Three-Dimensional Lunar Regolith Bucket Conveyor - LUREBUCON3D

The concept of a conveyor designed for efficient technological transport of lunar regolith over long distances

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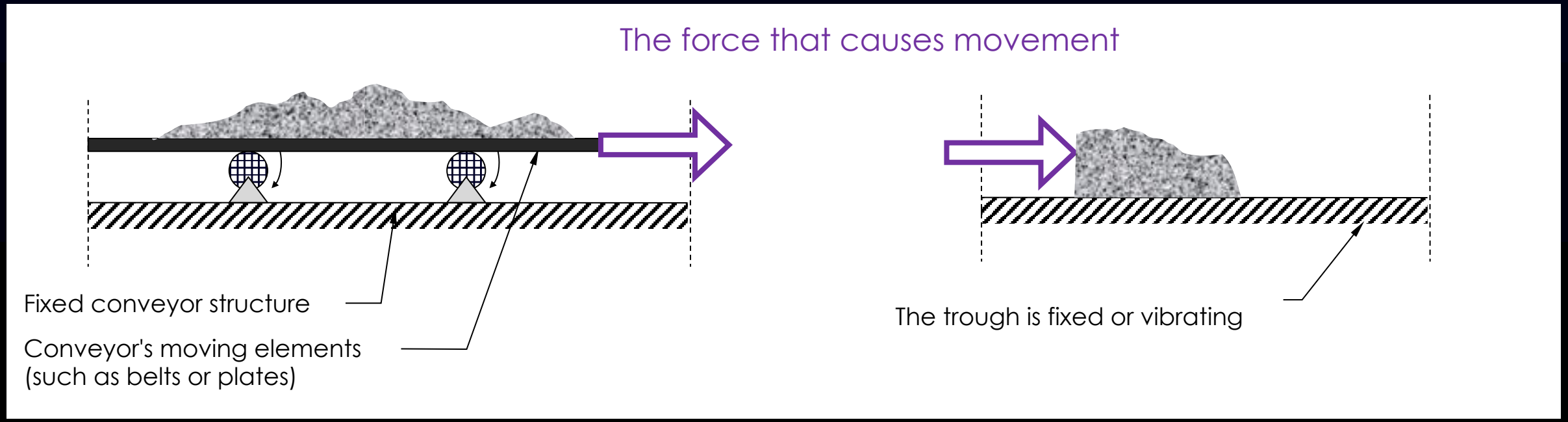
Conveyor for the transport of regolith?

Loose materials can be transported using conveyors

A. without causing relative movement between the transported material and the conveyor's moving elements

B. by guiding the material along the surface of the trough with the use of structural elements, an external force, or vibrations



Regolith could be transported using conveyors

– WHY NOT

A. by carrying them

- on a supporting belt (belt conveyor)
  - It is not possible to use elastic traction elements, like belts, cables
  - Lots of kinematic pairs sensitive to dust
  - Limited inclination angle
- on movable plates (apron conveyor)
  - Not for dusty, fine-grained materials
  - Dust-sensitive hinges and kinematic pairs
  - Heavy plates
- in buckets (bucket conveyor/elevator)
  - Problems with dust-free loading
  - Dust-sensitive kinematic pairs
- with liquids or gases (pipelines)
  - Problem with extreme ambient temperatures
  - Necessity to maintain tightness due to vacuum

B. by sliding them using

- a vibrating trough (vibrating conveyor)
  - Raising the dust deposited on the outer surface of the closed trough
  - A large mass of elements fixing the conveyor frame
  - Limited inclination angle
- rotating screw (screw conveyor)
  - Continuous mixing and crushing of the regolith can result in high resistance to movement
  - Wear of the conveyor auger and pipe
  - High energy consumption
- moving scrapers (drag conveyor)
  - In the case of a chain conveyor, there will be a large mass of return troughs and tail station
  - Wear of moving parts
  - High energy consumption

Regolith could be transported using conveyors

– WHY YES

A. by carrying them

- on a supporting belt (belt conveyor)
  - Reduced abrasive wear
  - High efficiency and long transport distance
  - Low energy consumption
- on movable plates (apron conveyor)
  - Made of rigid elements
  - Resistant to surface wear
  - Resistant to extreme temperatures
- in buckets (bucket conveyor/elevator)
  - Gentle material handling
  - Low energy consumption
  - Transport at any angle of inclination of the route
- with liquids or gases (pipelines)
  - Sealed transport
  - Rigid construction

B. by sliding them using

- a vibrating trough (vibrating conveyor)
  - No moving parts
  - Sealed transport
  - Low energy consumption
  - Simple construction
- rotating screw (screw conveyor)
  - Few moving parts
  - Movement reliability
  - Simple construction
  - Sealed transport
- moving scrapers (drag conveyor)
  - Resistance to harsh conditions
  - Simple construction

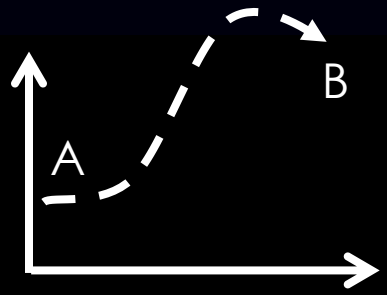
Transport task

transport a specified amount of material,

[pcs, kg , t, m^3]

at a given period of time,

[s, min, hour, day, years]



from point A to B

[m, km, miles]

Choice of transport modes and the structure of the system depends on:

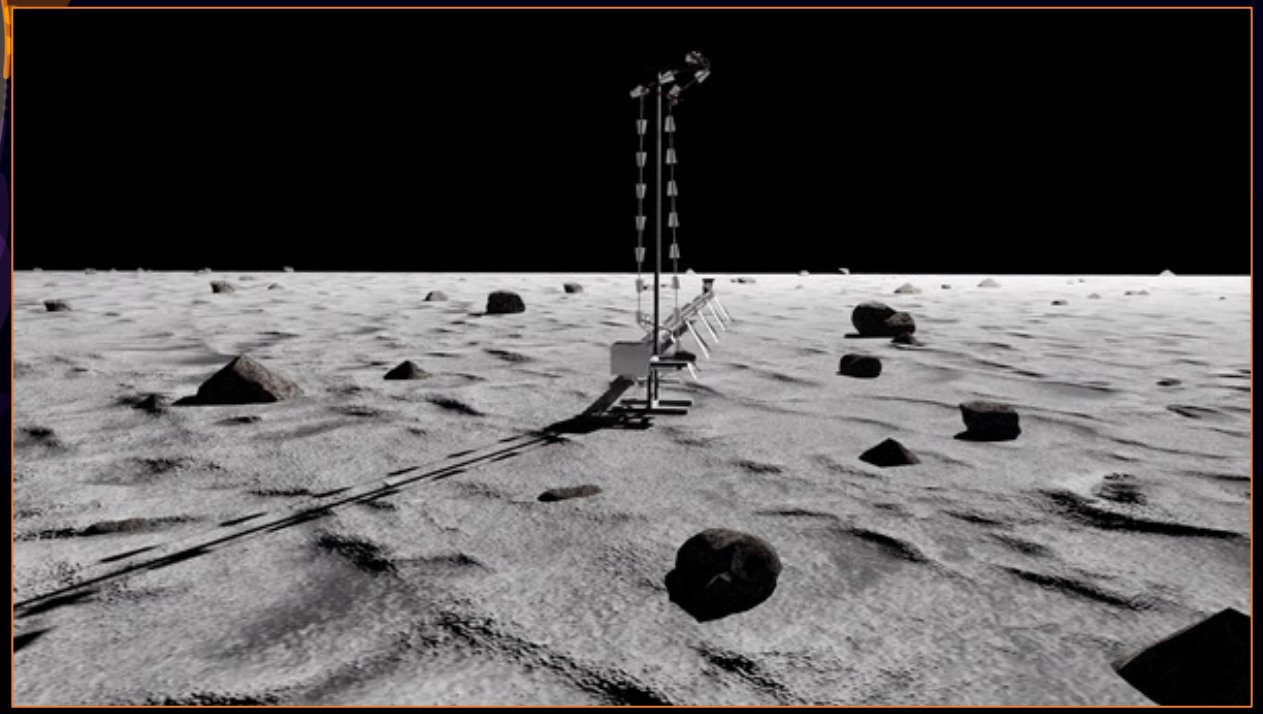
- **materials** being transported, the amount of transported material - capacity,
- **path of transport**, the type and geometrical parameters (distance, angle of inclination),
- type of machinery or equipment **loading and unloading**
- **time** using the transport system,
- **external factors** affecting the operation of the transport,
- the **ecological** effects.

