



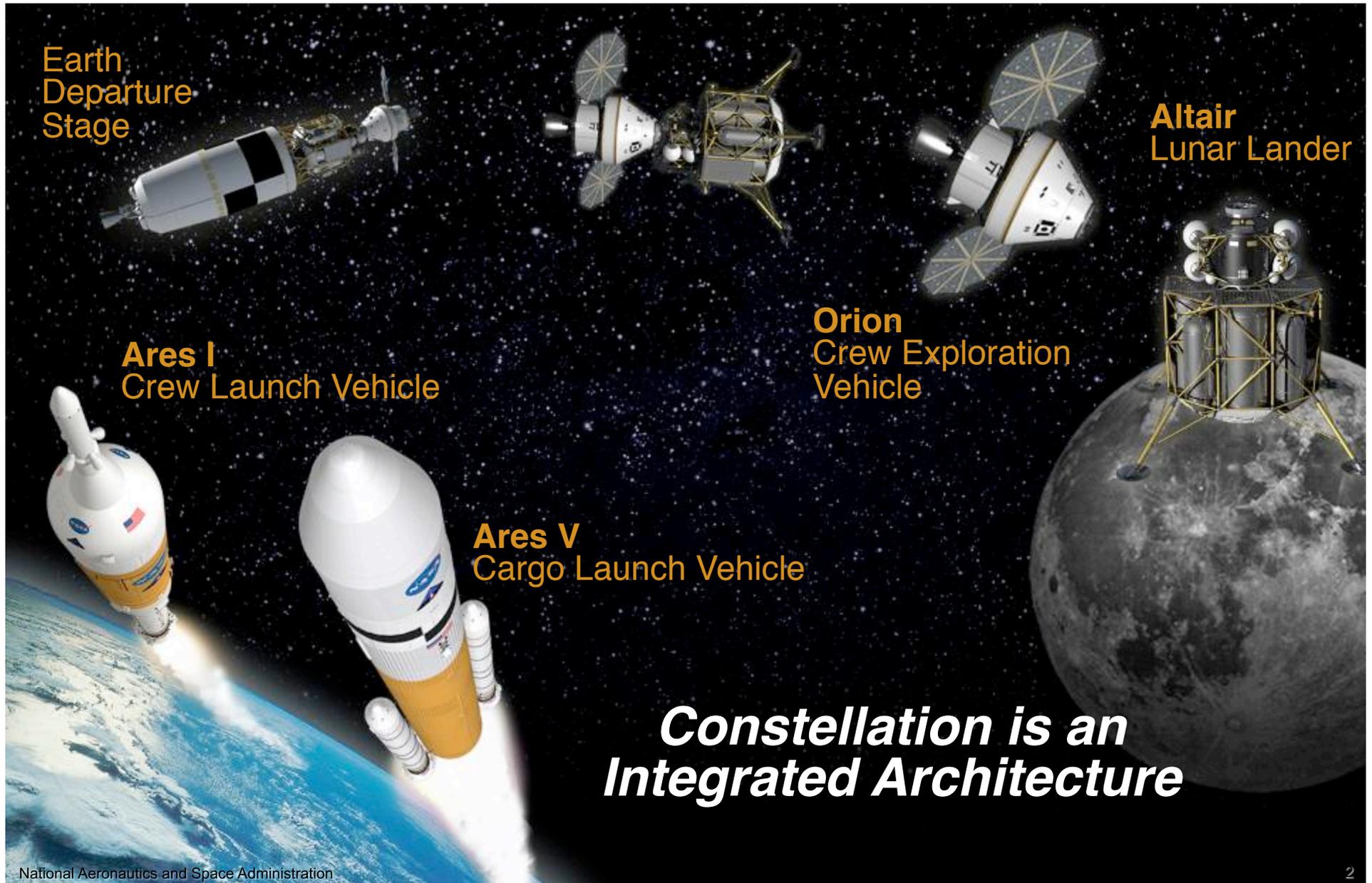
# Review of Human Spaceflight Plans

## *Constellation Overview*

*June 17, 2009*

Doug Cooke  
Jeff Hanley

# Constellation Architecture



# Key Exploration Objectives

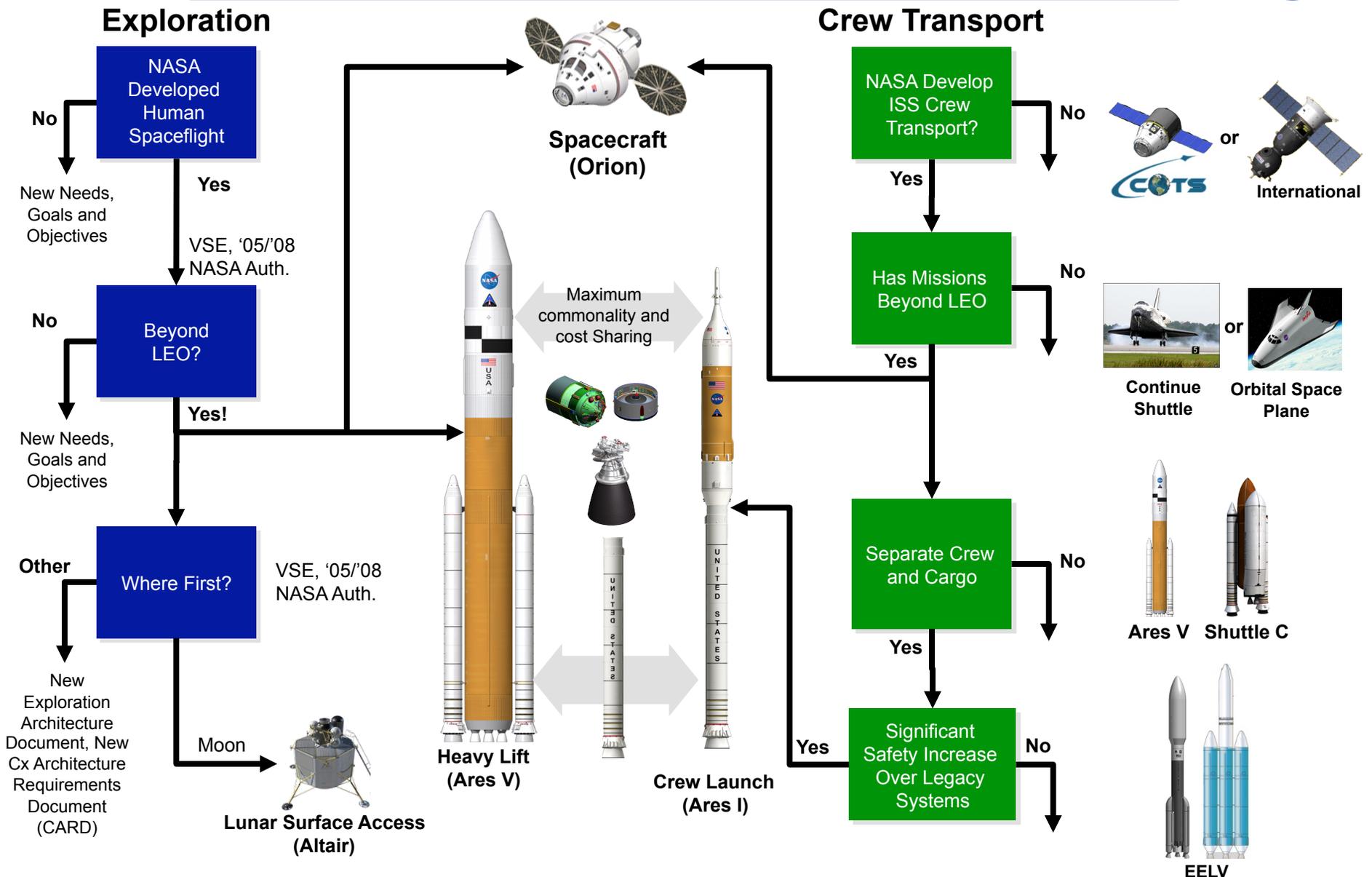
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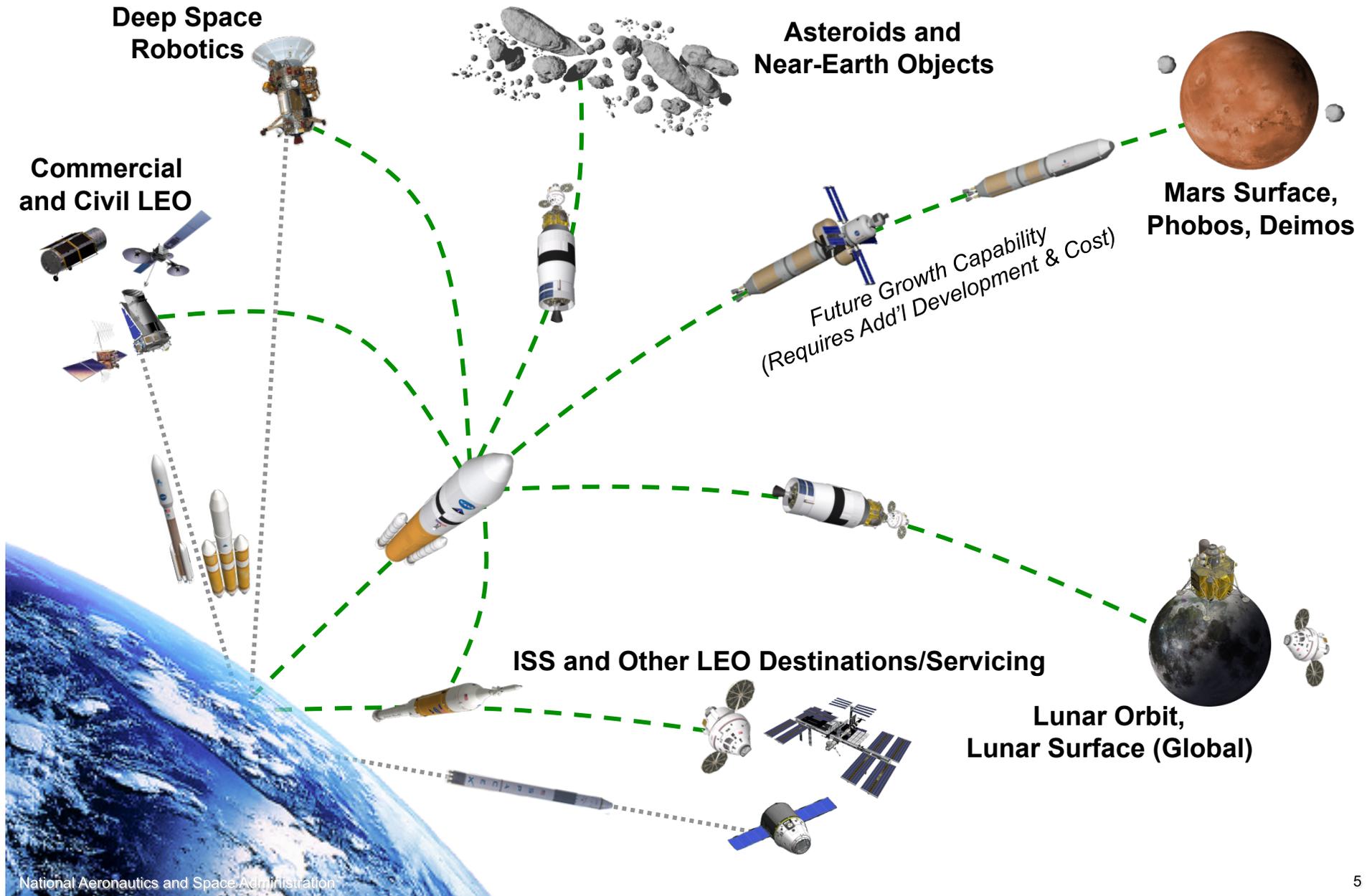
- 1. Replace Space Shuttle capability, with Shuttle retirement in 2010**
- 2. To ensure sustainability, development and operations costs must be minimized**
- 3. Develop systems to serve as building blocks for human exploration of the solar system using the Moon as a test bed**
- 4. Design future human spaceflight systems to be significantly safer than heritage systems**
- 5. Provide crew transport to ISS by 2015, to the lunar surface for extended durations by 2020, and to Mars by TBD**
- 6. Separate crew from cargo delivery to orbit**
- 7. Maintain and grow existing national aerospace supplier base**
- 8. Provide global lunar access to maximize science return**
- 9. Lunar “any time return” is a safety requirement**
- 10. Utilize ISS to support exploration goals**
- 11. Promote international and commercial participation in exploration**

