



# ***Exploration Systems Mission Directorate***



***Geoffrey Yoder  
Director, ESMD Directorate Integration Office  
NASA Exploration Systems Mission Directorate***

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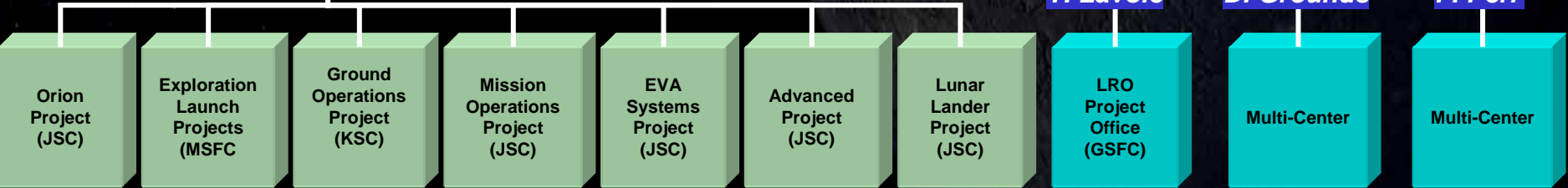
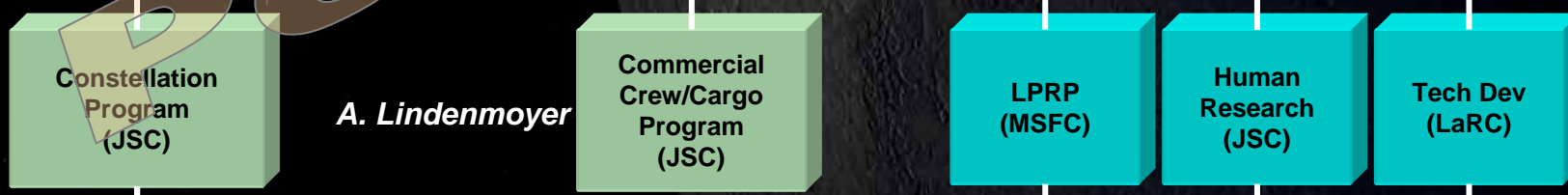
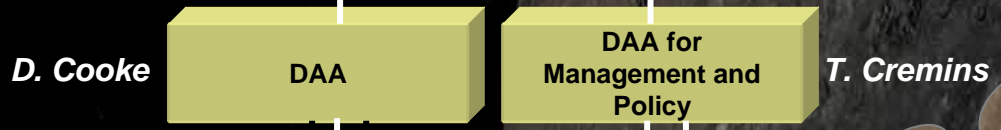
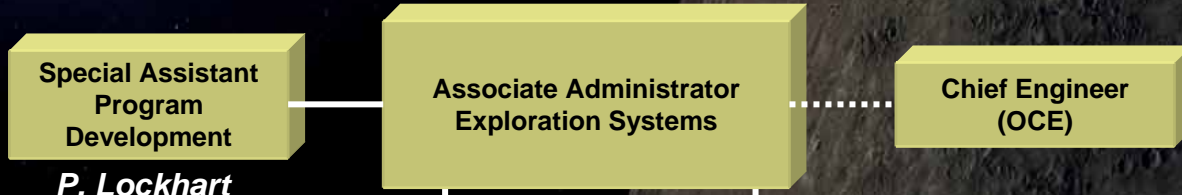
# *Exploration Overview*

- **ESMD Organization**
- **Exploration Plans & Progress in 2007**
  - Lunar Architecture
  - Constellation Systems
  - Advanced Capabilities
- **International and Domestic Participation in the Global Exploration Strategy**
- **Challenge**

