A Constellation-Enabled Mars Sample Return (MSR) and Preparation for Humans-to-Mars aka CEMMENT (Constellation-Enabled Mars Mission Exhibiting New Technology)

Summary for Ares-V Utilization Workshop

at NASA Ames

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A Word about Mars Sample Return

SMD is currently planning a Mars Sample Return (MSR) mission

- Utilizing currently available launch vehicles
- To occur near the end of the next decade
- In conjunction with ESA and other potential partners

This study goes way beyond the needs for the proposed MSR mission, but incorporates multiple sample returns as part of preparation for humans-to-Mars

Our Study Objective

The study objective is to examine the flight elements of the Constellation Program, such as the Orion Crew Vehicle and Ares launch vehicles, for application to human precursor robotic missions to Mars. These missions could test flight systems and technologies required for human travel, obtain relevant Mars environmental knowledge, and return scientifically valuable surface material samples from Mars.

Study Participant List

JPL

- Bob Easter
- Chad Edwards
- Frank Jordan - Study Coordinator
- Dan Lyons
- Richard Mattingly
- Dave Pierce
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- Ralph Roncoli
- Mike Sander - JPL Sponsor
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Aero Review Group

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Origin of Mission Objectives

Source	Objectives List
National Academy of Sciences Decadal Report 2003 (beyond approved program)	• Multiple sample returns • Surface network of seismology and meteorological stations
Mars Exploration Program Assessment Group (MEPAG) Goal IV 2006	• Sample Return • Aerocapture • Automated Mars orbit rendezvous • Pinpoint landing • ISRU demonstration • Surface in-situ measurements of dust, radiation, soil characteristics, etc. • Orbital studies of lower atmosphere
Space Operations Management Directorate (SOMD) Space Communications Architecture Working Group (SCAWG) 2006	• Robust K_a band high-power communications
Customer interaction and study participant suggestions	• Use of Constellation elements • Provide feed-forward technology demonstrations for human missions, including large-mass landing • TPS test Earth entry • Measurements during transit flights

The Study's Driving Requirements

- Aerocapture a large mass at Mars, utilizing aeroshells, vehicle parameters, and trajectories, similar to human missions
- Land a large mass at Mars, utilizing aeroshells, vehicle parameters, and trajectories, similar to human missions
- Return multiple samples of Mars to Earth
- Utilize a single Ares V launch vehicle

