NASA Advisory Council
Space Operations Committee

NASA Headquarters

July 16, 2009

Space Operations Committee

- Eileen Collins, Chair
- Pat Condon
- Owen Garriott
- Jay Greene
- Tom Jones

- Jacob Keaton, Executive Secretary, NASA

Summary of Activities

- 2009 Second Quarter Space Operations Highlights
- Space Operations Mission Directorate Budget Briefing
- With Exploration Committee:
  - Constellation Land vs Water Recovery Decision
  - Status of Plans for Lunar Exploration Program
  - Constellation Plans for Operations Beyond Moon
- April 2009 Aerospace Safety Advisory Panel meeting at Johnson Space Center
- NASA Space Flight Human System Standards & Human Integration Design Handbook

2009 Second Quarter Highlights

- Hubble Space Telescope Servicing Mission 4 (STS-125)
- Six full-time crew onboard the International Space Station
  - The Expedition 20 crew, currently onboard, represents all five ISS partners (Canada, European Space Agency, Japan, Russia, U.S.)
- Space Shuttle flew one of four ISS missions scheduled for 2009
- Launch Pad 39B handed over to Constellation for Ares I-X launch
- Eight Space Shuttle missions remain on the manifest
- Space Shuttle Transition & Retirement Activities

Space Operations FY 2010 Budget Summary

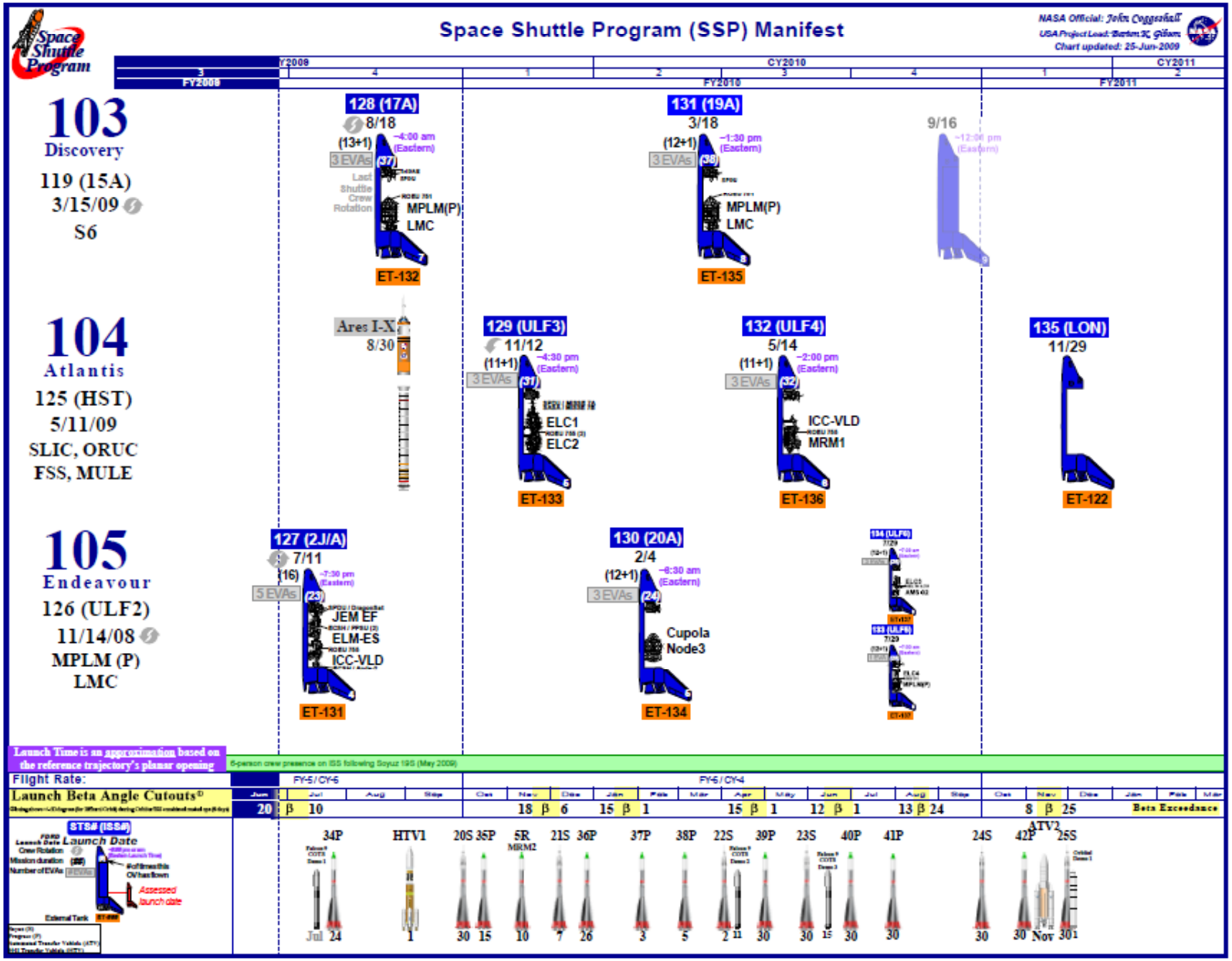
- SOMD is implementing programs as planned and within budget
- The FY 2010 Budget provides the necessary resources to safely and reliably fly the Space Shuttle and complete ISS assembly
- Funds allocated from within the Space Communication and Navigation (SCaN) Program to replace aging and obsolete infrastructure while moving the Space Network into an integrated architecture
- The budget is workable but tight. SOMD is running lean programs. Program reserves should be minimally sufficient to execute as planned in 2010
- Per previous Council observation, funding stability is especially important in the transition years

