MATS Maglev Transportation System: A lunar transportation system with minimum dust creation using magnetic levitation principles. ExaMining LLC, M. Meinshausen, Founder and CEO, 632 Arden Ave., Glendale, CA 91202, martin_meinshausen@yahoo.com.

Introduction: Lunar dust, known as regolith, is one of the most significant challenges the rising lunar economy will face.

Quote from **Eugene (Gene) Cernan**, the commander of Apollo 17 and the last person to walk on the Moon. During a technical debrief following his mission in 1972, he famously stated:

"I think dust is probably one of our greatest inhibitors to nominal operation on the Moon. I think that we can overcome other physiological or physical or mechanical problems except dust."

The first, most crucial engineering principle is to avoid hazards through inherently safe design, which focuses on eliminating hazards rather than managing them.

This proactive strategy introduces new ideas and designs that replace hazardous practices with safer alternatives, benefiting both the immediate system and surrounding operations.

If a hazard cannot be completely eliminated, engineers follow a hierarchy, starting with the most effective method. The Hierarchy of Hazard Control begins with Elimination/Substitution, which removes the hazard.

Imagine, for a moment, that it is 2035, and NASA's Artemis team is using the dust-free Magnetic Levitation Transportation System ("MATS") to move ore and other materials across the lunar surface. The dust-free MATS mitigates risks to health, equipment, and operations.

Terrestrial Magnetic Levitation: MagLev technology, developed in the early 20th century, was first realized in the 1980s with the German Transrapid [1]. This system, which uses Electro Magnetic Suspension (EMS) to levitate a trolley via electromagnets and a C-shaped arm, was successfully tested in Germany and later implemented in Shanghai, which remains operational today. As of 2026, MagLev technology is used only for high-speed passenger transportation [1].

Key Features and Benefits of MATS:

Dust-reduced operation: Due to levitation principles [2][3], no wheels touch any tracks during operation. As the trolley moves, there is no drag because there is no lunar atmosphere [4]. ExaMining will design experiments to test whether this lack of drag eliminates dust generation in transit.

Reduced maintenance: The magnetic levitation concept's contactless design reduces maintenance and wear and tear by eliminating moving parts and system vibration. This improves system reliability, lowers costs, increases speed and efficiency, and reduces energy use and travel time.

Adaptability and scalability: ExaMining examines payloads, terrain types, weight limits, and potential track length. We are studying how many different payloads MATS can transport. We are researching tolerances for various terrain types and hill angles. Additionally, we are investigating the feasibility of a 5 km-long track as called for in [5].

Advancing the State of the Art in Lunar Transportation:
Current lunar transportation projects predominantly center on rovers utilizing tire systems [5]. These rovers rely on the surface for traction, with dust mitigation efforts focusing on the pathway itself, which could be constructed from bricks or sintered regolith. MATS would allow NASA to lift transport above the surface, providing a new dust-mitigation technique.

We evaluate how MATS will reduce particulate matter (PM) emissions per kilogram of payload (PM/kg) on the lunar surface.

MATS could travel over 7000km a year fully burdened, potentially exceeding the 155t as envisioned by NASA by an order of magnitude. [5]

Some NASA lunar concepts combine digging, hauling, and transportation into a single vehicle [5]. This is only efficient on Earth for very short distances (a few hundred feet). In terrestrial mining over longer distances (e.g., 1 mile), material is loaded into a haul truck at the excavation site, transported to the primary dump location (usually the primary crusher), and then conveyed. In terrestrial mining, combining processes into a single vehicle has been shown to be inefficient over longer distances.

MATS will provide a "long haul" option across the lunar surface, allowing rovers to traverse shorter distances and thus increase their operational efficiency. We assess that MATS might be able to exceed 5km of dust-free operation.

Technical Objectives:

- Estimate the power consumption based on the lunar gravity.
- Select feasible magnets, either permanent, electromagnetic, or a combination of both.
- Evaluate propulsion motor requirements.
- Develop the MagLev tracks.
- Investigate environmental sustainability
- Trolley design for material.
- Develop MATS loading and unloading technology.
- Build the MATS launch integration and installation plan.
- Validate MATS dust-free operation.

Additional lunar transport projects:

The Lunar Pipeline [6] and FLOAT [7] are two concepts for lunar transportation that are still under development. FLOAT employs magnetic levitation in a unique way and shows great potential. The NEXT Prototypes e.V., based at the TU Munich, participated in the discontinued SpaceX Hyperloop Challenge [8].

Summary:

MATS, when implemented, will have a significant impact on the lunar economy and on all operators by lowering operational costs through reduced maintenance requirements, reduced spare part usage, and increased equipment life and availability.

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