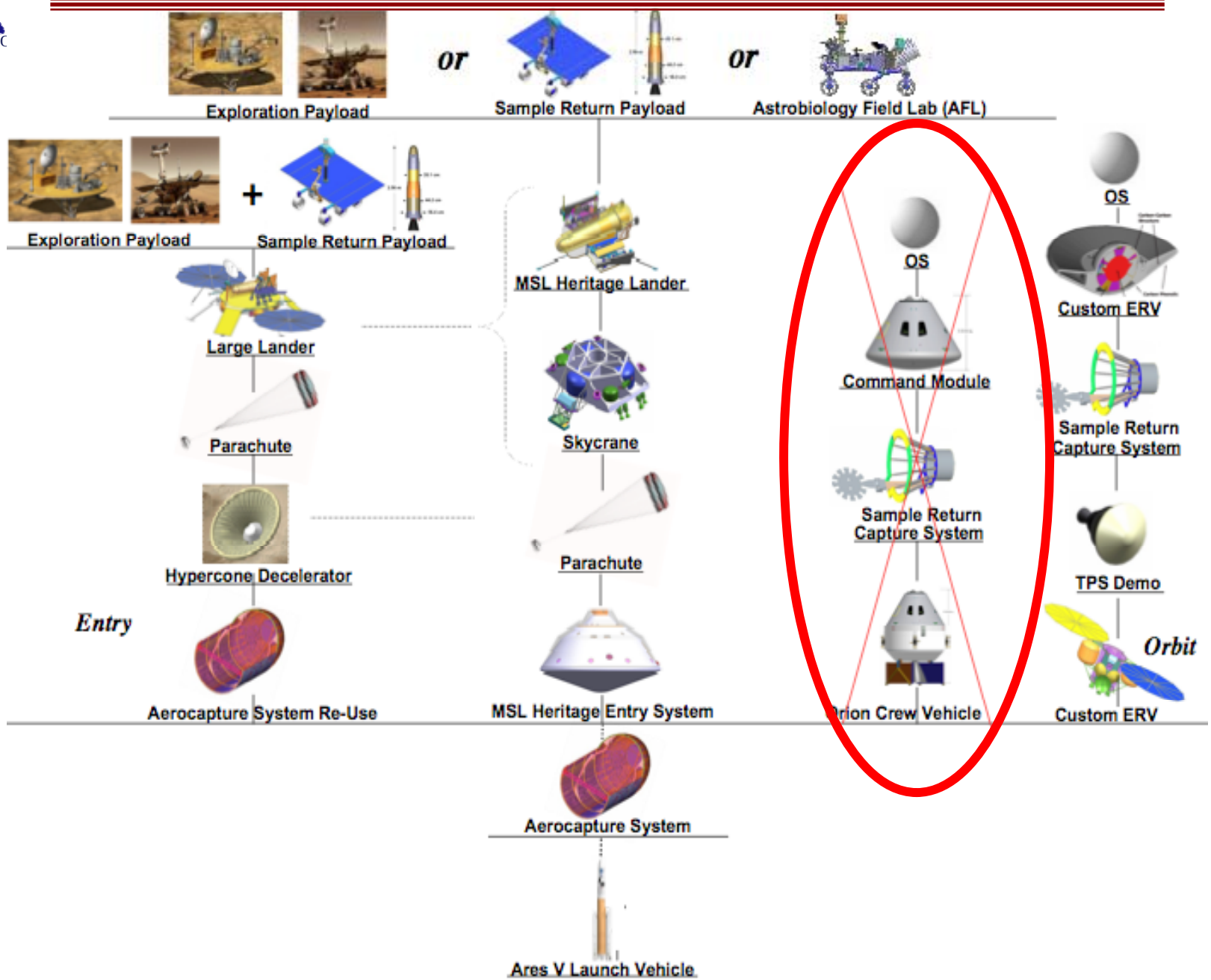
Potential Achievements of the Mission Concept

- Would aerocapture a 40 MT vehicle at Mars (the Ares V limit) into a low-Mars orbit [1/2 human (DRM) scale]
  - Atmospheric entry speed 7.4 km/sec
- Would re-enter 24 MT for landing [1/2 human (DRM) scale] and land 8 MT on Mars surface
- Would return three 500 gram samples of Mars to Earth from two separate Martian surface locations:
  - **(1)** Excursion mobility (>1 km) and subsurface with local mobility (<1 km)
  - **(2)** Excursion mobility (>1 km)
- Would obtain a wealth of information about the Martian environment from two separate surface locations
- Would test Earth-entry Thermal Protection System (TPS) at 13 km/sec atmospheric entry speed.

