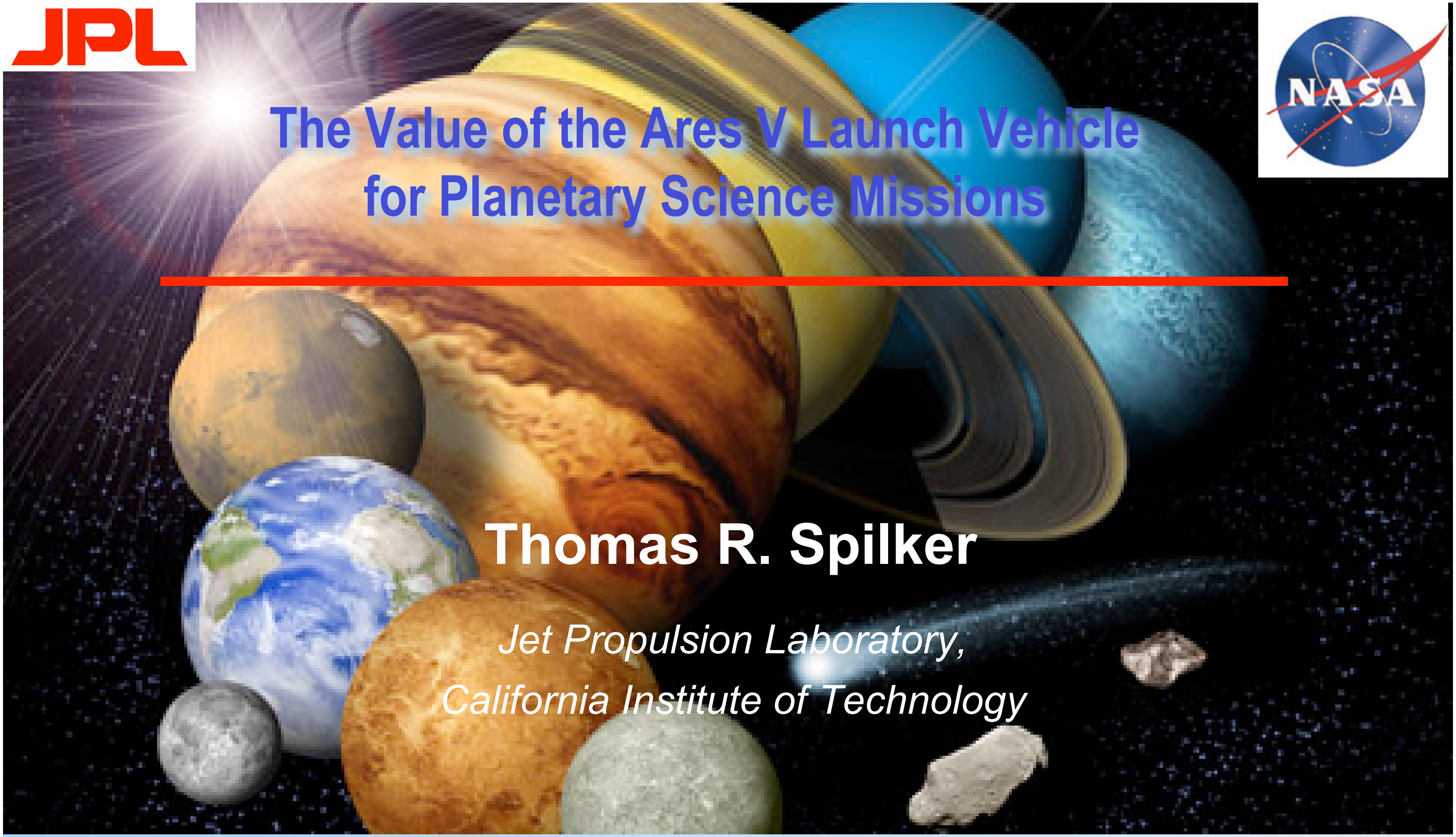

The Value of the Ares V Launch Vehicle for Planetary Science Missions

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Ares V Solar System Science Workshop

