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Introduction: Mars Science Laboratory: The Next Generation of Mars Landers

THE Mars Science Laboratory (MSL) will provide scientists with access to previously inaccessible landing sites by providing precision landing within less than 10 km of a target landing site, at landing sites with elevations up to 2.5 km. With these capabilities, MSL will be the first lander in a new generation of landers, providing near-global access to the Mars surface. The first-generation landers, Viking and Pathfinder, provided successful landing on Mars but by design were limited to large-scale, hundreds-of-kilometer, landing sites with minimal local hazards. Similar to Pathfinder, the Mars Exploration Rover landers used a ballistic entry at Mars with approximately 80-km landing footprints. The MSL technology will not only provide the capability to achieve the science goals defined for MSL but will provide capability needed for a range of mission classes including Mars Sample Return missions, potential Mars Scout missions, and human exploration missions. In addition, MSL provides the starting point for future pinpoint landing capability, landing within hundreds of meters from a target landing site.

Several design variants of the MSL have been developed over the past several years. Work presented in this special section will include that completed to support a 2007 MSL design (named the Mars Smart Lander).

The primary events in the Mars Smart Lander entry, descent, and landing sequence are illustrated in Fig. 1. The spacecraft is guided and navigated to the target entry corridor. Once the spacecraft encounters the Martian atmosphere, the entry guidance logic is activated. The guidance system computes bank angle commands to direct the capsule's lift vector, shown in Fig. 2, such that the desired position relative to the target landing site is achieved at the correct supersonic parachute deploy conditions. The bank angle magnitude is used to control the total range, and the bank angle direction is used to control cross range. Guided aeromaneuvering during entry is the technology that results in landing accuracies of less than ± 10 km from the target.

Deployment of the supersonic parachute is triggered by the entry guidance logic to be within the Viking parachute qualification box of Mach 1.13–2.2 and dynamic pressures of 239–850 Pa. The supersonic parachute is a derivative of the Viking mortar-deployed parachute and serves as a drogue parachute in this entry descent lander system, decelerating the spacecraft to subsonic velocities. Once the vehicle reaches approximately Mach 0.8, the backshell and supersonic parachute are jettisoned, and a much larger subsonic main parachute is deployed to further reduce the vehicle velocity to terminal velocities of 40–50 m/s before initiation of powered descent. Once on the subsonic parachute, the heatshield is released.

During subsonic parachute descent, terrain-relative navigation is initiated, allowing the onboard navigation system to accurately determine the spacecraft's surface-relative altitude and velocity. In the 1.5–1.0-km above-ground-level range, a scanning lidar begins periodically generating local elevation maps of the area surrounding the projected landing site. The lidar elevation maps are used to identify any potential hazards. Results are used by the guidance system to redesignate the target site to a safer location if necessary. Hazard detection and avoidance continues during powered descent to allow redesignation of the landing site as necessary. Powered descent concludes with thrust termination approximately 1 m above the surface, resulting in velocity components at touchdown well within the capabilities of the landing/arrest approaches under consideration.

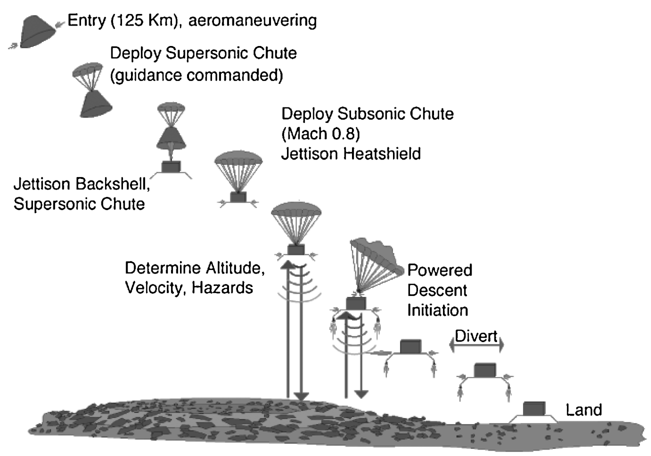

Fig. 1 MSL entry, descent, and landing sequence of events.

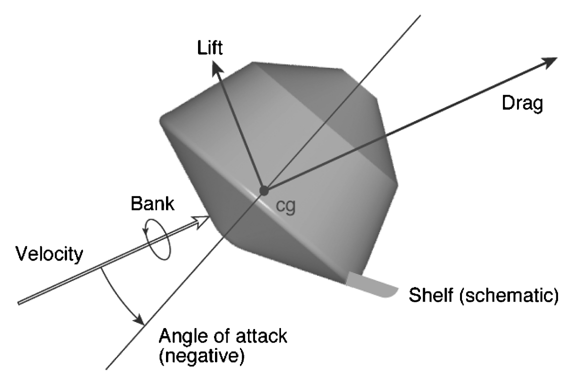

Fig. 2 Entry body lift, drag, and bank.

This issue of the *Journal of Spacecraft and Rockets* includes 13 papers on Mars Smart Lander entry, descent, and landing completed by a consortium of NASA centers, government agencies, industry, and academic institutions. Specific topics include entry body configurations and performance comparisons; aerothermodynamics, experimental and computational; entry, descent, and landing simulation; onboard entry, descent, and landing navigation; atmospheric flight entry vehicle control; thermal protection systems; parachute simulation; and powered descent guidance and control.

Mary Kae Lockwood
Guest Editor