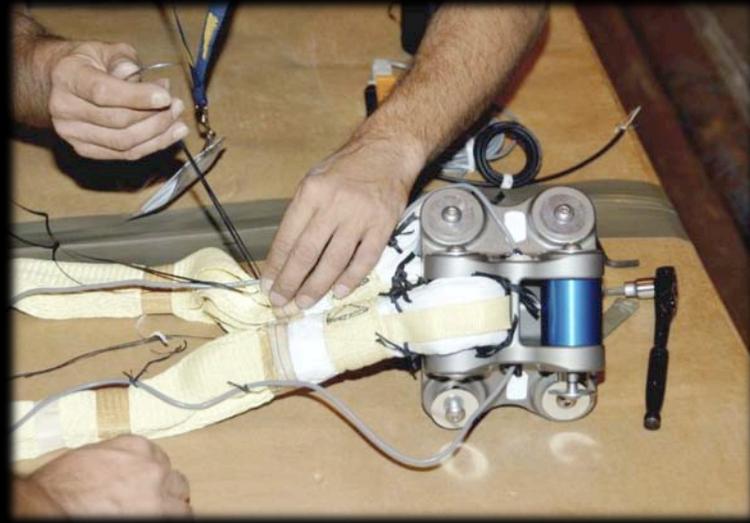


Personnel Opportunities



- **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



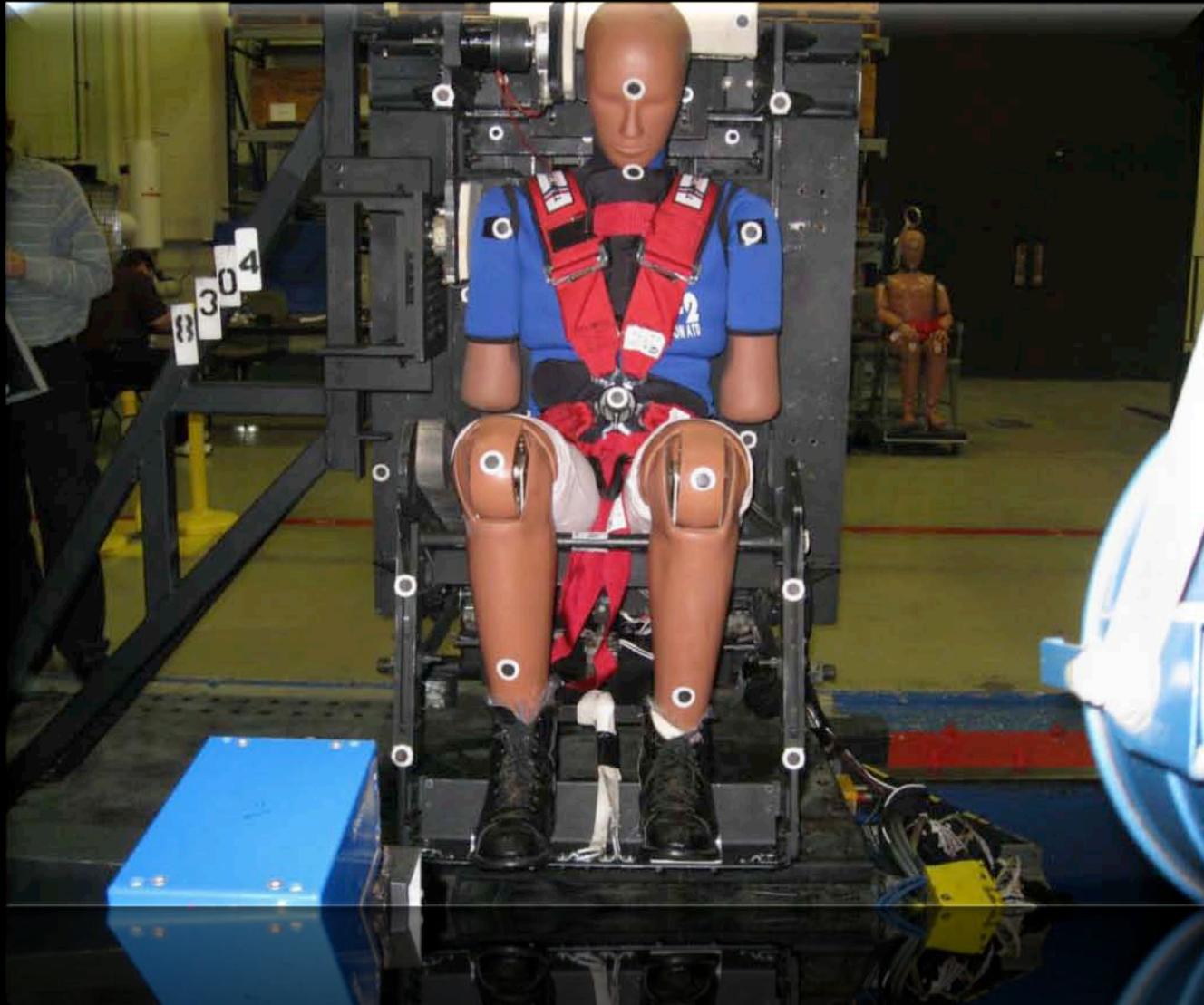
Crew Impact Attenuation System Test Fixture