Potential Achievements of the Mission Concept*(cont)*

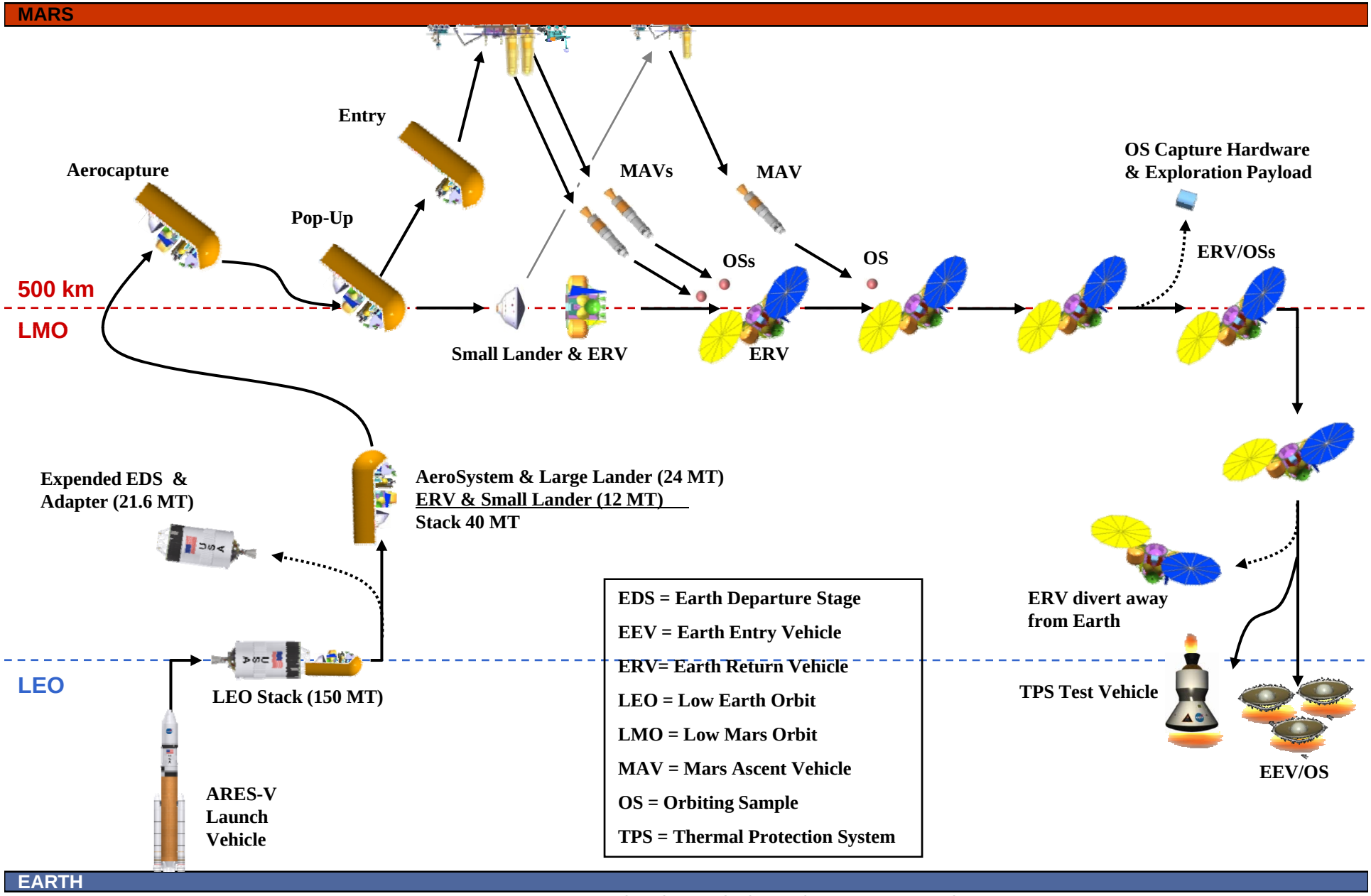
- Would explore subsurface to 10 m depth at several local places (<1 km) at a single-landed location
- Would perform pinpoint landing at two Mars surface locations
- Would conduct Mars ascent three times as part of the sample returns
- Would conduct three automated rendezvouses as part of the sample returns
- Would demonstrate robust K_a band Earth-Mars telecom
- Would demonstrate round-trip autonomous navigation
- Would prospect for water on the surface at one location
- Could perform an ISRU test at one location

