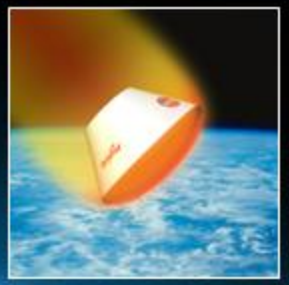
Concept Exploration and Refinement (CE&R)
Initial CA-1 Architecture Overview



September 13, 2004
Advanced Programs Group
Orbital Sciences Corporation

Orbital

Preface

"There is nothing more difficult to take in hand, nor perilous to conduct, nor more uncertain in its success, than to take the lead in the introduction of a new order of things ... because the innovator has for enemies all those who have done well under the old conditions, and lukewarm defenders in those who may do well under the new."

- Niccolo Machiavelli, 1513

Initial Lunar Exploration Objectives

- Developed Preliminary Science-Based Objectives for Lunar Exploration
- Grouped in Four Categories with Sub-Objectives
- Welcome NASA/Industry Input on Content and Format

1) Study Lunar Geology to Understand the Origins of the Earth and the Solar System

- Examine and Return Lunar Ice at Poles
- Study Impact History of Comets In Near-Earth Space
- Study History of Solar Activity (e.g., Solar Wind Surface Effects)
- Study Lunar Geological and Geochemical Evolution to Better Understand the Earth's Evolution

2) Test Critical Exploration Approaches, Technologies and Systems Required for Future Mars Exploration

- Gradually Increase Human Lunar Stay Times to Meet Mars Requirements
- Test Long-Term Closed-Loop Life-Support, Power, Radiation Shielding and Other Systems
- Test Surface Habitation, Mobility, Drilling and Support Systems in Environments Similar to Mars Requirements
- Test at Sites with Similar Surface Features to Mars Requirements

3) Examine and Test Suitability of the Moon for Solar System and Earth Observation

- Quantify Environmental Benefits (e.g., Lack of Atmosphere, Radio Interference, Seismic Activity)
- Select Site and Assemble Telescope and Instruments on Far Side of Moon
- Select Site and Assemble Earth Observation Station

4) Experiment with the Use of In-Situ Lunar Resources for Human Exploration and Commercialization

- Decomposition of Water Ice for Propellants
- Mining of Helium-3 for Nuclear Power
- Extraction of Minerals/Ores from Lunar Regolith
- Manufacturing Using In-Situ Resources and/or Environments