LUREBUCON3D - Genesis of the concept

Over the Dusty Moon Challenge

- Phase 1: design, Phase 2: prototyping
- Height: 3 m, Length: 5 m, Capacity: 100kg/h
- Competition took place in Colorado School of Mines in 2022 and 2023
  Victory in 2023 of the SpaceTeam AGH POLAND

TOLRECON - **T**andem **O**f **L**unar **RE**golith **CON**veyors



- The Rod Scraper Conveyor is synchronized with the Bucket Elevator by one drive and gives portions of regolith into the buckets,
- Horizontal length RSC: up to 10 m
- Lifting height BE: limited by requirements

LUREBUCON3D - Introduction

Assumptions

Analysis of the work and tests of the **TOLRECON** conveyor showed:

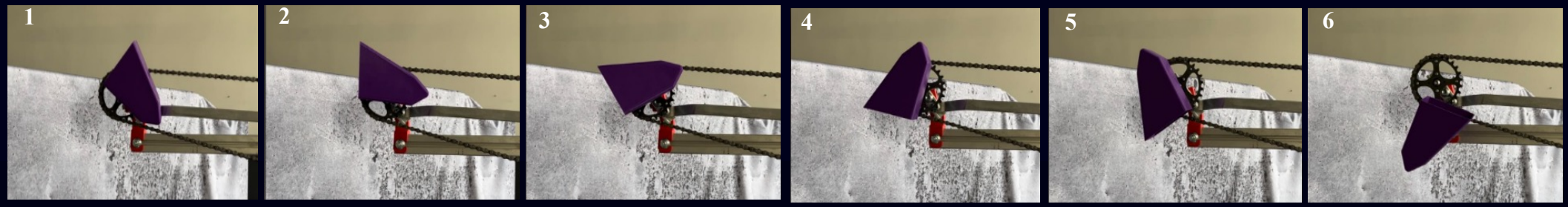
- possibility of reducing the weight of the device by shortening the rod conveyor and using it only as a pulsating feeder and using a bucket conveyor, also for horizontal transport,

- necessity to change the chain guiding system and use a swinging bucket mounting for achieving three dimensional transport

LUREBUCON3D

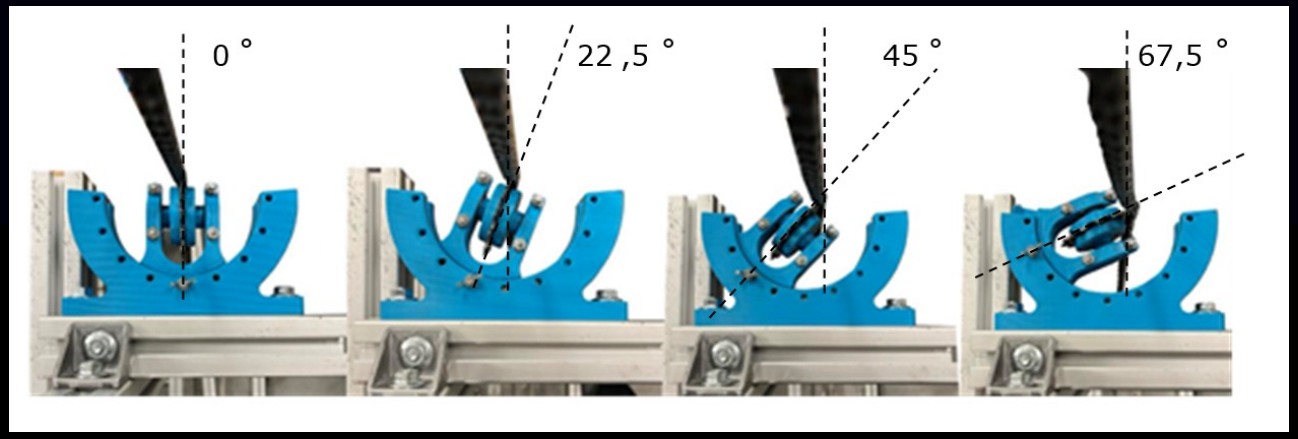
Laboratory test of elements

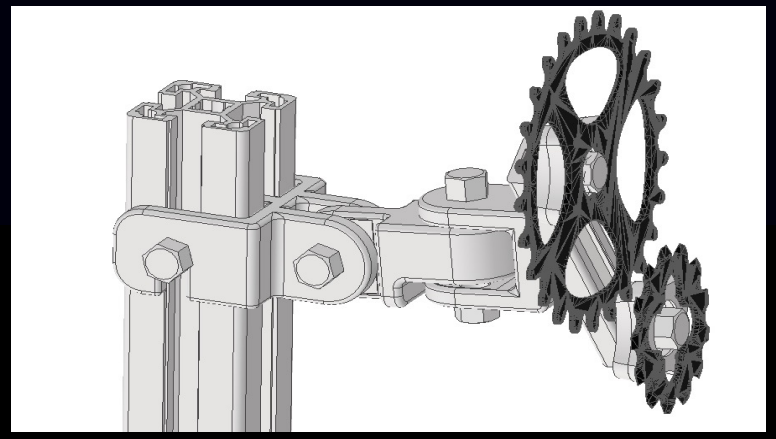
Swinging Bucket



It is possible to mount the swinging bucket and move the load in vertical and horizontal sections

