A MOTORCYCLE FOR THE MOON AND MARS

Kiefer Juliano[1] and Pascal Lee[1,2,3,4]
[1]Mars Institute; [2]SETI Institute; [3]Kepler Space University, [4]NASA Ames Research Center.
E-mails: kieferjuliano2025@gmail.com, pascal.lee@marsinstitute.net.

Summary: A design concept for a future motorcycle for astronauts on the Moon and Mars is presented.

Introduction: Astronauts on the Moon and on Mars will need transportation vehicles to conduct a wide variety of surface activities: exploration, science, logistics, etc. Motorcycles have been proposed as individual astronaut transports for the Moon and Mars [1-3]. During Apollo, a "*Lunar Motorbike"* (40 kg or ~ 90lbs, 5/8 hp, 30 Ah battery, frame & beeswax-cooled) was considered as a potential alternative to the *Lunar Rover*, and underwent early prototyping and testing, including on parabolic flights simulating lunar gravity **(Fig. 1)**. While the Apollo motorcycle never flew, the idea of a lightweight single astronaut transport remains relevant. Over the years, more conceptual designs of Moon and Mars motorcycles were created, but generally with few actual EVA (Extra-Vehicular Activity) engineering, operations, and safety constraints addressed in their design [*e.g.,* 4-6].

Figure 1. Apollo "Lunar Motorbike": *Testing under simulated lunar gravity (NASA).*

This Study: We revisited the idea of an astronaut motorcycle in context of current plans to send astronauts back to the Moon as part of NASA's Artemis Program, and soon on to Mars. A low-mass, low-power, high-torque, nimble, rugged, rechargeable electric motorcycle would be a useful and versatile means of short-range transportation at these destinations. Because a motorcycle is fundamentally intended to transport just its rider and not substantial cargo, the Moon/Mars motorcycle is envisioned as a convenience vehicle for astronauts to economically and swiftly roam around their base or a remote outpost site, to access and tend to a wide range of local but distributed assets, for instance rocket landing/launch pad areas away from base habitats, powerplants, comms antenna arrays, deployed instruments, monitoring stations, observatories, and more. The motorcycle would not only reduce EVA time compared to walking to/from these distributed assets, it would limit astronaut metabolic expenditure and physical fatigue, spacesuit wear & tear, and life support system consumables use.

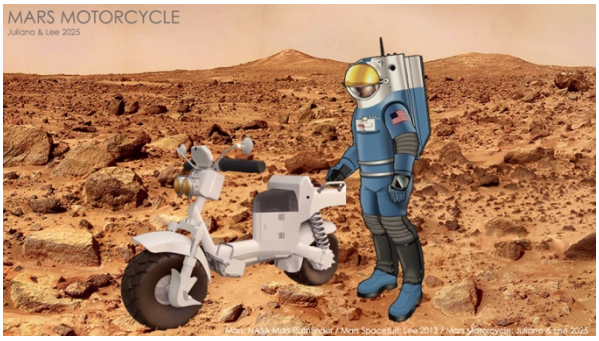

Figure 2. Astronaut with Mars Motorcycle.

Concept: While surface environments on the Moon and Mars are significantly different and would require specific design accommodations due in particular to differences in gravity and thermal conditions, our concept design focuses on ergonomics associated with mounting, dismounting, and riding, producing a configuration applicable, to first order, to both the Moon and Mars. For traction and robustness in the lunar and Martian rocky surface environments, and given also abundant sand on Mars, the Moon/Mars motorcycle features low ground pressure (but non-pneumatic) stubby mesh tires and high ground clearance (20 cm or ~8 in.). For ease of ground handling, in particular for uprighting the motorcycle resting on its side or to move or transport it without riding, the motorcycle is lightweight (70 kg or ~155 lbs). For riding stability, in particular to allow for a rider wearing a top-heavy spacesuit, the Moon/Mars motorcycle has a low center of gravity (CG). While there remain concerns, already identified during Apollo, that lunar gravity might be too low for safe riding a lightweight motorcycle while wearing a high inertia, 100 kg (~220-lb) Apollo-class spacesuit, let alone the heavier Artemis AxEMU suit, the future lightweight 60 kg (~132-lb) spacesuit needed for Mars [7] would enable more agile, less top-heavy riding.