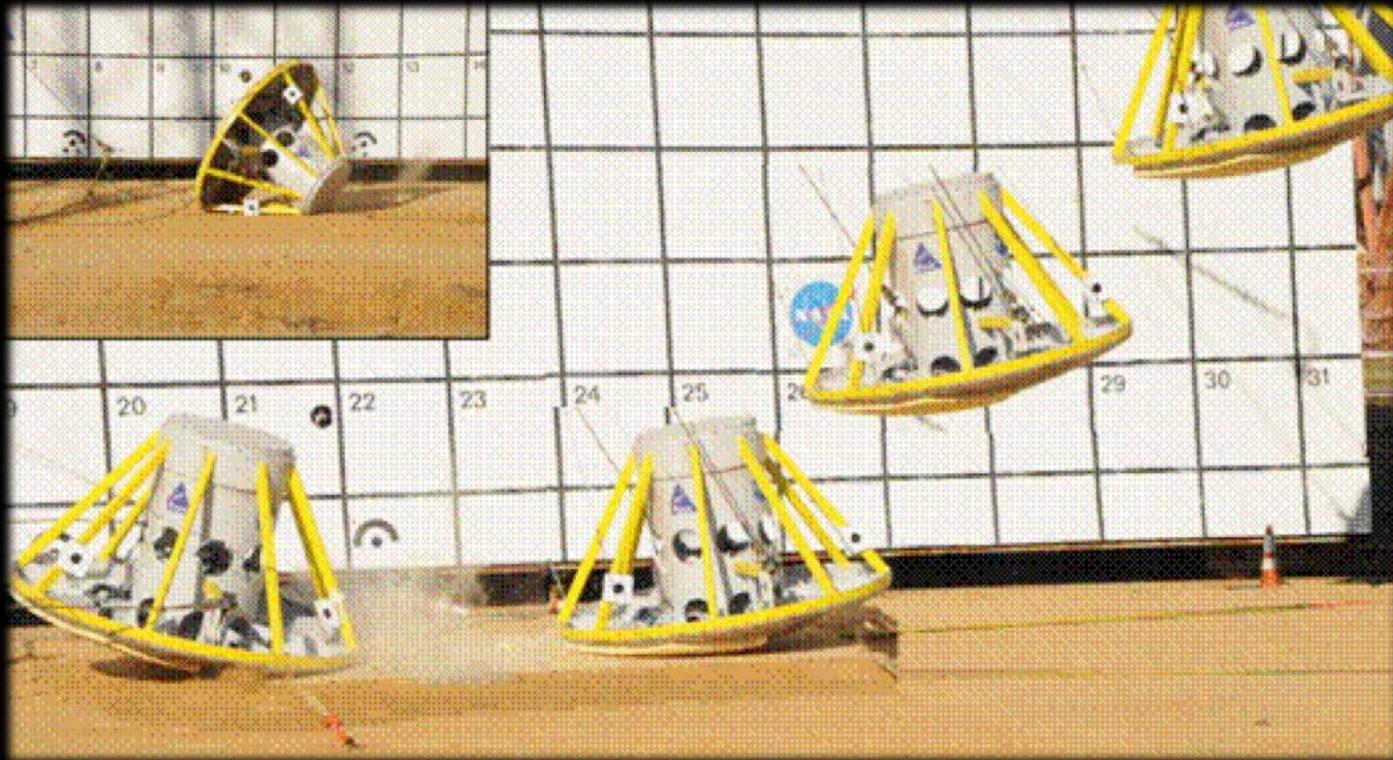
Orion Seat Evaluations



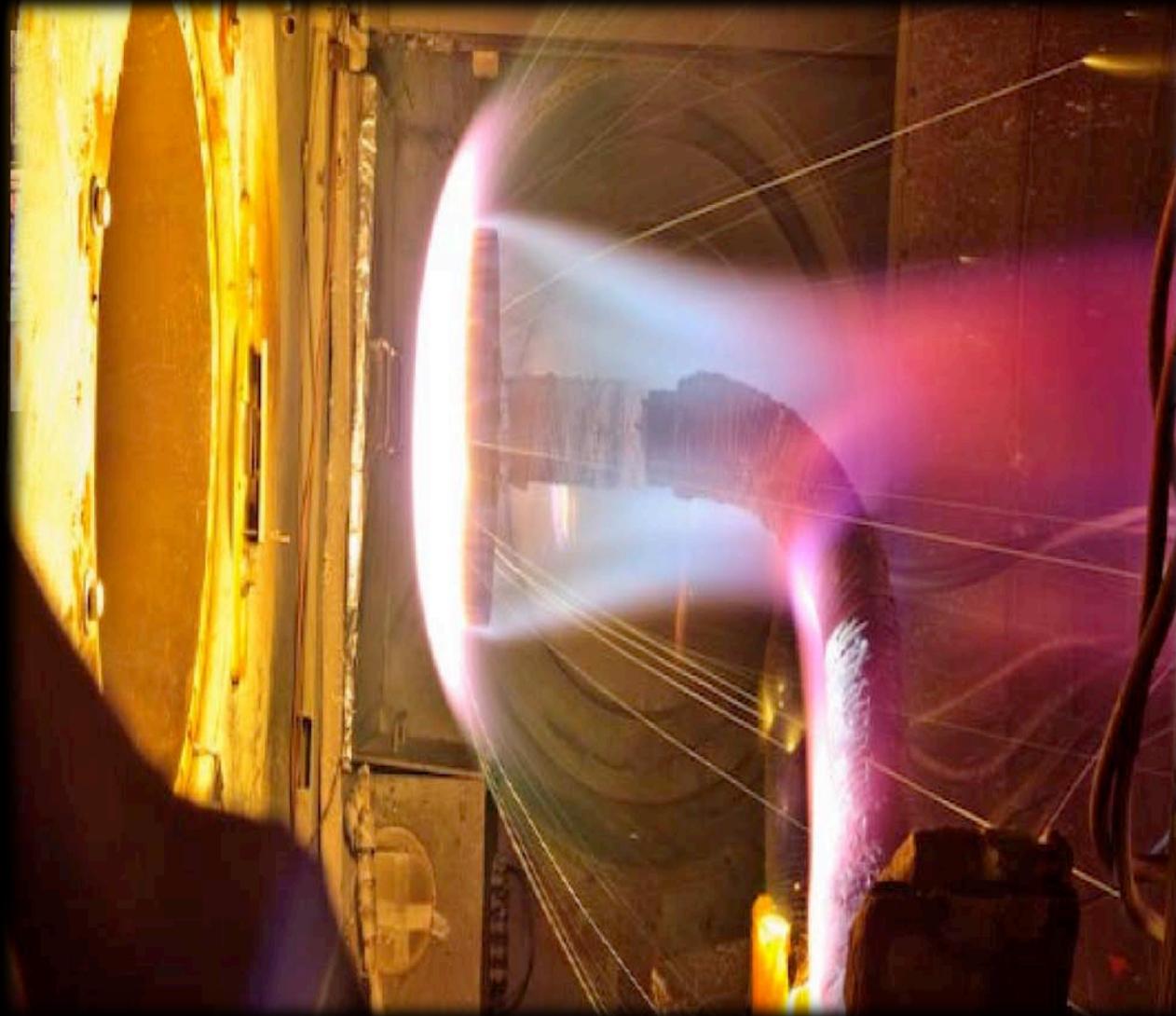
Crew Systems Lateral Restraint Sled Testing