Chain Guiding System



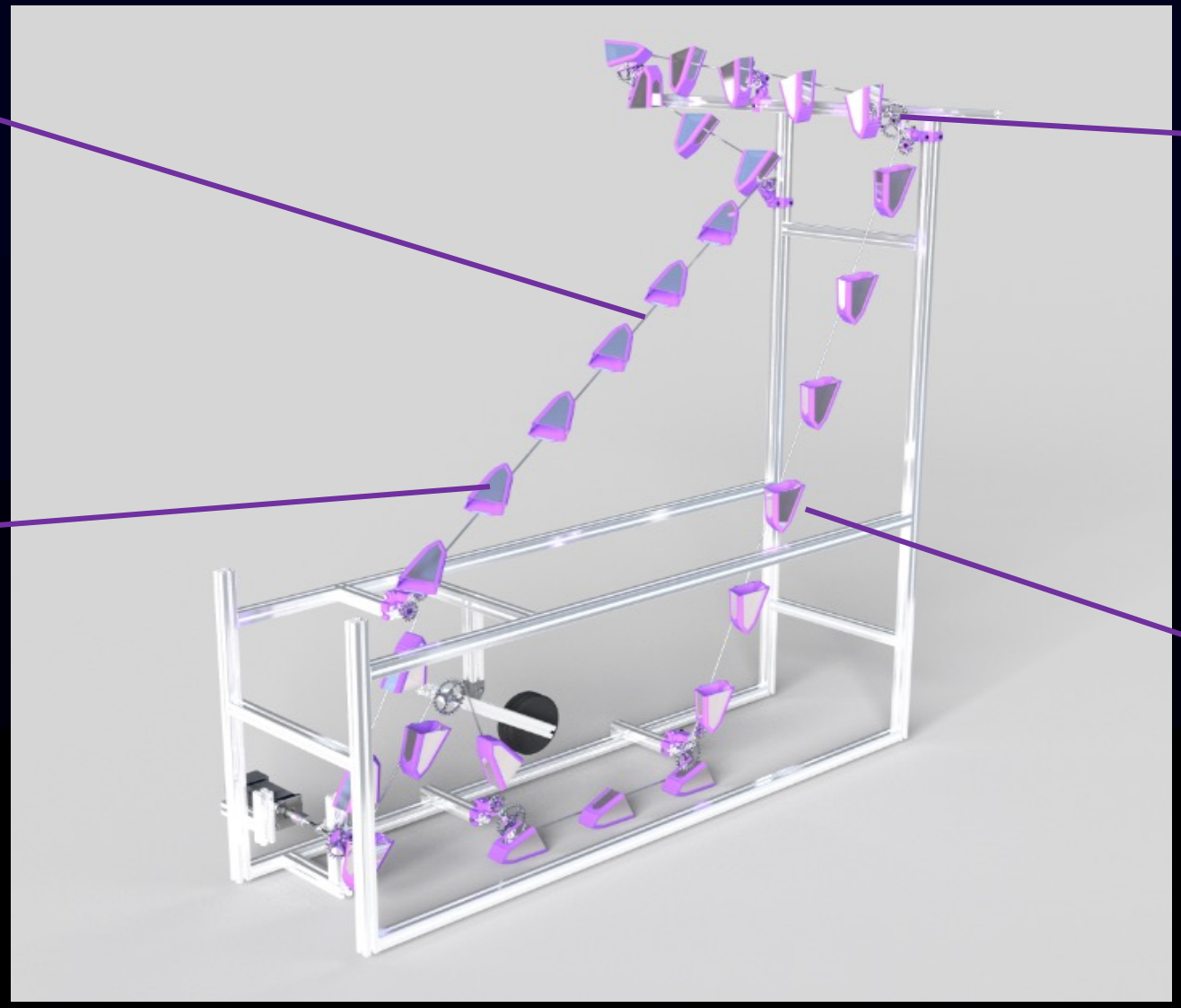


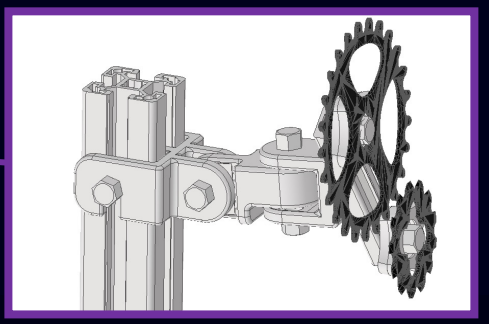
It is possible to twist the moving chain and guide it spatially, but using forced guidance

LUREBUCON3D - is it possible?

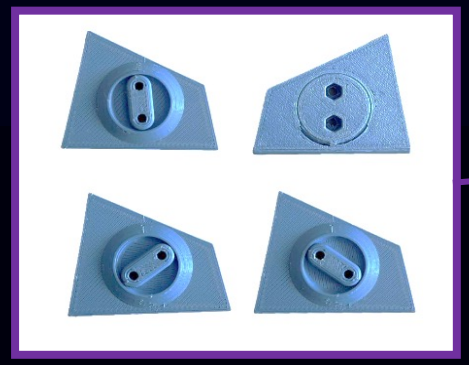
Laboratory stand for testing 3D chain guidance

super lightweight chain





reliable, forced guidance

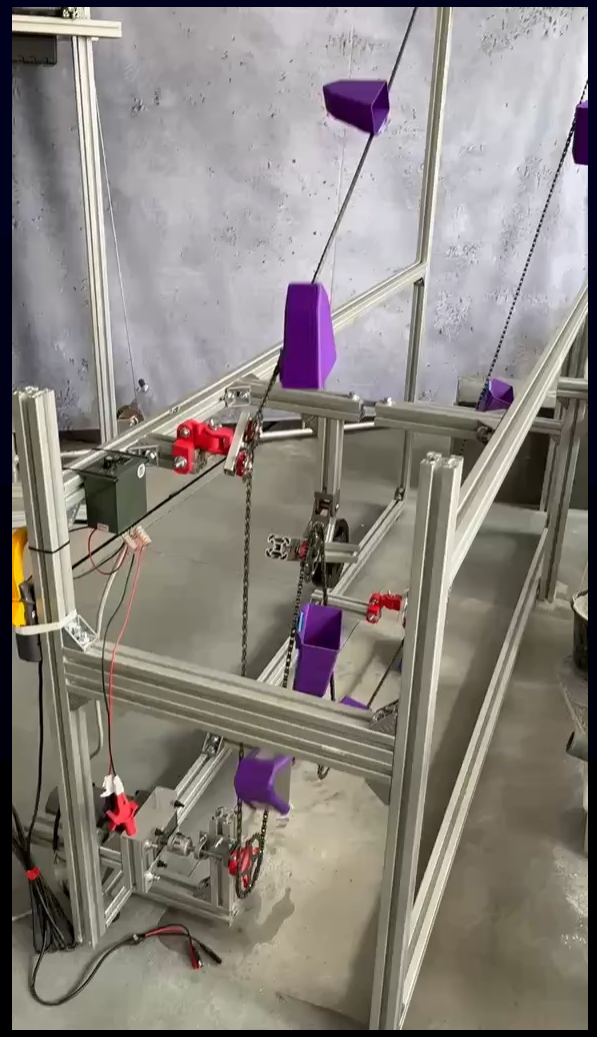


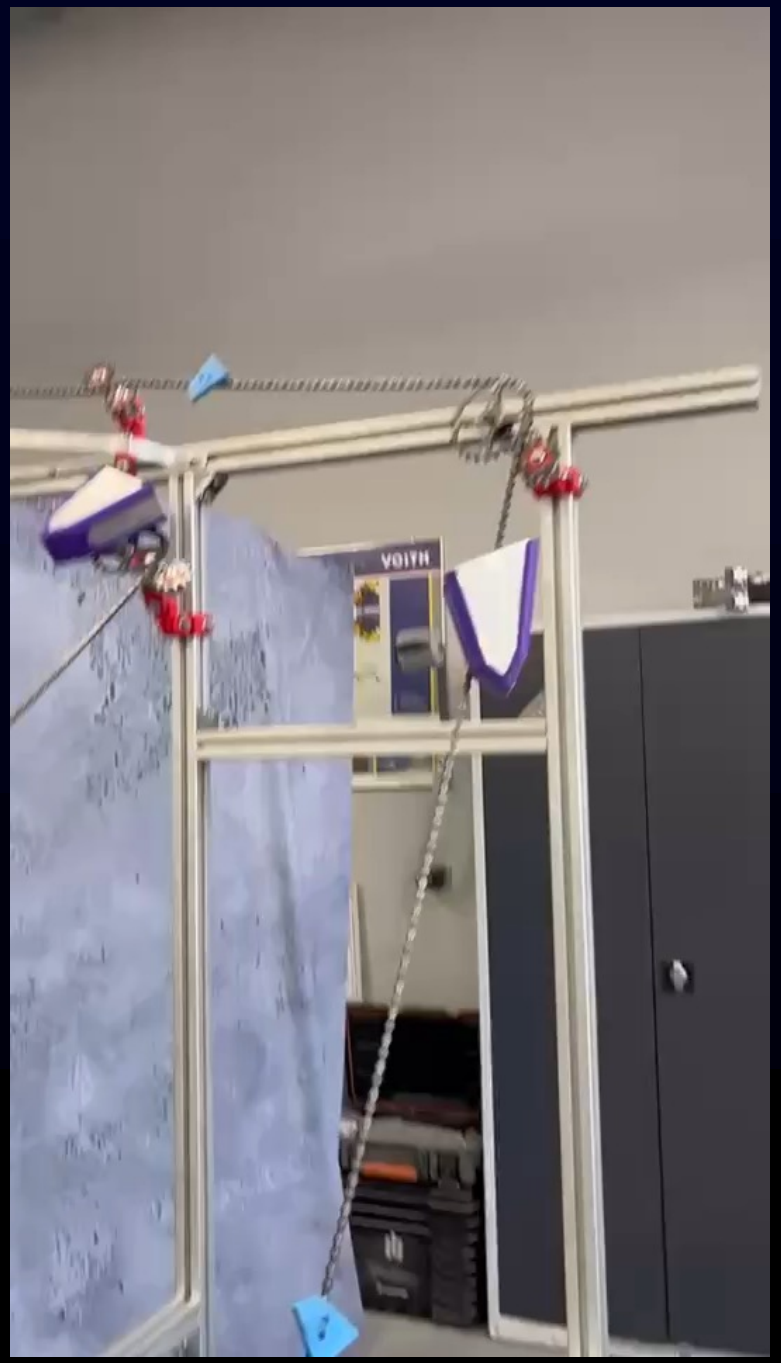
pendulum bucket attachment with anti-dust seal