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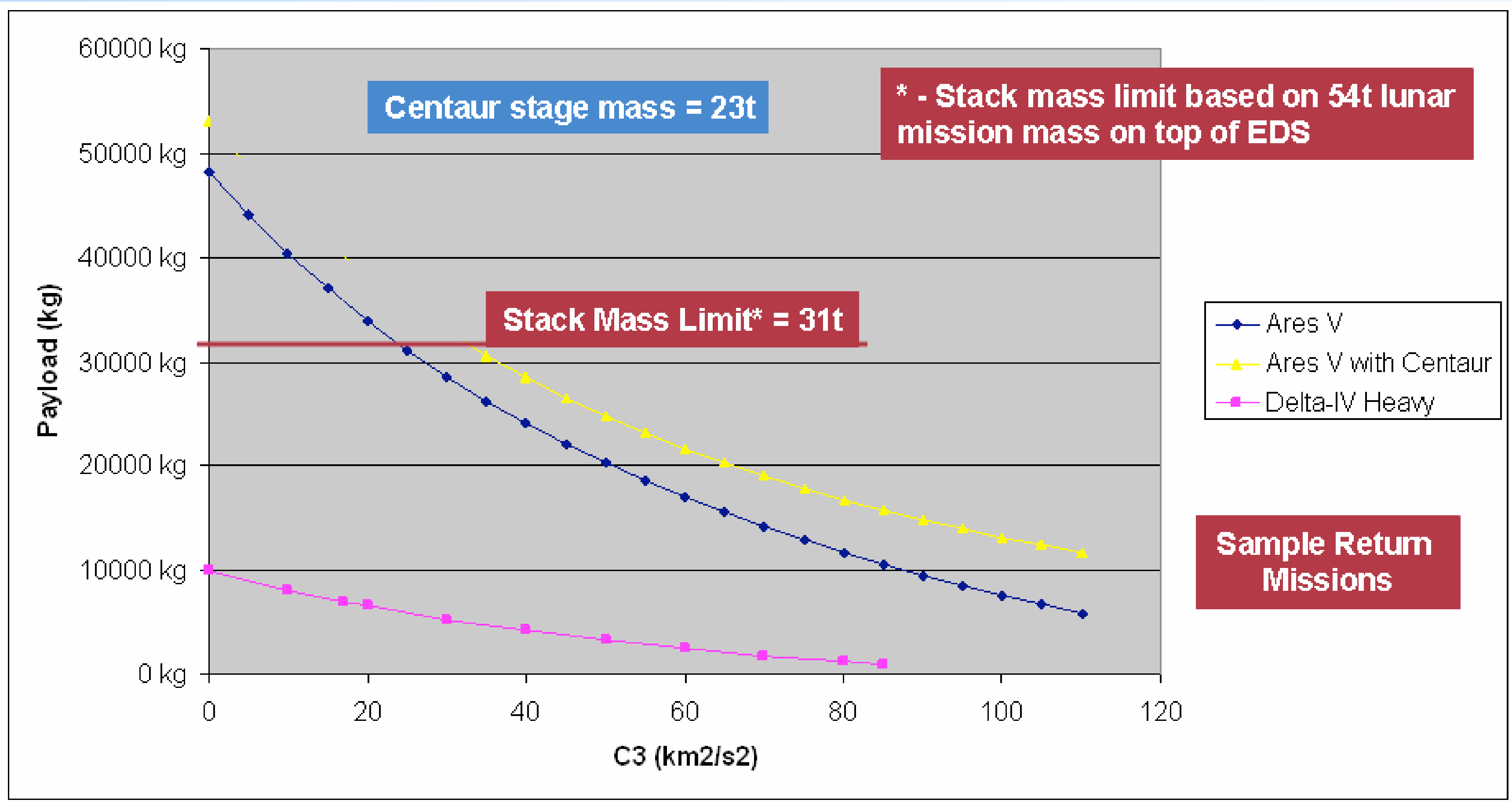
Topics Addressed