# Exploration Systems Mission Directorate Organization



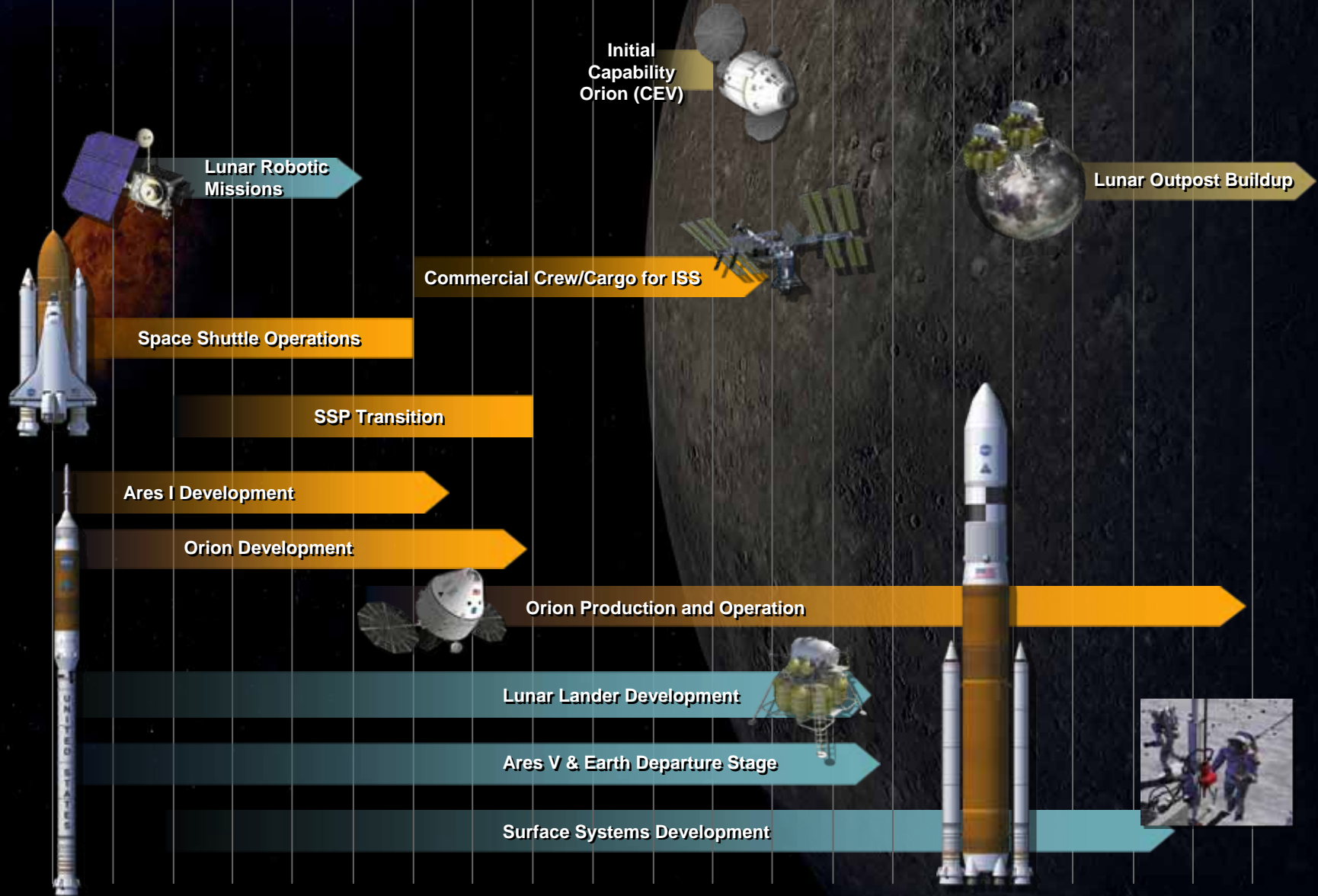
## Headquarters





# Exploration Roadmap

05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25...