swinging bucket

LUREBUCON3D

Laboratory tests





LUREBUCON3D - Possible application

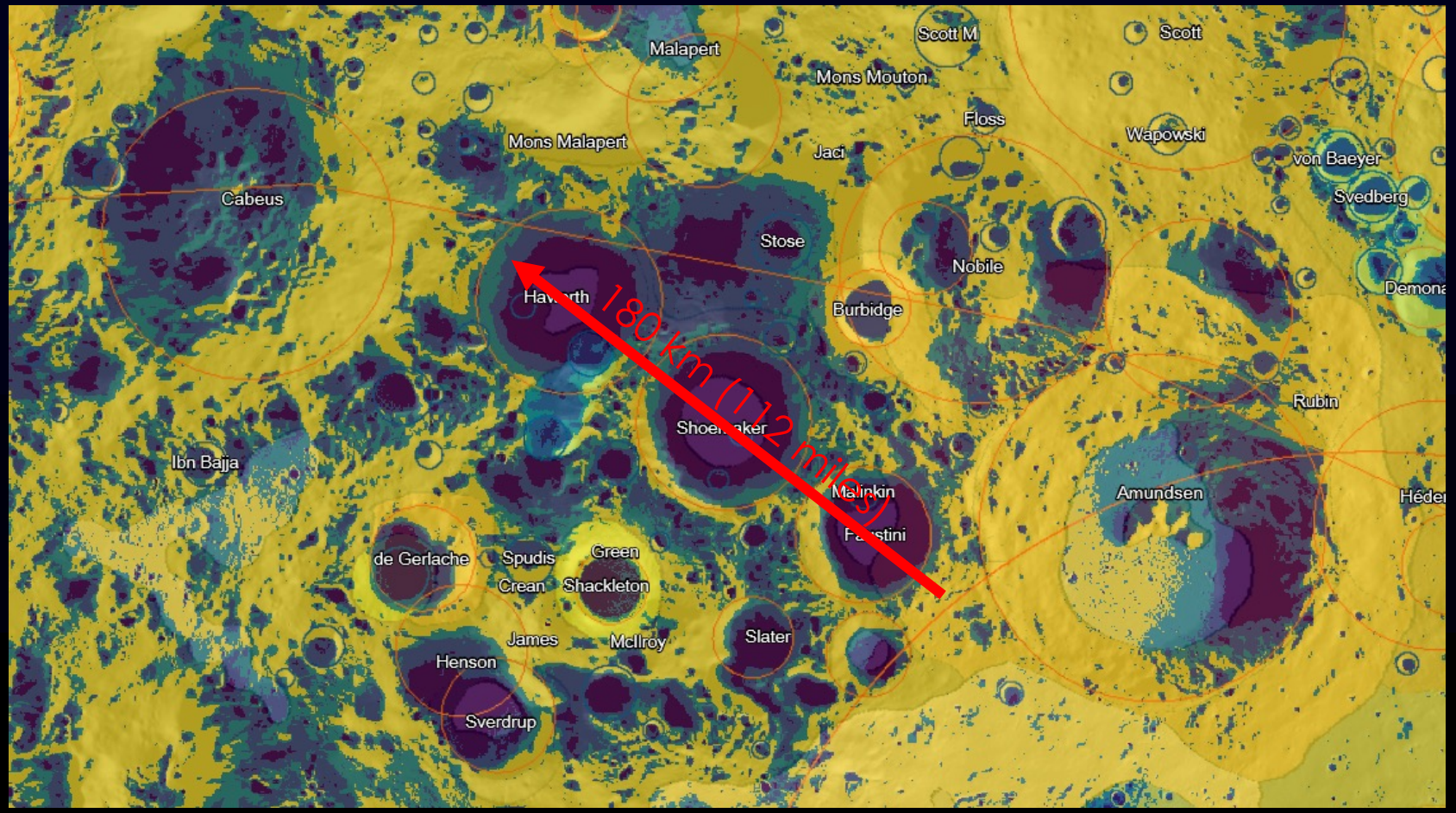
The concept of crater conveyor transport

