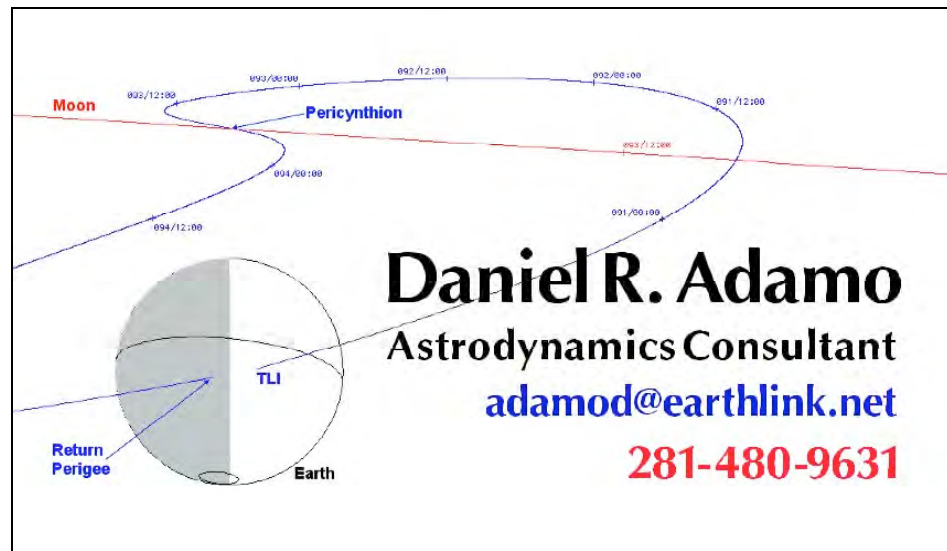


A Lunar Surface Rendezvous (LSR) Architecture Proposal



**AIAA Houston Section
Astrodynamics Technical Committee
12 June 2009 Lunch-and-Learn**

A Lunar Surface Rendezvous (LSR) Architecture Proposal

Agenda

- Compare current 1.5-launch architecture to proposed 2.0-launch LSR architecture
- Cite noteworthy LSR vehicle specifications and other attributes
- Illustrate "land anywhere; leave anytime" uniform LSR performance
- Examine LSR abort and rescue capabilities
- Speculate on LSR exploration legacy

