Rough Lander Concept for Mars Exploration

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Introduction

Exploration of the Martian surface has proceeded at a slow pace during the past three decades, due in large part to the sheer technical difficulty and cost of reaching the surface safely. Several different engineering approaches to entry, descent, and landing (EDL) have been employed in previous missions, using combinations of aerodynamic and propulsive deceleration to reach some desired terminal velocity near the surface, coupled with mechanical elements for shock attenuation and arresting of the vehicle's motion upon contact. With one exception, the EDL systems used in NASA's Mars missions such as *Viking*, *Mars Pathfinder*, and *Mars Polar Lander*, have been designed to limit the impact load factors experienced by landed elements to the 20-50 g range (relative to the terrestrial value of "g," or 9.8 m/s^2). The sole variant from this has been the experimental development of two small (3 kg) penetrators, designed to tolerate up to 40,000 g's at impact. Although low in cost relative to larger, "soft" landers, the shock environment associated with penetrators places severe limits on payload size and capability.

The proposed paper will describe an alternative Mars lander concept, a "rough" lander, designed to provide an intermediate landed payload capability targeted toward first use in NASA's Mars Scout Program in 2007-2008. The Rough Lander concept provides an impact shock environment in the 500-2,000 g range, low enough to accommodate a variety of modern scientific instruments, ruggedized electro-mechanical components, electronics, and power sources, but large enough to enable a substantial reduction in EDL system complexity and cost relative to soft landers. In addition, the ruggedness and simplicity of this concept may allow access to areas of the Martian surface that are otherwise too risky for all but the most sophisticated soft landers. Similarities and differences between the proposed concept and earlier, similar concepts for Lunar and Mars exploration dating back to the 1960's[1-3] will be explored as well.

As an example of this concept, a conceptual Rough Lander flight system design proposed for the 2007 Mars Scout opportunity will be presented, including top-level functional requirements, reference mission scenario, configuration, and payload accommodation capabilities. The projected landing site access capability for the 2007 launch opportunity will also be illustrated. Design trade-offs and alternative approaches considered during the formulation of this system will be outlined, including the incorporation of experience from similar terrestrial systems, where applicable.[4] Attributes of the design focused on minimizing development costs, such as the tailoring of mission parameters to enable flight-like subsystem testing in a terrestrial environment, as well as those focused on maximizing vehicle performance (in terms of science data return), will receive special emphasis. Finally, the applicability of this design to Mars mission opportunities beyond 2007 will be considered, as well as the potential for using other variants on the rough lander concept for the exploration of other planets and natural satellites besides Mars.

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Biography

Sam Thurman received his BS and MS degrees in Aeronautics and Astronautics from Purdue University (1983) and Massachusetts Institute of Technology (1985), respectively, and a PhD degree from the University of Southern California in Aerospace Engineering (1995). Over the past 15 years he has worked in a variety of positions at NASA's Jet Propulsion Laboratory, ranging from applied research and development to spacecraft design, systems engineering, and mission operations. He was the entry, descent, and landing systems engineer for the Mars Pathfinder mission, for which he later received the NASA Exceptional Achievement Medal. He went on to work as Project Engineer and later Mission Manager for both the Mars Climate Orbiter and Mars Polar Lander missions. Since then he has served as the Entry/Descent/Landing systems manager and later Deputy Manager of the Mars Smart Lander Project. Most recently he has participated in several proposal development efforts for new missions in NASA's Mars Scout and New Millennium Programs.

Tom Rivellini received his BS degree in Aerospace Engineering from Syracuse University in 1989 and his MS degree, also in Aerospace Engineering, from the University of Texas at Austin in 1991. He has been working at NASA's Jet Propulsion Laboratory since then, primarily in the development of Martian entry, descent, and landing systems. Tom has worked on several different projects within the Mars Exploration Program including Mars Pathfinder, Deep Space-2, Mars Sample Return and Mars Exploration Rover. He was the lead engineer for the airbag subsystem in the Mars Pathfinder mission, for which he was later awarded the NASA Exceptional Achievement Medal. In addition, Tom was the recipient of the AIAA Engineer of the Year award in 1998 for his role in Pathfinder. He went on to serve as the lead mechanical engineer for the New Millennium Deep Space-2 Micro-probe mission. Most recently, he has been leading the development of an advanced landing system for the Mars Smart Lander Project.