CE&R-002

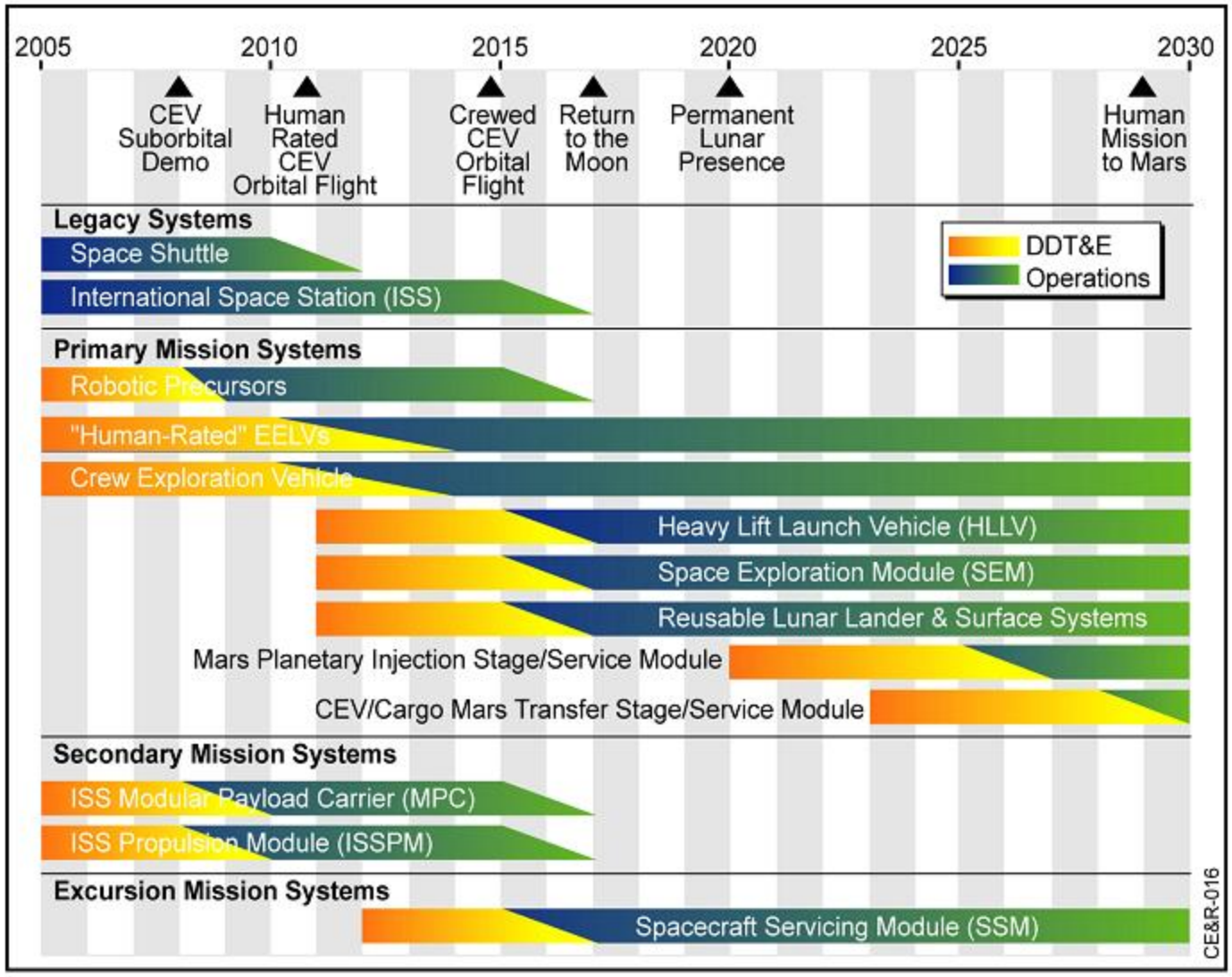
Initial Design Reference Missions

- Grouped by Primary, Secondary, and Excursion Missions

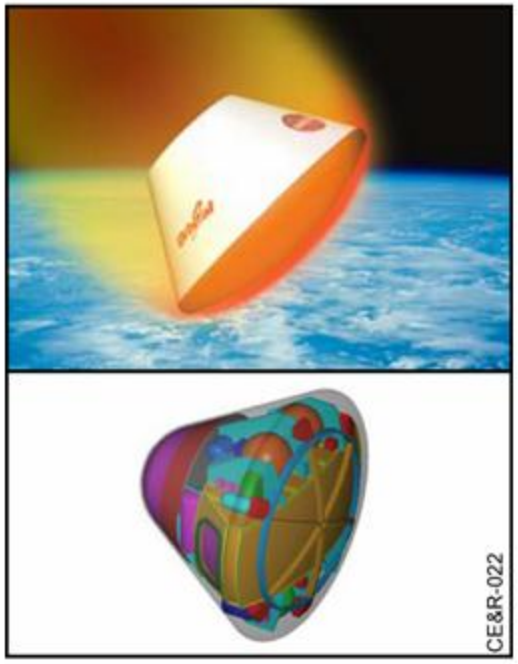
Primary Missions
• DRM 1 - Science Payload Delivery, LEO/Lunar (Due East)
• DRM 2 - Science Payload Delivery, LEO (Polar)
• DRM 3 - Lunar Infrastructure and Cargo Delivery
• DRM 4 - Lunar Crew Transfer
• DRM 5 - Mars Infrastructure and Cargo Delivery
• DRM 6 - Mars Crew Transfer
Secondary Missions
• DRM 7 - ISS Crew Rescue
• DRM 8 - ISS Crew Transfer
• DRM 9 - ISS Logistics Delivery
Excursion Missions
• DRM 10 - LEO Spacecraft and Platform Assembly and Checkout
• DRM 11 - Service, Repair and Reboost LEO Spacecraft and Platforms
• DRM 12 - HEO Spacecraft & Platform Assembly and Checkout
• DRM 13 - Ground Based Crew Rescue

