ESAS Update: Accelerating Lunar Missions

- **The ESAS was a 60 day study to establish a baseline exploration architecture**
  - Intent was to use as a baseline from which to do further trade studies.
  - ESAS focus was to enable both the ISS and lunar missions while enabling extensibility to Mars.
  - After further analysis, NASA has elected to alter the architectural baseline.
  - New approach places more emphasis on lunar missions sooner at lower overall risk and cost, while still meeting our commitments to the ISS.
    - Still employs a "1.5 launch" approach.
    - Still within the Constellation 5 year budget run out.
    - Will likely enable Mars missions earlier.

- **Crew Exploration Vehicle**
  - ESAS baseline was to use LOx/Methane propulsion.
    - Initial studies indicated a performance advantage coupled with an ISRU strategy for Mars.
    - Common development for CEV, lunar ascent stage and Mars ascent/descent propulsion.
      - Significant risk, cost, schedule and technical driver. Reliability growth through multiple applications.
    - Mars mission ISRU strategy is very conceptual today
      - Don't want to over constrain the Mars architecture while increasing cost and risk to initial CEV deployment
    - After further analysis, it was determined that LOx/Methane has little if any benefit to the lunar architecture.
    - CEV and lunar ascent stage will not utilize LOx/Methane propulsion. Other state-of-the-art alternatives, including storable and non-toxic options will be evaluated. Still achieves reliability growth through multiple applications.
  - ESAS baseline required an unpressurized ISS cargo delivery vehicle.
    - A combination of planned ISS mission alternatives, design of the CEV service module, and the Commercial Orbital Transportation System (COTS) should provide NASA with the required capability without a dedicated development.

- **Launch Systems**
  - Initial ESAS assessments utilized a 5 segment RSRM with new liquid upper stage for the CLV
    - The five-segment development added significant near-term cost and risk and the J–2S/expander engine for the upper stage could not meet the 2011 schedule target."

Accelerating Lunar Missions (cont'd)

- ESAS final recommendation:
  - CLV: 4 segment RSRM / 1 SSME upper stage (new SSME development for air start)
  - CaLV: 5 segment RSRM / 5 SSME expendable core stage (new SSME developed in 2 steps) / 1 J-2 EDS stage (new upper stage engine development).
  - Required development of two upperstage engines, a two step approach to a low cost SSME derivative and two solid booster stages.
  - Budget limitations forced NASA to slip the 1st CEV flight target to 2012, in addition to budget offsets from CEV design changes allowed NASA to reevaluate this recommendation.
  - The reevaluated cost and schedule to implement these changes will result in lower overall risk to the lunar mission, enabling the lunar missions sooner due to earlier development of the required hardware (fewer development steps/changes)
  - A 5 segment RSRM test motor was successfully ground fired in 2003 as a Shuttle margin test.
  - The J-2 engine successfully powered all Apollo/Saturn V missions (S-II & S-IVB stages).
    - A 1993 NASA funded study, updated under ESAS, laid out a plan for restarting production on the J-2S.
    - 4 sets of J-2S Mk 29 turbopumps were successfully fabricated, integrated and tested in the X-33 main engine in the late 1990's.
  - New accelerated approach:
    - CLV: 5 segment RSRM / 1 J-2X upperstage.
    - CaLV: 5 segment RSRM / 5 SSME core stage / 1 J-2X EDS stage.
    - Requires development of a single upperstage engine, a single low cost SSME derivative for the CaLV core stage and a single solid rocket booster stage.
    - As documented in ESAS, this concept achieves similar loss of mission / loss of crew estimates to that of the 4 segment /1 SSME concept.

Definitions for the J-2 engines:
- J-2: original LOx/H2 engine used on the Saturn V 2nd and 3rd stages
- J-2S: simplified J-2 developed as a replacement engine for the J-2 at the end of the Apollo Program
- J-2X: Nomenclature for modern day replacement for the J-2/J-2S

Summary Advantages of Accelerated Approach

- **Reduces overall risk to the Constellation program.**
  - Addressing critical systems sooner.
  - Eliminates the top two ESAS identified risks (LOx/Methane propulsion and SSME air start) and addresses another risk earlier (J-2 development).
- **Lower overall Constellation costs to 1st human lunar landing**
  - Reduced post-2010 funding ramp-up.
- **Lower overall integrated risk to a 1st human lunar landing.**
  - Lower overall development risk for CEV: use current propulsion technology and eliminate dedicated unpressurized cargo delivery vehicle.
  - Fewer launch vehicle development steps to lunar missions:
    - Single upperstage engine development (J-2X).
      - More robust upperstage engine cycle for altitude start / capable of restart - proven in Saturn.
    - Single solid rocket booster development (5 segment RSRM).
    - Single core engine development (expendable SSME).
  - More 'balanced' engine production rate requirement between J-2X and SSME.
- **Maintains safety and reliability projections with significant reliability growth with evolution from proven systems.**