SOMD FY 2010 Budget Request

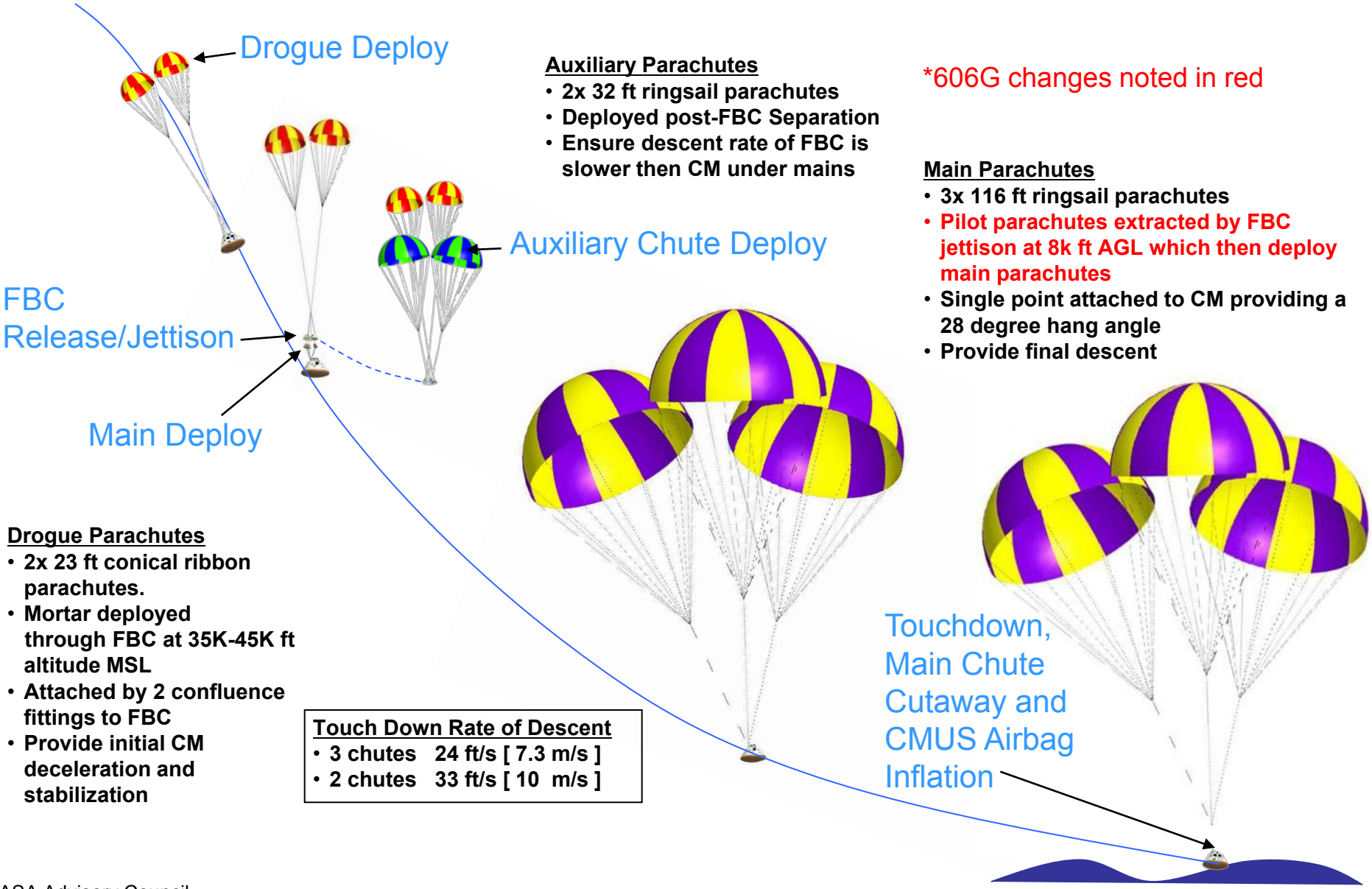
	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Space Operations	**5,427.2**	**5,764.7**	**6,175.6**	**3,663.8**	**3,485.3**	**3,318.6**	**3,154.8**
Space Shuttle	3,295.4	2,979.5	3,157.1	382.8	87.8	0.0	0.0
International Space Station	1,685.5	2,060.2	2,267.0	2,548.2	2,651.6	2,568.9	2,405.9
Space and Flight Support	446.2	725.0	751.5	732.7	745.9	749.7	748.9
Space Communications	303.9	582.9	496.6	506.9	520.3	524.0	524.0
Launch Services	91.8	91.7	85.9	84.1	83.9	83.9	82.8
Rocket Propulsion Testing	41.9	41.8	45.8	44.6	44.5	44.5	44.5
Crew Health & Safety	8.7	8.6	8.6	8.5	8.5	8.5	8.5
Human Space Flight Operations	0.0	0.0	114.7	88.5	88.6	88.7	89.0