CE&R-006a

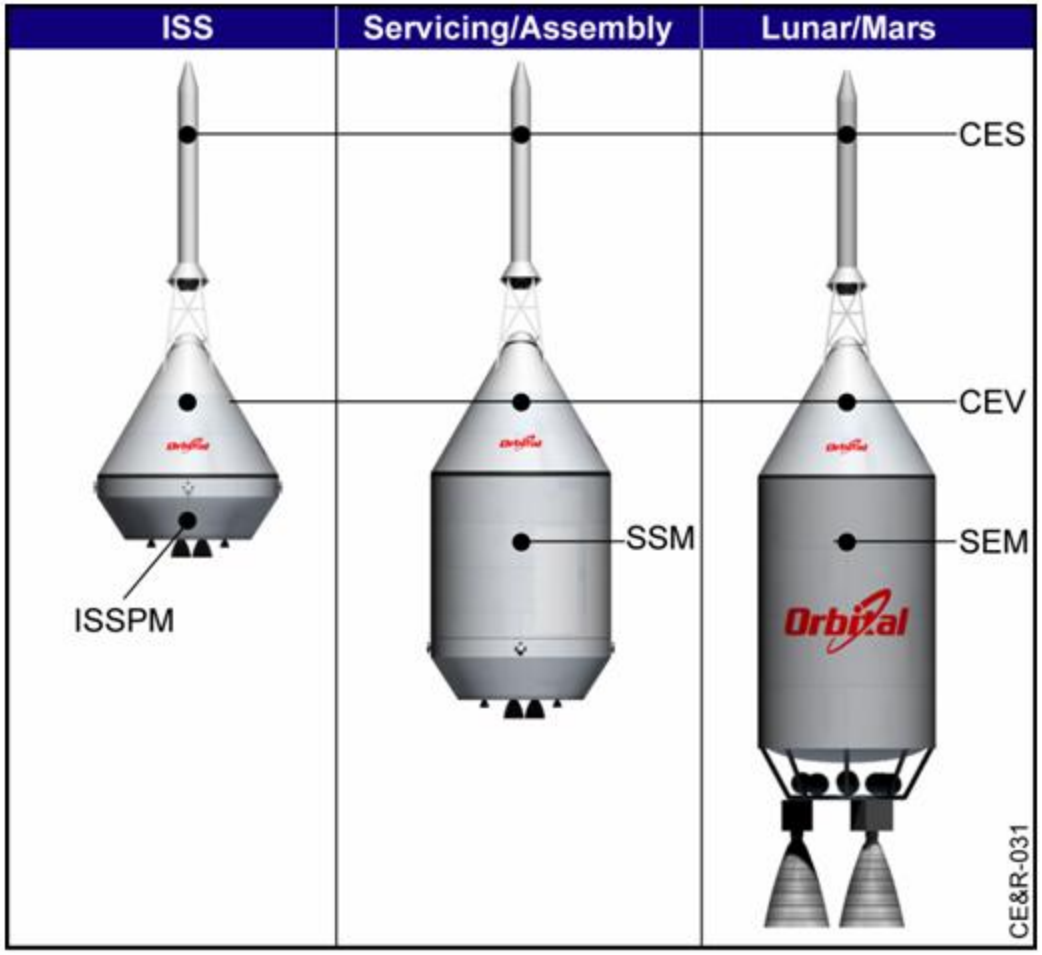
System-of-Systems Development Timelines



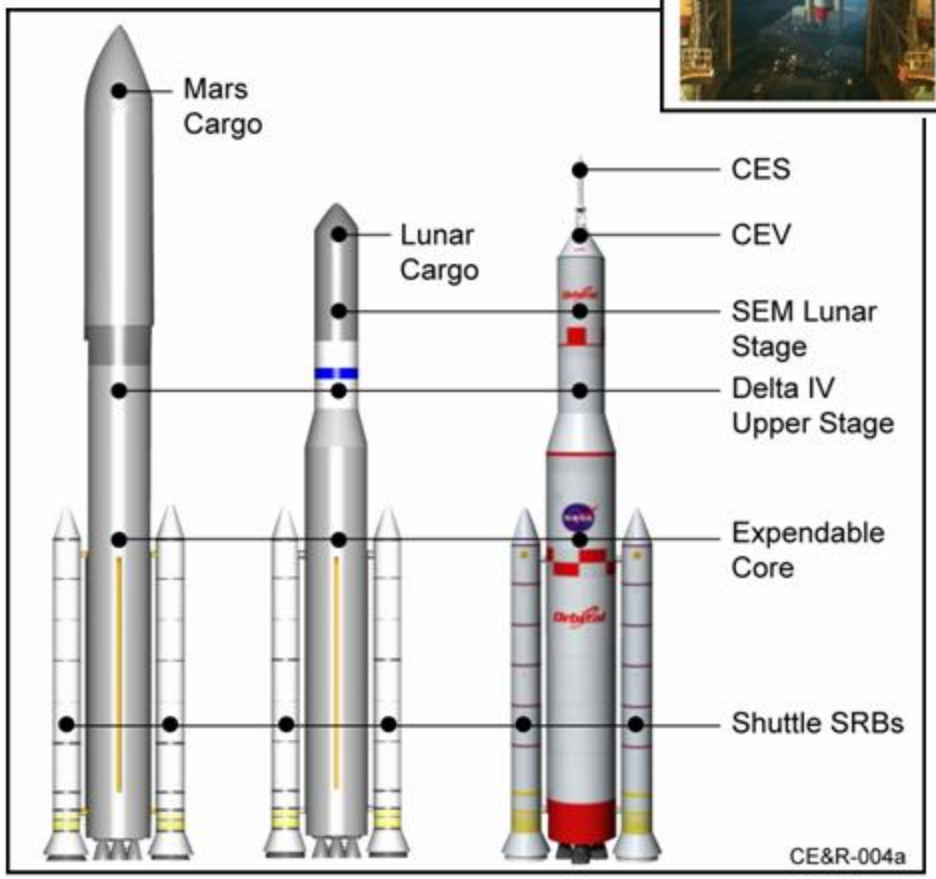
Modular, Multifunctional CEV