Flight Element Trade Tree



PRE-DECISIONAL- For Planning and Discussion Purposes Only

Candidate Reference Mission Architecture



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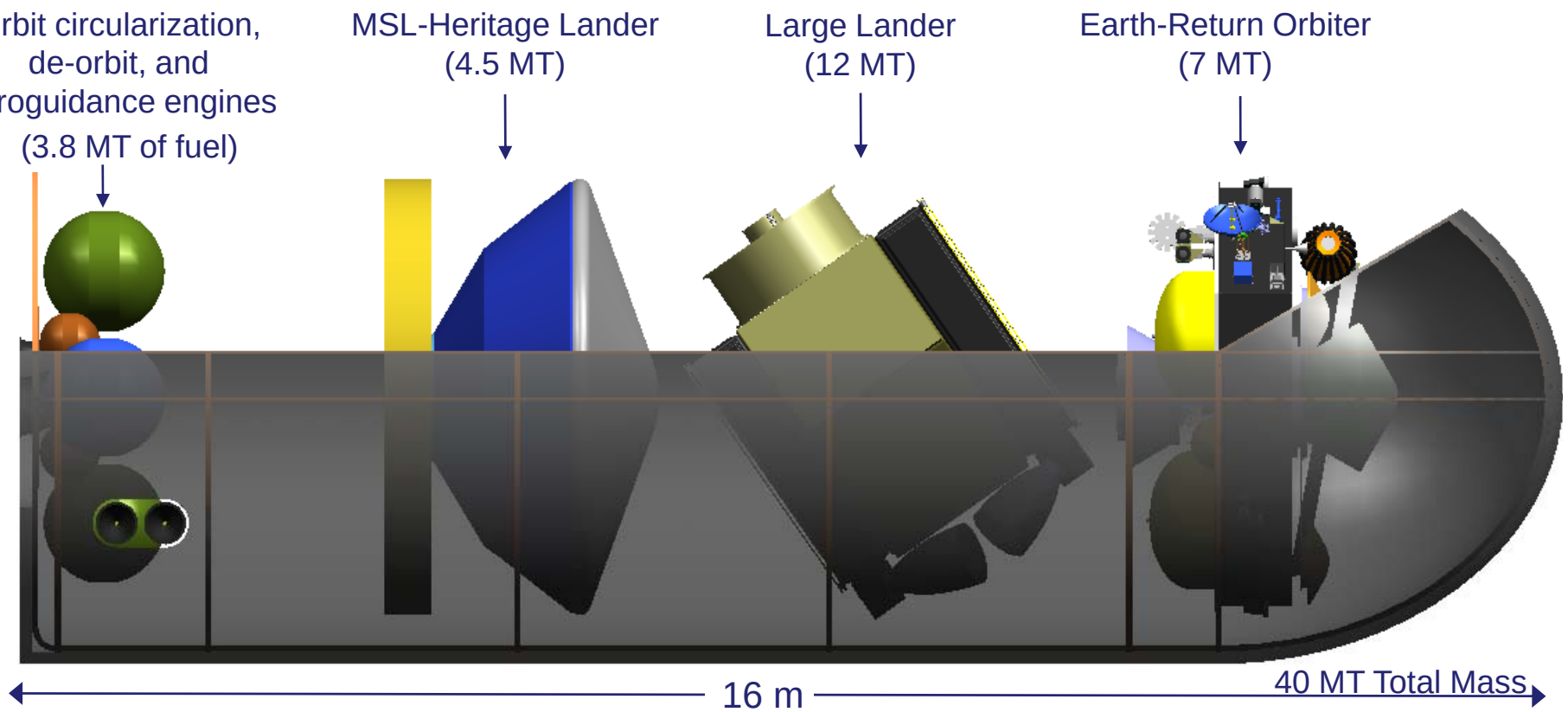
Candidate Flight System to Mars - Option 2 (Single MSL-Heritage Lander)