Space Shuttle Manifest

as of June 25, 2009



Orion Recovery System



Auxiliary Parachutes
- 2x 32 ft ringsail parachutes
- Deployed post-FBC Separation
- Ensure descent rate of FBC is slower then CM under mains

*606G changes noted in red

Main Parachutes
- 3x 116 ft ringsail parachutes
- Pilot parachutes extracted by FBC jettison at 8k ft AGL which then deploy main parachutes
- Single point attached to CM providing a 28 degree hang angle
- Provide final descent

Drogue Parachutes
- 2x 23 ft conical ribbon parachutes.
- Mortar deployed through FBC at 35K-45K ft altitude MSL
- Attached by 2 confluence fittings to FBC
- Provide initial CM deceleration and stabilization

Touch Down Rate of Descent
- 3 chutes 24 ft/s [7.3 m/s]
- 2 chutes 33 ft/s [10 m/s]

Orion Land vs Water Landing

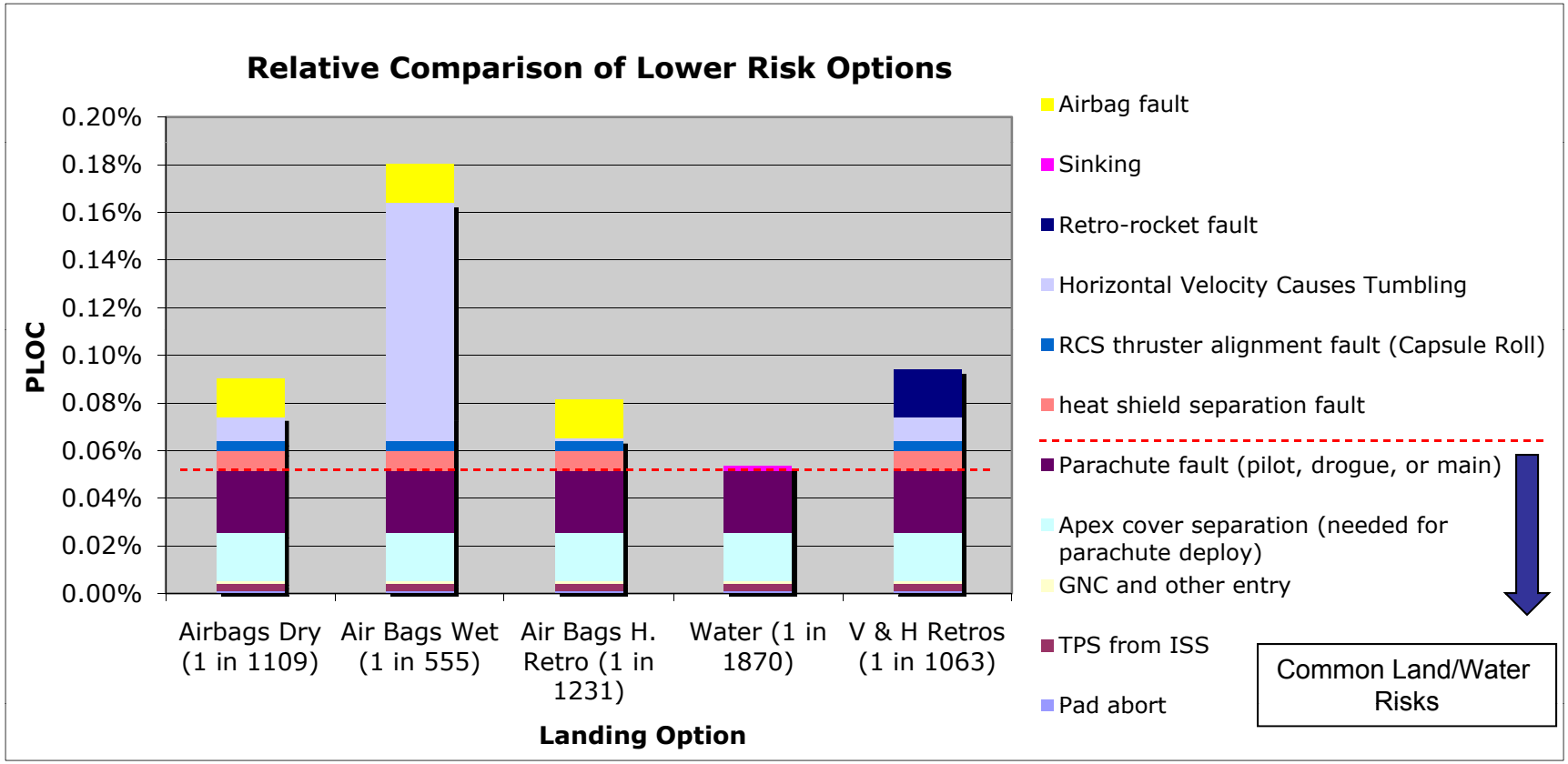
- Briefing with Exploration Committee
- Constellation decision for end-of-mission Orion water landing
- Very thorough analysis based on safety, performance, and affordability
- Our committees understand this decision was justified by safety and “weight under parachutes” constraints
- Operational concerns:
  - We observe that there is very little difference in overall risk between land and water landings
    - Difference of 0.12% in PLOC (tumbling)
  - Skylab crews strongly support land landings from a safety standpoint (Skylab Medical Operations Summit, January 2008)
  - Land landings yield higher reusability rates (82% for land vs 42% for water)

- Weight and safety tradeoffs (land vs water) were considered which show advantages for land landing for nominal end-of-mission flights. These should be further investigated.

- Our joint committees request the team reexamine our operational concerns and total mission safety trades and report at a future NAC meeting.

