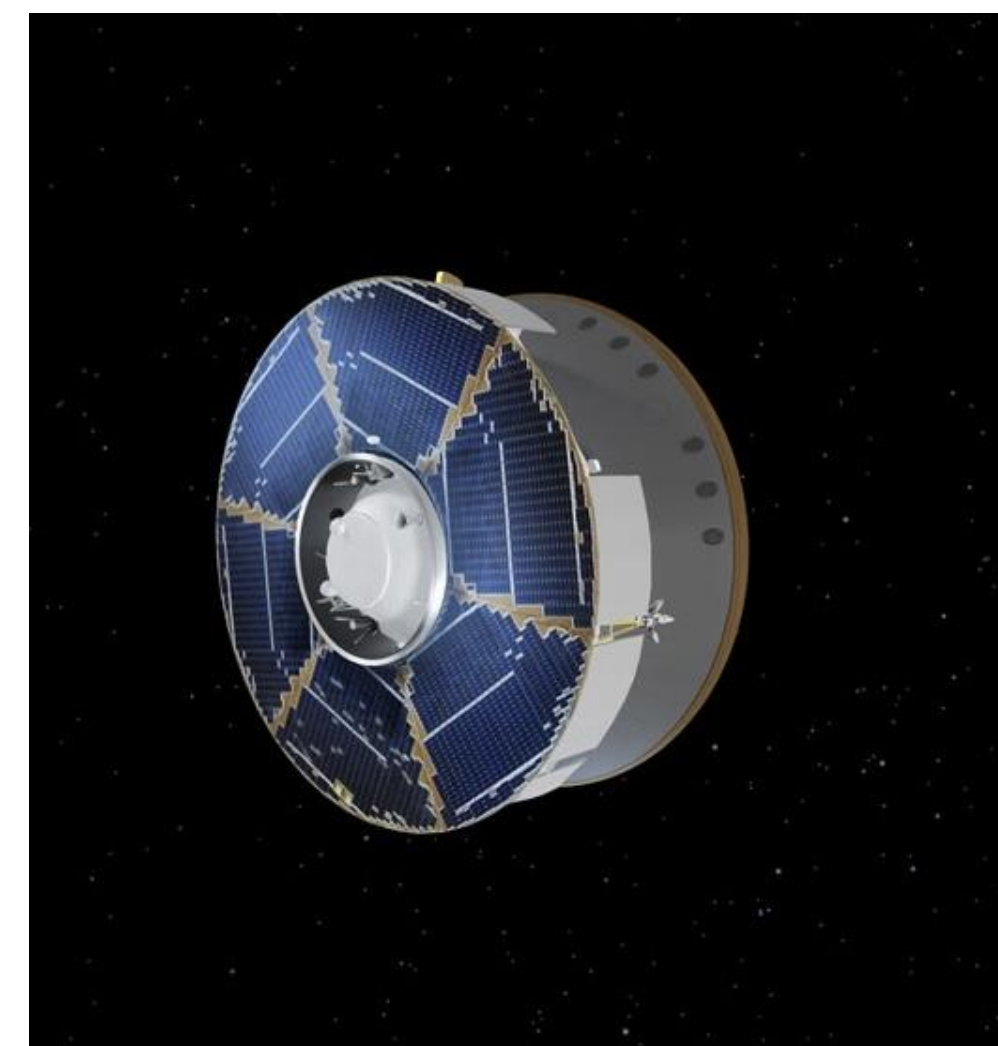


PURPOSE/FOCUS

We discuss the mathematical data, issues and equations related to the 2020 Mars mission that culminated in the Perseverance rover landing on Mars. The success of MARS 2020 program depended on many variables, and we analyze them including trajectories, forces, materials and changeable conditions.



TIMELINE

- Launch
 - Launched at Cape Canaveral Air Force Base on the 30th of July 2020.
 - Launch vehicle was the Atlas V Rocket, which is credited with 76 successful launches since 2007.
 - The Tsiolkovsky (Ideal) Rocket Equation is the basis for all rocket-based travel beyond the atmosphere

$$\Delta V = v_e * \ln\left(\frac{m_0}{m_f}\right)$$

- Interplanetary Cruise
 - Required over 200 days to travel almost 300 million miles from Earth to Mars at speeds of 24,600 mph.
 - Used the Hohmann Transfer Orbit to get from Earth's orbit to Mars' orbit. H.T.O. has a launch window that occurs approximately every 26 months.
 - Uses Newton's first law, Kepler's laws of planetary motion, and the principle of conservation of mechanical energy.

Vis-Viva Equation

$$v^2 = \mu \left(\frac{2}{r} - \frac{1}{a} \right)$$

Time of Flight

$$t_H = \frac{1}{2} \sqrt{\frac{4\pi^2 a_H^3}{\mu}} = \pi \sqrt{\frac{(r_1 + r_2)^3}{8\mu}}$$

Tangential Velocities

$$\Delta v_1 = \sqrt{\frac{\mu}{r_1}} \left(\sqrt{\frac{2r_2}{r_1 + r_2}} - 1 \right)$$

$$\Delta v_2 = \sqrt{\frac{\mu}{r_2}} \left(1 - \sqrt{\frac{2r_1}{r_1 + r_2}} \right)$$

- Entry, Descent, & Landing (EDL)
 - Occurred on the 18th of February 2021.
 - Time required for EDL was approximately 7 minutes.
 - Guided entry reduces the size of the targeted ellipse-shaped landing area, and compensates for variations in the density of the Martian atmosphere and drag.
 - The rover was lowered to Mars' surface by the missions hovering sky crane.