Total mass at aerocapture entry: 40 MT

Jettison 1 lander, orbiter, cruise solar panels, telecom and thermal - 13 MT

Enter for descent: 24 MT ← Ballistic # okay

Leaves 11.5 MT for aeroshell* ← Adequate mass for aeroshell

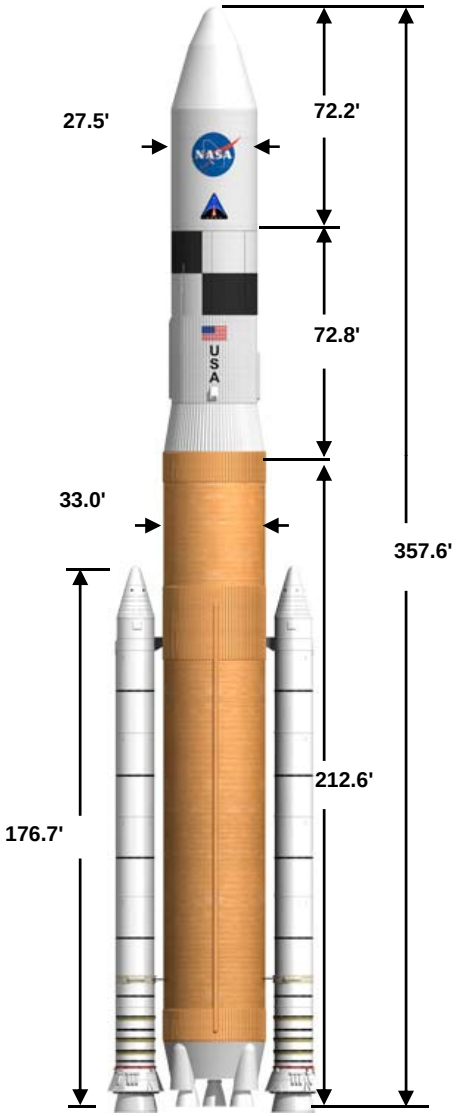
(TPS, structure, mechanical)

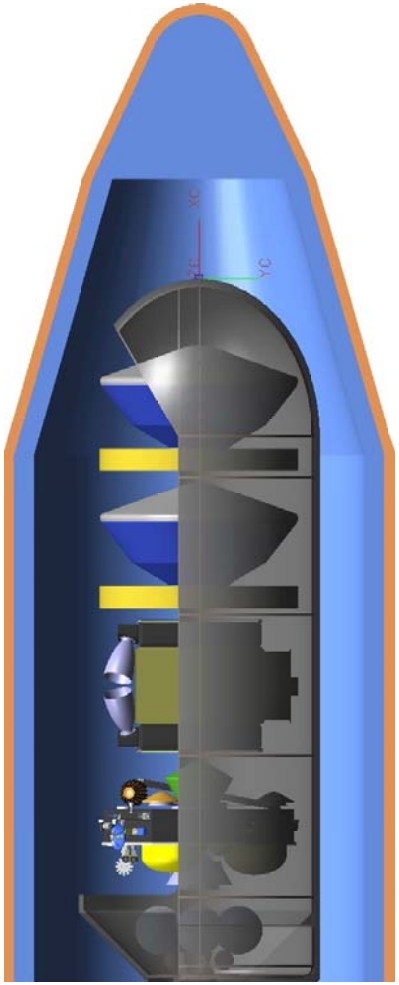
after subtraction of propstage

Ares V Launch Vehicle

- Launches ~40MT vehicle to Mars with a C_3 of 15 $(km/s)^2$
- Provides launch adapter for payload
- Provides a standard ARES V shroud
- Shroud dynamic envelope

  12m x 7.5m dia, + 6.3m x 7.5m dia. tapered to 3.9m dia.