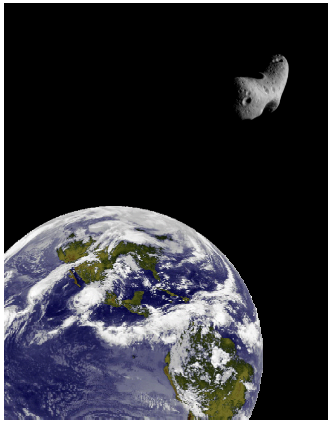
Integrated Risk Assessment

- NASA Engineering and Safety Center's final risk assessment (06-020E, June'07) concluded that water landing is safer than land landing
  - Risk analysis included contributions from all events beginning at entry interface and ending with post-landing recovery of the crew



Human Exploration of Near Earth Objects

- Why NEOs for Exploration?
  - Expand human exploration of space beyond Earth orbit (and beyond lunar orbit…)
  - Gain operational knowledge and system performance for longer durations beyond low-Earth orbit (90 – 360 days away from Earth)
  - Puts humans demonstrably on the way to Mars
- Key Scientific Return
  - Sample return from solar system bodies radically different from Moon/Mars. Samples from known geologic context.
  - Study the internal structure of asteroids
  - Knowledge of NEO internal strength refines impact physics models
  - Assess deep space radiation characteristics in context of human habitation
- Excitement and Inspiration
  - Unprecedented deep space voyages with dramatic perspective of Earth-Moon system ("Where no one has gone before…")
  - Point to expanded exploration progress using Constellation investment
  - Cultivate and maintain public support by taking on dramatic new challenges (e.g. impact threat)

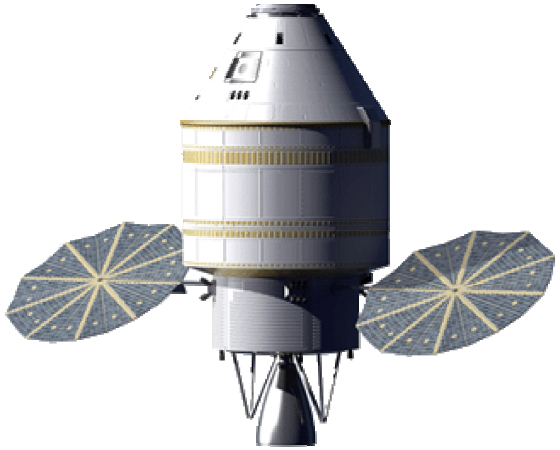


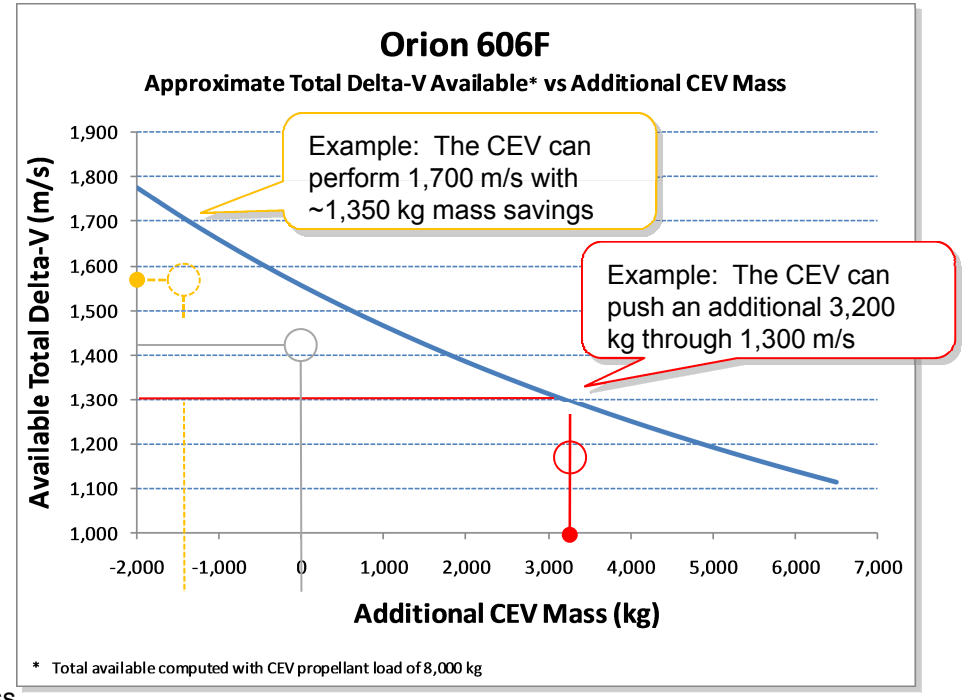
NEOs close proximity to Earth make them excellent exploration destinations.

