Lunar Landing Pad Site Preparation

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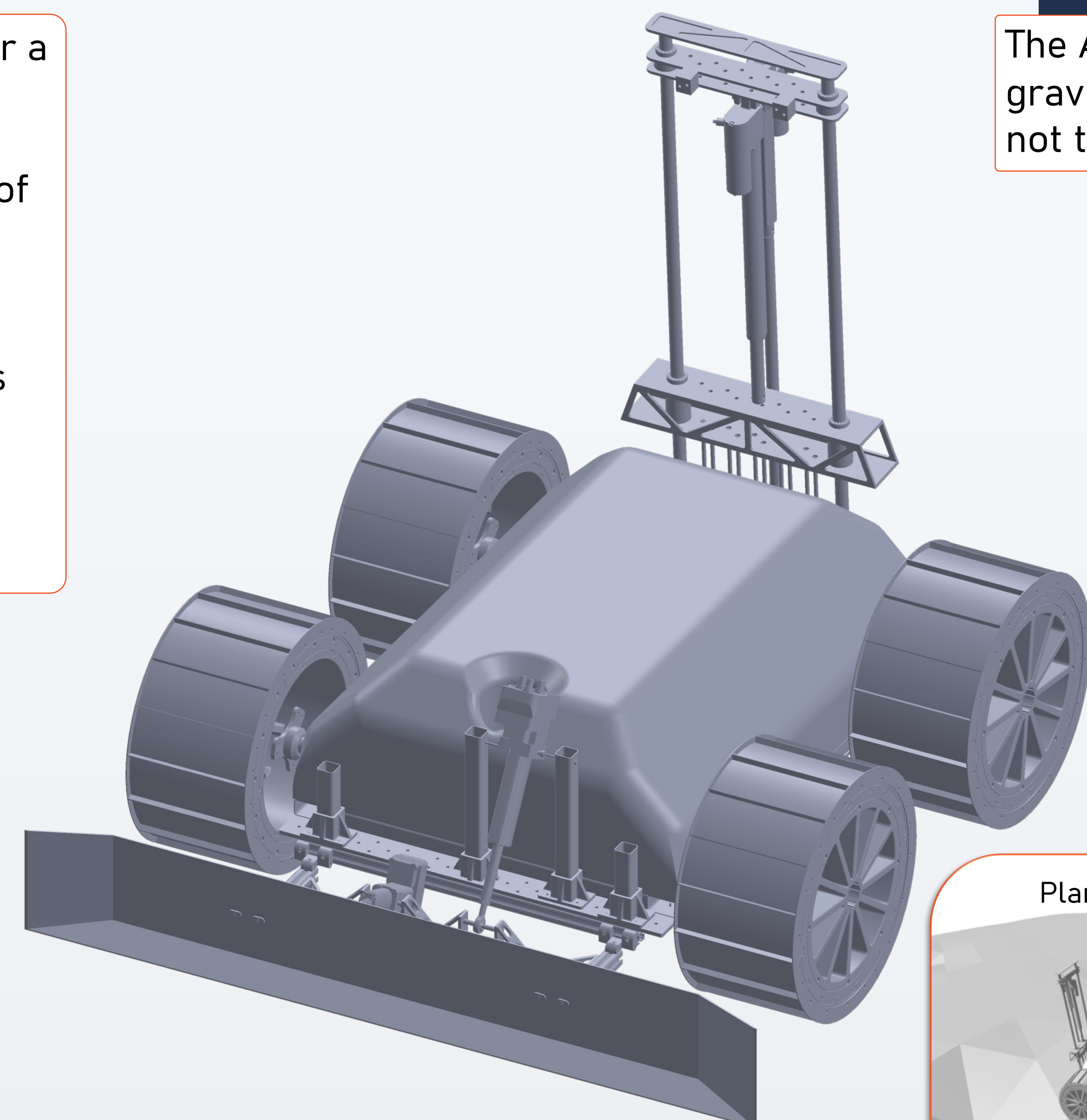
BACKGROUND

The lunar surface is marred by impact craters and rocks over a wide range of length scales. Lunar landing pads are anticipated to be up to 200 m in diameter, which will contain hundreds of craters of 2 m diameter and less and hundreds of rocks. The first step in building a landing pad on the lunar surface will be to clear, level, and compact the surface. Landing pads are an infrastructure element expected to support human exploration of the Moon [1]. The Autonomous Site Preparation: Excavation, Compaction, and Testing (ASPECT) project is a NASA LuSTR [2] funded project to demonstrate site preparation of the lunar surface for the construction of a lunar landing pads.