LRO Peers into Permanent Shadows

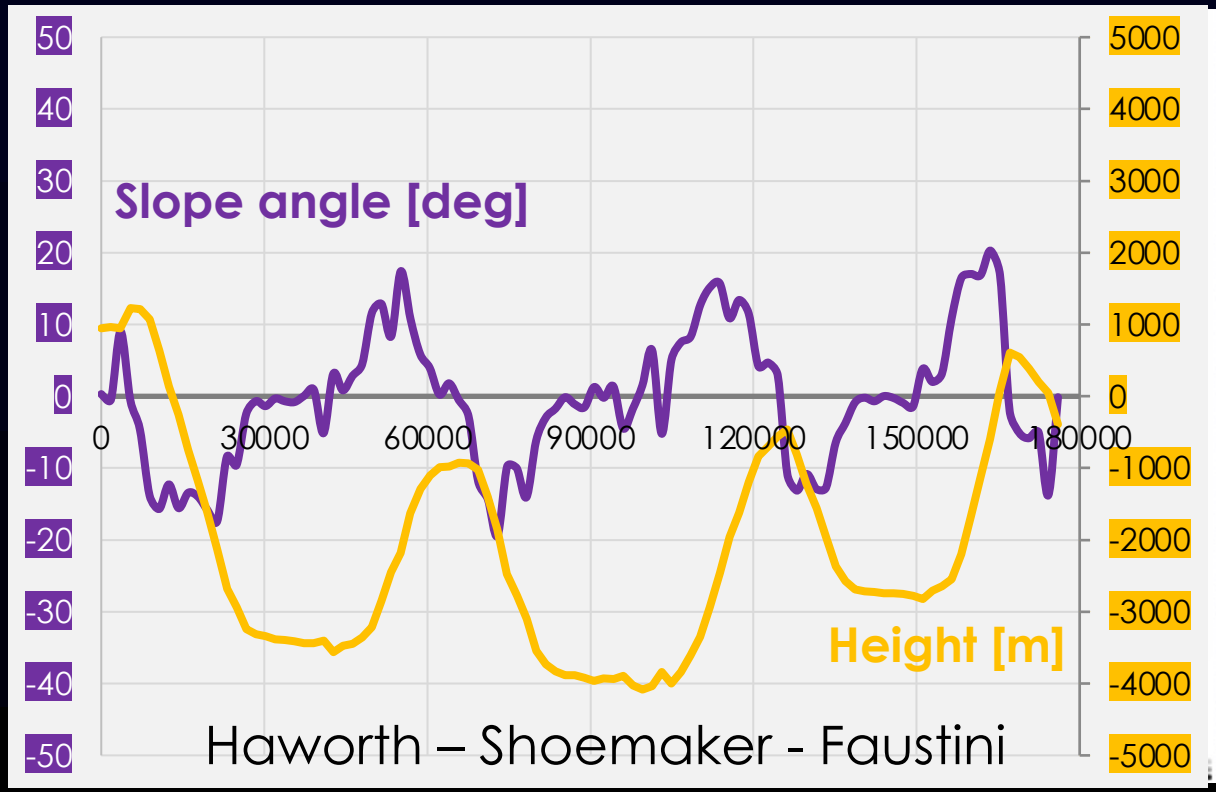
LUREBUCON3D - Possible application

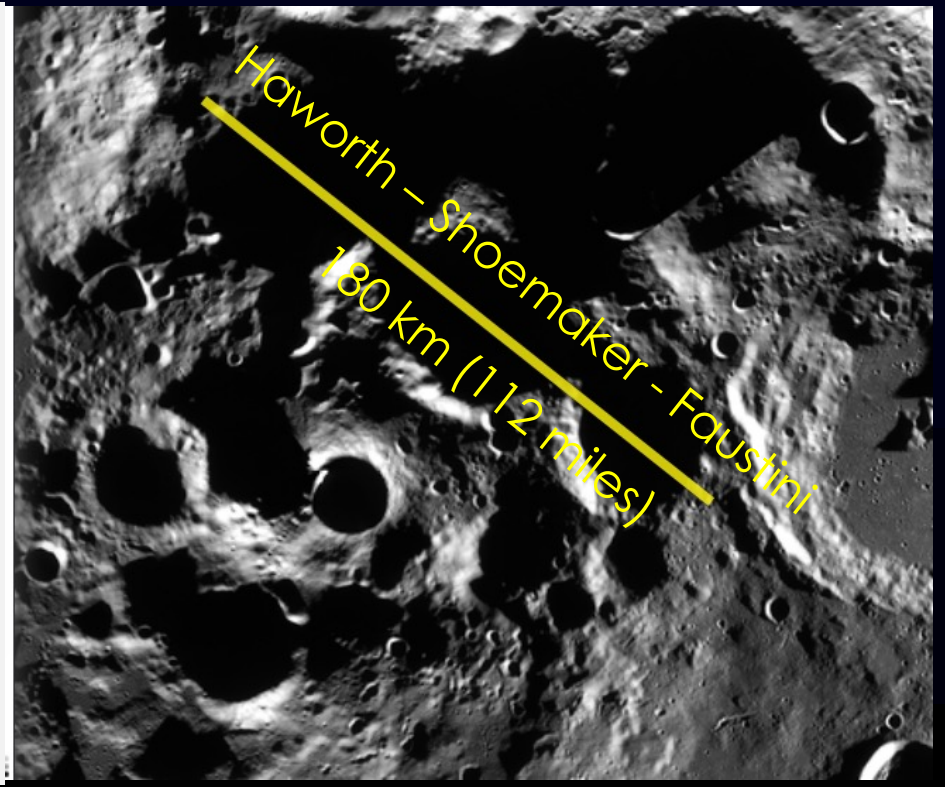
South Pole Ice Depth Stability

Haworth – Shoemaker - Faustini



LUREBUCON3D - Possible application
Elevation Profile
Haworth – Shoemaker - Faustini