***Solutions Must Be Addressed Through an Integrated Architecture***

# Influence of Key Drivers on Architecture Selection



# Current Development for Future Exploration Capabilities



# Transition of Shuttle Capabilities

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- ◆ **Constellation makes extensive use of Shuttle capabilities, but in a leaner, smaller footprint to reduce life cycle costs:**
  - JSC: Crew systems and mission operations
  - KSC: LC39, VAB, O&C, SSPF
  - MSFC: Large scale launch vehicle development and test
  - SSC: Large scale liquid propulsion test
  - MAF: Large scale cryogenic stage production
  - ATK: Large solid rocket motor development, production and test
  - PWR: Large liquid engine development and production
  
- ◆ **Significant synergy in capabilities of the human spaceflight workforce between Shuttle, ISS and Constellation**
  
- ◆ **Challenge is in converting a large, fixed base LEO-capable workforce to a beyond-LEO architecture in a cost effective manner**
  
- ◆ **The U.S. has a unique, once-in-a-generation opportunity to capitalize on Apollo and Shuttle investments**

# Constellation Economic Impact: Civil Servant (2,950 FTE)

## Ames

- Lead Thermal Protection System Advanced Development Program
- Ares mission operations simulation
- Software & Guidance, Navigation & Control support
- Lunar systems support

## Marshall

- Home for Ares Project
- Ares I and V development and integration lead
- Support LAS and Service Module, Ares V EDS development, test and oversight
- Core stage development, test and oversight
- Altair decent stage and subsystem support

## Glenn

- Lead Service Module and Spacecraft Adapter integration
- Flight Test Article "Pathfinder" fabrication
- Ares I-X upper stage simulator lead
- Lead Ares V power, thrust vector control and payload shroud development
- Lead EDS orbital environments testing at Plum Brook
- Lead lunar lander ascent stage propulsion, ascent and descent stage power generation
- Passive thermal systems and surface element communications
- J-2X altitude/in-space testing

## Goddard

- Lead program requirements for unpressurized cargo carriers
- Subsystem lead for lunar lander avionics
- Lunar surface and surface telenet communications
- EVA tools and equipment

## Langley

- Lead Launch Abort System integration
- Ares I-X vehicle integration
- Ares aerodynamics lead
- Lead Ares V aerodynamics
- Subsystem lead for lunar lander structures and mechanisms including ascent and descent stages
- Lunar lander and lunar surface radiation protection

## Kennedy

- Home for Ground Ops Project
- Ground processing
- Launch operations
- Recovery operations
- Final assembly, ground processing for human lunar lander
- Lead for lunar surface in-situ resource utilization systems

## Stennis

- Rocket propulsion testing
- Lead Ares V liquid rocket systems and stage testing at sea level and altitude
- Lead altitude development and certification testing for upper stage engine

## Dryden

- Lead Abort Flight Test Integration/Operations
- Abort Test Booster procurement
- Flight Test Article

Pratt and Whitney  
Rocketdyne

Alliant Techsystems, Inc.

Lockheed Martin

White Sands Test Facility

- Orion Abort Test Booster test site

Boeing

Boeing

Michoud Assembly Facility

- Manufacturing of Ares I Upper Stage, Ares V Stages and Orion Primary Structure

## Jet Propulsion Laboratory

- Thermal protection system support
- Lunar lander support including spacecraft design; guidance, navigation, and control; life support systems, and avionics
- Lead specific robotic surface mobility
- Environmental monitoring and control and surface system local element communications

## Johnson Space Center

- Home for Program and Projects: Orion, MOP, EVA, Altair, Lunar Surface
- Element lead for lunar lander crew module/ascent stage
- Lead lunar surface crew habitation, environmental control /life support systems, human mobility
- GFE projects management
- Flight Test Program

# Constellation Economic Impact: Contractor (7,530 WYE)

## Alliant Techsystems, Inc.

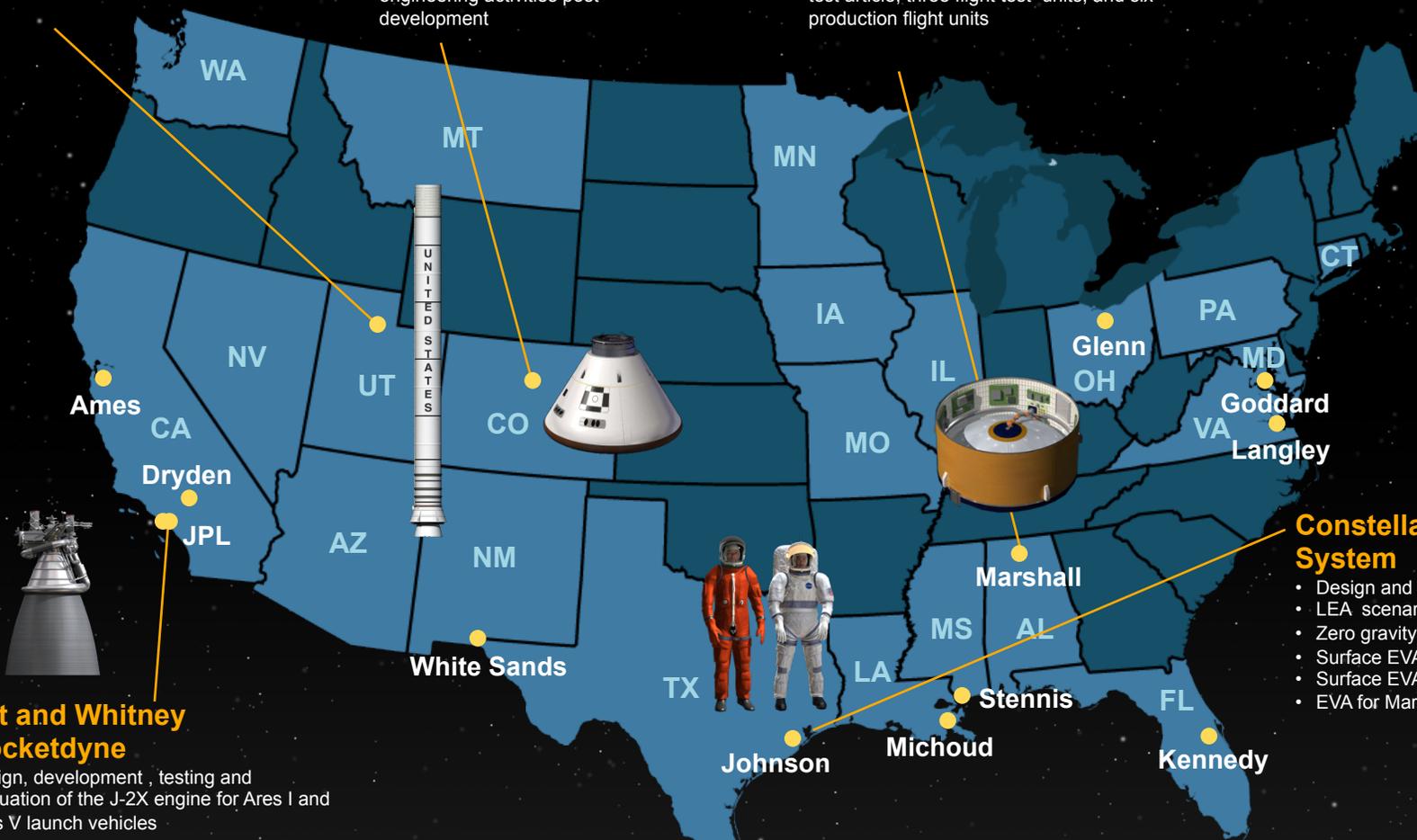
- Build five ground static test motors, two ground vibration test articles, and four flight test stages.