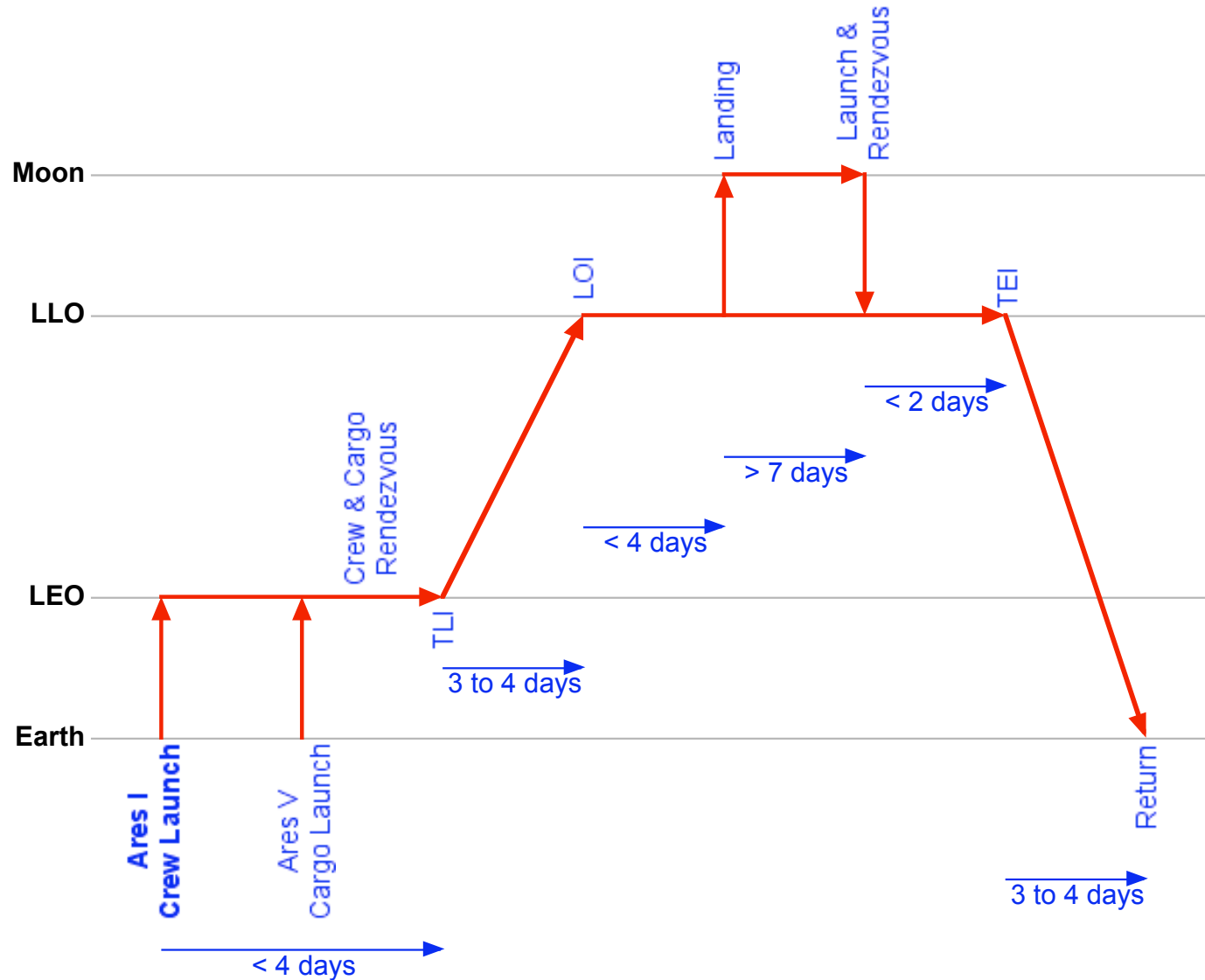
Format

- Please confine questions during ~40-min presentation to clarification requests
- Post-presentation, we have ~45 min to discuss:
 - Vulnerabilities in 1.5-launch architecture addressed by LSR
 - Risks posed by LSR and payoffs from their effective management
 - ???

E-mail the author for LSR white paper and detailed mission design example

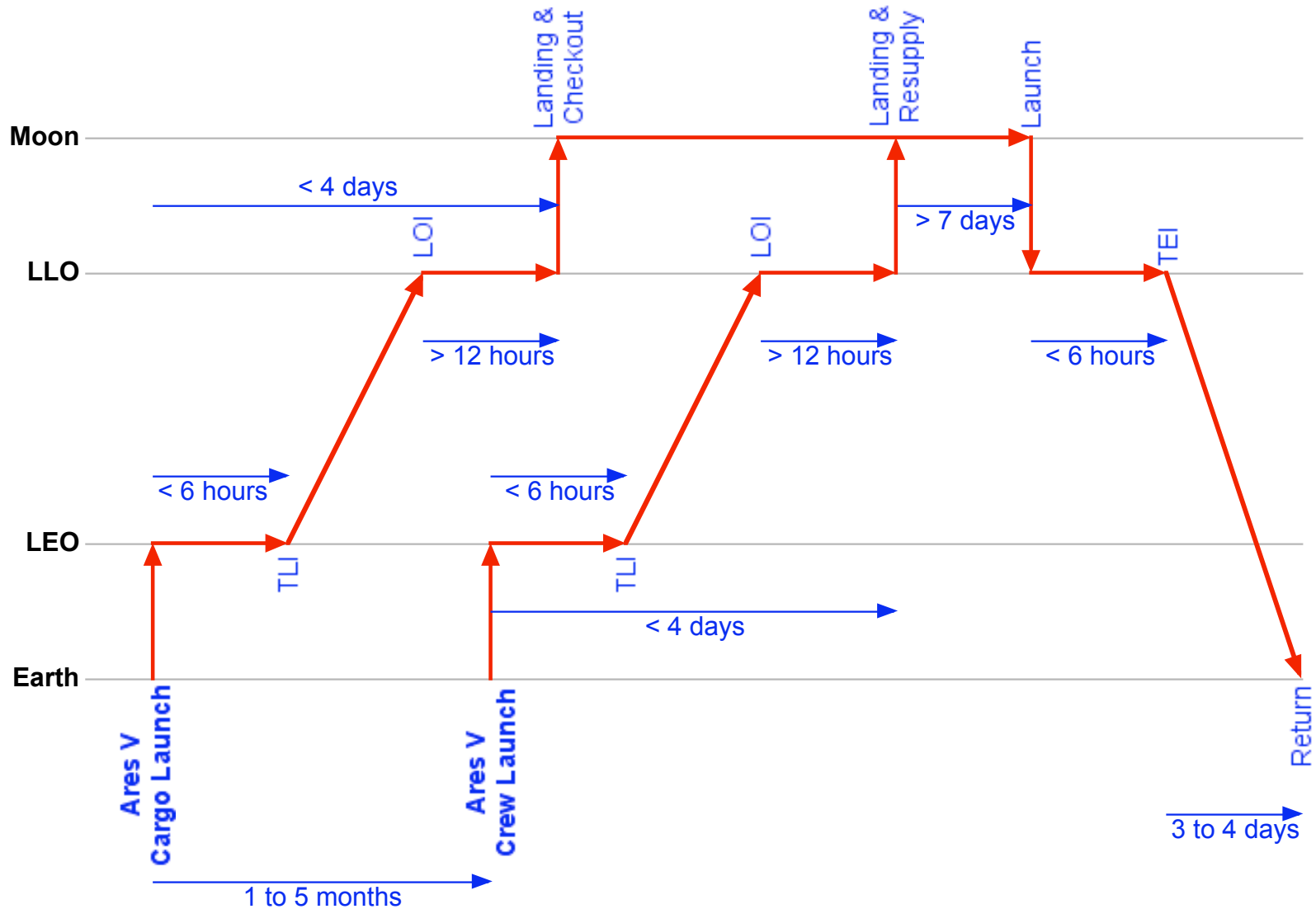
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Current 1.5-Launch Architecture