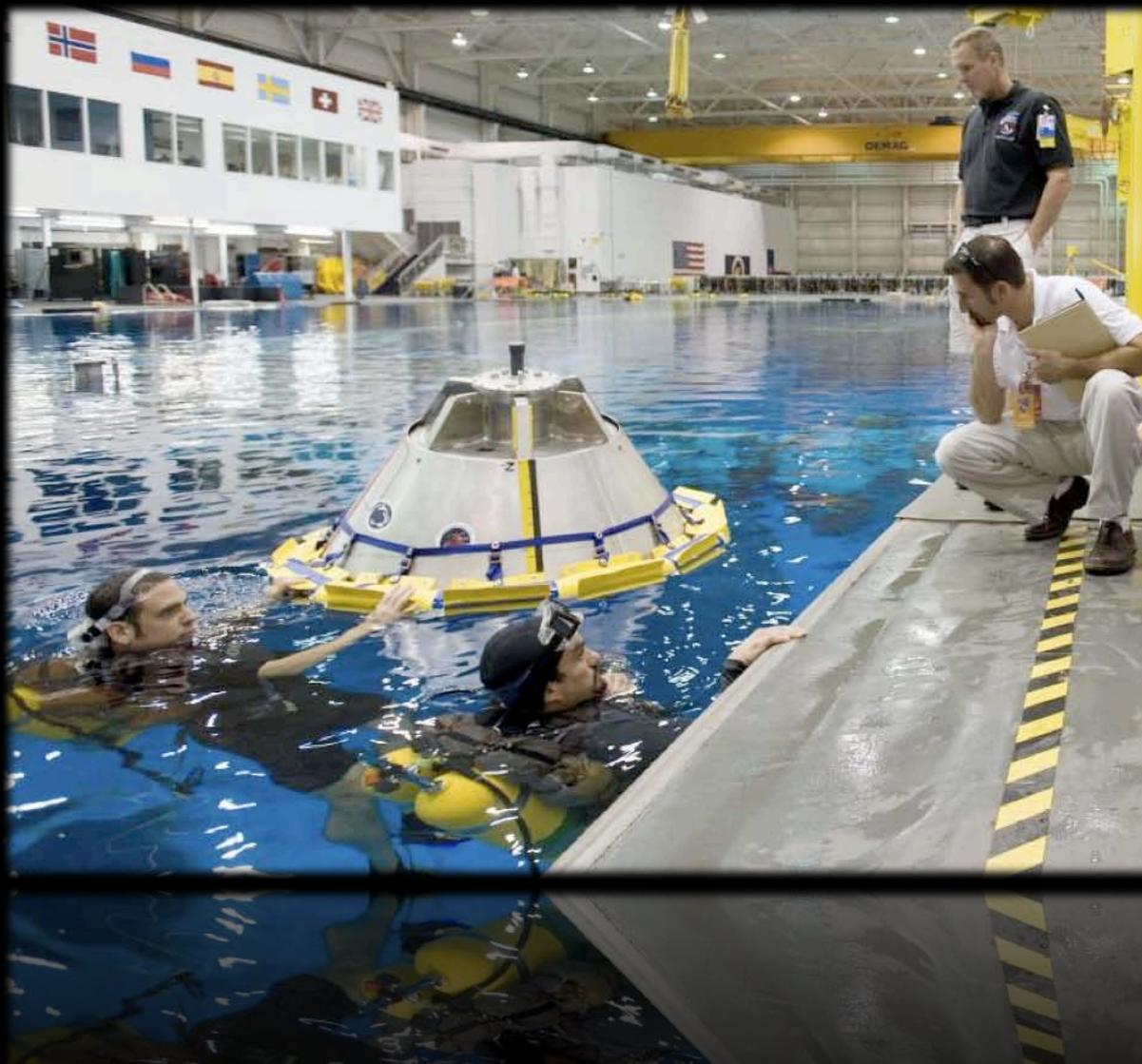
Avcoat Friction Drop Tests



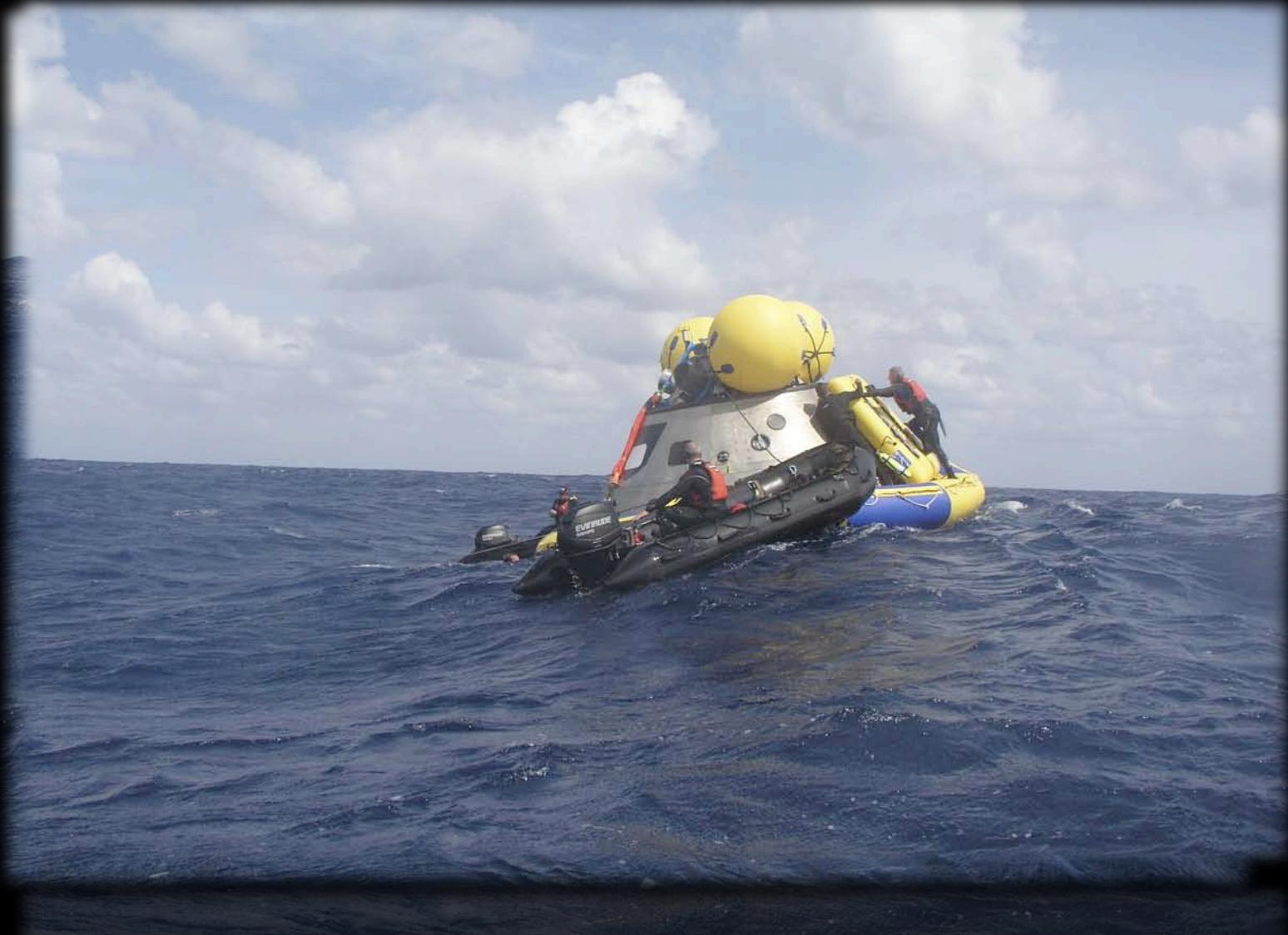
Downselect of Avcoat & Thermal Protection System Transition