## Lockheed Martin

- Engineer, assemble, and integrate the Orion vehicle
- Production and sustaining engineering activities post-development

## Boeing

- Produce, deliver and install avionics systems for Ares I rocket
- Provide one instrument unit avionics ground test article, three flight test units, and six production flight units



## Pratt and Whitney Rocketdyne

- Design, development, testing and evaluation of the J-2X engine for Ares I and Ares V launch vehicles

## Constellation Space Suit System

- Design and build space suits for
- LEA scenarios
- Zero gravity EVA
- Surface EVA for lunar sorties
- Surface EVA for lunar outpost
- EVA for Mars missions

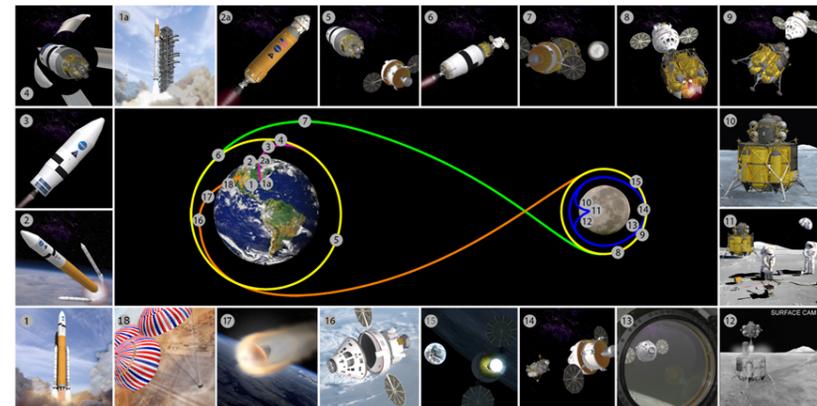
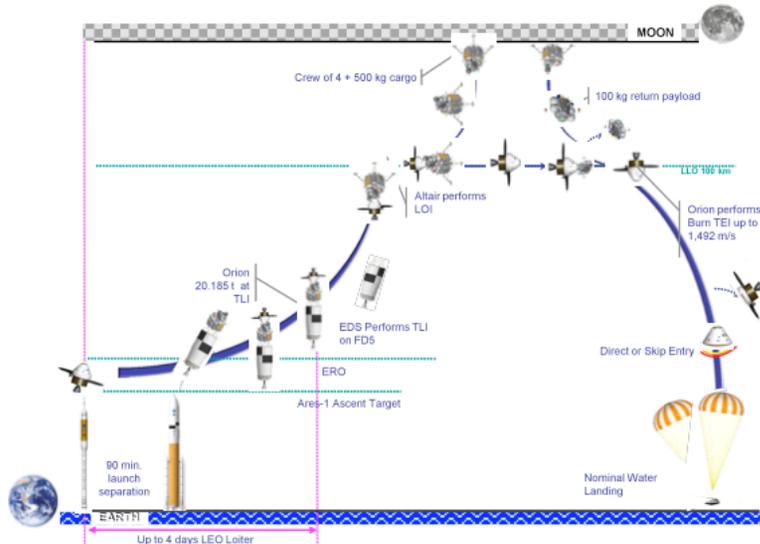
# Overview of Lunar Capability



## ◆ Constellation Transportation Architecture Enables Independent Delivery of Crew and Large Cargo to the Surface of the Moon:

- 4 crew members
- 7 days (living out of lander in sortie mode)
- 210 days (crew at outpost with lander waiting in standby)
- Global surface access
- Anytime return to Earth
- 14 metric ton cargo to surface on a single launch

## ◆ Lunar Surface Systems Currently Under Study, Including Contributions from International Partners

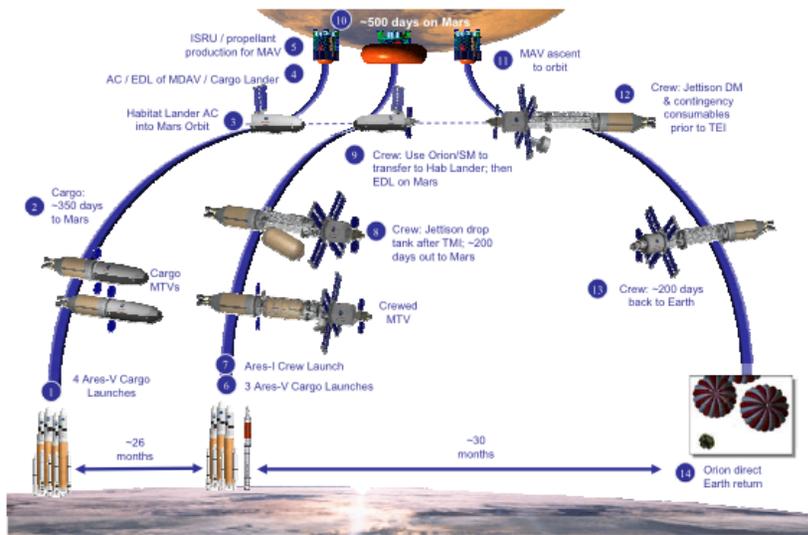


1. Ares V liftoff.
2. Solid Rocket Booster (SRB) separation.
3. Earth Departure Stage (EDS) fires for Earth Orbit Insertion (EOI).
4. Payload shroud separates to expose Altair Lunar Lander.
5. Orion docks with Altair/EDS.