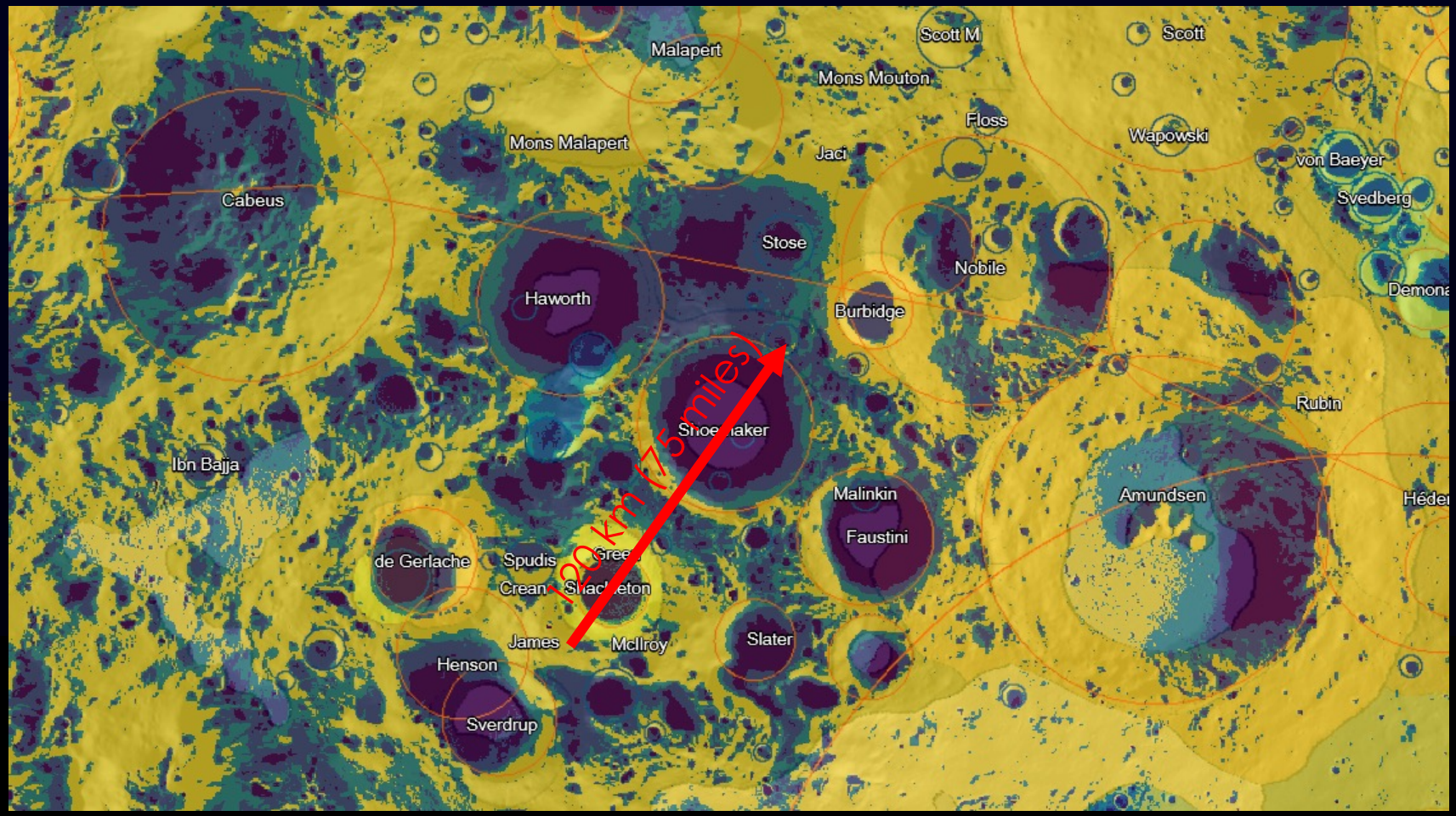


https://trek.nasa.gov/moon/

LUREBUCON3D - Possible application

South Pole Ice Depth Stability

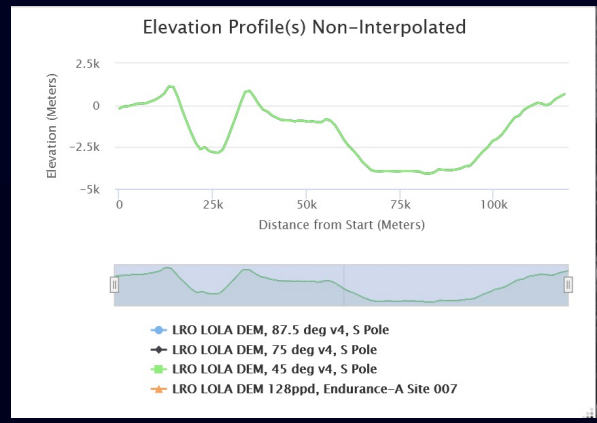
Shackleton -Shoemaker

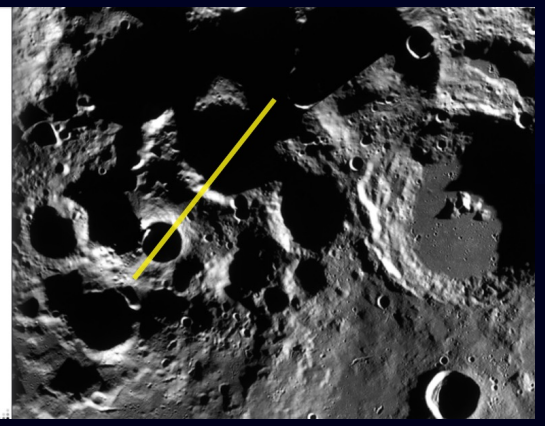


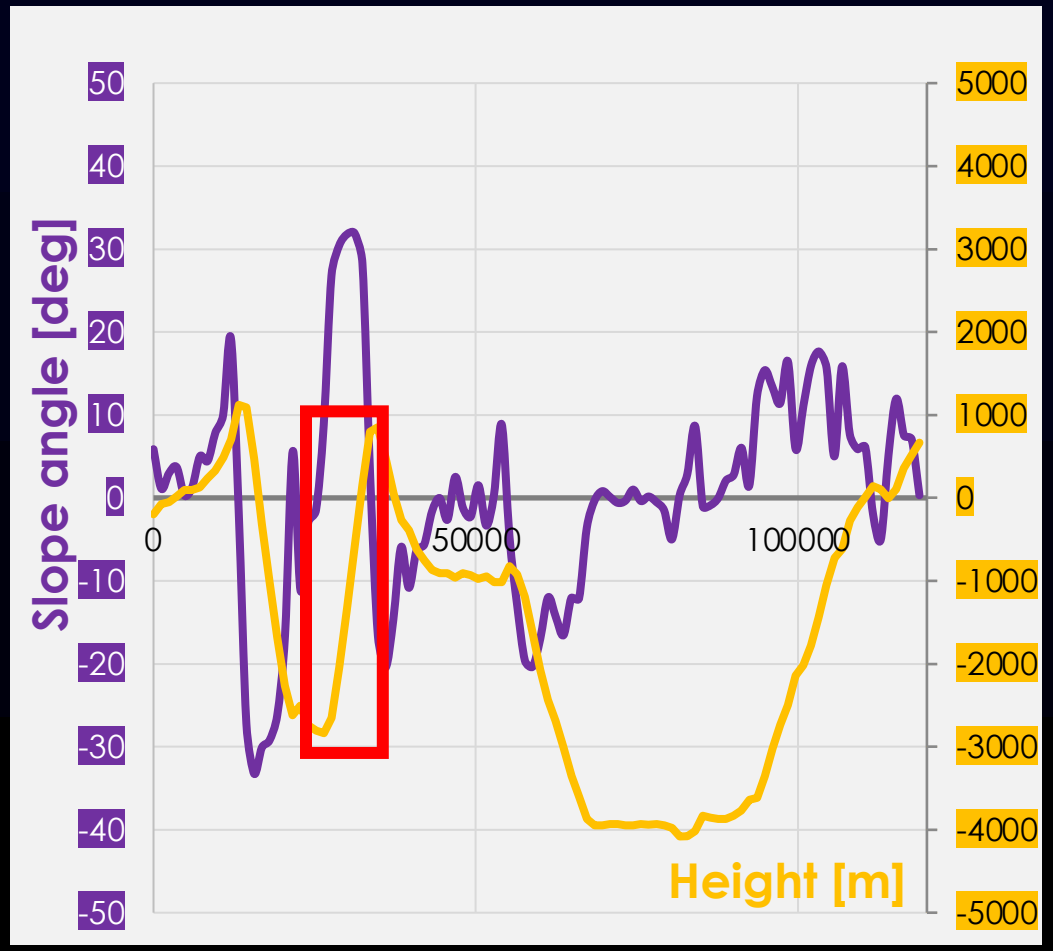
https://quickmap.lroc.asu.edu

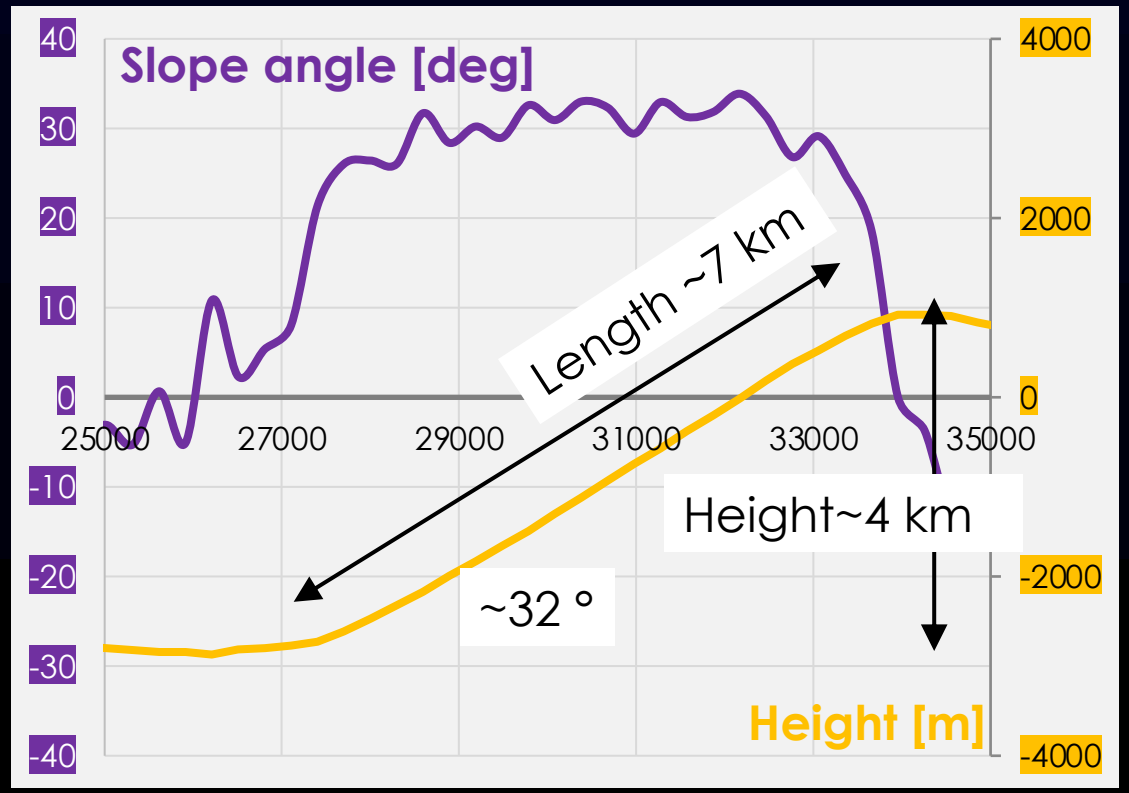
LUREBUCON3D

Elevation Profile
Shoemaker - Shackleton

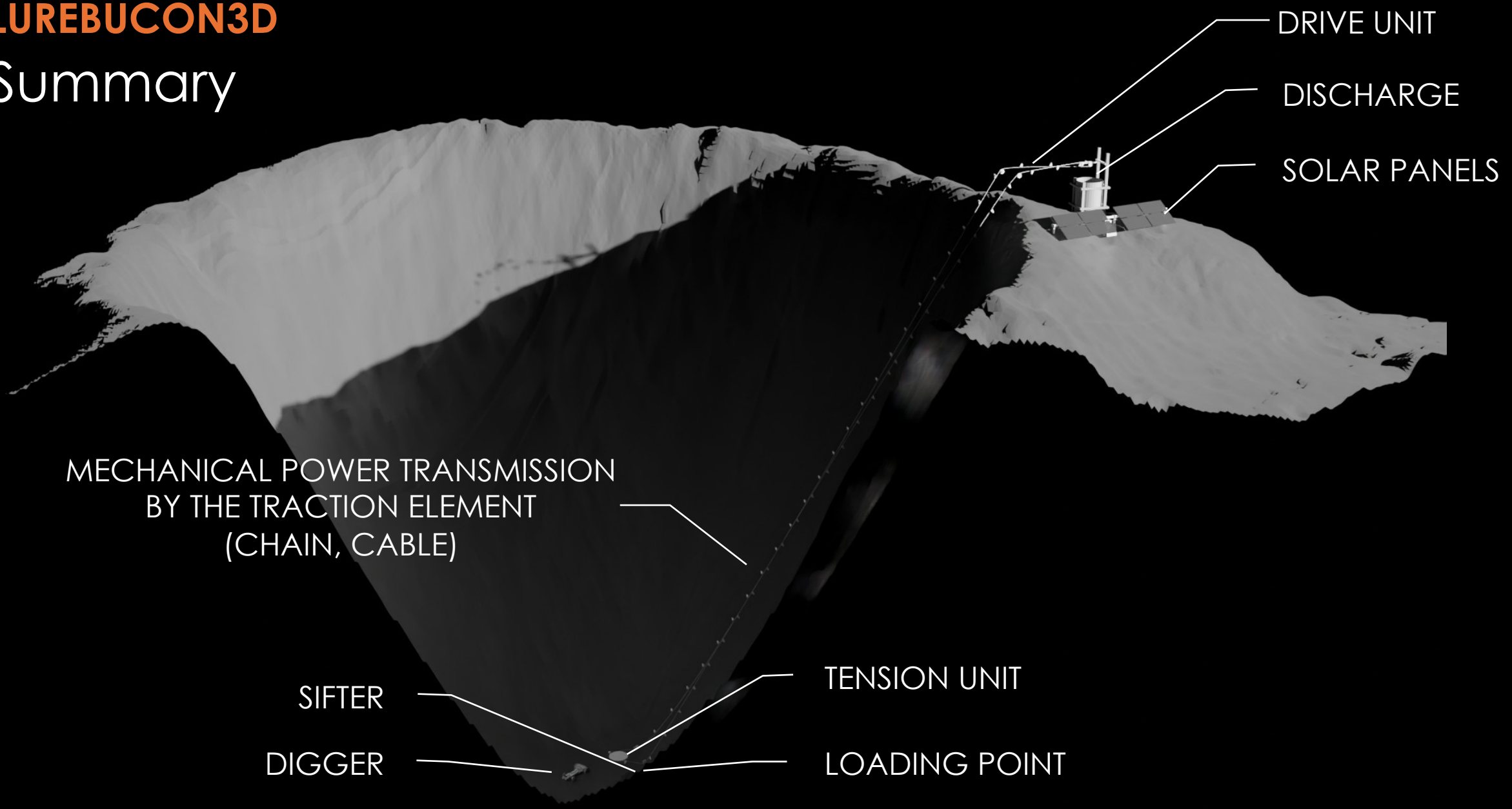








Summary


DRIVE UNIT
DISCHARGE
SOLAR PANELS
MECHANICAL POWER TRANSMISSION
BY THE TRACTION ELEMENT
(CHAIN, CABLE)
SIFTER
DIGGER
TENSION UNIT
LOADING POINT

LUREBUCON3D - Summary

LUnar **RE**golith **BU**cket **CON**veyor **3D** features:

- Low energy consumption
- Lightweight construction