**2007: A Year of Progress for Exploration**

# *Lunar Architecture Team (LAT)*



- The Vision told us what we had to do, and when, but.....
- We needed to better define why we are going there, what we are going to do when we get there, or how we will get there.
- For the 'Why' and 'What', a Synthesis Team was formed to develop a consensus from the Science community, from IP interests, and from Commercial interests (~180 Objectives).
- For the 'How', a multi-center, cross disciplinary, Lunar Architecture Team (LAT) was formed in Summer of '06 to draft a plan that would support prioritized list of objectives. First phase completed in December '06
- Phase 2 of LAT began in January '07, for completion in Summer '07. Goal is to refine a Point of Departure architecture to facilitate open discussions with potential partners and collaborators.

# Architecture Driven By A Strategy



**Global Exploration Strategy Development**

**Themes & Objectives**

**National  
Priorities  
Defined**



**Architecture Assessment**

**Reference Architecture  
& Design Reference  
Mission  
*Outpost First at one of  
the Poles  
Elements critical to US***

**LAT-1**

**Detailed  
Requirements  
Defined**



**Detailed Design**

**Operations Concept,  
Technology Needs,  
Element Requirements  
Maintain flexibility**

**LAT-2**

# 2007 Mars Study Objectives / Products



**Develop integrated program strategies and decision timelines for different assumed launch dates.**

**Includes:**

- **Updating NASA's human Mars mission reference architecture, that defines:**
  - Long term goals and objectives for human exploration missions
  - Flight and surface systems for human missions and supporting infrastructure
    - Integrate the current Constellation elements, as well as other Mars elements which have been updated since DRM 3.0, 4.0 and ESAS, to document the Mars DRM 5.0.
    - Update and incorporate Mars surface reference mission into DRM 5.0
    - Schedule and definition of supporting development activities
  - An operational concept
  - Key challenges including risk and cost drivers
  - Development schedule options
- **Developing a plan for reducing the cost/risk of human Mars missions through investment in research, technology development and synergy with other exploration plans, including:**
  - Robotic Mars missions
  - Cis-lunar activities
  - ISS activities
  - Earth-based activity, including analog sites, laboratory studies, and computer simulations
  - Additional research and technology development investment
- **Assessing strategic linkages between lunar and Mars strategies.**

# Mars Study Approach



- Non-Science Requirements
- Systems Development
- Human Exploration Architecture

**ESMD**

- Science Requirements
- Integration with ongoing MEP
- Interpretation of science results