6. EDS fires for Trans-Lunar Injection (TLI).
7. Orion and Altair undock from EDS.
8. Altair fires for Lunar Orbit Insertion (LOI).
9. Altair separates from Orion.
10. Altair lands on lunar surface.
11. Conducting activities on the lunar surface.
12. Altair ascent stage liftoff viewed from surface camera.

13. Altair ascent stage prepares to dock with Orion.
14. Altair ascent stage and Orion separate.
15. Service Module (SM) fires for Trans Earth Injection (TEI).
16. Orion separates from SM.
17. Orion re-enters Earth atmosphere.
18. Chutes open for recovery.

# Overview of Mars Extensibility



## ◆ Current Human Mars Mission Highlights:

- Long stay (conjunction)
- Pre-deployed assets
- Nuclear thermal in-space propulsion
- 9 Ares V launches
- Preliminary assessments indicate launch vehicle shroud can be used for both ascent to LEO as well as entry, descent, & landing aeroshell structural element

**Mission Cargo (2)**

**Propulsion Systems (3)**

**Cargo Mission**

- Surface Habitat
- Cargo Lander
- Outbound Propulsion

**Previous Opportunity**  
**5 Ares V Launches**

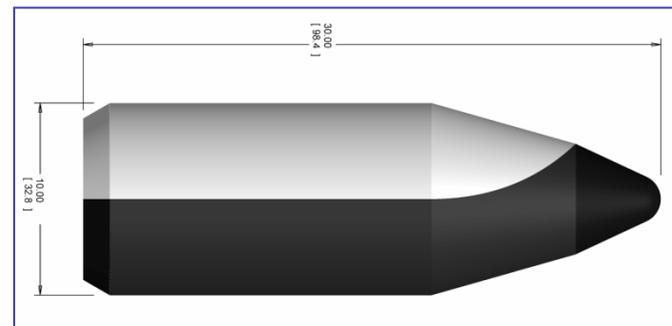
**Crew Hab (1)**

**Propulsion Systems (3)**

**Crew Mission**

- Transfer Habitat
- Roundtrip Propulsion
- Orion

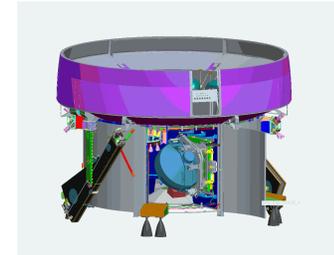
**Current Opportunity**  
**4 Ares V Launches**



# Architecture Flexibility Enables New Science and DoD Applications



- ◆ **Orion Will Fully Utilize Vehicle System Capabilities to Accommodate a Variety of Prospective Payloads**
  - Heliophysics, Environmental Monitoring, Atmospheric and Oceanic Studies, Laser Communications Satellites and Dust Studies
- ◆ **“It is very clear from the outset that the availability of the Ares V changes the paradigm of what can be done in planetary science.” – *Workshop on Ares V Solar System Science***
- ◆ **“Exciting new science may be enabled by the increased capability of Ares V. The larger launch mass, large volume, and increased C3 capability are only now being recognized by the science community.” – *National Academy of Science’s “Science Opportunities by NASA’s Constellation Program***
- ◆ **Large Optics Are Needed By Many National Security Applications**
- ◆ **An 8+ M Surveillance System at GEO Could Provide 24/7 Coverage of Military or Politically Significant Areas**
- ◆ **Optic Size and Mass Are Limited By Current Launch Vehicles**



**Orion  
Unpressurized  
Cargo**



**Ares V will have the  
largest payload and  
volume capability of  
any existing launch  
system**

# Status on Key Constellation Issues

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## ◆ Integrated Performance Across the Mission Phases

- Element level control masses are established to ensure integrated performance
- ISS mission total margin: Ares I: 22% / Orion: 23% / Cx: 5%
- Lunar mission total margin: Ares I: 18% / Orion: 10% / Cx: 4%
- Orion Crew Module mass limit set by recovery system and water landing constraints, not by Ares lift mass

## ◆ Tower Clearance/Launch Drift

- All launch vehicles experience drift due to winds at the pad
- Ares being designed for a 34 knot wind requirement
- No contact with pad assured by either: 1) constraining Southerly winds to 15-20 knots and/or 2) steering at liftoff (Saturn V). Focus now is on best combination to minimize plume damage

## ◆ Induced Environments : Thrust Oscillation and Vibroacoustics

- All launch vehicles experience vibration
- Thrust oscillation occurs because stack and motor resonance frequencies align late in 1<sup>st</sup> stage flight
- Pursuing baseline solution plus alternatives that will reduce loads to crew performance requirements with high (3 sigma) confidence
- All subsystems being designed to accommodate / mitigate liftoff and flight vibroacoustics

# Status on Key Constellation Issues (cont'd)

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## ◆ Ares/Orion Loss of Mission/Loss of Crew

- Ares and Orion are being designed from the outset to maximize crew safety
- Goal is to be 10x safer than Shuttle (LOC of 1:160-270)
- Current ascent estimate is 1 in 2,850 for a loss of crew event
- To date, over 60 vehicle design changes on Orion have been made to improve LOC/LOM during 5 design/analysis cycles.

## ◆ Post Landing Crew Survival

- Orion design supports several contingencies: including land landing and a minimum of 24 hours of crew water survival time

## ◆ Budget requirement through 2015

- Current requirement for IOC capability is \$35B at 65% confidence
- Original plan was to spend an additional \$9B on lunar system developments (Ares V, Altair, etc)

## ◆ Schedule for ISS initial operating capability

- External commitment stable at March, 2015
- Methods to improve schedule confidence were recommended in early FY09 study
- Program-wide content review in progress
- 6 vs 4 crew on Orion was driven by these activities

