OVERVIEW OF A PRELIMINARY DESTINATION MISSION CONCEPT FOR A HUMAN ORBITAL MISSION TO THE MARTIAN MOONS.

D. D. Mazanek[1], P. A. Abell[2], J. Antol[1], B. W. Barbee[3], D. W. Beaty[4], D. S. Bass[4], J. C. Castillo-Rogez[4], D. A. Coan[2], A. Colaprete[5], K. J. Daugherty[1], B. G. Drake[2], K. D. Earle[1], L. D. Graham[2], R. M. Hembree[2], S. J. Hoffman[2], S. A. Jefferies[1], R. Lewis[4], M. L. Lupisella[4] and David M. Reeves[1]

[1] NASA Langley Research Center, Hampton, Virginia 23681
[2] NASA Johnson Space Center, Houston, Texas 77058
[3] NASA Goddard Space Flight Center, Greenbelt, Maryland 20771
[4] Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California 91109
[5] NASA Ames Research Center, Moffett Field, California 94035

Introduction: The National Aeronautics and Space Administration's Human Spaceflight Architecture Team (HAT) has been developing a preliminary Destination Mission Concept (DMC) to assess how a human orbital mission to one or both of the Martian moons, Phobos and Deimos, might be conducted as a follow-on to a human mission to a near-Earth asteroid (NEA) and as a possible preliminary step prior to a human landing on Mars. The HAT Mars-Phobos-Deimos (MPD) mission also permits the teleoperation of robotic systems by the crew while in the Mars system. The DMC development activity provides an initial effort to identify the science and exploration objectives and investigate the capabilities and operations concepts required for a human orbital mission to the Mars system. In addition, the MPD Team identified potential synergistic opportunities via prior exploration of other destinations currently under consideration.

Activity Goal: The primary goal of the activity was to determine whether an opposition-class mission (short-stay mission of ~30-90 days at Mars) provides sufficient time to meet all or most of the science and exploration objectives at Phobos and Deimos, or if a conjunction-class mission (long-stay mission of ~450-540 days at Mars) is required.

Study Areas: This presentation will provide a brief overview of the HAT MPD activity, including discussions of the following seven study areas that were investigated: 1) science objectives and requirements formulation; 2) exploration objectives and requirements formulation; 3) destination activity implementation strategy; 4) mission implementation strategy; 5) synergies with cis-lunar activities; 6) synergies with human and robotic precursor missions to NEAs; 7) robotic precursor requirements for a human mission to Mars orbit and its moons.

Science Objectives and Requirements Formulation. Identify and prioritize the scientific objectives and requirements for a Mars orbital mission, including small body origin/geology and field science through sampling and geophysical station deployment, Mars geology through the possible collection of Martian meteorites from Phobos, and completing the Mars Sample Return (MSR) mission by retrieving the sample cache from low Mars orbit after ascent from the surface. Additionally, identify possible science opportunities during the transit to the Martian system.

Exploration Objectives and Requirements Formulation. Gather and articulate the exploration goals and objectives for the human exploration of Phobos and Deimos pertinent to Mars exploration, including orbital missions, surface missions, and preparation for sustained human presence in the Mars system.

Destination Activity Implementation Strategy. Determine whether a worthwhile human mission to Phobos and Deimos can be accomplished with a high degree of confidence during an opposition-class (short-stay) mission opportunity. Determine operational timeline and required equipment, and formulate tele-robotic operations (moons and Mars surface) and extravehicular acitivity (EVA) support strategies.

Mission Implementation Strategy. Formulate the overall MPD mission exploration strategy options and provide a preliminary analysis of trajectories within the Martian system to facilitate the destination activities.

Synergies with Cis-lunar Activities. Identify how cis-lunar space missions and activities can provide preparation for an MPD mission and how an MPD mission might enhance cis-lunar activities.

Synergies with Human and Robotic Precursor NEA Missions. Identify synergies between human and robotic NEA missions and Phobos/Deimos missions. Determine the information and experience that can be gained from NEA missions prior to Mars system missions and assess the associated advantages.

Robotic Precursor Requirements for a Human Mission to Mars Orbit and its Moons. Identify the strategic knowledge gaps (SKGs) and required robotic precursor measurements necessary to address them prior to a short-stay human orbital mission to interact with Phobos and Deimos.

Activity Conclusions: Preliminary results from the MPD activity indicate that a meaningful human orbital mission to explore both Martian moons and robotically retrieve a MSR cache from low Mars orbit

could be performed during an opposition-class mission opportunity. The initial destination mission plan indicates that 56 days are required to accomplish all science and exploration objectives. Margin and mission reduction opportunities provide confidence that a successful and worthwhile mission could be completed within 60-90 days in the Mars system. Preliminary parametric based estimates of the expected initial mass in low-Earth orbit (IMLEO) for a transportation architecture utilizing nuclear thermal propulsion to support an opposition-class mission (total duration of approximately 550 days) range from 350 to over 1000 metric tons. The IMLEO is highly dependent on the Mars departure opportunity, with 2033 offering a minimum in the 2030-2040 timeframe. Detailed mass sizing and volumetric analyses are needed to validate these initial estimates. Finally, the results from each of the activity study areas provide valuable information regarding the development of a human MPD mission and the synergistic activities required prior to undertaking such an exploration endeavor.

Summary: Through a comprehensive approach starting with the development of key mission objectives and working through activity implementations and overall mission implentation strategies, our preliminary results suggest that an opposition-class mission to Phobos and Deimos could meet the identified objectives. In addition, there are key synergies to leverage with human missions to cis-lunar destinations and NEAs. Robotic precursor missions to Phobos and Deimos would provide dramatic risk reduction by addressing strategic knowledge gaps early enough to inform human mission design**.**