**SMD**

- Policy Makers
- Industry
- Entrepreneurs

**Mars Plan**

- Internationals
- Science Community
- Public

**ARMD**

- Aeronautics research
- Mars atmospheric entry

**SOMD**

- Human Spaceflight Operations
- Tracking, navigation and communications

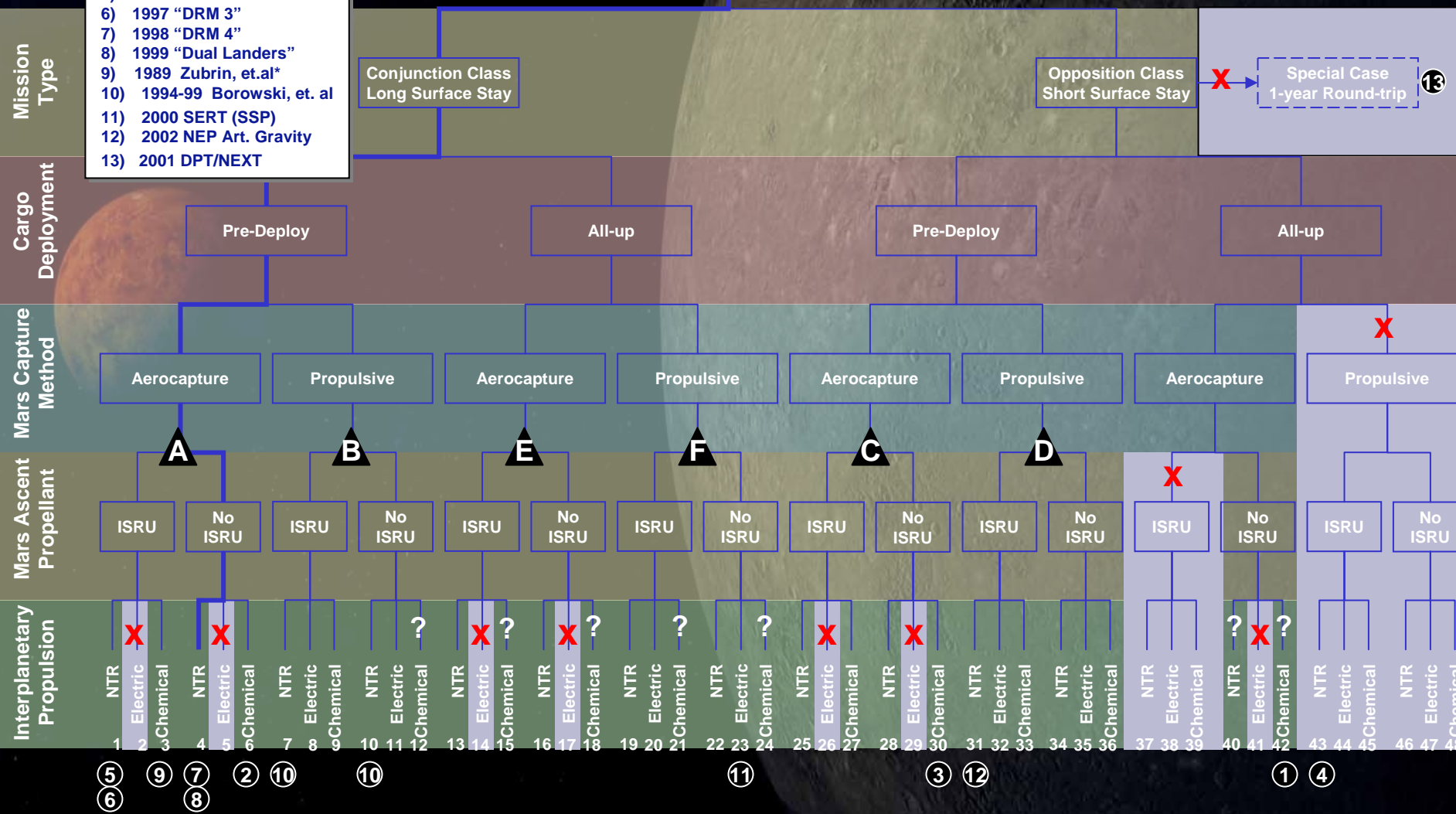
- Integrating all stakeholders while leveraging recognized subject matter experts

# Top-level Trade Tree (Crewed Elements)



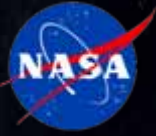
- 1) 1988 "Mars Expedition"
- 2) 1989 "Mars Evolution"
- 3) 1990 "90-Day Study"
- 4) 1991 "Synthesis Group"
- 5) 1995 "DRM 1"
- 6) 1997 "DRM 3"
- 7) 1998 "DRM 4"
- 8) 1999 "Dual Landers"
- 9) 1989 Zubrin, et.al\*
- 10) 1994-99 Borowski, et. al
- 11) 2000 SERT (SSP)
- 12) 2002 NEP Art. Gravity
- 13) 2001 DPT/NEXT

Human Exploration  
Of Mars



**A** → **F** = Priority order of branches to study

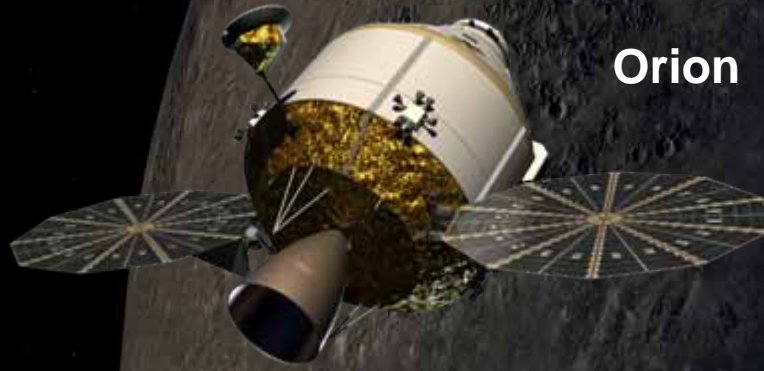
NTR- Nuclear Thermal Rocket  
Electric= Solar or Nuclear Electric Propulsion