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Proposed LSR Architecture



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Let's Look Under LSR's "Hood"

- Earth launches are all stand-alone Ares V (no Ares I dependency) with similar payloads
 - Key requirement: 62.8 mT payload mass to TLI with a single Ares V launch¹
 - With each LSR launch, 21.7 mT payload mass delivered to lunar surface
- Cargo-only launch: Return Consumables Module on a Descent Module (RCM/DM)
 - RCM payload delivers Earth return consumables and lunar exploration systems mass
 - DM has cryogenic propellant with 3015 m/s Δv capability²
- Crew launch: Crew Exploration Vehicle on a Descent Module (CEV/DM)
 - CEV depends on DM for consumables through Moon landing
 - Service Module (SM) consumables nominally only used during CEV Earth return
 - SM has hypergolic propellant with 907 m/s contingency Δv at Earth launch
 - After resupply from RCM, SM Δv capability is 2800 m/s at Moon launch³

¹ Cook, S., "Lunar Program Industry Briefing: Ares V Overview", NASA-MSFC Ares Projects Office, 25 September 2008, http://www.nasa.gov/pdf/278840main_7603_Cook-AresV_Lunar_Ind_Day_Charts_9-25%20Final%20rev2.pdf [retrieved 20 November 2008].

² DM mass is equivalent to ESAS study's LSAM descent stage mass x 1.17.

³ Fully loaded SM mass supporting LSR Earth return is equivalent to ESAS study's SM mass x 2.25.

