National Aeronautics and Space Administration

SLS / MPCV Status Briefing

Dan Dumbacher

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Outline

- Background
- Overview and Strategy
- Overall Strategy to Achieve Integrated SLS/MPCV Plan
- MPCV Decision
- SLS Alternatives
- SLS/MPCV Integrated Analysis Process
- Next Steps

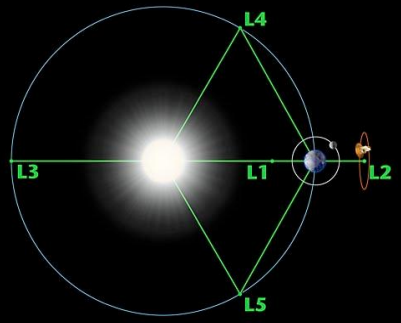
Background

A New Path: The NASA Authorization Act of 2010

- **The Congress approved and the President signed the National Aeronautics and Space Administration Authorization Act of 2010**
  - Bipartisan support for human exploration beyond low Earth orbit (LEO)

- **The law authorizes:**
  - Extension of the International Space Station (ISS) until at least 2020
  - Strong support for a commercial space transportation industry
  - Development of a multi-purpose crew vehicle and heavy lift launch capabilities
  - A "flexible path" approach to space exploration opening up vast opportunities including near-Earth asteroids and Mars
  - New space technology investments to increase the capabilities beyond LEO

A Bounty of Opportunity for Human Explorers



HEO/GEO/Lagrange Points:
– Microgravity destinations beyond LEO
– Opportunities for construction, fueling and repair of complex in-space systems
– Excellent locations for advanced space telescopes and Earth observers

Mars and its Moons:
– A premier destination for discovery: Is there life beyond Earth? How did Mars evolve?
– True possibility for extended, even permanent, stays
– Significant opportunities for international collaboration
– Technological driver for space systems

Earth's Moon:
– Witness to the birth of the Earth and inner planets
– Has critical resources to sustain humans
– Significant opportunities for commercial and international collaboration

Near Earth Asteroids:
– Compelling science questions: How did the Solar System form? Where did Earth's water and organics come from?
– Planetary defense: Understanding and mitigating the threat of impact
– Potential for valuable space resources
– Excellent stepping stone for Mars

INCREMENTAL EXPANSION OF HUMAN EXPLORATION CAPABILITIES

Capabilities required at each destination are determined by the mission and packaged into elements. Capability-Driven Framework approach seeks to package these capabilities into a logical progression of common elements to minimize DDT&E and embrace incremental development.

Distance

Long Duration Habitation Needed

Surface Capabilities Needed

Advanced Propulsion Needed

High Thrust in-Space Propulsion Nee

Mission Duration

Mars Missions 35A 35B
Mars Elements
6: Enable Mars Missions

Full Capability NEA Missions 34B
Space Exploration Vehicle (SEV)
Solar Electric Propulsion (SEP)
5: Enable Deep Space Missions

Minimal NEA Missions 34A
Deep Space Habitat (DSH)
4: Enable Long Duration Missions

Lunar Surface Missions
Crew EVA Suit Block 2
Lunar Lander & GPOD
3: Enable Lunar Surface Missions

Lunar Flyby &Orbital Missions 33A 33B
GEO/HEO Missions 32A 32B
Cryogenic Propulsion Stage (CPS)
2: Enable Missions Beyond LEO

Robotics & EVA Module (REM)
Crew EVA Suit Block 1
New LEO Missions 31A
Multi-Purpose Crew Vehicle (MPCV)
Space Launch System - HLLV
1: Enable New LEO Missions

Key
Capability Gates
Candidate Destination
Ultimate Destination Goal
Element Capability
DRM

