

Dust Mitigation Roadmap. J.H. Litofsky, NASA Johnson Space Center (Contact: joshua.h.litofsky@nasa.gov)

Introduction: As humans return to the Moon and set their sites on Mars with spacesuits, rovers, habitats, and other assets during the Artemis missions, the lunar and Martian regolith (i.e. dust) covering the surface will be an environmental and performance challenge to nominal and contingency operations. Accounts from Apollo astronauts and analysis of hardware returned from the surface illustrate just how deleterious the dust can be [1]. During Apollo missions, the lunar dust adhered to the spacesuits mechanically and electrostatically, and the rovers experienced mechanical malfunctions [2]. The Exploration Systems Development Mission Directorate (ESDMD) defines and manages systems development for programs critical to NASA's Artemis program and planning for NASA's Moon to Mars (M2M) exploration approach. ESDMD manages the human exploration system development for lunar orbital, lunar surface, and Mars exploration [3].



Credit: NASA

Technology Maturation: The ESDMD M2M Extravehicular Activity (EVA) and Human Surface Mobility (HSM) Program (EHP), Gateway Program, and Human Lander System (HLS) Program collaborate to address dust mitigation needs, gaps, and solutions. The M2M Programs are leveraging dust mitigation technology development efforts from NASA's Space Technology Mission Directorate (STMD), as well as efforts from industry and academia.

There are several STMD-sponsored technologies in development being considered as dust mitigation solutions for the M2M Programs. STMD

dust mitigation efforts involve a series of partnerships geared at developing these technologies and advancing the state of dust mitigation at NASA. These partnerships include the Lunar Surface Innovation Consortium (LSIC), Small Business Innovation Research (SBIR), Early Stage Innovations (ESI), Space Technology Research Grants (STRG), Announcement of Collaboration Opportunities (ACOs), Tipping Points (TPs), and Challenges and Crowdsourcing, among others.

Dust Mitigation Roadmap: Using solutions from the STMD technology pipeline, ESDMD programmatic efforts, industry, and academia, a roadmap of relevant dust mitigation technology investments and needs has been created to communicate the shortfall and gap closure activities in work and needed for M2M safety and mission success. This roadmap ties knowledge data acquisition projects, technology development projects, programmatic risks, STMD shortfalls, and ESDMD architecture-driven technology gaps together to provide a long-term strategy for addressing dust mitigation across numerous surface element use cases and applications..

The dust mitigation roadmap is divided into four swim lanes:

- Dust Measurement, Modeling and Testing
- Passive Dust Mitigation Solutions
- Active Dust Mitigation Solutions
- Dust Tolerant Components

The roadmap's focus to date has been on mitigating lunar surface dust and the associated investments. The updated roadmap now lays the additional groundwork to address Martian dust mitigation.

References: [1] J. R. Gaier, NASA/TM—2005-213610, The Effects of Lunar Dust on EVA Systems During the Apollo Missions [2] T. J. Stubbs, et al. Impact of Dust on Lunar Exploration, 2005 [3] <https://www.nasa.gov/exploration-systems-development-mission-directorate/>