# Constellation Update



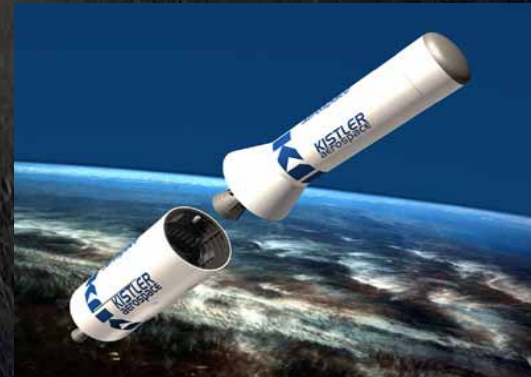
**ARES**



**Orion**



**COTS**



# 2007: A Year of Technical Progress



## Ares I (Crew Launch Vehicle)

- Vehicle Integration: Monopropellant Reaction Control Thruster Testing
- 1<sup>st</sup> Stage: Test Motor firing to Measure Roll Torque for Ares I
- Upper Stage: Mock-up of Ares I Instrument Unit with CAD Imagery
- Upper Stage Engine: Dismantle of X-33 J-2S Turbomachinery
- Ares I-X: Ares I-X Avionics / Solid Rocket Booster Thrust Vector Control Test

# Ares I 1<sup>st</sup> Stage Components in Progress



Nose Inlet Billet



Forward Exit Cone



Forward End Ring



Nose Inlet Housing



Aluminum Ingots



Throat Housing

# Core Tooling



RSRM fwd core mandrel  
(without tip fins attached)

Forward Core

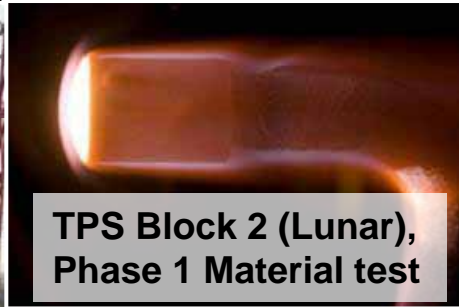


Aft Core

# Orion Project FY 2007 Accomplishments



ILC Airbag Test



TPS Block 2 (Lunar),  
Phase 1 Material test



ARC IHF TPS  
Arcjet Testing



PA-1 Heat shield



Parachute Testing



Heat shield Stiffener

## Orion Project

- Awarded contract to provide rockets for abort system testing
- Completed Orion Systems Requirements Review (SRR) and moving towards Systems Definition Review (SDR)
- Released Request for Proposals (RFP) for integrated Qualification Test facilities at Glenn Research Center/Plumbrook
- Began fabrication of flight test article for Pad Abort Test -1 (PA-1)
- Performed drop tests to gather data on parachute designs

# Constellation Acquisition Update



**Draft RFP**

**Final RFP**

**Planned award**

**Ares I 1<sup>st</sup> Stage**

Awarded  
August 2007

**J2-X**

Awarded  
July 2007

**Upper Stage**

Awarded  
September 2007

**Upper Stage  
Instrument Unit**

Apr 2007

June 2007

Nov/Dec 2007

**Space Suit System**

June/July 2007

Aug/Sep 2007

Summer 2008

# Ares I-X Test Flight 2009



Ares I-X Data	
First Stage Thrust (Avg.)	2.6 Mlbf
Max Speed	Mach 4.7
Max Altitude	130,000 ft
Liftoff Weight	1.8 Mlbm
Length	324 ft
Max Acceleration	2.5g

Demonstrate and collect key data on:

- Vehicle controllability
- Staging/separation
- Roll control
- KSC launch ops
- Aerodynamics and vehicle loads
- Atmospheric entry dynamics for recovery



# 2007: A Year of Progress - COTS



## Commercial Orbital Transportation Services (COTS)

- Began integration of K-1 flight systems at MAF
- Completed development of the Falcon 9 flight vehicle
- Completed Dragon Capsule engineering model
- Completed Merlin 1C engine qualification testing
- Began production of flight Merlin 1C engines, Falcon 9 launch vehicle, and Dragon Capsule

# Facility Transition

- **KSC / Operations & Checkout Building**

- Highbay for all Orion final assembly
- Highbay cleanout Complete
- Highbay design in work

- **KSC / Pad 39B**

- Launch Pad and Support Facilities
- Lightning Protection System

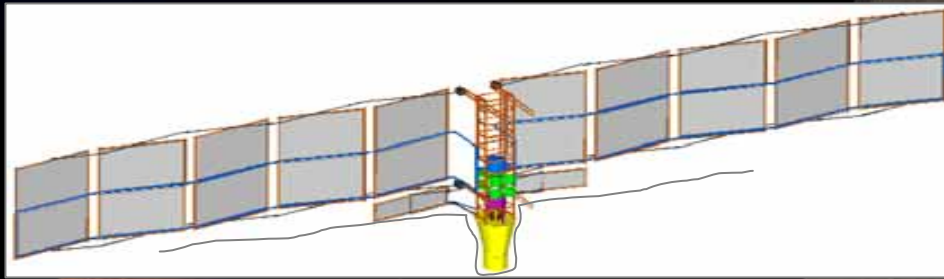
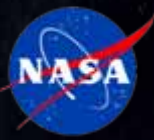


- **Michoud Assembly Facility (MAF)**

- **Primary structure manufacturing**
- **Composite and metal fabrication**
- **Users: Orion, Ares I Upper Stage, Ares V Earth Departure Stage, Ares V Core Stage, COTS - RPK**



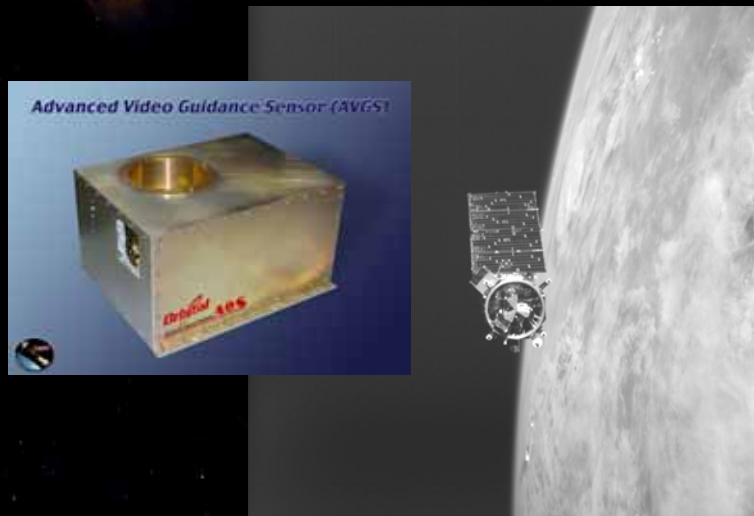
# Advanced Capabilities Division 2007: A Year of Technical Progress



NASA, DOE, and industry team developed a conceptual design for an affordable fission surface power system to provide power for the lunar outpost.



Test fired a liquid oxygen-liquid methane rocket engine for potential use on the Lunar Lander ascent stage.



Demonstrated an advanced video guidance sensor for automated rendezvous and docking operations on the DARPA Orbital Express mission.