Overview

- **NASA is developing plans for exploration systems that are affordable, sustainable, and realistic**
- **Earlier this year NASA selected a Reference Vehicle Design for both the Space Launch System (SLS) and Multi-purpose crew vehicle (MPCV)**
  - Consistent with direction in the NASA Authorization Act of 2010
  - Provides a baseline from which to start developing schedule, costs and requirements, as well as acquisition plans
- **NASA has been examining alternative designs and potential acquisition approaches to validate and/or challenge those concepts**
  - Due diligence to ensure final vehicle choices will be the best value for the taxpayer with respect to cost, risk, schedule, performance, and impacts to critical NASA and industrial skills and capabilities
- **Important to prepare an integrated plan (through an SLS/MPCV Integrated Analysis Process) before plans for these critical exploration capabilities can be finalized**
- **NASA also is working to develop and understand cost estimates and potential affordability measures**

Overall Strategy to Achieve Integrated SLS/MPCV Plan

Overall Strategy to Achieve Integrated SLS/MPCV Plan

- **Successful development of new Human Exploration Systems requires careful planning, analysis and integration**
  - SLS, MPCV and supporting elements are coupled, so planning requires cycles of consideration of individual elements, followed by integrated planning in order to achieve solutions that are technically viable and affordable
- **Element planning activities:**
  - Complete SLS architecture trades, including inputs from industry through NASA study contracts
  - Validate MPCV requirements
  - Develop initial plans for Ground Operations and other supporting activities
  - Develop element acquisition strategy and assess procurement options
- **Integrated planning activities:**
  - Combine single element inputs into a set of integrated options that align SLS and MPCV to deliver an integrated capability
  - Conduct an independent cost assessment to improve confidence in budget requirements
  - Validate integrated acquisition strategy and procurement options
- **Results will comprise key components of updated Congressional Report on NASA's Space Launch System and Multi-Purpose Crew Vehicle**

Guidance Used to Develop MPCV and SLS Strategies

- **Current strategy for SLS/MPCV Based on architecture analysis and Authorization Act direction**
- **Key Auth Act direction**
  - For SLS
    - The Administrator shall, to the extent practicable, extend or modify existing vehicle development and associated contracts
    - The initial capability of the core elements, without an upper stage, of lifting payloads weighing between 70 tons and 100 tons into low-Earth orbit (LEO)
    - The capability to lift the multipurpose crew vehicle
    - The capability to serve as a backup system for supplying and supporting ISS cargo requirements or crew delivery requirements not otherwise met by available commercial or partner-supplied vehicles
  - For MPCV
    - The vehicle shall continue to advance development of the human safety features, designs, and systems in the Orion project
    - The capability to provide an alternative means of delivery of crew and cargo to the ISS, in the event other vehicles, whether commercial vehicles or partner-supplied vehicles, are unable to perform that function.

Integrated Independent Cost Assessment (ICA)

- **Why have an ICA now?**
  - Integrated, early ICA will be an important "sanity check" of NASA-generated integrated cost and schedule estimate
    - Since key goal is affordability, ICA is part of NASA's due diligence
    - The ICA will *inform* the Program Budgets
  - Integrated, early ICA will reflect the maturity of the program concepts
    - SLS and MPCV are at very different points of maturity along the program life cycle
    - Acknowledge that Program content in early planning (especially for SLS) may not fully capture and reflect all potential content in cost estimate (e.g., ground systems, software, etc.)
    - Confidence level of the ICA will reflect this lack of definition – the integrated picture of SLS and MPCV is not at the point where a Joint Confidence Level (JCL) assessment or even a risk-based cost assessment can be accomplished

- **Further independent technical, schedule and cost analyses will be performed as part of NASA's standard processes for reviewing and approving Programs as they move through key decision points**

MPCV Decision

MPCV Functional Requirements

Authorization Act and NASA requirements drive the following basic MPCV functionalities:

- **Serve as the primary crew vehicle for missions beyond low-Earth orbit**
- **Safely perform regular in-space operations**
  - Rendezvous, docking, and extravehicular activities in conjunction with payloads delivered by the SLS or other vehicles, in preparation for missions beyond low-Earth orbit or servicing of in-space scientific assets, or other assets in cis-lunar space
- **Provide an alternative means of delivery of crew and cargo to the ISS as a backup (if needed) to Commercial Crew**
- **Pursue evolvable approach that is inclusive of potential new technologies, competition of sub-elements, and commercial operations.**

MPCV Development - Key Decision

- **NASA will develop MPCV using the current Orion plan and contract**
  - Revisited architecture pertaining to MPCV requirements
  - Considered whether New Acquisition for MPCV would enable more optimized integrated SLS/MPCV plan
  - Considered potential for use of advanced technologies and changing approach to MPCV development in context of advances already integrated into Orion plan
  - In context of requirements in NASA Authorization Act of 2010, NASA determined that it was practicable and appropriate to develop MPCV using the current Orion plan and contract

Challenges with using the same vehicle for LEO (ISS) mission and for exploration

- **Analysis to look at a LEO capsule**
  - Exploration (beyond low Earth orbit) requirements are very different than those needed for a LEO trip (to and from ISS); not an easy comparison
- **Some differences:**
  - Requirement for 21 day mission means the crew needs more habitable living and cargo space.
  - A deep space mission requires approximately 5 times the propellant
  - The thermal protection system (heat shielding) needs to be much more robust as the capsule reenters at about twice the speed as compared to a LEO reentry
  - Farther distances from earth require us to have increased reliability of systems (not easy to abort)
  - More radiation shielding is required to protect our astronauts

SLS Alternatives

SLS Analysis Approach

Approach:

- Leverage three government Requirement Analysis Cycle (RAC) Teams to create and study different design concepts that leverage capability across American industry
- In parallel, solicit industry input and concepts via study contract input

Implementation:

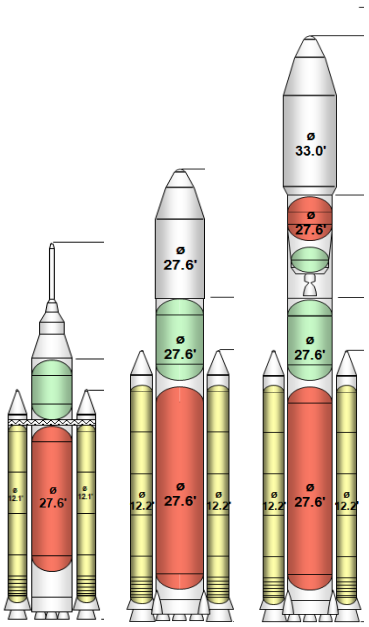
- HEFT and FOM studies (Fall 2010) concluded without architecture decisions
- Government Requirements Analysis Cycle (RAC) – Kick-off Nov 4
  - Three competing configurations with fourth team looking at cross-cutting affordability
  - Approaches to affordability addressed by all 3 teams
  - Common requirements (from HEFT), goals/threshold approach - tradable
  - Incorporate incremental inputs from NASA Heavy Lift study contracts
  - Out brief to SLS Feb 16-18
- Contractor Heavy Lift Study Contracts–awarded November 2010
  - 13 Contractors, $650K each, 6 month studies – broad SOW ideas
  - Initial Out briefs Feb 22-24
  - Final Out briefs Apr 25-28

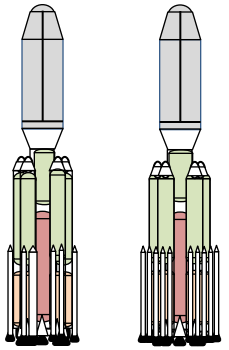
SLS Alternatives and Inputs from Industry

