MOBILE TUBE EXCAVATOR AND BRUSH ASSISTED MECHANICAL SIFTER IN THE DISTOBEE SYSTEM FOR LUNAR SURFACE OPERATIONS. P. Kulinowski[1], [1]AGH University of Krakow, AGH Lunar Resources Initiative Team, al. Mickiewicza 30, 30-059 Kraków, Poland, piotr.kulinowski@agh.edu.pl, distobee@agh.edu.pl

Introduction: The DISTOBEE project, developed by the AGH Lunar Resources Initiative, is an integrated system designed to autonomously collect and process lunar regolith in support of in-situ resource utilisation (ISRU). The system was developed to meet the requirements of the 2nd ESA Space Resources Challenge "Collection and Processing of Lunar Regolith" competition (2025), which tasked participants with extracting and mechanically processing 15 kg of lunar regolith simulant in 150 minutes, using equipment with a total mass not exceeding 60 kg and a maximum energy consumption of 300 Wh.

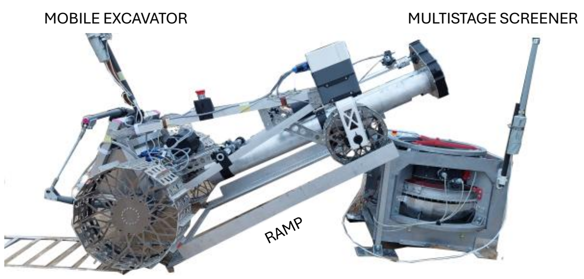

Fig. 1. Mobile excavator positioned on the ramp of the multistage screener

The resulting technological system consists of two main components: a mobile excavator equipped with storage tubes and a stationary multistage screener (Fig.1). Operations proceed cyclically: the excavator travels to the designated digging area, collects a batch of regolith, then transports and unloads it into the stationary screener. Material throughput is continuously regulated according to the screener's capacity (Fig.2).

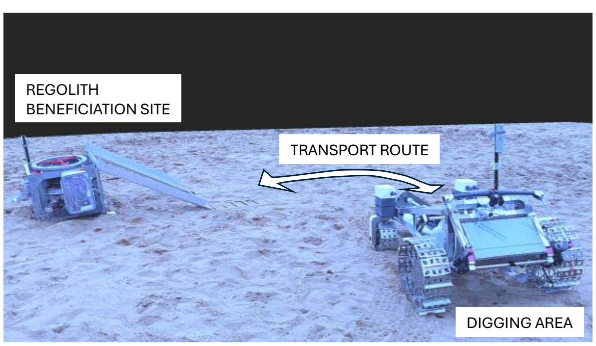

Fig. 2. DISTOBEE system during field driving tests

The system name, DISTOBEE, from DIgging, STOring and BEneficiation, also referring to the work of a swarm of bees, modeling their organization, diligence, and teamwork.

Mobile Tube Excavator: Currently, the excavator has two steerable wheels and two drive wheels with internal motors, as well as battery power for the entire system. The excavator's center of gravity has been positioned to ensure optimal traction and stability (Fig.3).

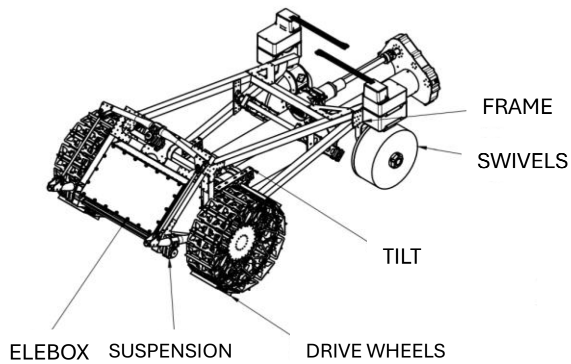

Fig. 3. Structure of the excavator's mobile platform

The mobile excavation platform uses a dual-screw mechanism capable of digging, storing, and unloading regolith. The screw design incorporates a variable pitch to maximize tube filling efficiency, while dust mitigation is supported by a brush-based sealing system.