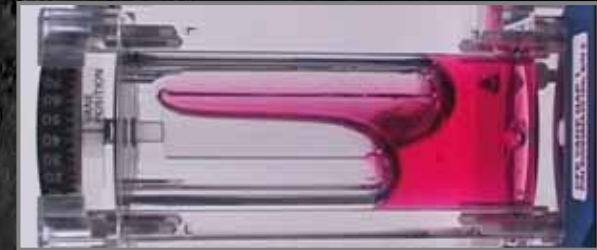


Flight tested a lidar sensor for autonomous hazard detection and avoidance system on Lunar Lander.

# Advanced Capabilities Division 2007: A Year of Technical Progress



Tested Lab-On-A-Chip instrument for detecting harmful bacteria on the ISS.



Discovered new fluid behavior in microgravity using Capillary Flow Experiment on the ISS.



Demonstrated hydrogen-air fuel cell power system for ATHLETE rover that can carry large payloads over rough terrain.

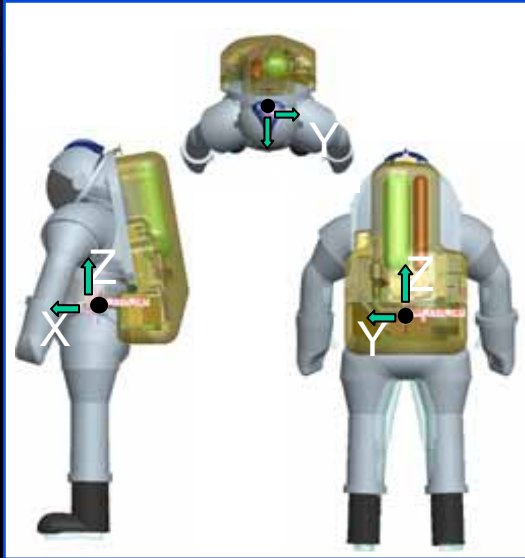


Fabricated proof-of-concept inflatable habitat for the lunar outpost.

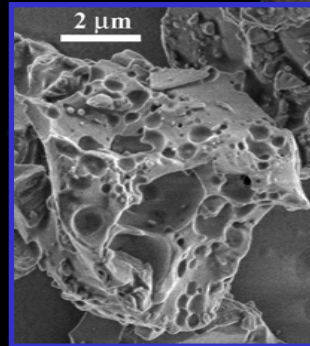


Developed lithium-ion battery for powering portable life support system on EVA suit.

# 2007: A Year of Human Research Progress



EVA physiology testing has improved the design of the new planetary suit with a lower center of gravity.



NASA scientists have produced activated simulants of lunar dust for toxicity testing.



Completed pilot study on intermittent exposure to artificial gravity



Completed investigation of countermeasure for risk of renal stone formation during long duration missions

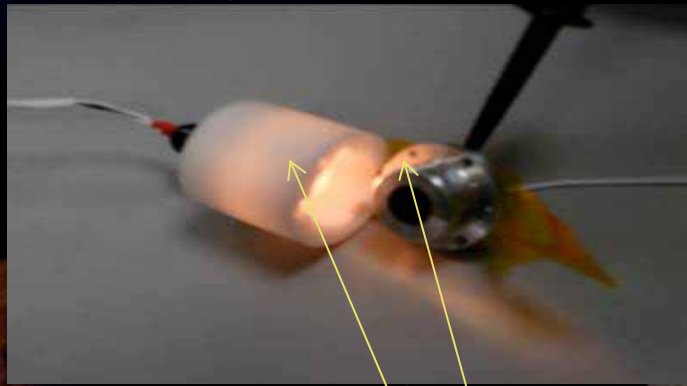


Direct measurements of Oxygen Uptake Measurement using Pulmonary Function System



Nutritional Status Assessment investigation started. Will provide insights into time course of changes in nutritional status, bone loss

# 2007: A Year of Lunar Robotic Progress



Light Source — CSS

MAC



Successful Interface testing between Coarse Sun Sensor (CSS) and Multipurpose Access Card (MAC).



LCROSS flight primary structure received April 2nd



LCROSS harness fabrication in process using structure mock-up.



**Achieving Our Exploration Goals and Objectives**

**More detailed LAT briefing later today**



# Working Together