- What makes the Ares V different from other launch vehicles?
- How do those differences benefit planetary science missions?
  – What types of science investigations or operations might be enabled?
- What missions might be enabled?
- Limits of Ares V capability
- Implications for Ares V development
- Summary

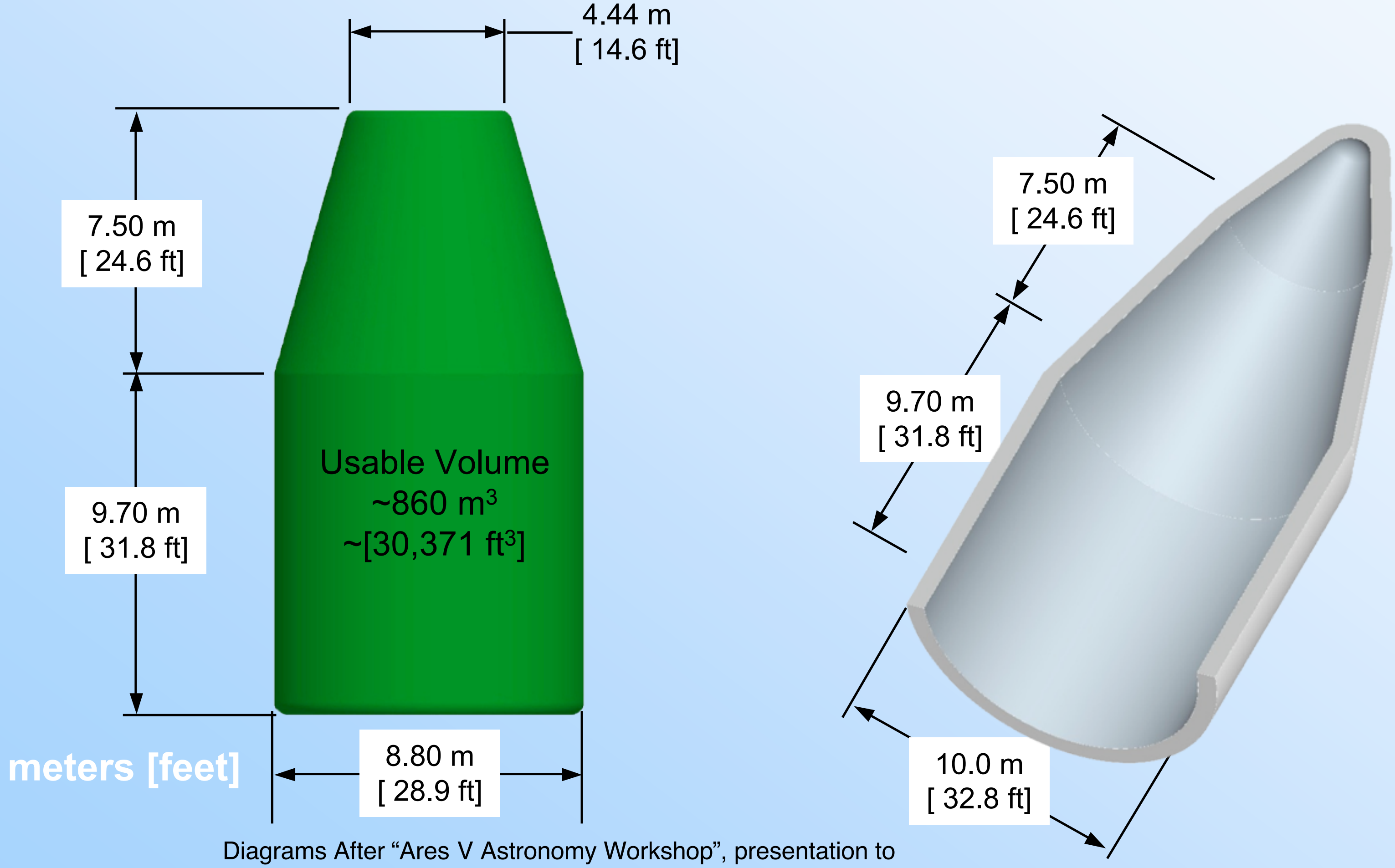
What makes the Ares V Different? -- 1

- Its launch performance is far above that of any other current vehicle
  - Performance is summarized by curves of C_3 (= V_∞^2) vs payload capacity



