The Challenges of Landing on Mars
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(1) People have been fascinated with the idea of exploring Mars since the very beginning of the space age. Largely because of the belief that some form of life may have existed there at one time, surface exploration has been the ultimate ambition of this exploration. Unfortunately, engineers and scientists discovered early on that landing a spacecraft on the surface of Mars would be one of the most difficult and treacherous challenges of robotic space exploration.

(2) Upon arrival at Mars, a spacecraft is traveling at velocities of 4 to 7 kilometers per second (km/s). For a lander to deliver its payload to the surface, 100 percent of this kinetic energy must be safely removed. Fortunately, Mars has an atmosphere substantial enough for the combination of a high-drag heat shield and a parachute to remove 99 percent and 0.98 percent respectively of the kinetic energy. Unfortunately, the Martian atmosphere is not substantial enough to bring a lander to a safe touchdown. This means that an additional landing system is necessary to remove the remaining kinetic energy.

(3) On previous successful missions, the landing system consisted of two major elements, a propulsion subsystem to remove an additional 0.002 percent (~50 to 100 meters per second [m/s]) of the original kinetic energy and a dedicated touchdown system. The first-generation Mars landers used legs to accomplish touchdown. The second generation of touchdown systems used air bags to mitigate the last few meters per second of residual velocity. The National Aeronautics and Space Administration (NASA) is currently developing a third-generation landing system in an effort to reduce cost, mass, and risk while simultaneously improving performance as measured by payload fraction to the surface and the roughness of accessible terrain.

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