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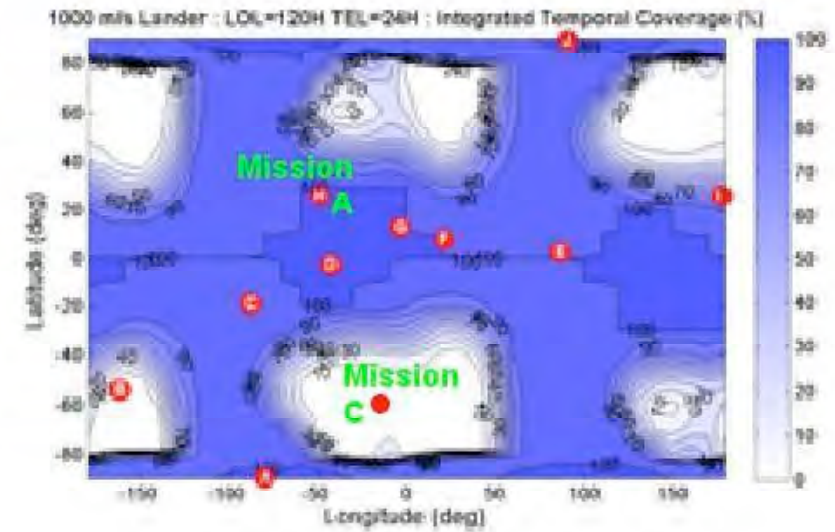
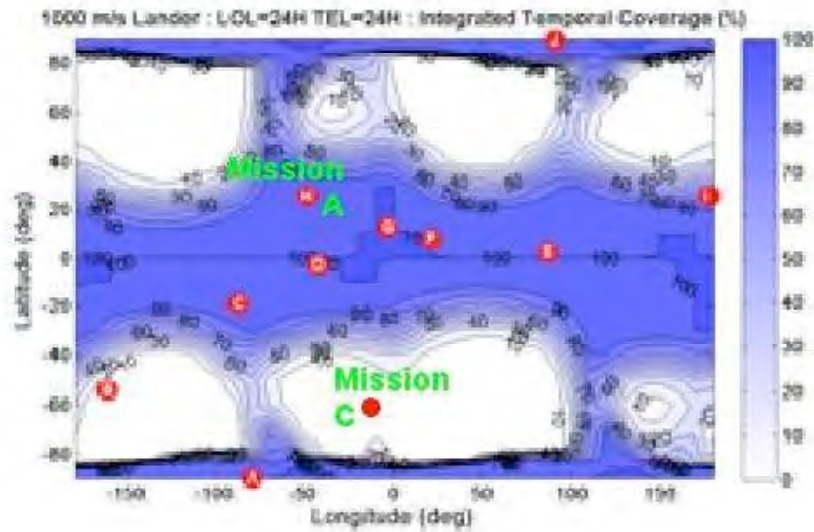
Noteworthy LSR Attributes \Rightarrow "Land Anywhere; Leave Anytime"

- No orbit rendezvous or docking required
- Single habitable volume during Earth/Moon/Earth transits is in the CEV
- TLI targeted for lunar approach in trajectory plane imposed by landing site location
 - Apollo 13-style circumlunar abort requires ~ 100 m/s Δv
 - Single-impulse LOI is always in plane, contributing to uniform mission performance
 - Landing always < 4 days after launch, contributing to uniform mission performance
- Resupply CEV with 18.5 mT of Earth return propellant mass before lunar liftoff
- Lunar launch and TEI unconstrained by LLO rendezvous plane geometry
 - Contributes to "anytime return" capability and uniform mission performance
 - Posigrade lunar launch leads to TEI with unobstructed Earth line-of-sight

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Two LSR Mission Designs Confirm Uniform Mission Performance

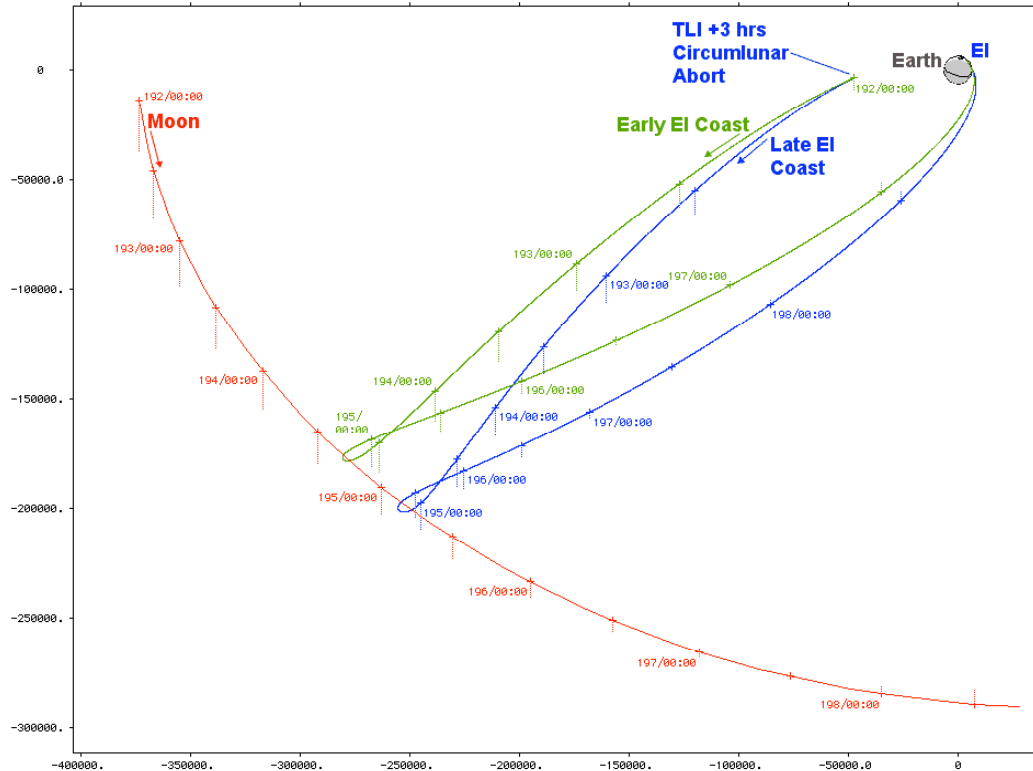
Mission	Landing Site Name	Selenocentric Latitude	Selenocentric Longitude
A	Aristarchus Plateau	26° N	49° W
C	Clavius Crater	59° S	15° W