RESULTS/FINDINGS

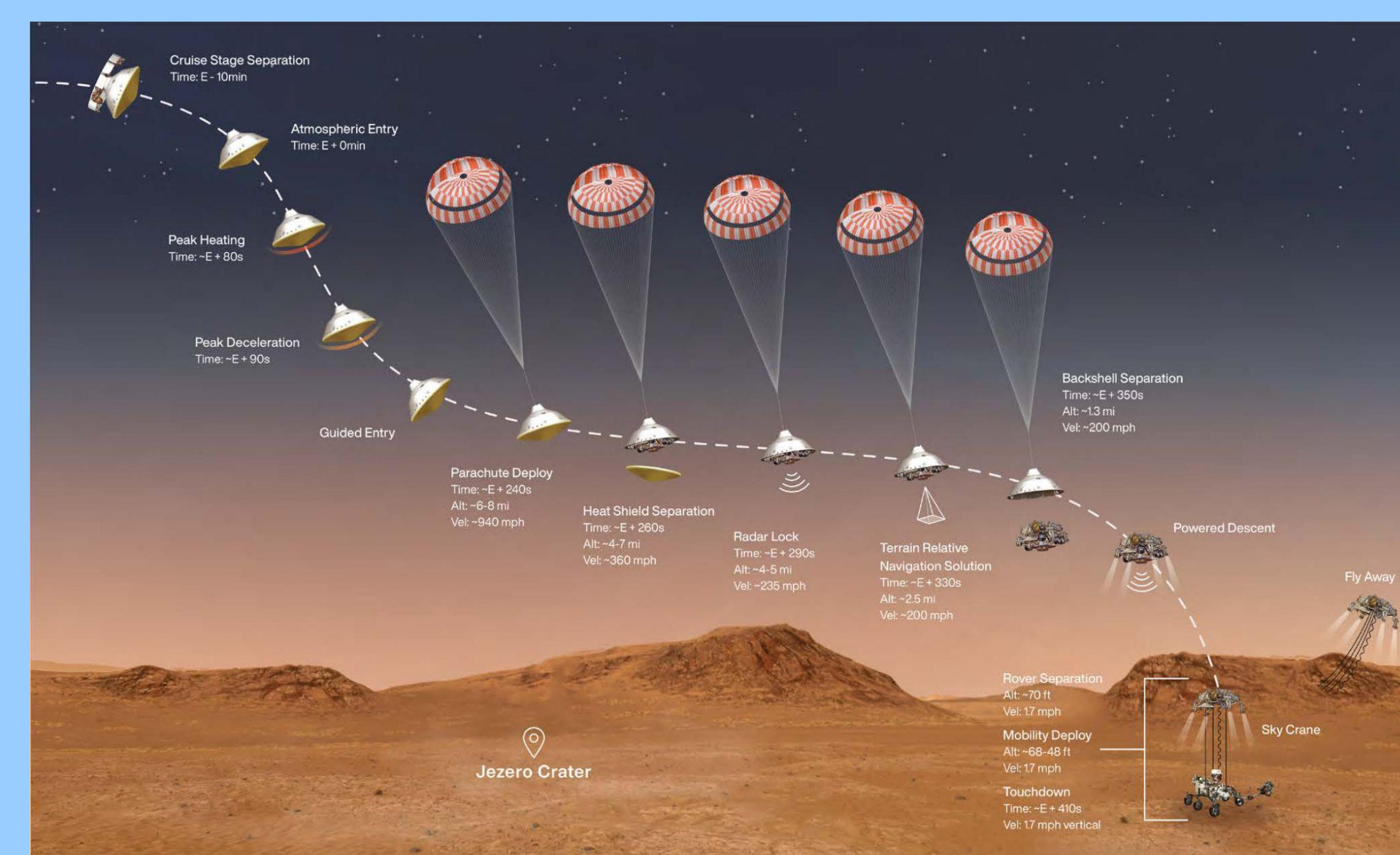
The Perseverance Rover successfully landed on Mars and began its surface mission.



Image of the Perseverance Rover



Graphic of the Hohmann Transfer Orbit



Depiction of the Landing Process

PRACTICAL IMPLICATIONS

The Perseverance Mars mission has four main goals:

1. Determine if life existed on Mars:
 - Perseverance rover will focus on surface-based studies in order to seek signs of biosignatures in rock samples and conditions favorable to life.
2. Analyse Mars's Climate:
 - Analyzing Mars climate for evidence of habitable environments which would allow life to exist in the past.
3. Characterize Mars's Geology:
 - Study of rock samples in Mars crust and surface in order to determine evidence of rocks formed in water and any chemical building blocks of life.
4. Prepare for Human Exploration on Mars:
 - Determine any natural resources in Mars environment for life support and fuel.
 - Understanding Mars environment for future human explorers.

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