MONTANUNIVERSITÄT LEOBEN

Mining and conveying technologies for application in space

Solar system exploration and planned upcoming missions to Moon and Mars require consideration of sustainable raw materials supply

In recent years Mars and Moon have moved into the focus of both public institutions and private companies. Amongst the goals of these endeavours is implementing a sustained human presence on Mars and Moon, proving the possibilities of living in these environments with low gravity and lack of atmosphere. In order to reduce the payload necessary for transporting supply from Earth, it will be necessary to source from local resources. The main focus is set on extracting water and oxygen from rock (mainly regolith) for human life support, and also as rocket propellant.

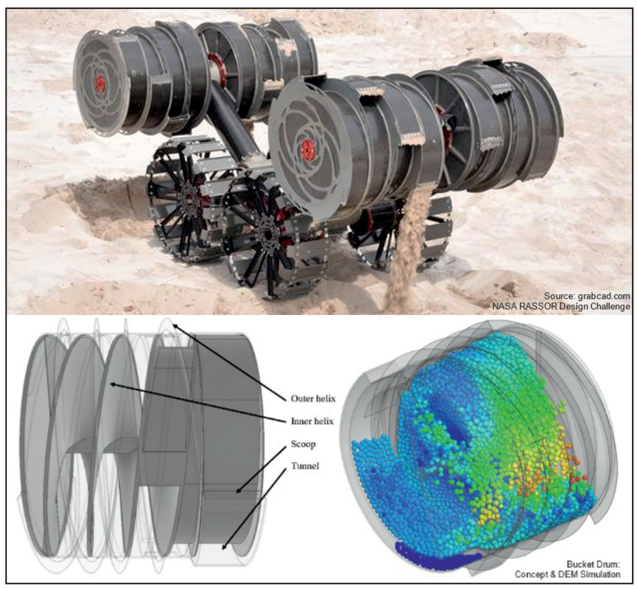
Research at the Chair of Mining Engineering focusses on how rock can be mined under low-gravity conditions and how the mined material can be transported to further processing.

Many mining processes on Earth rely on gravity to fragment rock with high forces and hence have to be re-invented for extra-terrestrial application where utilisation of large and heavy equipment is not possible. Furthermore, the processes have to run autonomously with no human interaction for a very long time. This puts special emphasis and wear-resistance and reliability.

A team of students in conveying technology successfully participated in the NASA RASSOR challenge in 2020, in which the goal was to design a cutting drum for an excavation robot prototype. The students reached 4th from a total nearly 350 submissions.

As part of the Sustainable Offworld Network (SONet) researchers of the Chair of Mining Engineering participated in the Mars City State contest of the Mars Society. Here the goal was to design a self-sustaining city on Mars (including raw materials supply, life support, politics, ...). The submission was ranked top 10 out of 175 submissions.

Researchers of the chair are active in European and international communities and working groups on the subject as the ESA topical team on in-situ resource utilisation (ISRU), or the commission on planetary rock mechanics with the International Society of Rock Mechanics (ISRM).



ME mining engineering mineral economics

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SONet

NÜWA

Excavation & Conveying Concepts for Lunar Regolith

Research and development for in-situ resource utilisation (ISRU) of lunar regolith

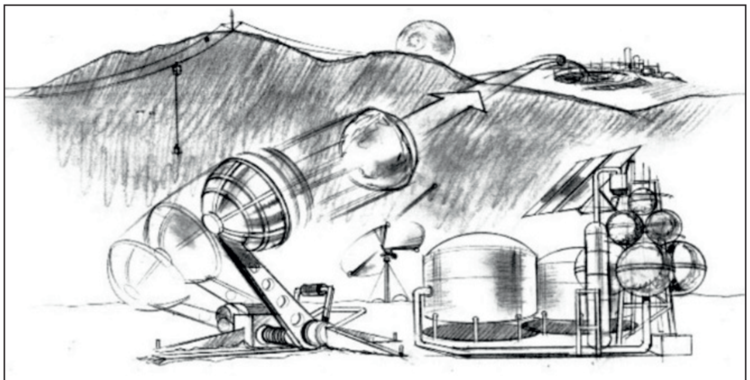

Fig. 2: Ballistic conveyence concept (Schrunk D. 2007)

The utilisation of lunar regolith on the Moon, e.g. for the production of propellant, vital oxygen, and building materials, corresponds to in-situ resource utilisation (ISRU), where the lunar regolith is used for further processing independent from the Earth. In general, the ISRU chain consists of four main stages: excavation, conveying, beneficiation, and processing. In the course of this work, the first two stages – excavation and conveying – are in focus. In this context, basic developments of mechanical equipment for lunar application are dealt with (in related master's theses). Thereby, the conditions on the Moon need to be considered, which are very different from typical Earth conditions.

On excavation: By analysing various principles, a horizontal bucket chain excavator has proven to be a high potential concept. This concept can be described as consisting of two robots, linked with an additional bucket chain bridge between them (Fig. 1). Several shovels are moved along this bridge, and by that, the material is scraped from the lunar surface, and lifted off the ground onto one robot for further conveying.

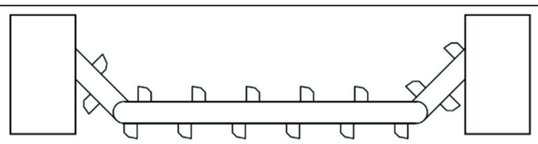

Fig. 1: Excavation principle as schematic concept, a bucket chain bridge (middle) connecting the two robots (both sides)

On conveying: The principles for the conveyance of excavated regolith were fundamentally reconsidered – and a ballistic conveyor (Fig. 2) was found to be feasible. In fact, the environmental conditions on the moon were identified to be quite beneficial for this type of conveyor: The lack of atmosphere, and therefore the lack of associated mid-air resistance, as well as the lower gravity, favour this concept. Also, a ballistic conveying robot can be designed rather small and moveable, and would allow the conveyance of material (gathered in the previous excavation stage) over difficult topology, as well as over relatively long distances.

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