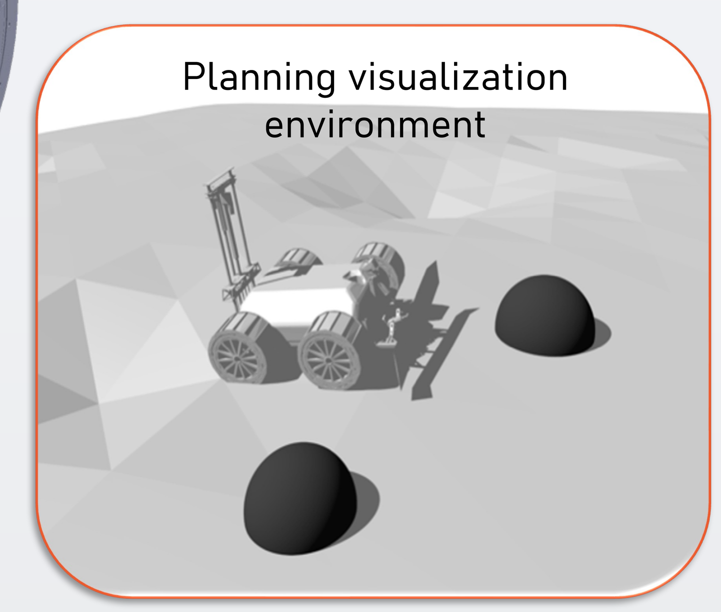
Approach

The ASPECT project consists of a team of lunar technology experts, roboticists, and computer scientists from several institutions. A mobility platform based on the Lunar Outpost Hound will be light-weighted and a dozer blade added by Mines with a compaction system from MTU. Mines also provides sensing and autonomy/planning. Tests will be conducted at a 10 m diameter site at Mines. The site is to be cleared of rocks, leveled to +/- 1°, compacted to 90% relative density, and smooth to 1 cm RMS.



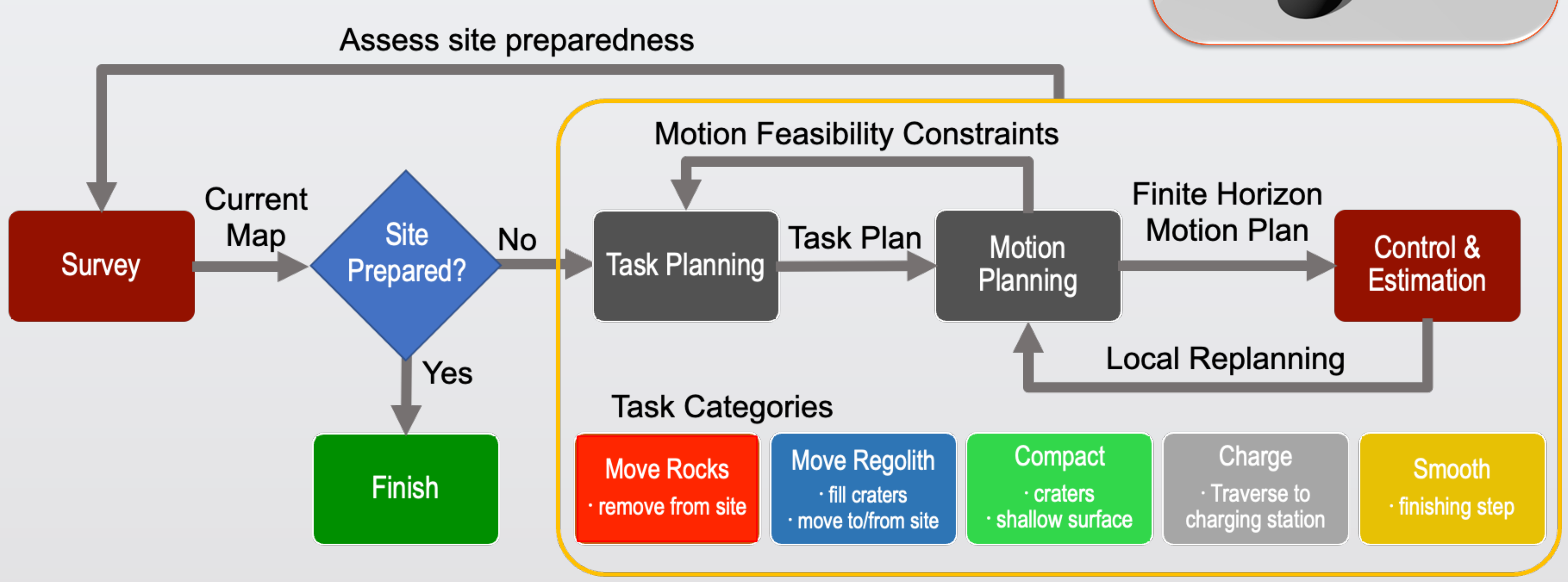
ASPECT Vehicle

The ASPECT vehicle is based on a Lunar Outpost HOUND. To simulate lunar gravity while tests are conducted in 1-g, all systems are light-weighted to a not to exceed mass of 83 kg, which simulates a 500 kg vehicle on the Moon.