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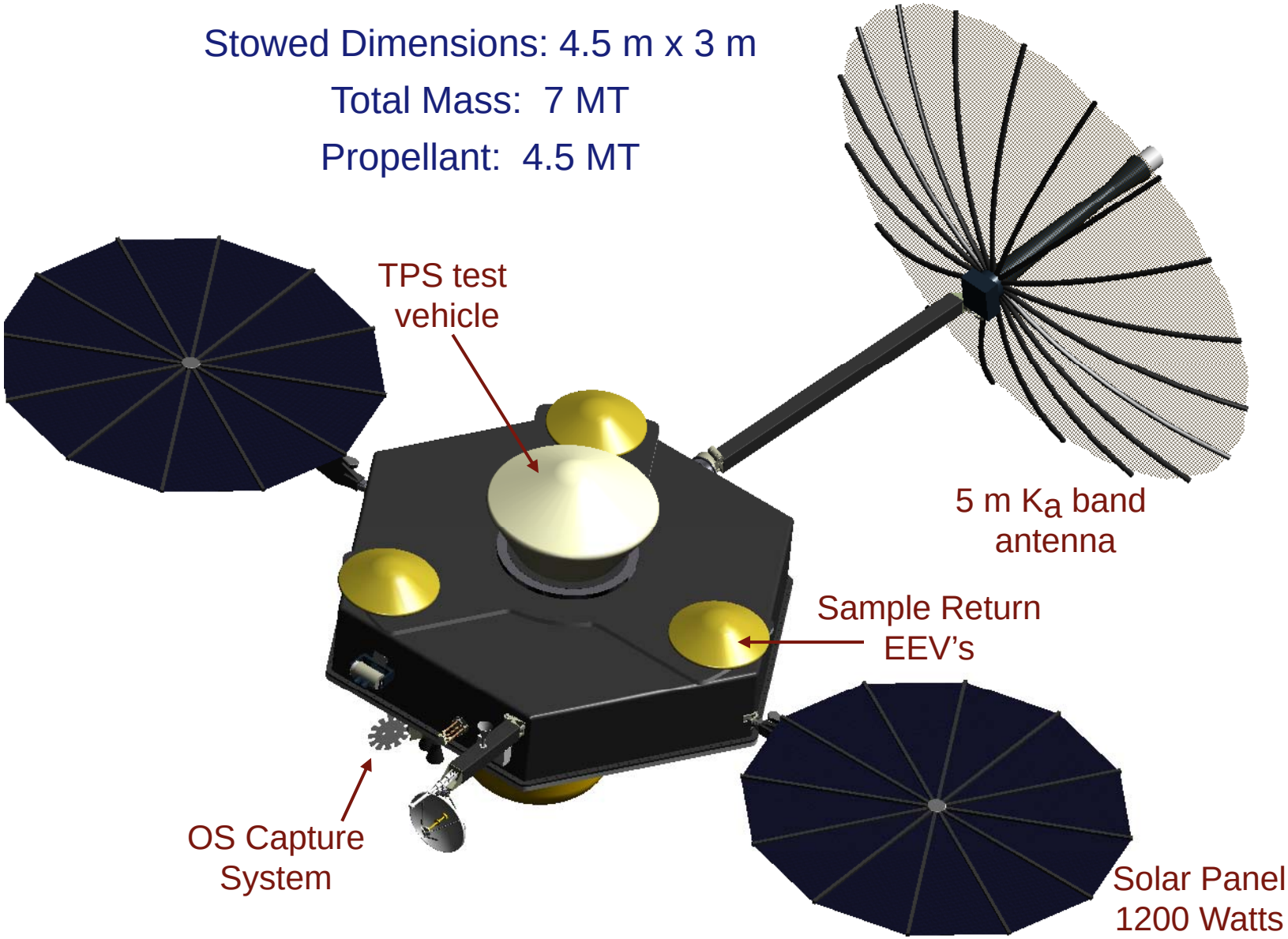
Orbiter - Earth Return Vehicle Concept