Black Boulders on Itokawa. Courtesy JAXA, NASA

Orion Support of NEO Missions

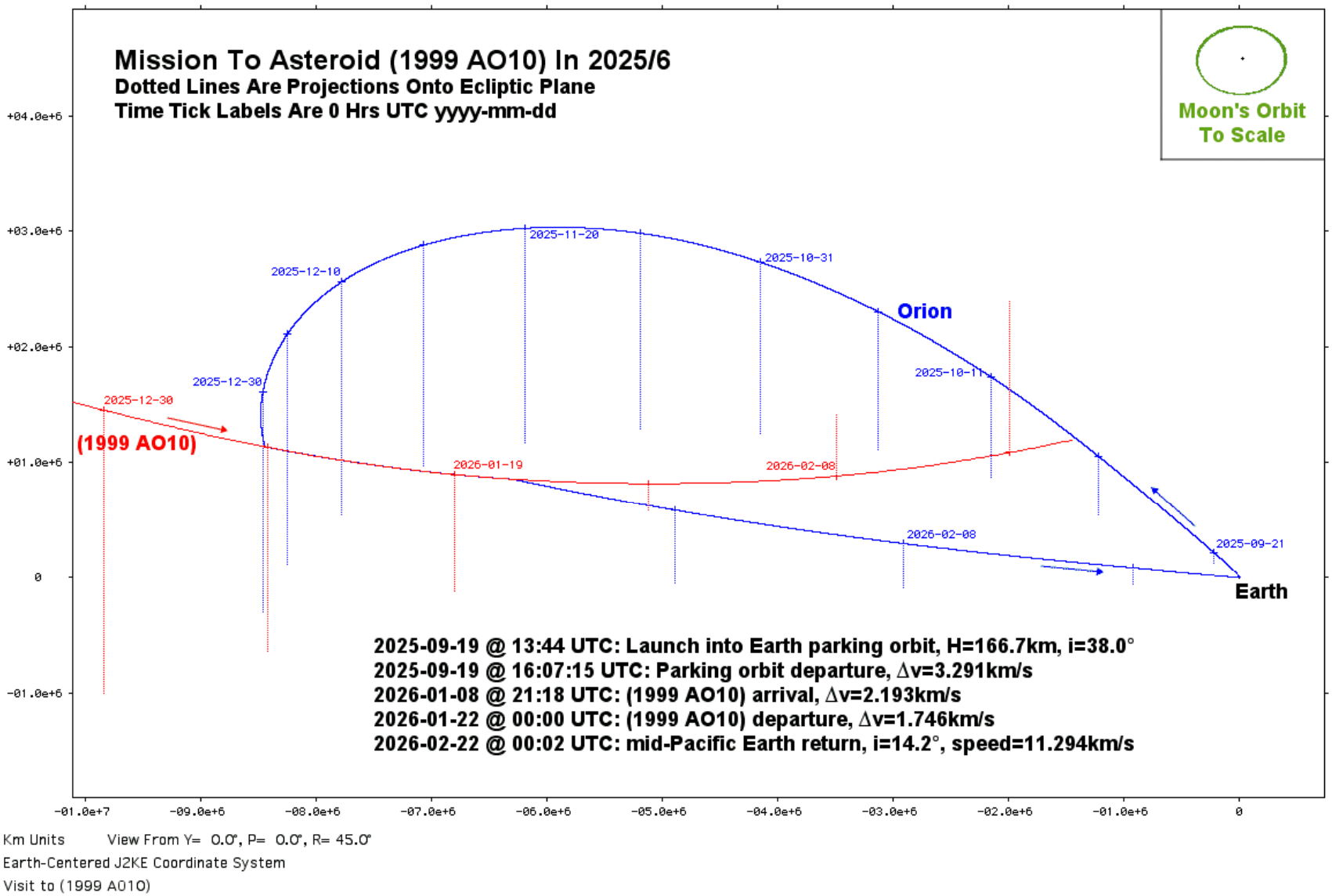
- "Lunar" Orion Capabilities
  - Support of up to 4 crew for 18 days
  - Provides ~1,550 m/s total delta-v*
  - ~1,500 We power to other elements
  - Docking and transfer via Low Impact Docking System (LIDS)
  - Earth return & recovery if entry speed < 11 km/s
- Additional Functionality Needed for NEO Missions
  - Support of crew for 90+ days
    - Consumables/Regenerable Life Support
    - Volume, crew health (exercise, etc.)
  - Additional propulsion for difficult targets or faster trip times
  - Radiation protection for longer duration deep-space mission
  - Additional TPS if entry speed exceeds 11.0 km/s