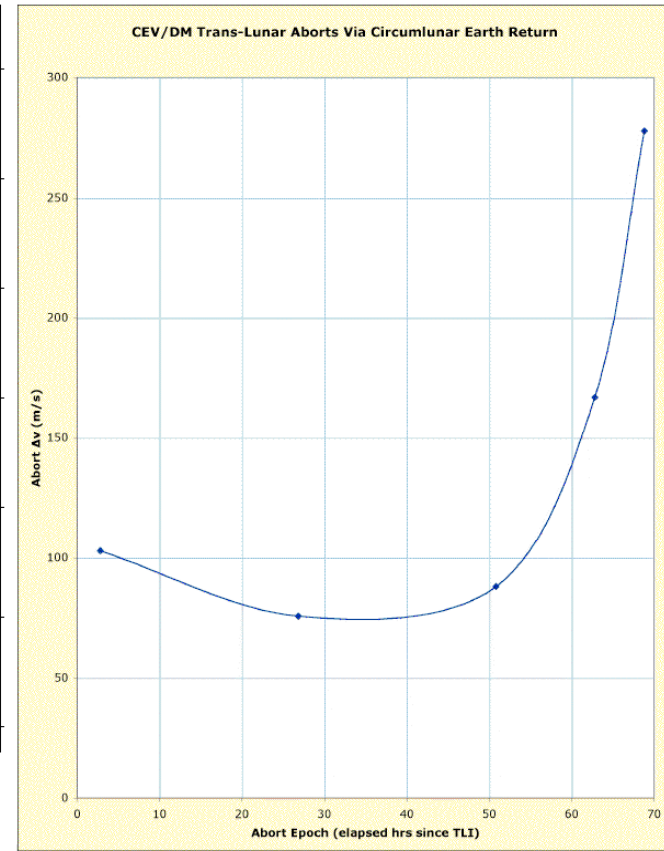
Mission	Cargo LOI Δv (m/s)	Crew LOI Δv (m/s)	TEI Δv (m/s)
A	862.304	874.668	916.729
C	897.130	899.913	890.644
Apollo 17 Budget	910.7	910.7	928.5

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Trans-Lunar Aborts Via Circumlunar Earth Return