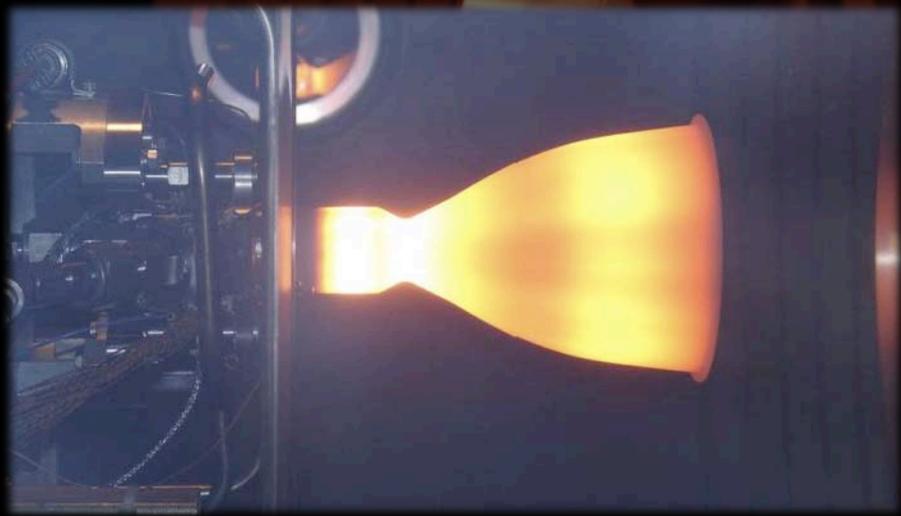
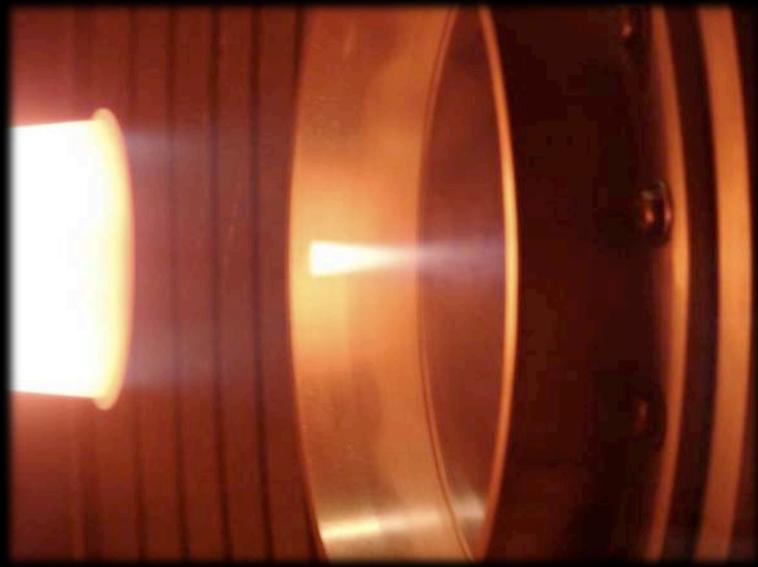
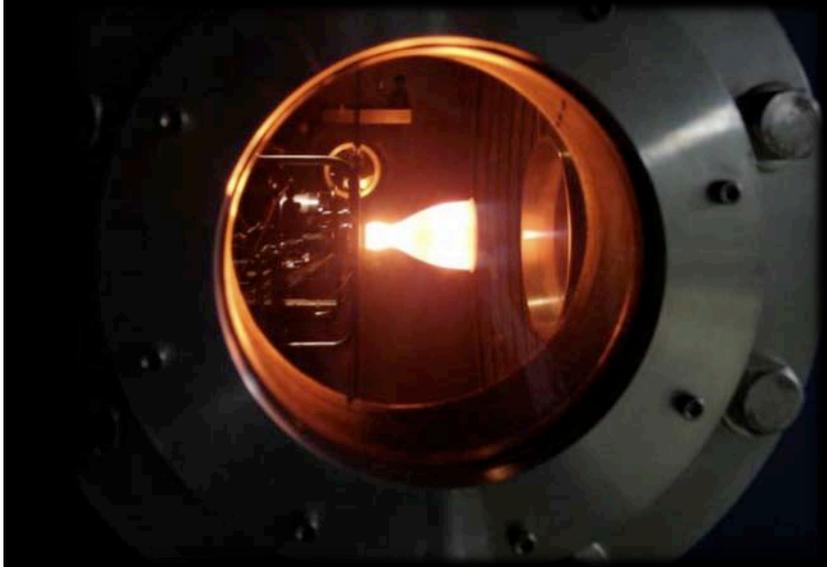
1/4 Scale Crew Module Testing Neutral Buoyancy Lab