- Modular, Multifunctional
- Crew Escape System
- Four Crew
- OSP Heritage



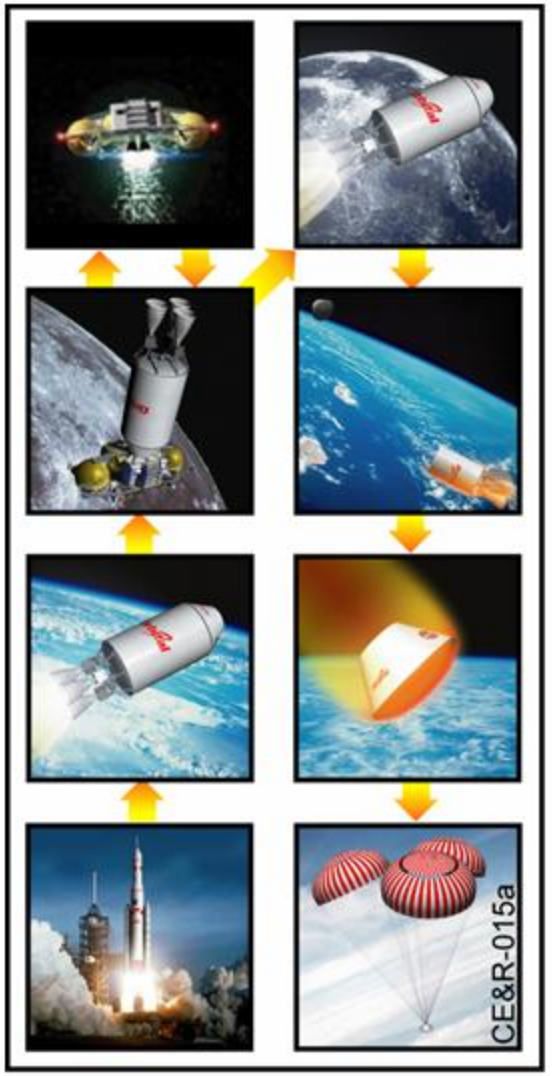
Heavy-Lift Launch Vehicle w/SRBs (80 MT)