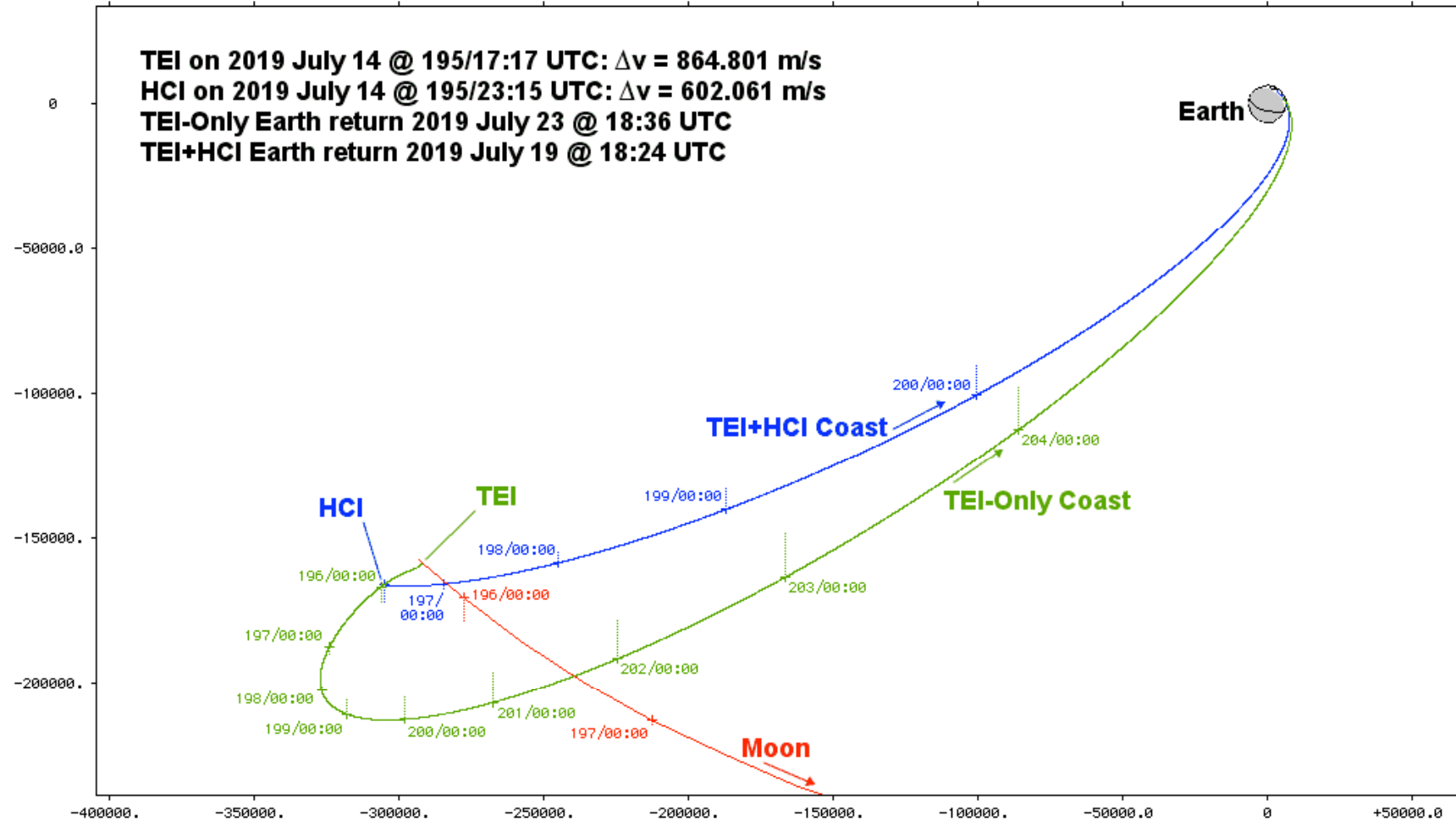


Km Units View From Y= 30.0°, P= 0.0°, R= 45.0° Sun Illumination
 Earth-Centered J2KE Coordinate System
 LSR mission: CEV-DM TLI circumlunar abort with late EI at -140 Lon