- **NASA is evaluating inputs from all 13 Heavy Lift Study Contractors**
  - In general, contractors' analyses favored their individual business models, however there are numerous innovative ideas
  - RAC Teams already incorporated several inputs into NASA studies: Requirements Stability to Minimize Cost, Commonality, Incentive-Based Acquisition, Risk-Based Insight/Oversight
  - Assessing: Lean Ground Operations, International Partnerships, In-space Refueling, Long-Term Program Stability Approaches

- **Only 3 contractors provided detailed cost and configuration data; these are being compared to NASA SLS RAC Study results**
  - Technical findings consistent with NASA RAC Teams
  - Provided data consistent with individual business models
  - Costs consistent for comparable content; in some cases complete system costs not provided (e.g. Ground Operations, engines, stages)
  - Comparing RAC to Study Contract Inputs
    - Inputs have been evaluated for applicability to SLS
    - This is the first step in an on-going and iterative process to evaluate cost basis of estimate and credibility
      - Will include RAC and applicable study contract submittals
      - Data will be used to support HEC independent cost assessment

SLS Concepts





	LOX/H_2 – Reference Vehicle Design	LOX/RP	Modular
Description	Hydrogen core configuration with solid strap-on boosters; multiple evolution paths	Large RP configuration (large diameter tanks) with multiple engine options, incl. NASA/USAF common engine	Modular RP configuration (smaller diameter tanks) with multiple engine options, incl. NASA/USAF common engine
Lift Capability	70 mT – 150 mT	100 mT – 172 mT	70 mT – 130 mT

Note: Images based on government design solutions from RAC teams

Integrated Analysis Process and Options

Integrated Analysis Process

- **Goal**
  - Explored the range of affordable, sustainable and credible alternatives for developing beyond LEO exploration capability by integrating various SLS and MPCV options
  - Ensured common understanding of drivers and features of each option through evaluating each alternative using common set of attributes
  - Worked to optimize cost, performance and schedule to meet goals of Authorization Act
- **Alternatives consisted of combinations of options studied by SLS and MPCV teams which explored the trade space in terms of technical and acquisition approach**
- **For each of the alternatives, analyzed a set of discriminating attributes in areas of: Cost, Risk, Schedule, Performance, and Impact to NASA, industrial, national, and international capabilities**
- **Affordability Treated as a Gate, Not an Attribute**
  - Annual budget for integrated solution should not exceed available funding
  - Remainder of affordability factors tracked under cost attribute
- **ESMD/SOMD used analysis of attributes for each integrated alternative to provide facts / data to NASA leadership for consideration**

Current SLS Status

- **Current Technical Path for SLS**
  - Exploration-class, heavy-lift launch vehicle initially capable of lifting 70-100 metric tonnes (mT) to LEO, while ultimately being evolvable to a lifting capacity of 130mT
  - Common use of liquid oxygen/liquid hydrogen propulsion for both the SLS core stage as well as the upper stage
  - Continue to evaluate the multitude of existing liquid oxygen/liquid hydrogen engines in the United States fleet that include the RS-25, RS-68, and J-2X
  - Still assessing best approach for strap-on boosters
  - Looking at feasibility of first uncrewed test flight of 70-100 mT configuration in late 2017 (based on funding levels from FY2012 budget request) followed by crewed flight in early 2020s
- **Evaluating procurement strategies; including competition options and scope and applicability of current contracts**
- **Assessing all trades against cost estimates, affordability measures, schedule estimates, and adherence to the NASA Authorization Act of 2010.**

Summary and Next Steps

- Integrated Analysis Process continues to develop schedule and initial cost estimates
- Results will guide NASA's approach to providing beyond LEO transportation capability for the Nation
- Results will form input to updated SLS/MPCV Report to Congress
- Interim results are being provided to NASA leadership, OMB / OSTP, and Congress over the coming weeks
- Schedule is challenging due to complexity of analysis and iterative nature of developing acquisition strategies, schedule, and cost estimates
- NASA is committed to performing due diligence in our planning to ensure SLS and MPCV plans are affordable, sustainable, and credible