VIDEO



# ONSTELLATION

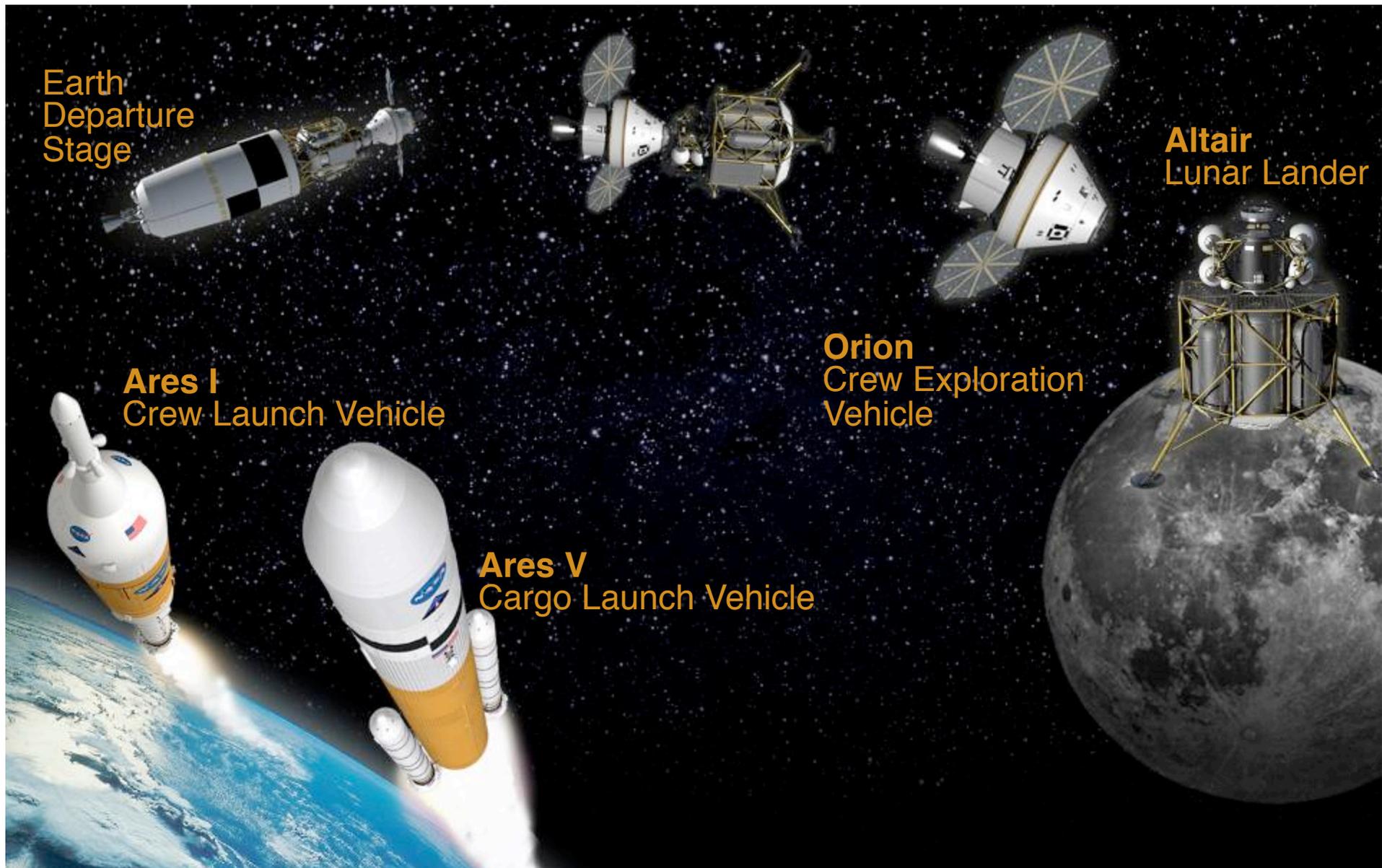
[www.nasa.gov](http://www.nasa.gov)

# Summary

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- ◆ **NASA's near term plan is to maintain March 2015 goal for the first crewed Orion/ Ares flight to the International Space Station**
  - Maximizing existing resources to reduce risk; funding increases in FY09 and FY10 improve ability to meet schedule
- ◆ **Technical progress to date is substantial; Constellation preparing for system level Preliminary Design Review (PDR)**
  - Ares I PDR complete; preparing for Orion PDR as testing continues on critical components and subsystems
  - Abort motor static test for the launch abort system (LAS) ,(11/08)
  - LAS attitude control motor high thrust test firings #6 and #8 (1/09 and 3/09)
  - Orion post landing and recovery testing (1/09-4/09)
  - Ares drogue parachute drop test #2 (2/09)
  - Completed KSC operations and checkout facility renovation and modification for Orion spacecraft assembly, modification, integration and test (1/09)
  - Completed launch pad lightning protection towers (2/09)
  - Mobile launcher platform-1 handover for Ares I-X test flight modifications (3/09)
- ◆ **NASA has a point of departure exploration architecture which enables many missions / destinations**
- ◆ **We continue to conduct trades to improve life cycle cost, safety, reliability and technical performance**



**Earth  
Departure  
Stage**

**Altair  
Lunar Lander**

**Ares I  
Crew Launch Vehicle**

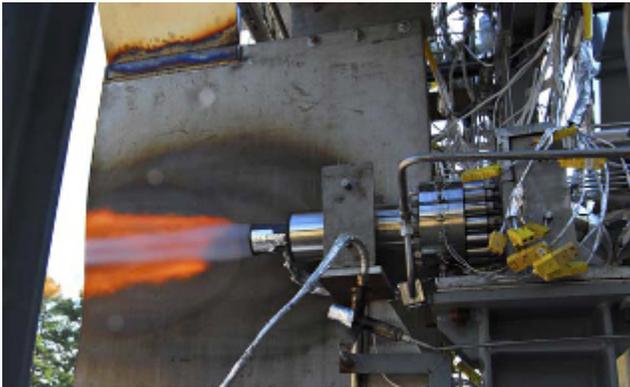
**Orion  
Crew Exploration  
Vehicle**

**Ares V  
Cargo Launch Vehicle**

***For the Latest On the Constellation System and  
Accomplishments:  
[www.nasa.gov/Constellation](http://www.nasa.gov/Constellation)***

# Technical Progress

## Hardware Fabrication and Testing – Ares I



**J2X Workhorse Gas Generator Test**



**Deceleration Subsystem (DSS)  
Drogue Parachute Drop Test  
(DDT-1)**



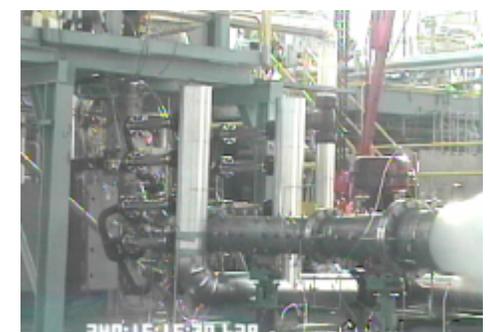
**Friction Stir weld being performed on the new Vertical Weld Tool at MSFC, AL**