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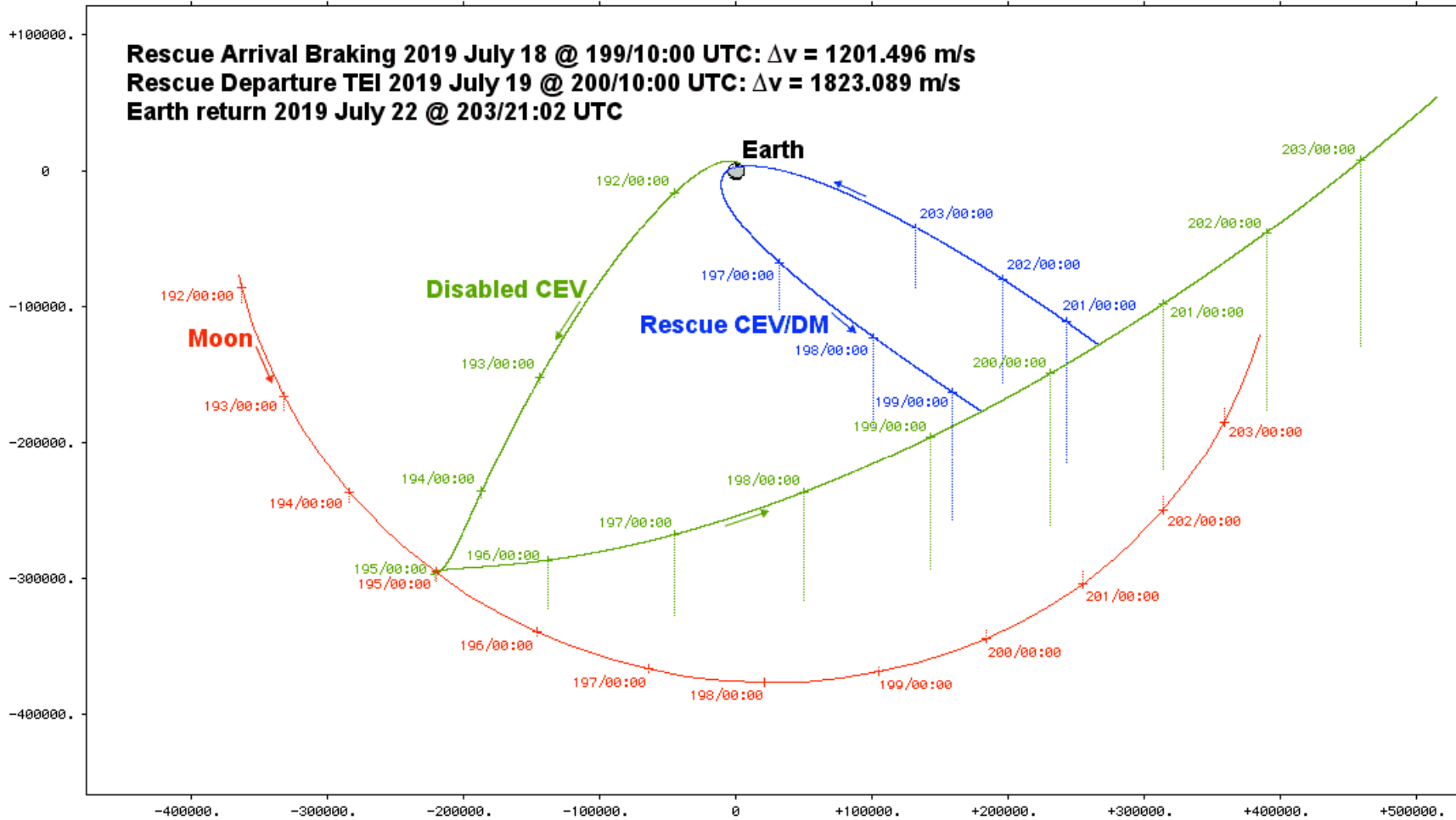
TEI+HCI Aborts From LLO



Km Units View From Y= 45.1°, P= 0.0°, R= 50.0° Sun Illumination
Earth-Centered J2KE Coordinate System
LSR mission: CEV-DM LLO #9 TEI+HCI abort

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"No LOI" Deep Space Rescue: A Rendezvous Like No Other



Km Units View From Y= 22.0°, P= 0.0°, R= 20.0° Sun Illumination
Earth-Centered J2KE Coordinate System
LSR rescue mission: CEV-DMr Trans-Rescue Injection segment

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LSR's Space Exploration Legacy: A System Of Systems

- Conduct simultaneous lunar base and sortie logistics
 - Contingencies require two parallel Ares V vehicle flows and launch facilities
 - Launches need not be planned more frequently than at monthly intervals
 - Cargo-only payloads can evolve into in-situ resource utilization (ISRU) facilities
- Access destinations beyond the Moon
 - Evolved DMs: use storable propellant; permit "rack and stack" in-space assembly
 - Pre-emplace RCM and one or more DMs at destination or staging point
 - Sun/Earth L2 (SEL2) can be destination (infrastructure repair) or staging point
- Fly missions to near-Earth objects (NEOs, all the way to Phobos & Deimos at Mars)
 - Pre-emplace RCM/DMs at the NEO destination (possible ISRU)
 - Stage RCM/DMs at SEL2 for departure with CEV
 - High DM thrust not required: high I_{SP} engines may be practical

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Mr. President, Houston Has A Solution!