- Human-Rated Shuttle SRBs
- Expendable SSMEs
- New ET-Diameter Core
- Modified Shuttle Infrastructure
- 80 Metric Ton Capacity
- Modular, Multifunctional
- Cargo/Crew Separation
- Cargo/Crew Launch Synergy
- Reduced On-Orbit Assembly

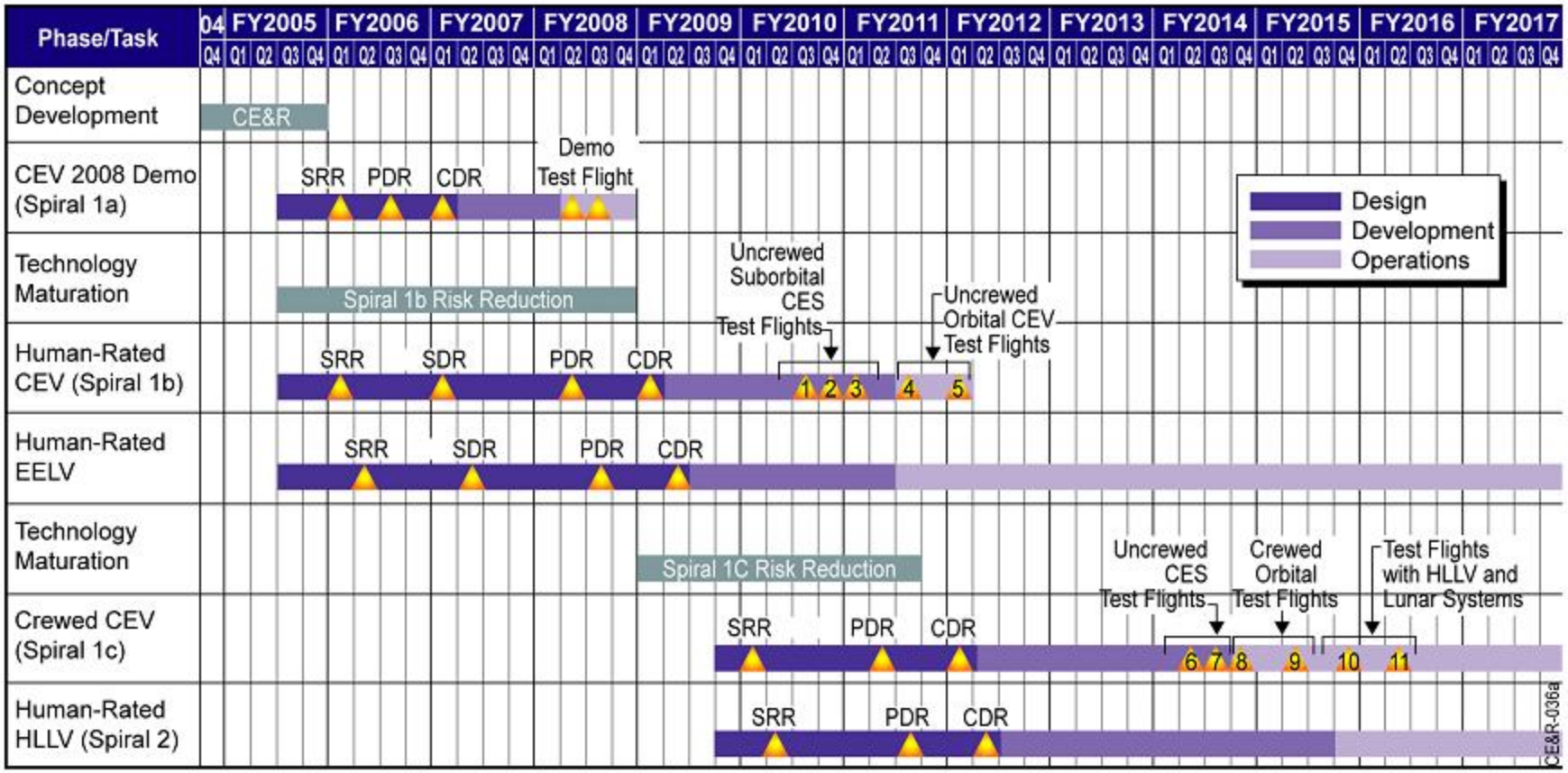
Lunar Crew and Cargo Delivery Missions

- Modular Reusable Lunar Lander
- Crew/Cargo Separation
- Crew/Cargo Lander Synergy
- Deliver 32 klb of Cargo or Four Crew
- Pre-Position Lander Propellants
- Allow Evolution from Extended-Duration to Long-Duration Missions
- Support Option for Permanent Human Lunar Presence After 2020
- Point-to-Point Lunar Transport Option



Initial CEV Spiral Development Plan

- Spiral 1 Included Three Sub-Spirals (2008, 2011, and 2014 Flights)



Initial CEV Flight Test Objectives

- Objectives Defined for 2008, 2011, and 2014 Flights -- Including Options

Sub-Scale Prototype CEV Suborbital Flights (2008)

- Validate CEV OML, c.g., and Aerodynamic Characteristics
- Demonstrate Uncontrolled, Stable CEV Entry
- Obtain Flight Data on Spiral 1b CEV Subsystem Designs/Technologies
  - TPS, GN&C, Avionics, LV Integration, Landing/Recovery
- Demonstrate CES and Separation System Approaches (Option)

Full-Scale Human-Rated CEV Orbital Flights (2011)

- Validate Aerodynamic and Aerothermal Database
- Demonstrate Nominal and Uncontrolled Entry
  - Propulsion, TPS, Structures, GN&C, Avionics, Software, Power, Mechanisms, EELV Integration, Landing/Recovery
- Demonstrate Full-Scale CES and Separation Systems
- Validate Ground and Flight Operations Approaches