**Common Bulkhead Dome Delivery**



**Shell Buckling Test  
2/5/09, MSFC**



**A3 Test Stand Subscale Diffuser Test**

# Technical Progress

## Hardware Fabrication and Testing – Ares I



**Engineers prepare for Ares I parachute Tests**



**Ares I main cluster parachute test**



**Development Motor X-ray setup**



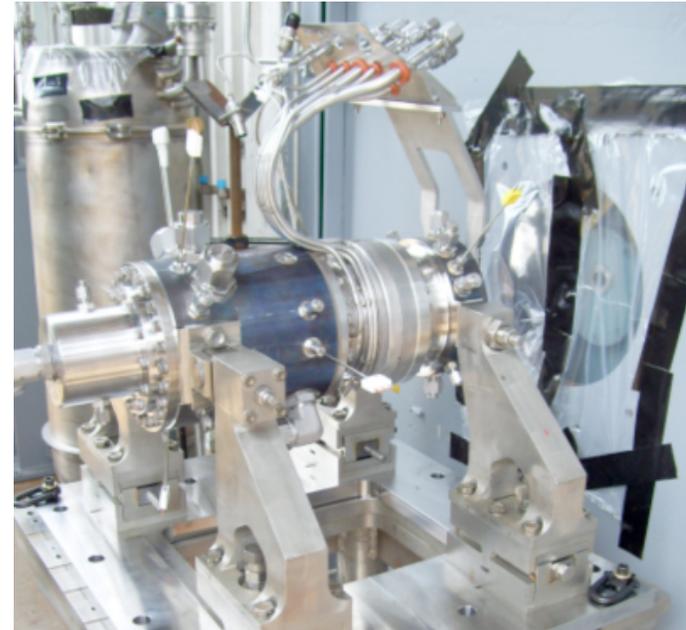
**Development Motor Igniter Test**

# Technical Progress

## Hardware Fabrication and Testing – Ares I



**Workhorse Gas Generator Turbine Simulator Test**



**Seal Tester at MSFC's Test Stand 500**

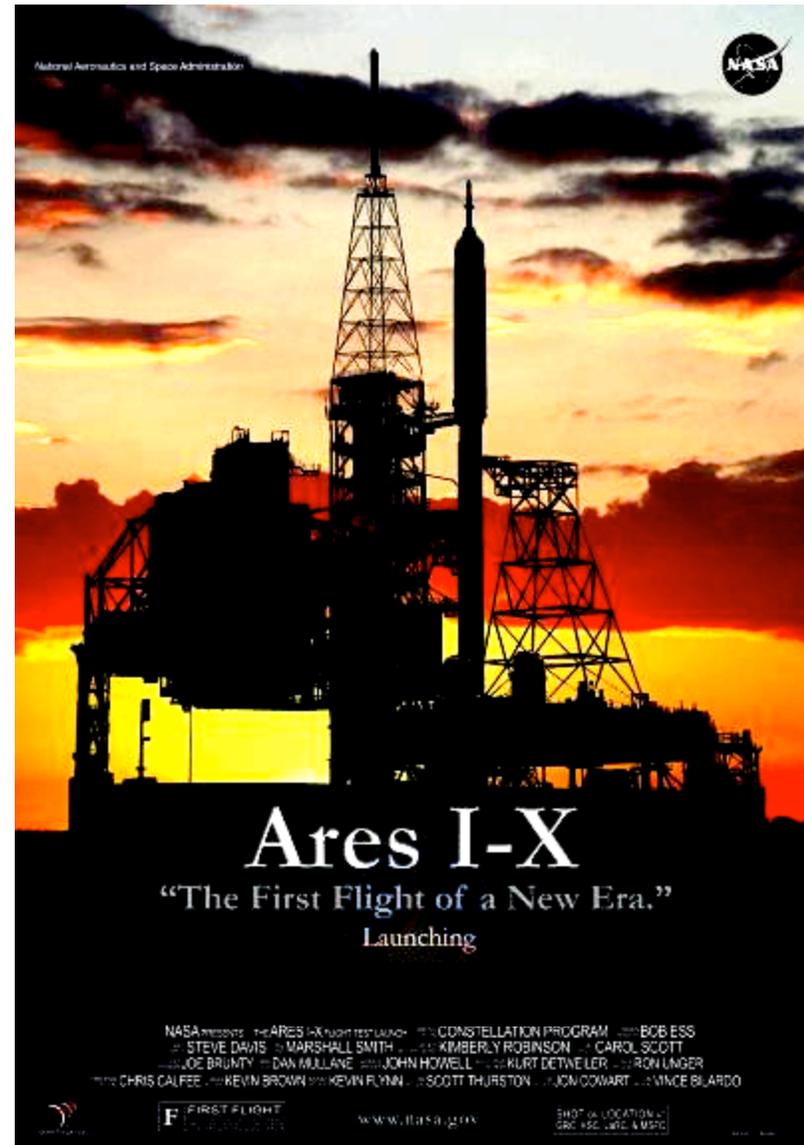


**Upper Stage  
robotic weld  
tool**

# Progress Towards Launch



- ◆ **Ares I-X is an uncrewed, sub-orbital development flight test**
- ◆ **Ares I-X is the first flight of the Constellation Program**
- ◆ **Ares I-X provides the opportunity to test ground facilities and operations at Kennedy Space Center**
- ◆ **Ares I-X provides the opportunity to test flight operations**
  - 1st stage recovery
  - Guidance and Navigation
  - Aero acoustics
- ◆ **Ares I-X is on track for a 2009 launch date**



# Technical Progress Ares I-X



# Technical Progress

## Hardware Fabrication and Testing – Orion



The boilerplate Orion crew module used for the Orion Launch Abort System Pad Abort-1 flight



I-X Crew Module and Launch Abort System Arrive at KSC



Nose Cone



Adapter Cone

PA-1 Launch Abort Systems Composite Structural Elements



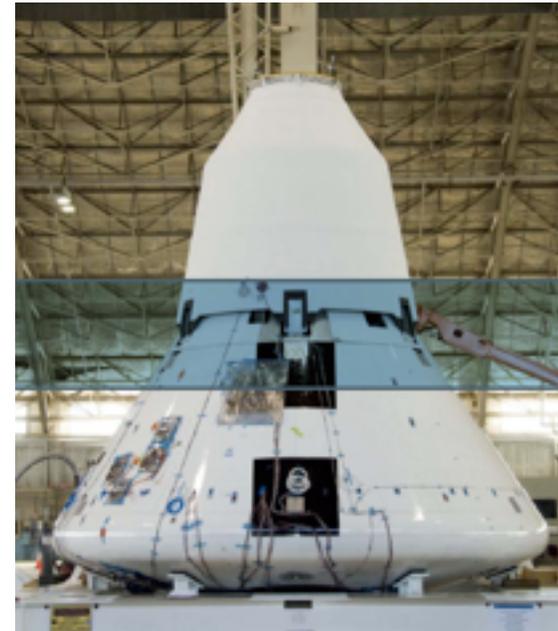
Launch Abort System (LAS) PA-1 Modal Test 12/11/08