What makes the Ares V Different? -- 2

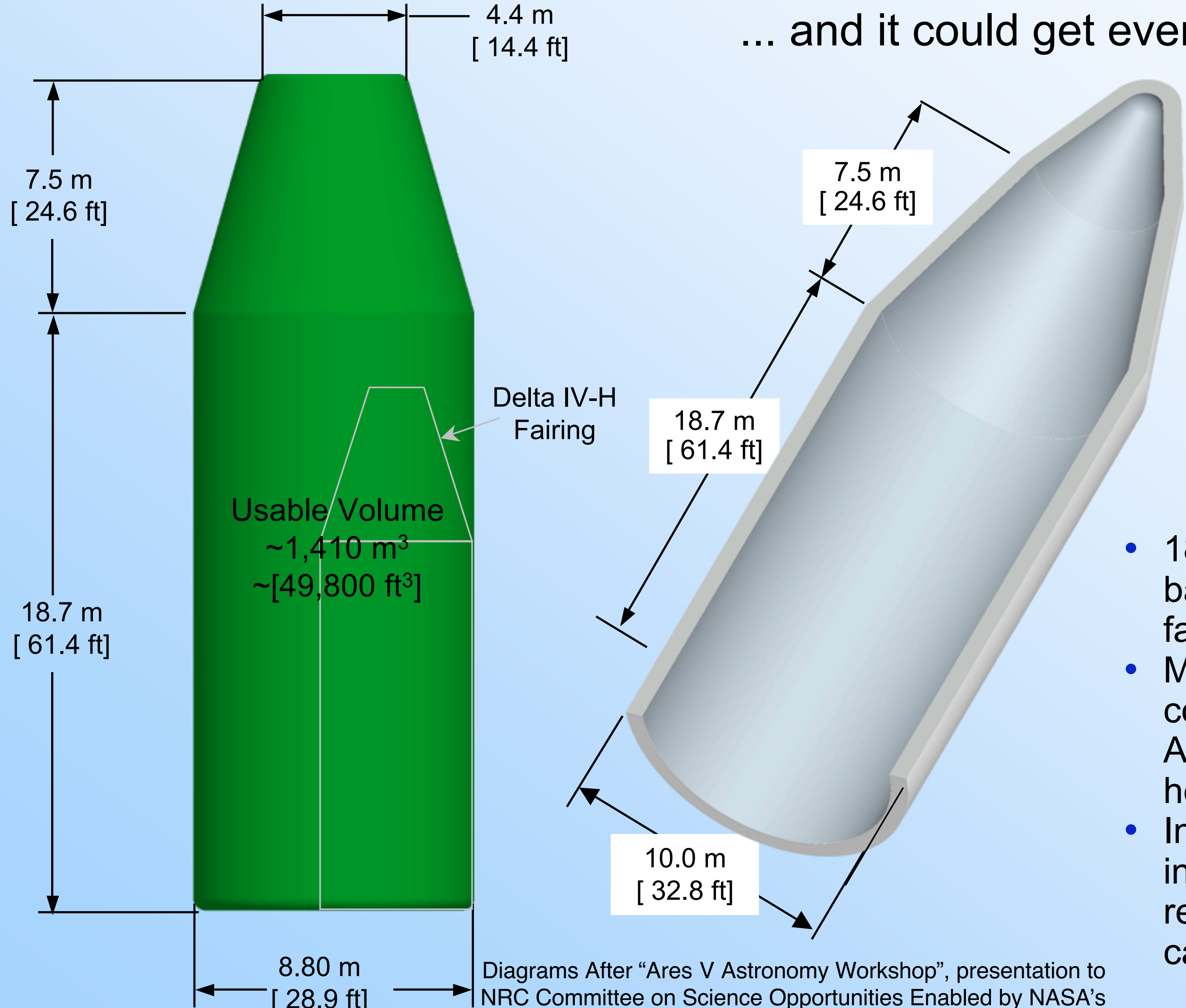
- The dimensions of its launch fairing are huge ...
  - Accommodates payloads of large spatial dimensions



Diagrams After "Ares V Astronomy Workshop", presentation to NRC Committee on Science Opportunities Enabled by NASA's Constellation System", Stephanie Langhoff, 2008 Jun 9.