- Due to the lack of atmosphere and low gravity, the length can reach several kilometers
- Scalable capacity – depending on the speed of the traction element, the numer of buckets and their capacity
- Dust mitigation through gentle conveying in buckets and loading using a pulsating scraper feeder
- Drive and batteries in a sunny location
- Transmission of mechanical power via a traction element (cable/chain) to power the sifter and feeder

- No selected traction element that would meet the requirements of the environment, resistance to temperature and dust impact

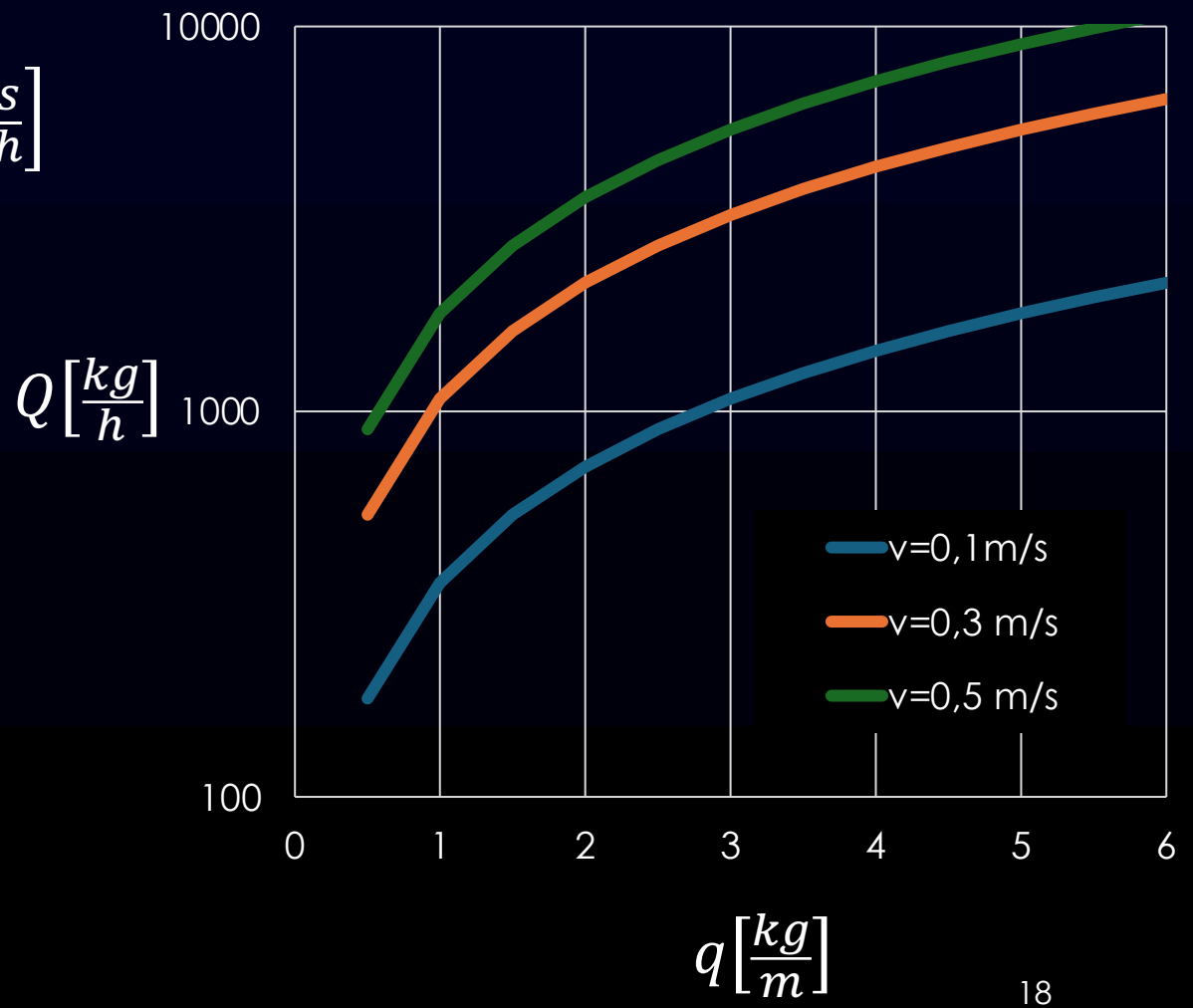
Capacity

$$Q\left[\frac{t}{h}\right] = v\left[\frac{m}{s}\right] * \frac{1{,}5\left[\frac{kg}{dm^3}\right] * V_B[dm^3]}{a[m]} * 3600\left[\frac{t}{kg} * \frac{s}{h}\right]$$