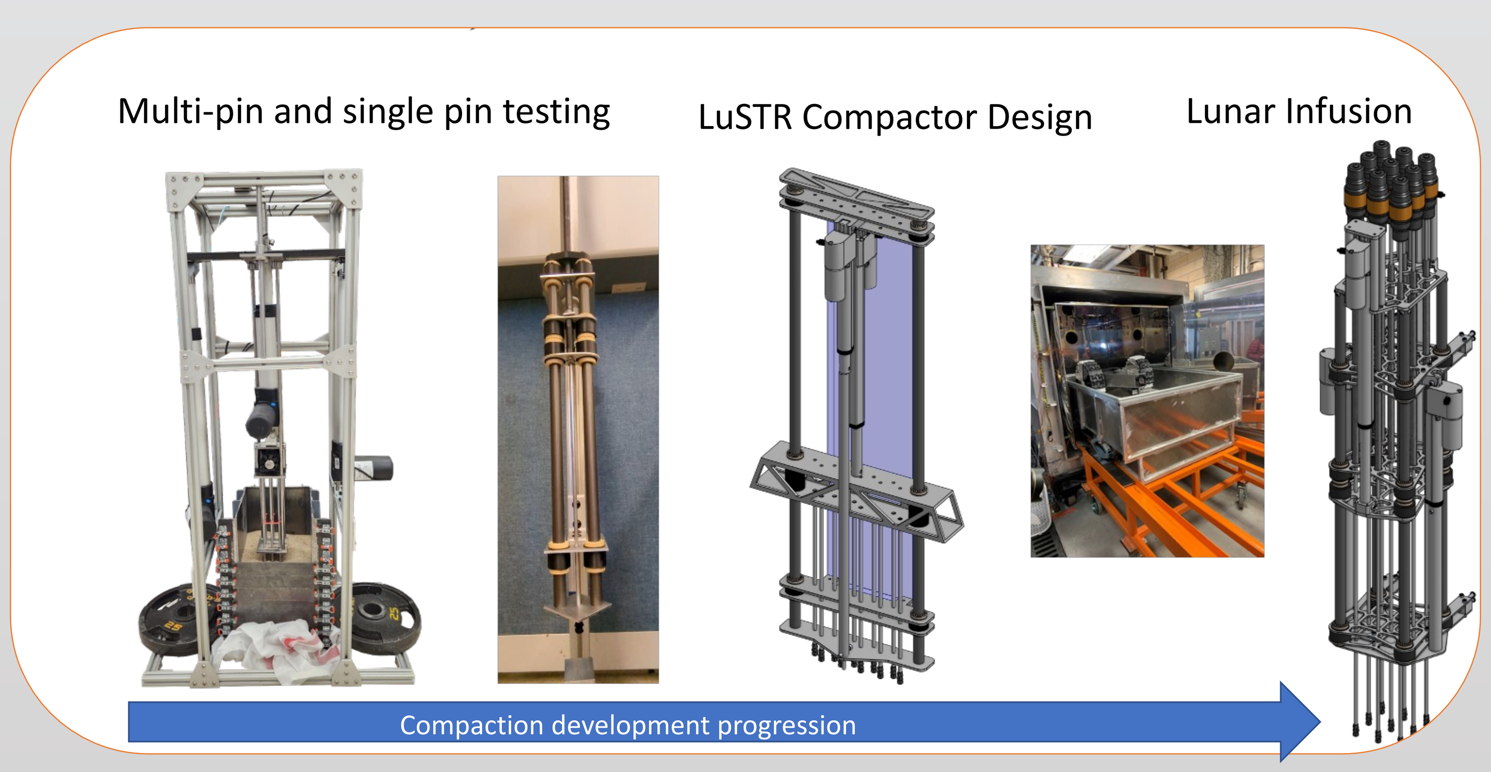
Concept of Operations

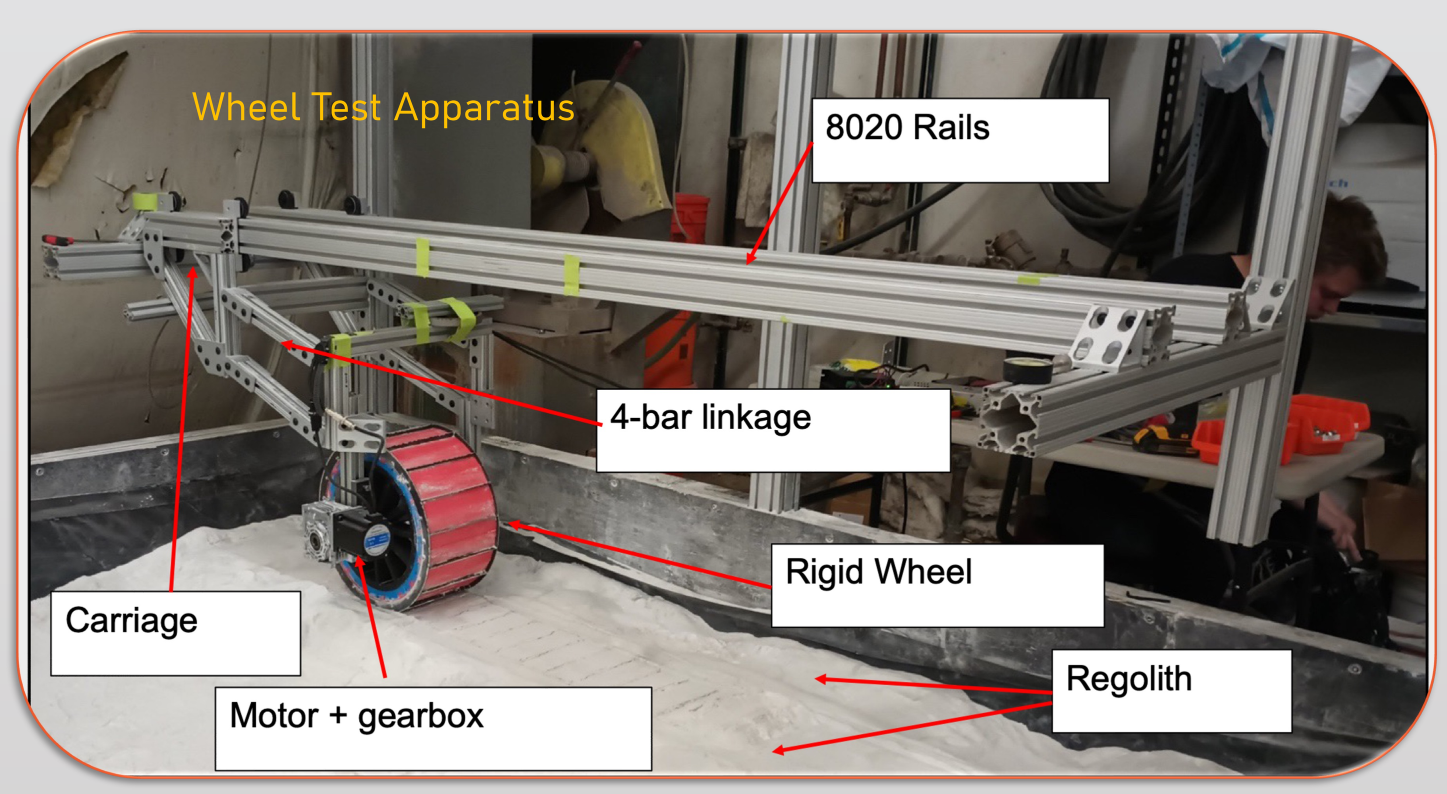
CONOPS begins with a survey of the site and assessment of the deviation of the site from the site preparation requirements. Next, task and motion planning algorithms formulate a plan. Possible tasks include Move Rocks, Move Regolith, Compact Surface, Charge, and Smooth Surface. Control and state estimation limits may require local replanning. When the local motion plan is complete site preparedness is surveyed and the process repeats.



Subsystems

Sensing and localization is provided by several Intel RealSense L515 Lidar Cameras. Rocks provide localization. A multi-function **dozer blade** pushes and/or lifts regolith and rocks. In principle, to limit pushing forces only low-density regolith is manipulated. Wheel grousers or rippers on the back of the blade are used to tear the surface if necessary. The **wheels** and dozer blade are designed together to ensure the vehicle can push a fully loaded blade. Forces and wheel slip are carefully managed during operation. **Compaction** is produced by a series of pins pressed into the surface aided with a pressure plate. Vibration of the pins cause the regolith to compact, and pins automatically retract as the compaction state achieves the desired compaction level. The required pressure applied by the plate and vehicle mass limit the area that can be compacted per placement of the system. Full site compaction is achieved by repeated placements. Subsystem development employees extensive use of testbeds at Mines and MTU (shown).





CONCLUSION

ASPECT development is proceeding with subsystem designs and validation. The vehicle chassis will be delivered in summer 2023 with integration of subsystems beginning soon afterward. A >11m x 11m testbed with high fidelity lunar regolith simulant will be ready by Fall 2023.

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References:[1] NASA, "Artemis Plan: NASA's Lunar Exploration Program Overview," 2020. [Online] https://www.nasa.gov/sites/default/files/atoms/files/artemis_plan-20200921.pdf. [2] NASA, "Lunar Surface Technology Research (LuSTR) 2021," [Online]. https://www.nasa.gov/directorates/spacetech/strg/lustr/2021/