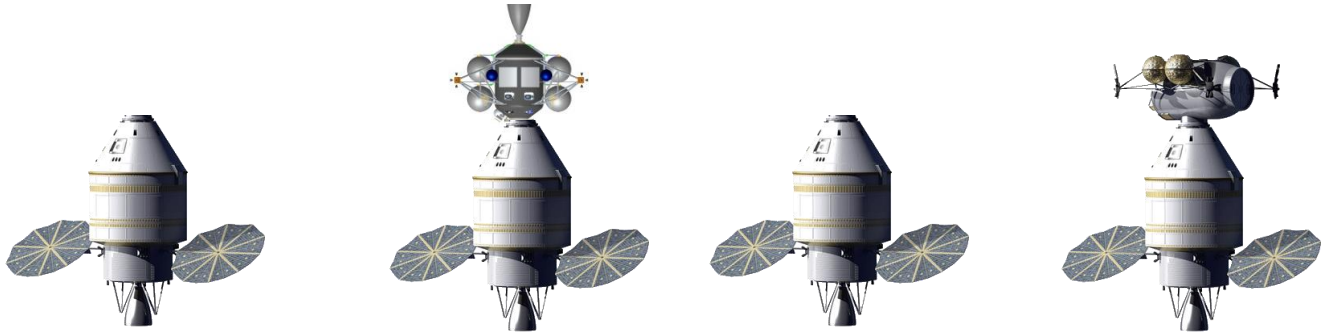


* Total delta-v available dependent on propellant load and vehicle mass

Example 150-Day Mission to 1999 AO_{10} Earth-fixed Trajectory Plot for Mission



Possible NEO Options Which Could Be Evaluated



	606F	606F + Altair Ascent Module	Block II SM	Block II SM + Hab
Lunar Architecture	Current EOR / LOR	Current EOR / LOR	LOR	LOR
Post Escape Maneuvers	Orion SM (8,600 kg useable propellant)	Orion SM (8,600 kg useable propellant) + Altair AM (3,121 kg useable propellant)	LOI + TEI (~2,500 m/s)	LOI + TEI (~ 2,500 m/s)
Consumables	90 days	90-180 days	90 days	90-180 days
Habitation	Orion CM	Altair Ascent Module	Orion CM	Separate Hab •Altair Ascent or •Altair Airlock or •LSS Node or •MTV prototype Hab
Issues	• Insufficient propulsive capability • Limited living volume • Additional risk without radiation protection			

NEO Exploration Conclusion

- Performance/mass exist within the elements making up the Constellation transportation architecture which would allow human NEO mission analyses and assessments
- Currently, no systematic analysis on human NEO missions underway
- High-level assessments as part of Human Space Flight Review

Aerospace Safety Advisory Panel

- Held at Johnson Space Center, April 29-30, 2009
- Good opportunity to observe the inner workings of the ASAP
- Most issues were Constellation related:
  - Constellation Requirements Management and Traceability
  - Design Integration Maintenance and Database
  - Orion Requirements Flowdown
  - Human Rating and Risk
  - Ares I Top Risks
  - Occupational safety, astronaut crew proficiency, knowledge management
- Meeting included two hours of tours and two hours of public sessions

Activities for Next Quarter

Fact finding:

- Implications of the Augustine Report
- Commercial Orbital Transportation System (COTS) Update
- Human/Machine Interface of Orion for both ISS and Lunar missions
- Human Factors work with Mission Operations Directorate
- Orion Thermal Protection System (with Exploration Committee)
- Follow up on Constellation water vs land landings
- Ames work on vehicle handling qualities for Moon/Mars landings