- Demo Spiral 1c Technologies (e.g., TPS) (Option)
- Demonstrate ECLS Subsystem Design (Option)
- Fly Crewed Version with ISSPM for ISS Crew Rotation (Option)

Lunar-Capable Crewed CEV Orbital Flight (2014)

- Demonstrate Full-Scale ECLS Subsystem Functionality
- Demonstrate Full Functionality of All CEV Subsystems to/from LEO
- Validate Functional Human Interfaces with CEV System
- Demonstrate Full Range of Ground and Flight Operations Systems
- Demonstrate Integrated Performance with Human-Rated EELV
- Demonstrate EVA Systems Performance (Option)
- Demonstrate On-Orbit Rendezvous, Docking, Assembly (Option)

CE&R-032

Finding and Issues

- Modularity and Multi-Functionality Key to Affordability
- 80-MT HLLV is Required for Mars and Highly Desirable for Lunar Missions
- Lunar HLLV Could Reduce Launch Costs and Improve Mission Reliability and Human Safety By Greatly Reducing On-Orbit Assembly Requirements
- In-Line Shuttle-Derived HLLV Could Provide Lower DDT&E Cost and Risk
  - Use SRBs, SSME-Derivatives, and Modified Infrastructure
  - Could Improve Sustainability
- Maximizing Synergy Between Cargo/Crew Launchers Can Reduce Cost
  - High Value of Lunar Cargo Requires Human-Rated Launch Reliability
- Modular CEV Approach Could Allow Post-Shuttle ISS Crew Rotation
  - Must Decide Soon How Americans Will Get to ISS from 2010 to 2017
- Modular CEV Approach Could Allow Space Platform Assembly/Servicing
- Sustained Human Lunar Presence Could Greatly Benefit Mars Exploration for Little Additional Cost
- Benefits of Earth-Moon L1 Gateway Do Not Appear to Justify Costs