What makes the Ares V Different? -- 2

... and it could get even larger



- 18.7 m is the maximum barrel length for the fairing
- Maximum vehicle length constrained by Vehicle Assembly Building (VAB) height
- Increased barrel length introduces a theoretical reduction of payload capability of 200 kg

Diagrams After “Ares V Astronomy Workshop”, presentation to NRC Committee on Science Opportunities Enabled by NASA’s Constellation System”, Stephanie Langhoff, 2008 Jun 9.

T.R. Spilker 2008/08/16

In What Ways Does Increased Launch Capacity Benefit Planetary Science?

1) Ares V can propel much greater mass to a given C_3 (i.e., a given interplanetary trajectory)
   - At low-to-moderate C_3, ~5 times as much mass as a Delta IV-H; more at higher C_3

2) For a given payload (spacecraft) mass, Ares V can propel that mass to a higher C_3
   - Reduces trip times, especially to the outer solar system or Mercury

How Would Greater Launch Mass Benefit Planetary Science?

- Allows launching large, complex systems, such as multi-element systems
- Allows greater science instrument mass and mass fraction
- Allows larger electrical power supplies (for some missions, this assumes that the requisite amount of ^{238}Pu is available)
  - More power for science instruments
  - More power for telecom transmitters -> higher downlink data rates
    - Increased mass for larger high-gain antennas also increases data rates
- Allows greater post-launch delta-V
  - Expanded accessibility, access to multiple destinations, shorter pump-down tours
- Allows greater mass for shielding against environmental hazards
- Trade greater mass for lower-complexity engineering solutions
  - Ex: Replace a lengthy gravity-assist pump-down tour with propulsive deceleration

How Would Reduced Trip Times Benefit Planetary Science?

- Provide earlier return of science
- Reduce prohibitive mission durations to something manageable
  - Keep total mission duration within component or subsystem lifetimes
- Provide greater flexibility for extended science missions
  - Particularly important for single-element missions to multiple destinations

How Would Greater Fairing Volume Benefit Planetary Science?

- Allow large flight system components
  - Large apertures (optical instruments, radio)
  - Aeroshells
- Simplifies packaging for large, complex systems
  - Could eliminate expensive and/or risky deployments
- Simplifies launch configuration of multi-element missions
  - Integrated launch configuration does not impact individual element configurations

Example Mission Concepts: Large, Complex and/or Multi-Element Missions

- Just plain *BIG*
  - Long-lived surface elements at Venus or Mercury
    - Thermal environment yields inefficient cooling & electric power production
    - Landers & rovers
    - Mercury also benefits from large post-launch delta-V capability
  - Nuclear electric power & propulsion systems (yields very large post-launch Delta-V)
- Science constellations
  - Multiple simultaneous science measurements, *a la* Carl Sagan's "role of flagships"
  - Titan: orbiter + multiple aerobots (balloons, blimps, etc.) & landers
  - Titan & Enceladus: TandEM concept
  - Europa: orbiter + one or more soft landers
  - Venus constellation: orbiter + multiple balloons + multiple long-lived sfc elements
- Planetary networks emplaced with a single launch
  - Seismic & meteorological networks for interior and atmospheric science
  - GPS & communications constellations

Example Mission Concepts: Missions With High Post-Launch Delta-V

- Ice giant orbiters (with entry probes; satellite lander?) w/o aerocapture
  - Uranus & Neptune
- Orbiters + landers at satellites near gas giants
  - Io & Enceladus
- Single flight element orbiting multiple destinations
  - “Non-Fission Icy Moons Tour” (pre-JIMO study)
    - Two spacecraft, each orbiting two of Jupiter’s Galilean moons
    - Each spacecraft >17 mT mass

Example Mission Concepts: Sample Returns

Saving the best for last!