Stowed Dimensions: 4.5 m x 3 m

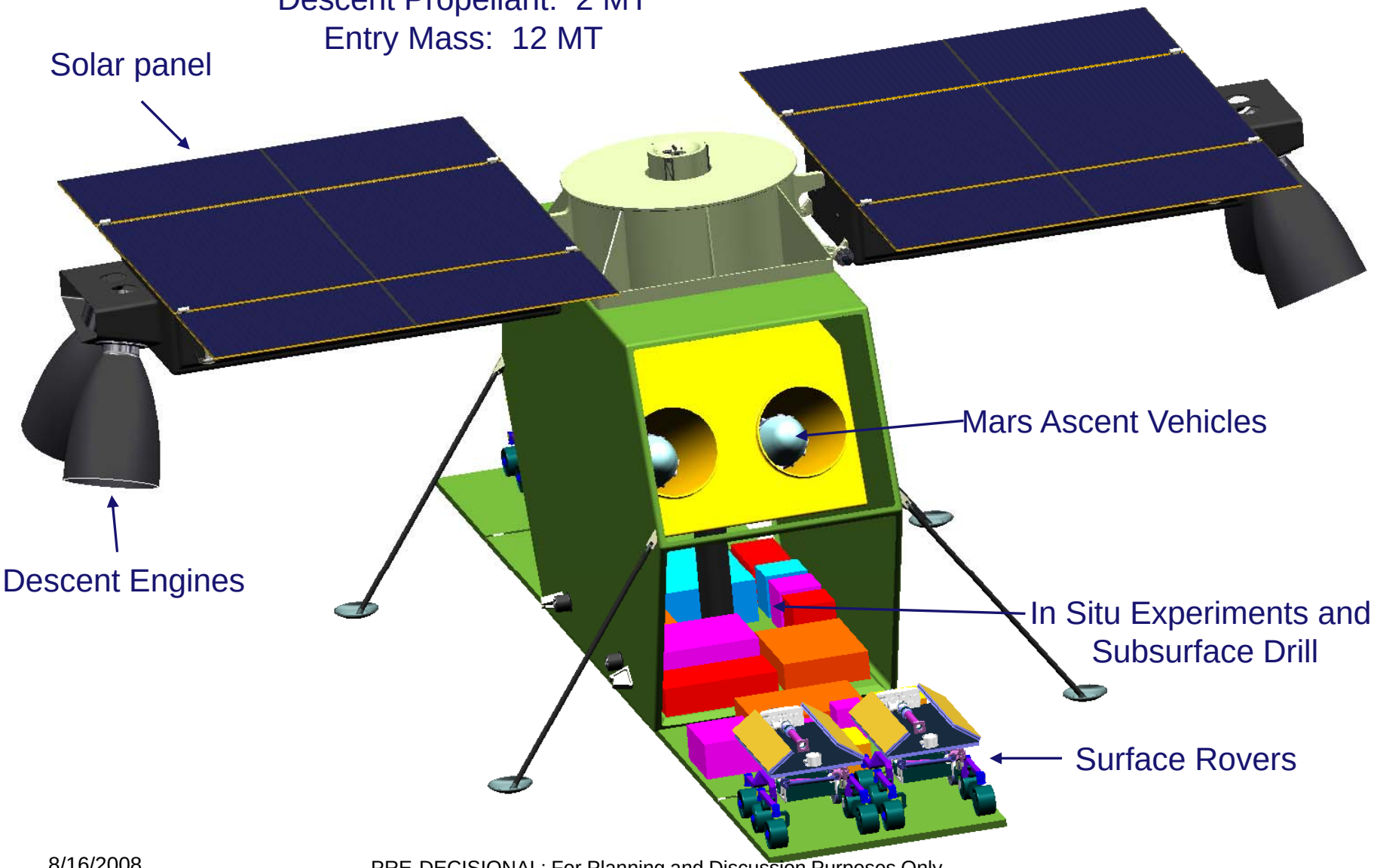
Total Mass: 7 MT

Propellant: 4.5 MT

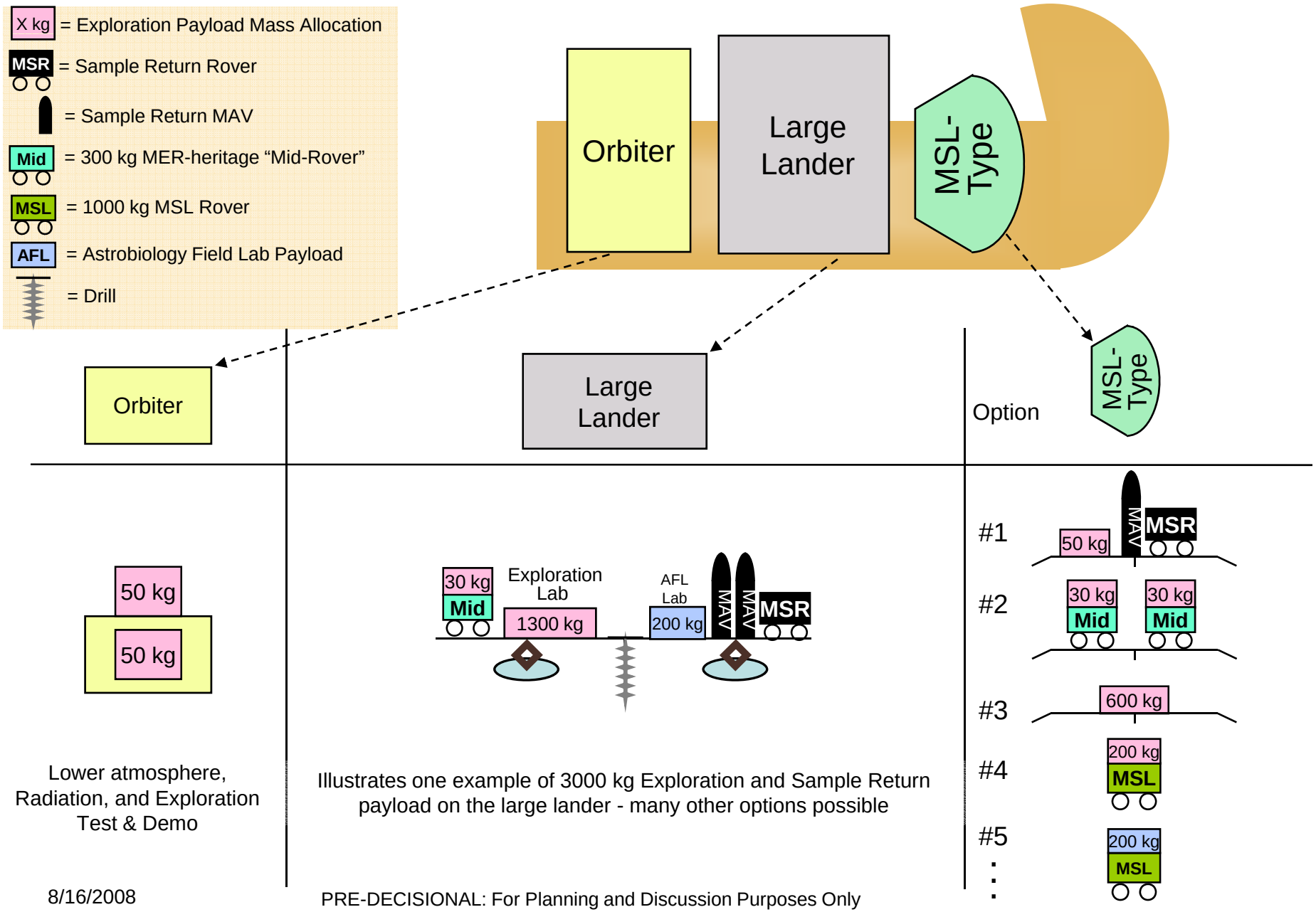


Large Lander Concept
(Front View)

Stowed Dimensions: 4.5 m x 3 m
Dry Mass: 8 MT
Descent Propellant: 2 MT
Entry Mass: 12 MT



Payload Opportunity Diagram



Summary

- The proposed aerocapture and entry vehicle, high-Mach decelerator, and entry trajectory parameters have no flight heritage and are technologies that must be developed before this mission could be flown

- Assuming these technologies can be developed, this study showed that a good candidate mission exists which would:
  - Provide ESMD human mission feed forward technology
  - Satisfy most MEPAG goal IV science requirements
  - Meet the original objectives of the study
  - Satisfy all of the major driving requirements of the study, including multiple returns of Mars samples to Earth