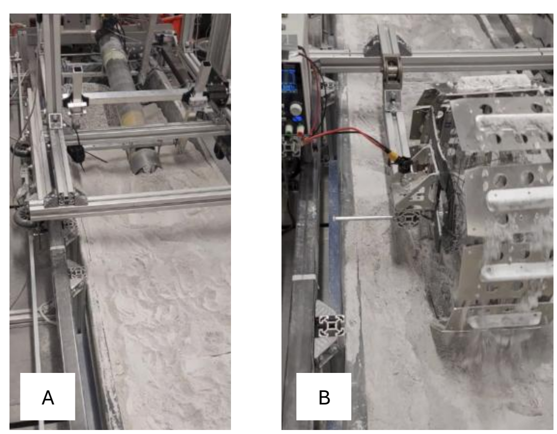

Fig.4. Laboratory test rig filled with AGK2010 lunar regolith symulant

Both the excavator tube (Fig.4A) and the drive system (Fig.4B) were tested during preliminary laboratory trials using a custom test bench filled with AGK2010 lunar regolith symulant. Measurements of loading efficiency and power consumption during excavation enabled the selection of optimal operating parameters, specifically screw rotational speed and excavator feed rate (Fig.5).

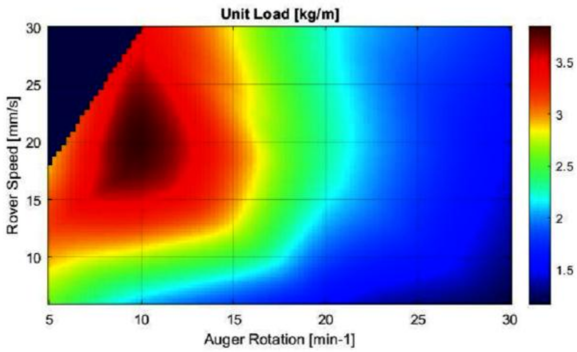

Fig.5. Heat map of the unit load of a 100 mm diameter excavator tube as a function of screw revolutions and rover speed

During the excavation phase, the digging module is tilted to engage the lunar surface. Laboratory tests confirmed that full tube loading can be achieved in under one minute. After the storage tubes are filled, the module returns to a horizontal position to improve the stability of the rover and reduce motion resistance during transport. The geometry of the mechanism and operating parameters were designed to minimize energy consumption while maintaining the required material throughput.

After each collection cycle, the rover returns to the sifting unit carrying up to 7 kg of mined regolith. A dedicated loading ramp, together with the geometry of the digging module, enables the screws to unload material directly from the storage tubes into the screener.

Multi-stage Screener: The stationary sifter uses three coaxial screens with decreasing mesh sizes: 1000 µm, 500 µm, and 100 µm, enabling sequential particle separation. To maximize screening efficiency and mitigate screen blinding, each stage is equipped with an independent vibrator and rotating brush-assisted arms.

The screener operates cyclically. After loading, the first phase is the screening process, during which brush-equipped arms move material across the screen surface. Each level is monitored by a dedicated camera system. When the screening is complete, the arms reverse the direction to discharge the retained material into external collection tanks. All screens are inclined at a fixed angle to facilitate smooth material flow toward the outlets.

Fig.6. View of the screen prototype

Summary: The DISTOBEE system - fully monitored and remotely controlled via cameras integrated into all major subsystems - met the intended performance targets for regolith collection efficiency and energy use. It was optimized through laboratory bench testing at AGH University of Krakow and subsequently validated during field trials at the LUNA facility (Fig.6.).

Fig.7. View of the DISTOBEE system at the end of the field test at the LUNA facility

The DISTOBEE system represents an innovative and promising approach to the future exploration of lunar rock and material beneficiation for ISRU applications.