- Why sample return?
  - Brings to bear all the power of large Earth-based laboratory facilities
    - Detailed analyses not yet possible with automatic procedures & instruments
      - Absolute age dating and other difficult analyses
      - Extremely accurate isotopic analyses
      - Definitive mineralogic analyses
  - Samples returned by the Apollo Program demonstrated the effectiveness of this approach in unraveling the Moon's past
- Many sample return missions would use all 3 Ares V advantages
  - Multiple large flight elements require large launch masses and a large launch fairing
  - Reduced trip time enables some missions

Example Mission Concepts: Sample Returns

- Mars
  - Thin atmosphere makes soft-landing heavy payloads difficult
    - Entry system *ballistic coefficient* (= M/C_DA) must not be too large
      - Must decelerate sufficiently to deploy parachutes before impact
    - For the large masses needed for sample return, need large A, and thus a large launch fairing
  - J.F. Jordan & R. Mattingly will present an Ares V-based concept at the ARC workshop
- Venus
  - Ballistic coefficient issue not as serious, *but* ... more massive planet, much thicker atmosphere
    - High delta-V ascent-to-orbit vehicle must be balloon-lofted - *massive*
    - High delta-V for return to Earth - *massive*
  - NASA-commissioned Venus Flagship Mission study currently underway
  - M. Bullock discussion at the ARC workshop
- Mercury
  - Feasibility even with Ares V is uncertain

Example Mission Concepts: Sample Returns

- Outer Solar System
  - Europa
    - Gordon Woodcock (Gray Research, Huntsville AL) estimates launch mass of 12 mT for this mission
  - Titan
    - Launch mass similar to Europa SR: more delta-V, but less radiation shielding
    - Trip-time reduction is important
  - Enceladus
    - Large post-launch delta-V due to proximity of Enceladus to Saturn
    - Trip-time reduction is important
  - Comet cryogenic sample
    - To preserve amorphous ice & interstitial species, need storage at <130K
      - Large, power-hungry two-stage refrigeration system
      - Cryogenic phase-change material (LN_2?) for Earth re-entry & recovery
  - Trojan asteroids? Probably, but long-duration mission
  - Centaur objects? Uranian satellites?

Missions Beyond Ares V Capability

- Orbiters at (or sample return from) distant small bodies: Pluto/Charon, trans-Neptunian objects
  - High speed needed to keep trip times reasonable
  - All that energy must be removed propulsively: extremely high delta-V
- Triton sample return
- Mercury sample return?
  - Combination of dealing with extreme thermal environment + high delta-V

Implications for Ares V Development

- What must Ares V designers consider to avoid precluding planetary mission launches?
  - Pre-launch flight system cleanliness, especially for planetary protection
  - Launch vehicle interface: mechanical, electrical, thermal
  - Launch environment: shock, vibration, acoustics
  - Pre-launch payload thermal control in launch configuration
  - Accommodation of planetary spacecraft configurations
  - Accommodation of an upper stage when needed
  - Interplanetary launch targeting capability
  - Handling of nuclear payloads: radioisotope power sources & heaters
  - Preparation of a comprehensive Payload Planner's Guide
- Requirements can be quantified via mission concept studies to determine:
  - Representative flight system designs
  - Key performance requirements
  - Design requirements related to payload accommodation
  - Cost estimates and cost trades for implementing planetary mission accommodation

Summary

- Ares V would revolutionize the way we accomplish solar system exploration
  - Shift to a better balance of field data acquisition and laboratory analysis
  - Greatly improve field data acquisition
    - Better instruments, better instrument complements
    - Larger data volumes returned
- Would require a new fiscal paradigm
- "Ares V Solar System Science" workshop should expand the known set of enabled missions

Questions?