# Technical Progress

## Hardware Fabrication and Testing – Orion



Orion's jettison motor is prepared for shipment to White Sands Test Facility



Pad Abort-1 Flight Crew Module



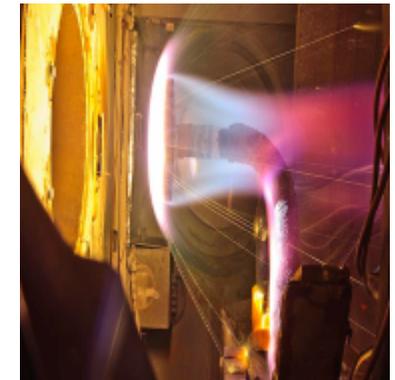
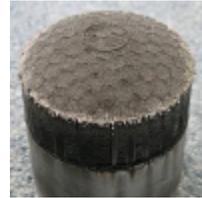
O&C Building Ribbon Cutting



Orion test module that will be flown in the Launch Abort System flight tests

# Technical Progress

## Hardware Fabrication and Testing – Orion



**Downselect of Avcoat & Thermal Protection System Transition**

**Arc Jet Testing**

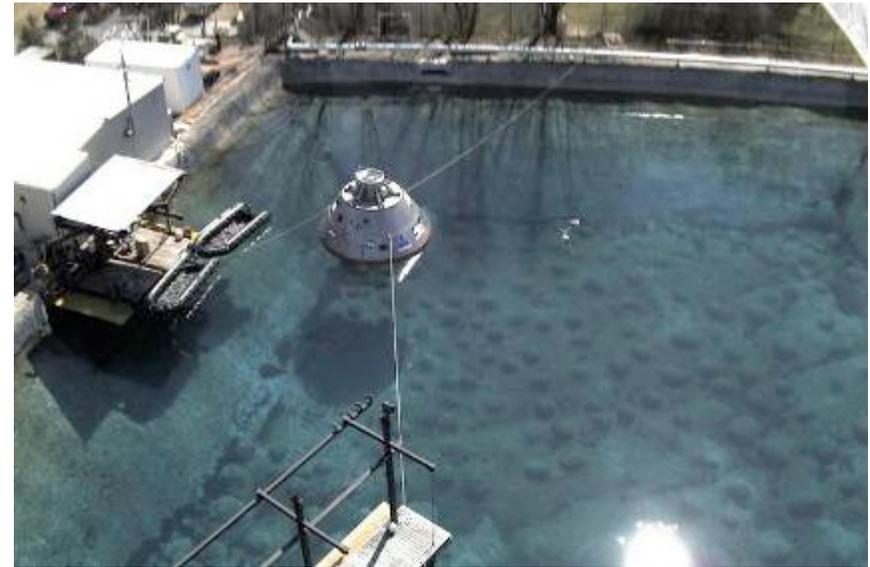


**Ascent Abort Gantry Construction**



**Operations and Checkout Facility**

# Technical Progress: Orion PORT Test



# Technical Progress Construction of Facilities



**J2X A3 Altitude Test  
Stand Construction**



**Ares I-X USAA at Pad 39B FSS**



**Launch Complex 39B Lightning Protection  
System Construction**



**High Bay looking west**



**Basement**

**Orion Manufacturing Facilities at  
KSC**



**Hangar AF Mods & Upgrades  
(Phase I) ~ 90% complete**



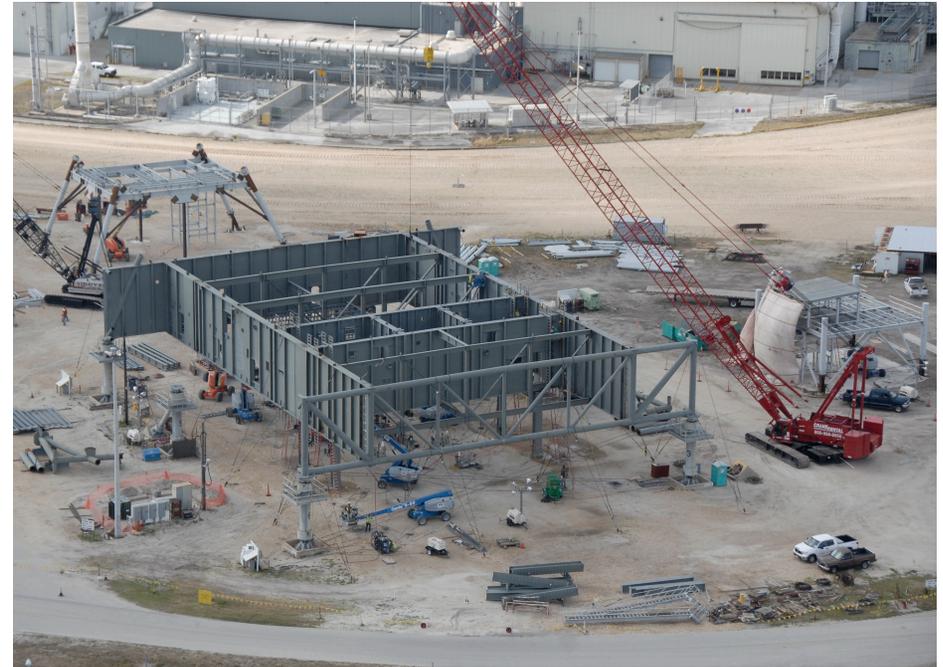
**FSAM installed onto RSS**

# Technical Progress – Ground Operations

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**Launch Control Center Firing Room 1**



**Mobile Launch Platform construction**

# Technical Progress

## Hardware Fabrication and Testing – EVA Systems



**Suit Don/Doff Volume Assessment**



**Handrail Translation Demonstration**



**Altair Hatches Ingress/Egress Test**



**Orion Hatch Ingress/Egress**