$$q\left[\frac{kg}{m}\right]$$

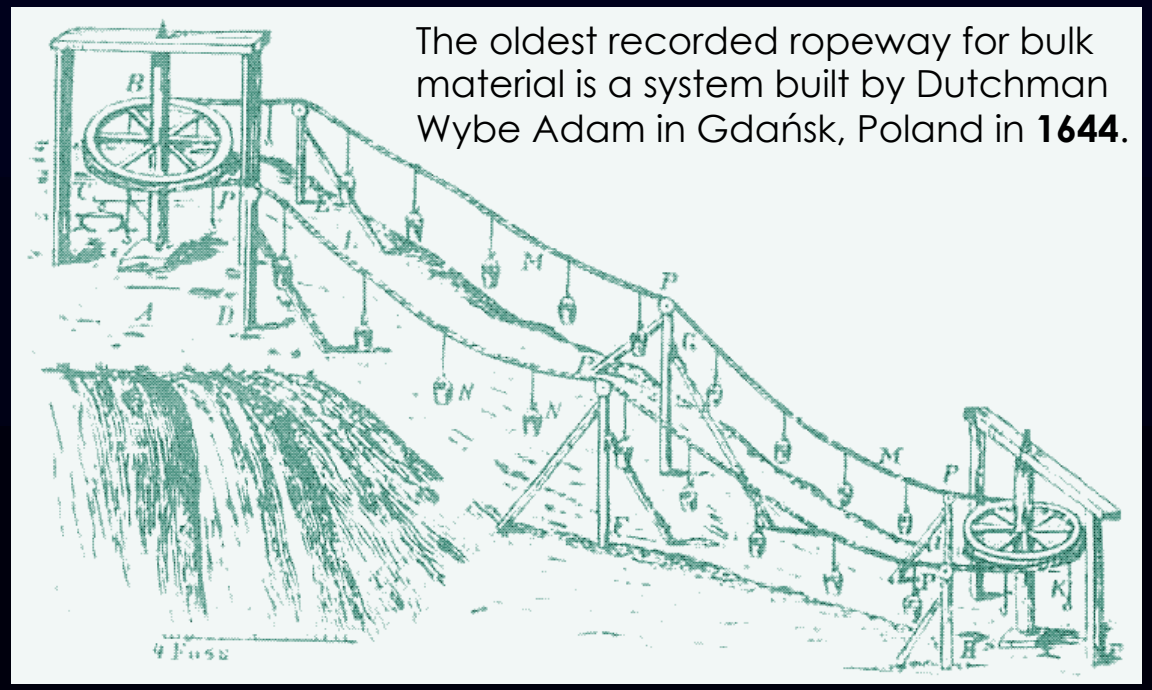
Where:

v	– Speed of Traction Element, [m/s]
q	- Unit Load, [kg/m]
V_B	- Bucket Volume, [m^3]
a	- Bucket Pitch, [m]



LUREBUCON3D

The oldest high-capacity conveyors for transporting bulk materials over long distances are rope bucket conveyors.

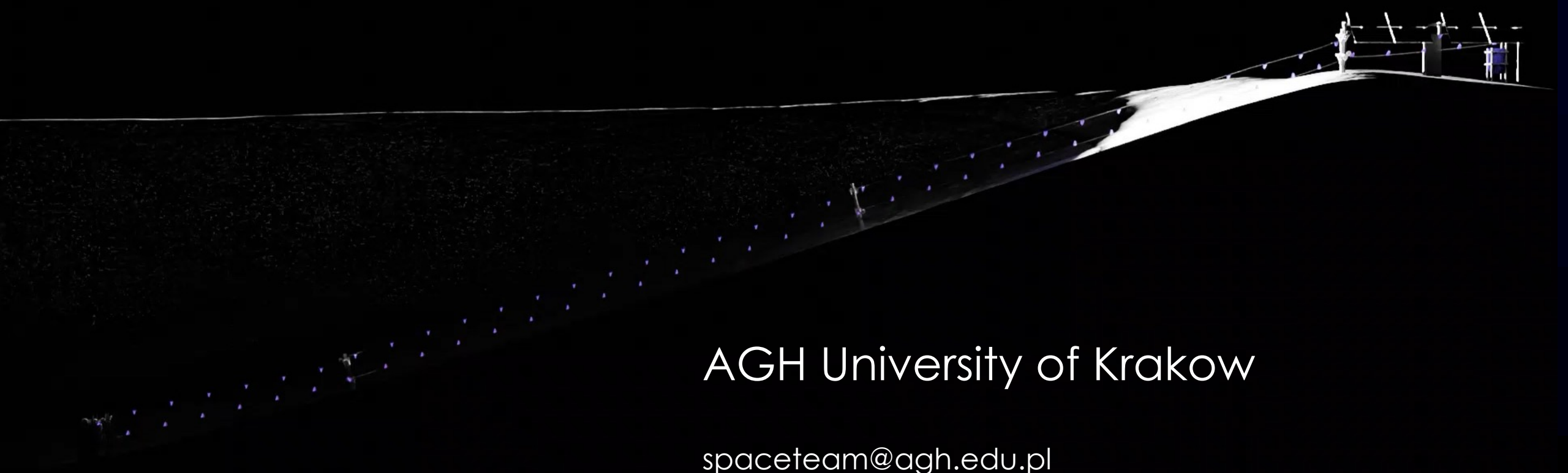


It was used to transport earthworks for a hilltop fortress and operated with a continuously circulating ropeway system using baskets.

The longest ropeways ever built, with lengths of up to 96 kilometres (60 miles).

Thank you!

Piotr Kulinowski



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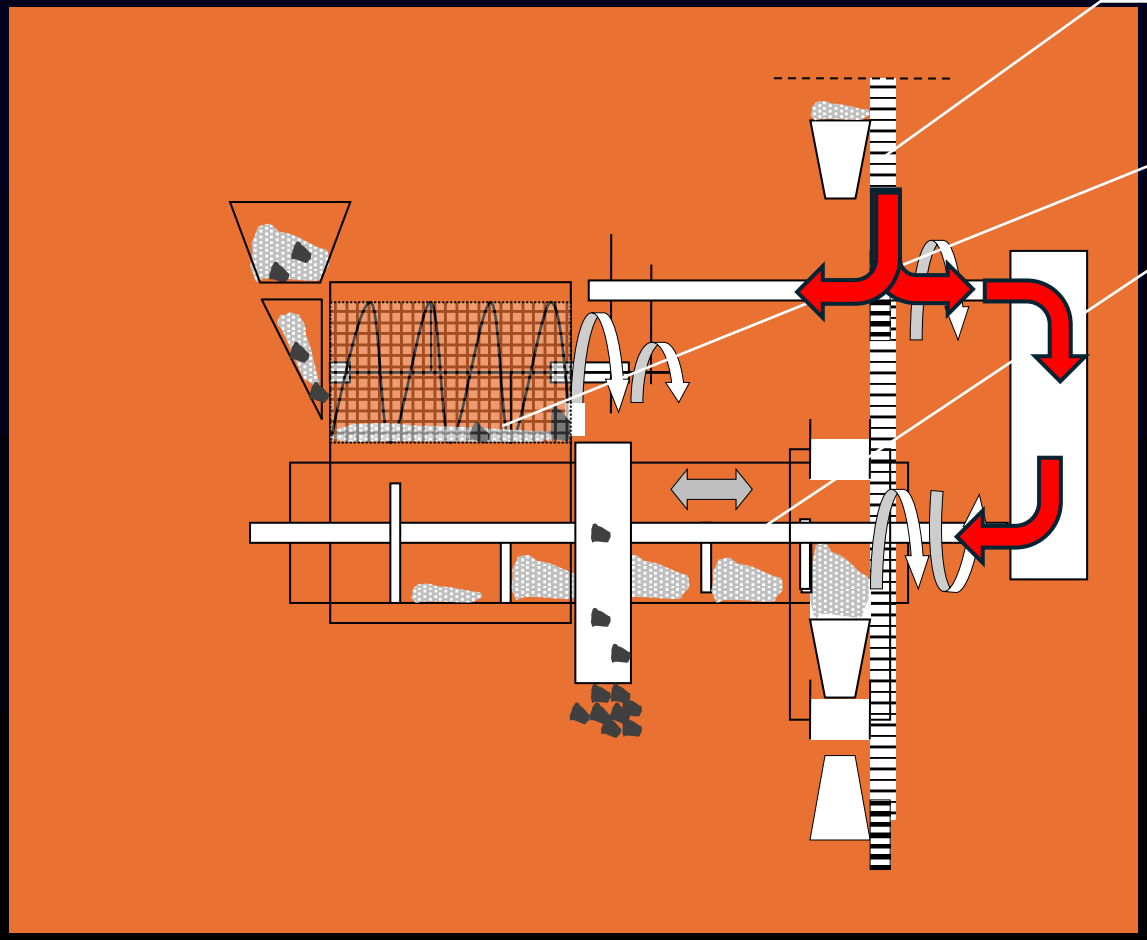
Loading point with the scraper feeder and spiral-drum sifter



TRACTION ELEMENT (CHAIN,CABLE)
MECHANICAL POWER TRANSMISSION

SPIRAL-DRUM SIFTER

PUSATING SCRAPER FEEDER