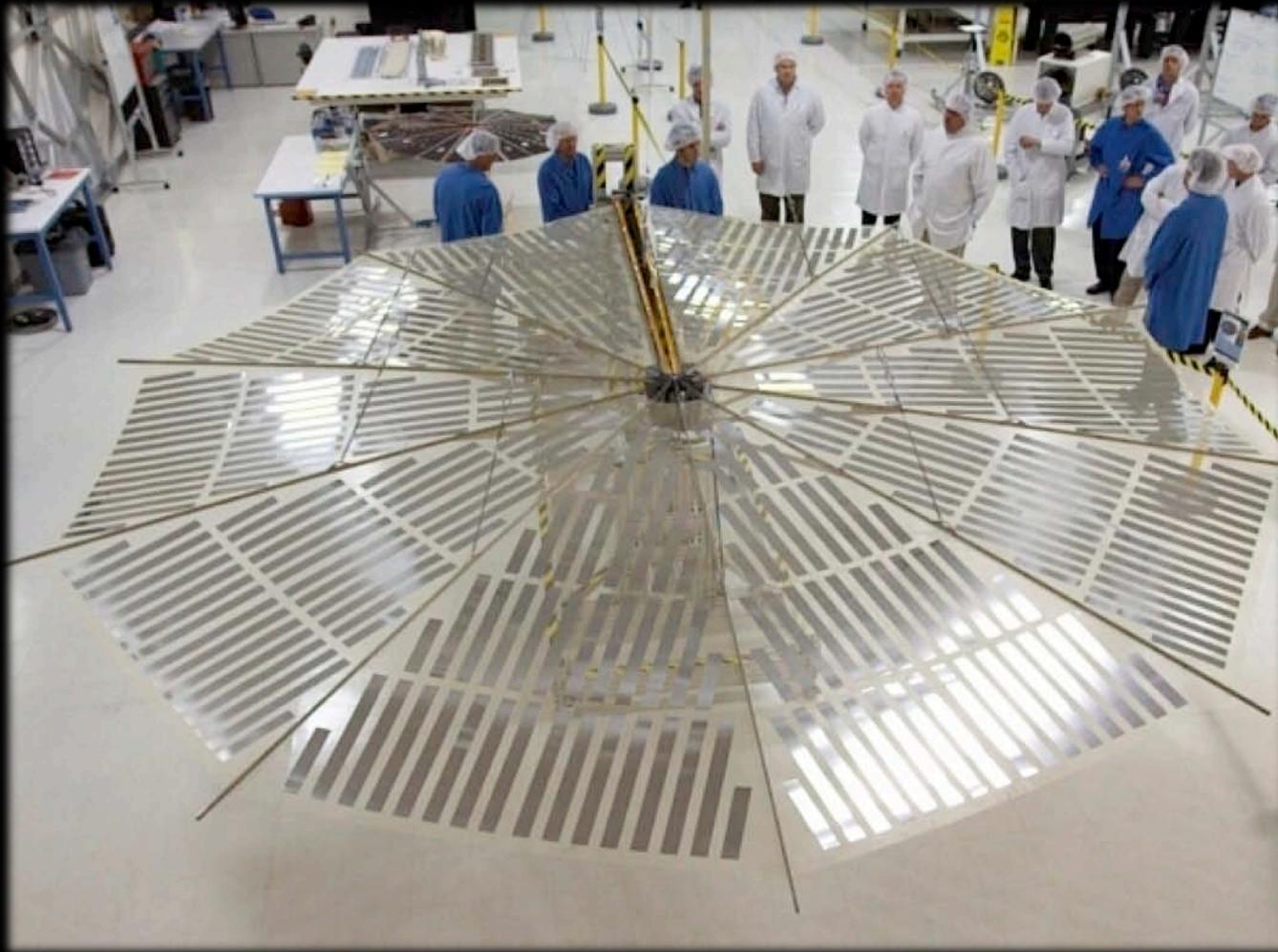
Orion PORT Sea State Testing



Service Module Auxiliary Propulsion



Solar Array Deployment Testing





Abort Motor Static Test-1

video

Launch Abort System Jettison Motor



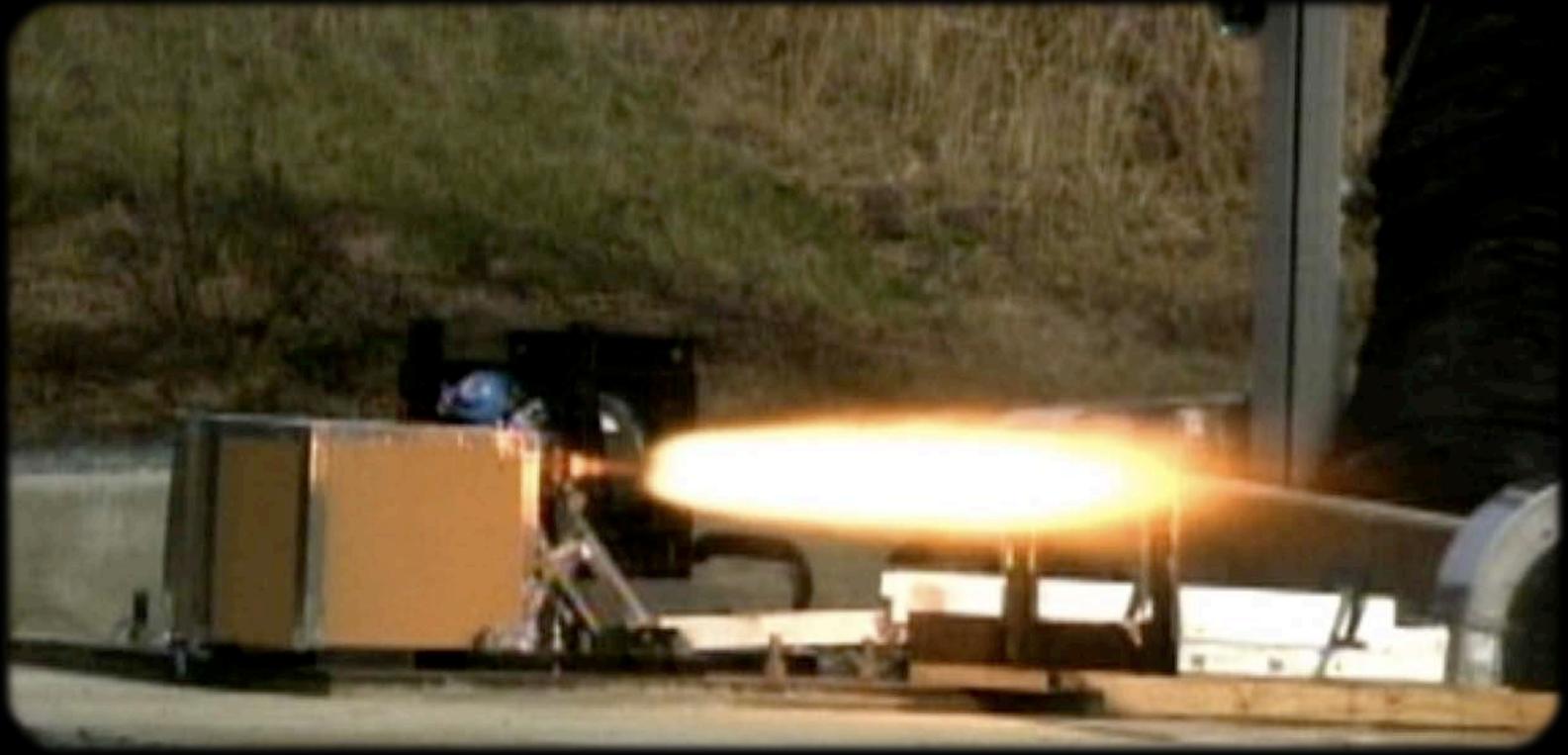
**SDU
Case**



**SDU
Core**



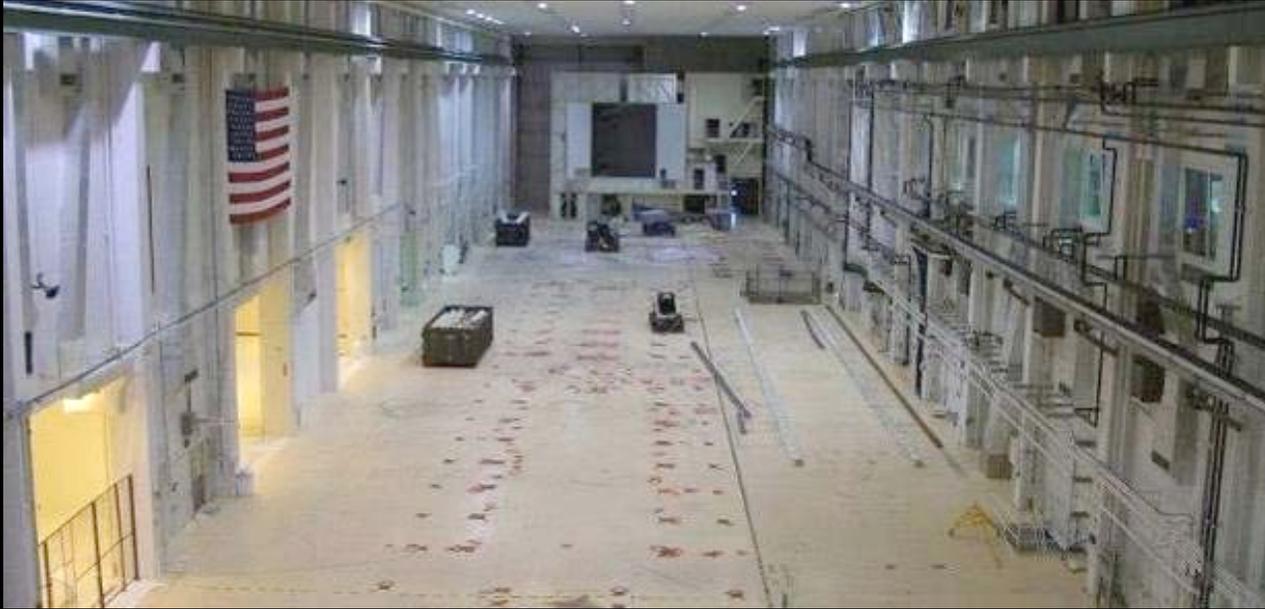