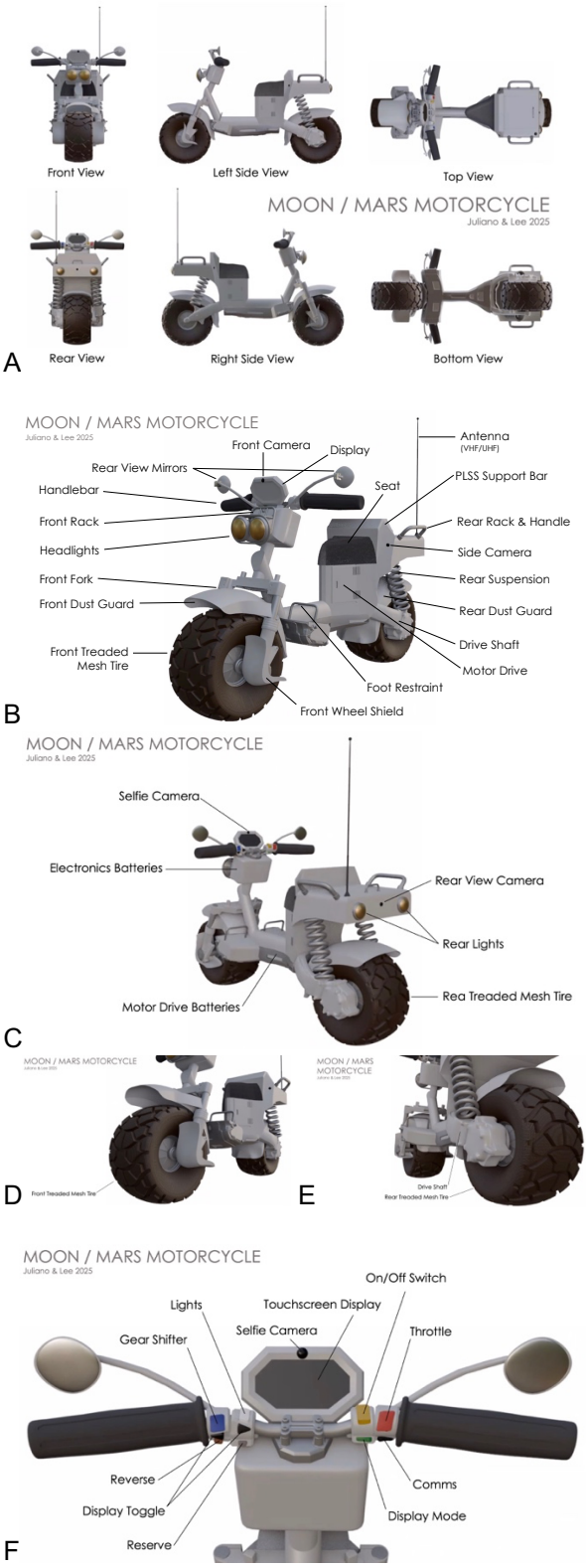

***Figure 3. The Moon / Mars Motorcycle. A**: Plan views; **B & C**: Main features. **E & F:** Wheels; **F**: Handlebar, controls, display, and mirrors. (CAD by K. Juliano using Blender 3.1).*

Design: Highlighted below are specific design features of the Moon / Mars motorcycle **(Fig. 3):**

Electric Motor and Wheels: An electric motor producing 2 hp and driven by rechargeable 40 Ah batteries, located under the seat, drives the motorcycle's rear wheel via a sealed drive shaft. The wheels have non-pneumatic treaded mesh tires. The front axel is protected from rock impacts by wheel shields.

Seat. Leg splitting to straddle a motorcycle is problematic in a pressurized spacesuit. The seat nose is designed to be narrow with slanting side walls to allow riding with limited leg splitting.

Beam & Legroom. Ample open legroom is available between seat and controls. The frame's central beam is load-bearing but narrow, allowing easy mounting/dismounting with limited leg splitting. The sturdy beam is placed low to keep the CG low.

Foot Rest & Restraints. Front foot rests and restraints allow spacesuit boots to be supported and lightly secured during riding.

PLSS Support Bar (PSB): Located behind the seat, the PSB supports the spacesuit's portable life support system (PLSS) as needed.

Handlebar. The handles are thick to allow easy grip with pressurized spacesuit gloves. Handle tips are robust to allow motorcycle to rest on ground.

Rear Handles. These allow the motorcycle to be easily uprighted from resting on the ground.

Control buttons. Allow easy function selection and motorcycle operation using a pressurized spacesuit's thick and rigid gloves.

Rear View Mirrors. These are adjustable in length and height as needed.

Conclusion: A concept design for a Moon and Mars motorcycle was created. Such a vehicle could serve Artemis astronauts on the Moon and future astronauts on Mars.

Acknowledgments: This work was supported in part via NASA Coop Agreement NNX14AT27A and via NASA grant award 80NSSC21M0004.

References: [1] Beeler, J. 2010. Motorcycling on the Moon, https://t.ly/Hpcbb; [2] Stumpf, R. 2020. NASA's iconic lunar rover was almost an electric dirt bike, https://t.ly/7NJcO; [3] Toll, M. 2020. Believe it or not, the lunar rover was almost an electric lunar motorbike, https://t.ly/lZswG; [4] Boshri W. et al. 1999. The exploration of Mars: Crew surface activities, https://t.ly/P4aOk; [5] Hookie.co 2021. Tardigrade, https://t.ly/3UNFD; [6] Hookie.co 2025. Tardigrade 2, https://t.ly/qgU4u; [7] Lee, P. 2025. Astronaut+ATV: A solution to the Mars spacesuit weight problem. ISDC-2025, Mars Track, #2004, https://t.ly/7yUhO.