Attitude Control Motor High Thrust 6



Attitude Control Motor High Thrust 8



Operations & Checkout Facility High Bay Looking West



Before

After



Operations & Checkout Facility Basement



Before

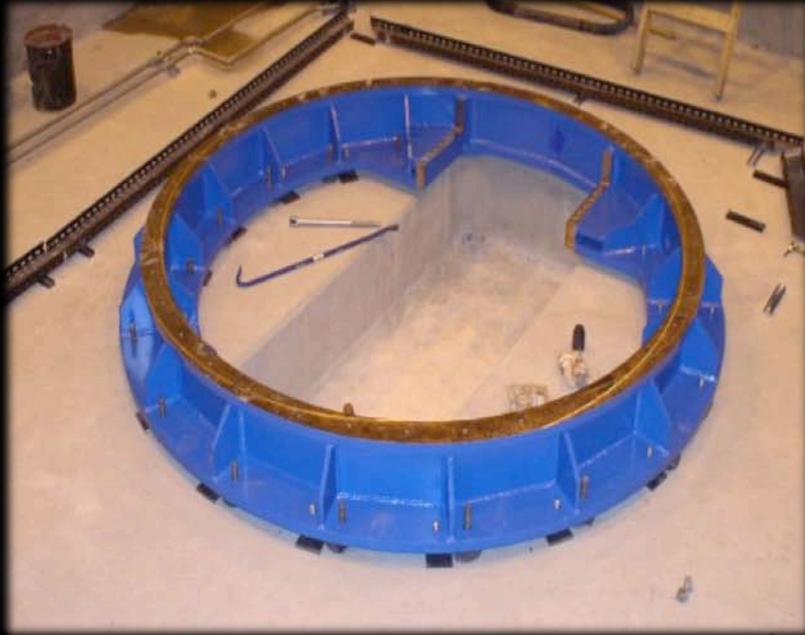


After

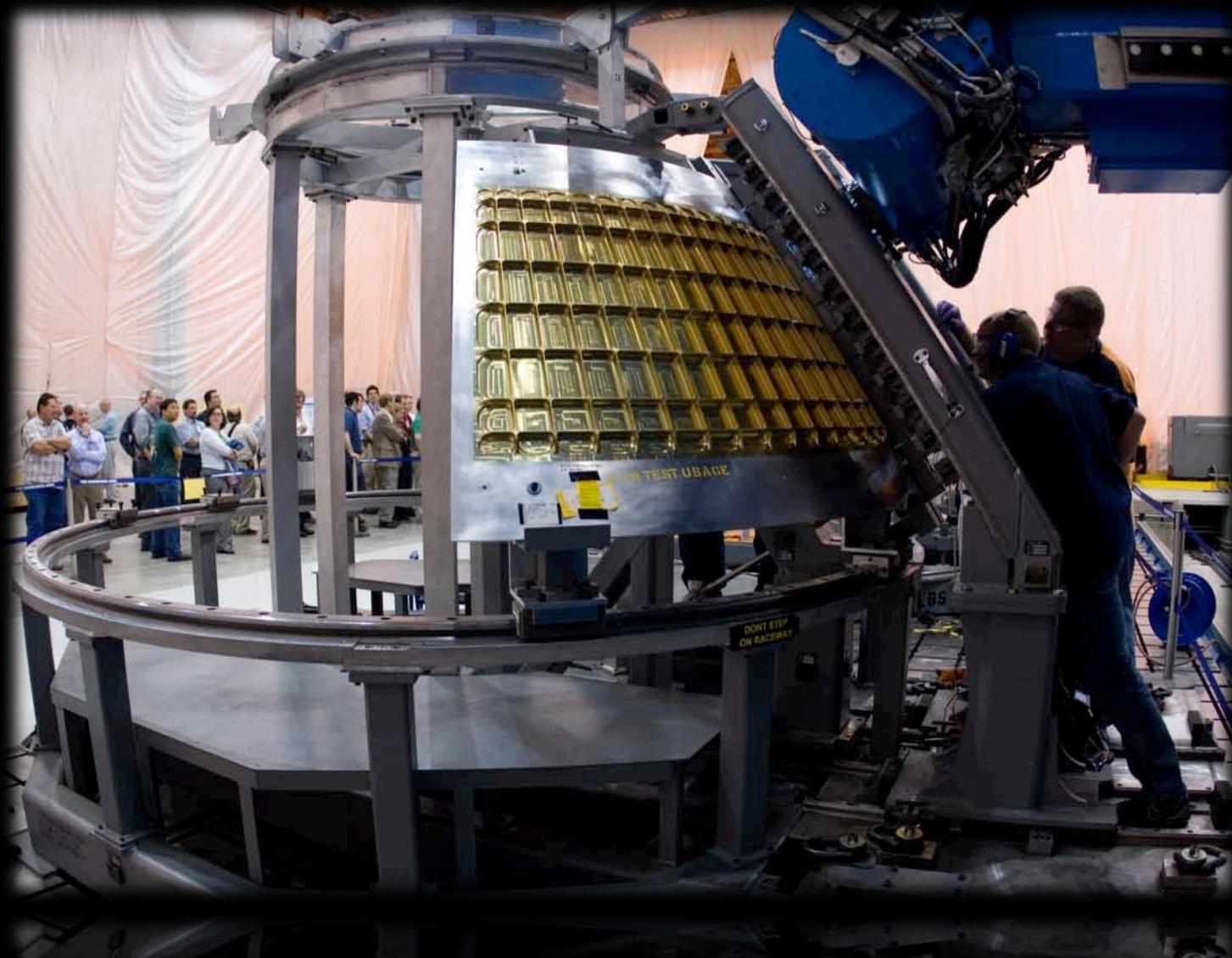
Michoud Assembly Facility Orion Structural Manufacturing



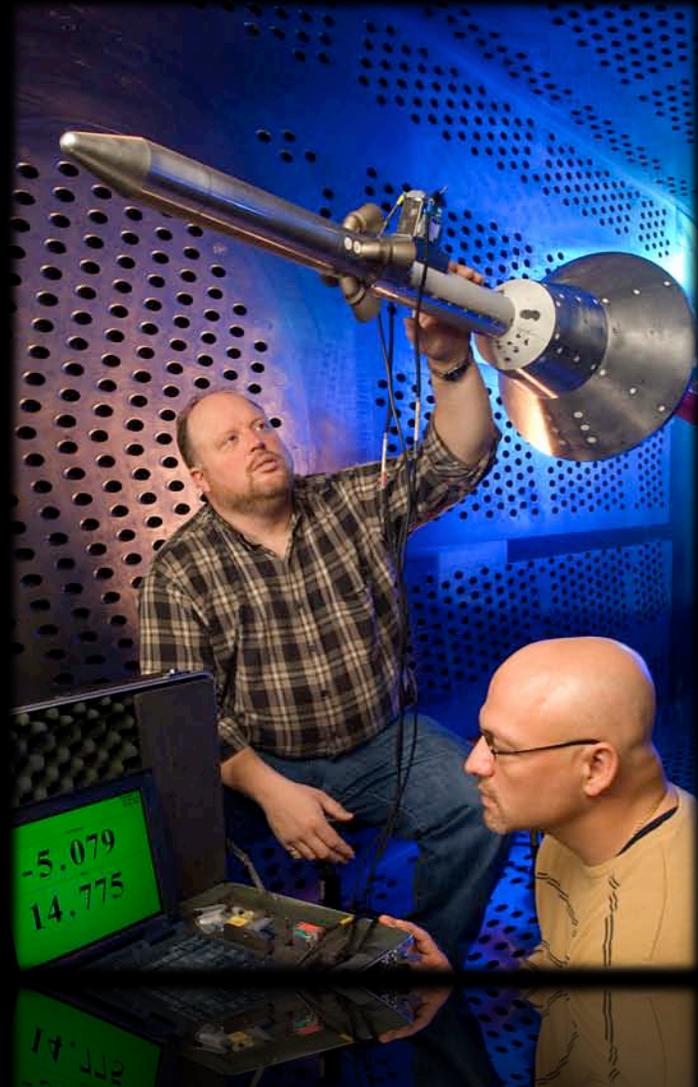
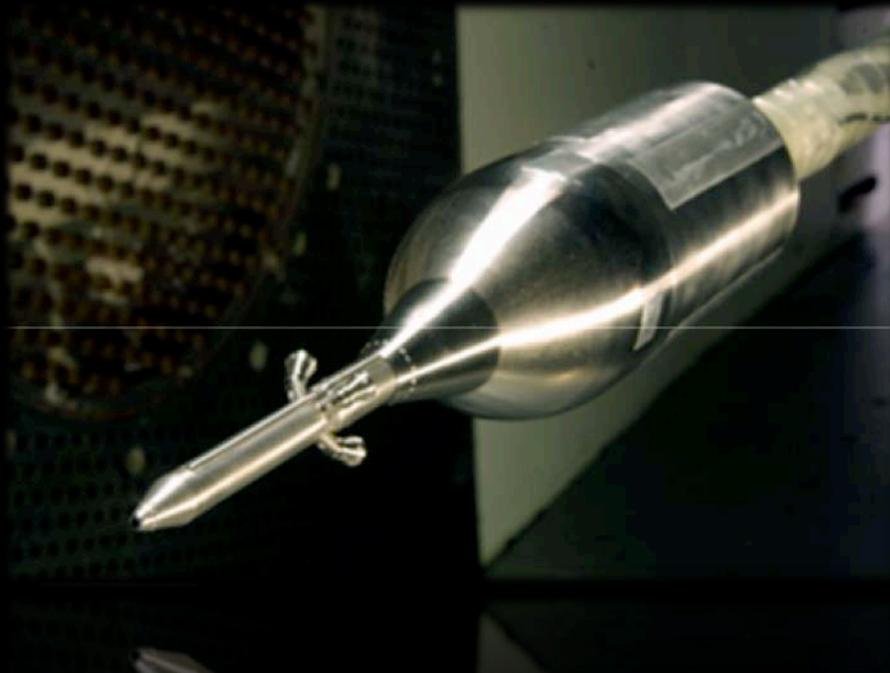
Michoud Assembly Facility Universal Weld System 2 turntable base and Y-Column X-Rails



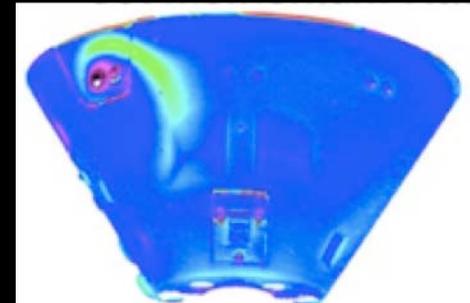
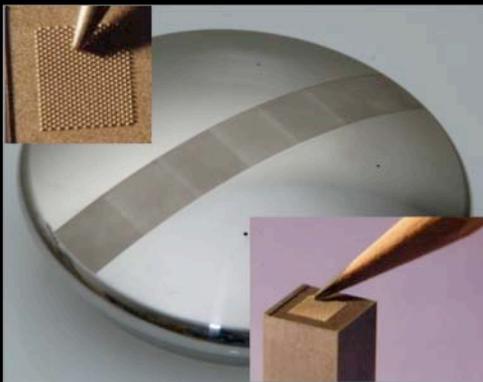
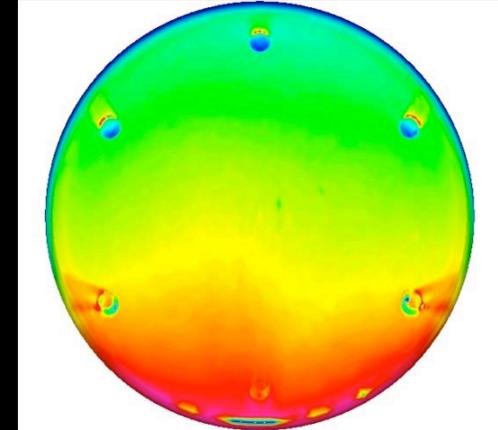
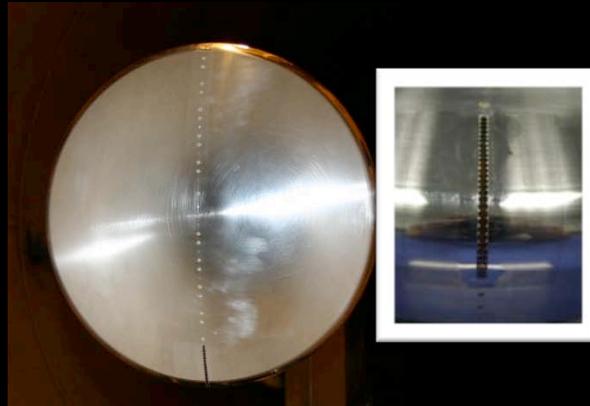
First friction stir weld
Orion crew module Ground Test Article Lite



Wind Tunnel Testing



CAP Aerothermodynamic Testing



Pad Abort 1 Crew Module Weight and balance testing



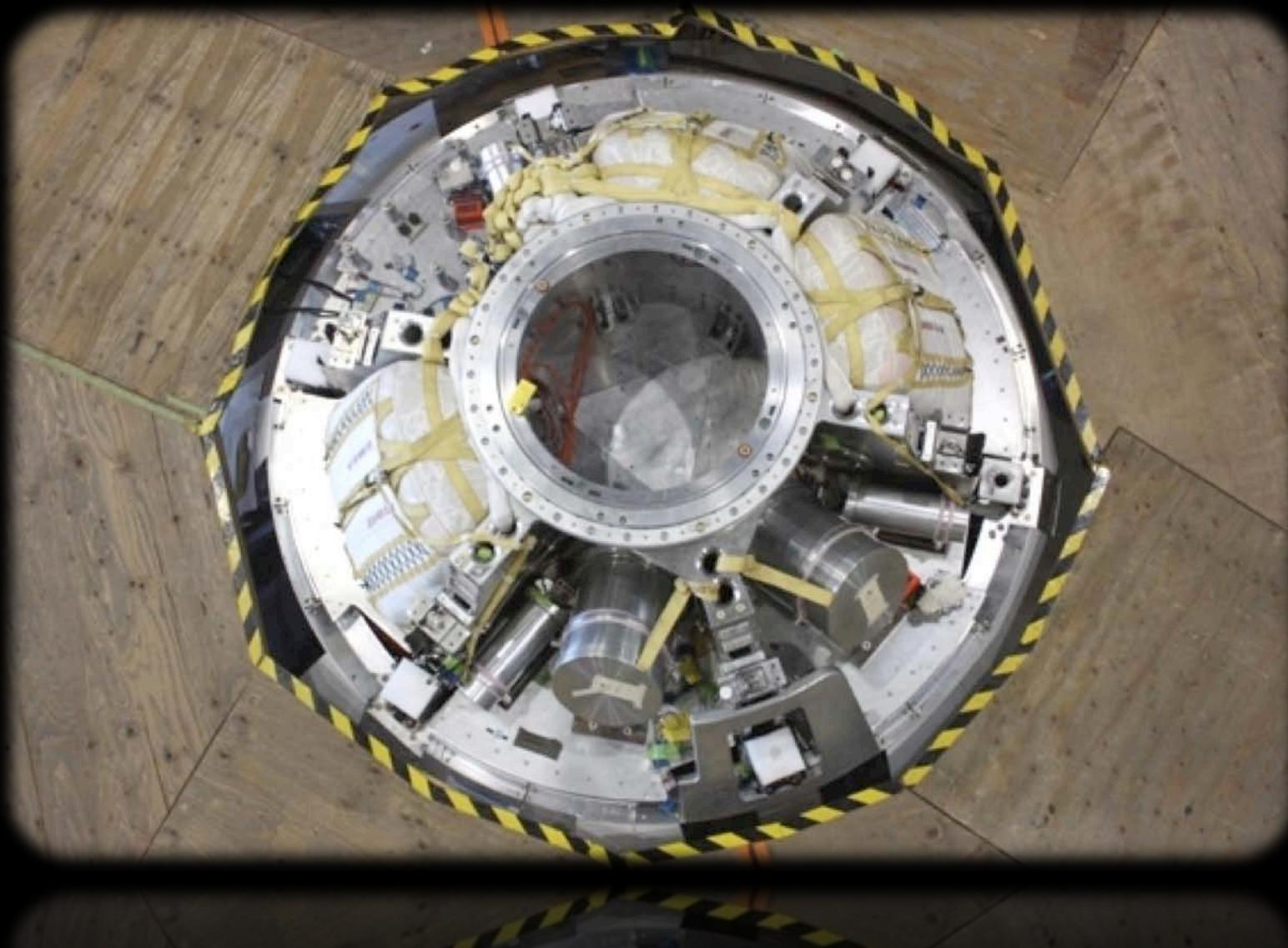
Pad Abort 1 Launch Abort System Jettison Motor Delivery



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

