# Soil Preparation System & Multi-Functional Drill for Future Subsoil Sampling Activities on Planet Mars

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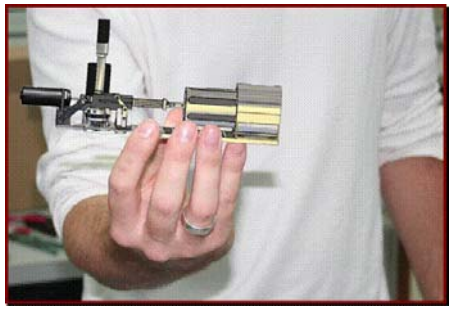
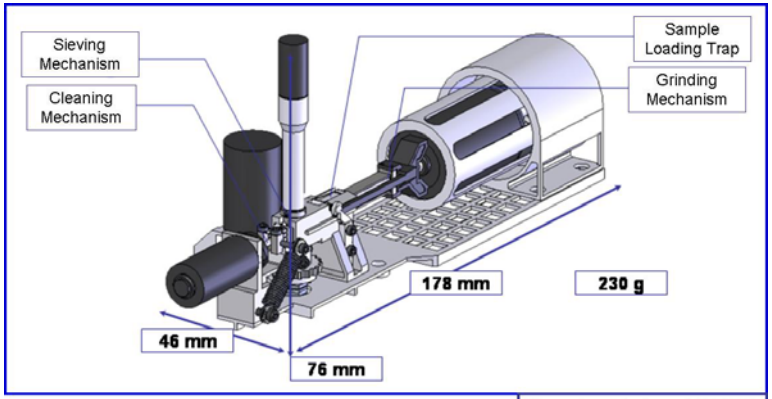
## Sample Preparation System (SOPSYS)

### A miniaturized sample preparation device: SOPSYS

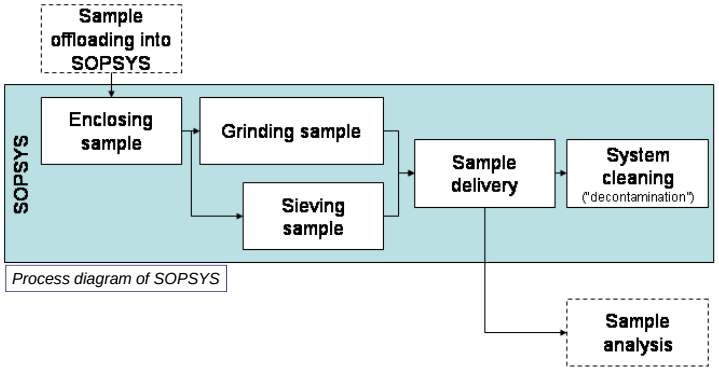





*General architecture of SOPSYS*

### Functionality:

Design of the device is to ensure all particles going into the analyzer are no larger than 1mm. The samples will be loaded into the system and crushed by a mechanical grinder. The grinder will press the sample against a sieve of size 1mm where the sieve itself will further enhance the grinding by a rotational movement around its axis, giving pieces of rocks in the sample.




*Process diagram of SOPSYS*

### Possible applications

Possible applications of this device is the coming Phobos mission (i.e. Phobos-Grunt) where fine samples of the soil will be retrieved and analyzed.

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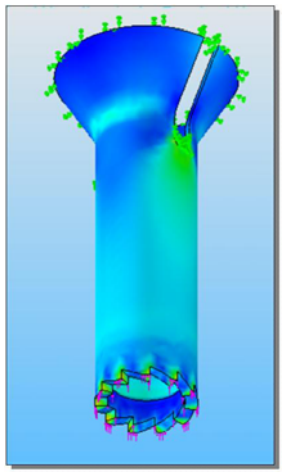
## Functionality:

A hybrid sampling head was developed which is able to enhance a drill's penetration capabilities through loose sand and hard rock. The mechanism includes a hammering device for advancing the head or sample acquisition. The sampling mechanism can take a core of diameter 7.5 mm and a length of 10 mm. A novel shutter mechanism is included in the sampling bit to saw hard rock cores but also retain fine sand samples.

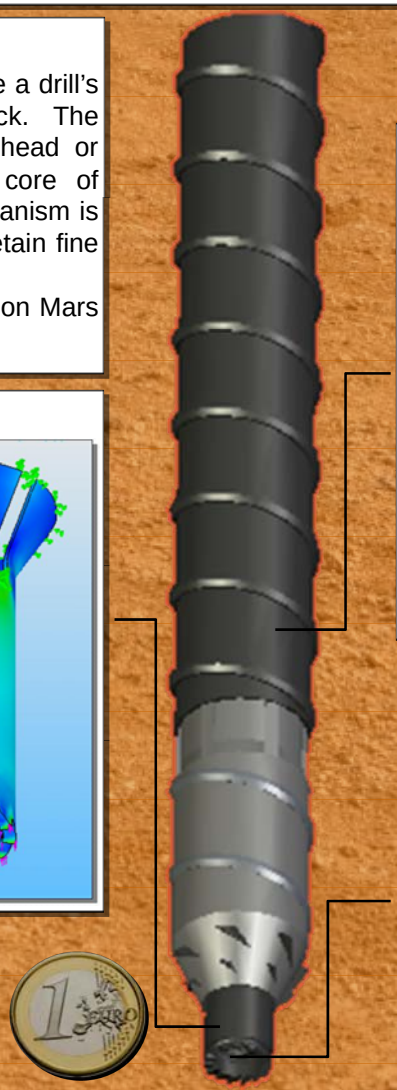
This development is dedicated for deep soil sampling missions on Mars and the Moon.

## The Core Sampler:

The sampling head includes a core sampler of 10 mm in diameter. The wall thickness is minimized in order to reduce the necessary cutting energy for hard rock samples. The sampler can hold loose sand or rock samples with a length of 10 mm and a diameter of 7.5 mm. A passive breaking mechanism is further implemented that breaks hard rock samples when the maximal length is reached. When returned to the surface, the sample can be ejected into a receiving device for further analysis by using the hammering mechanism.

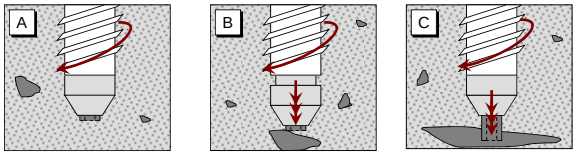


# Integrated Sampler Downhole Drill Head (ISDDH)

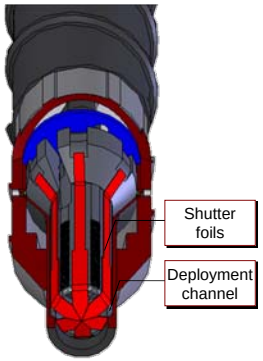


## The Core Sampler:

The unique design of the ISDDH is its worm-like advancement motion. The hammering is directed to the head to hammer it forward while further rotation of the drill string advances the body of the drill. The whole device is highly miniaturized and integrated to reduce the overall diameter to 20 mm. ISDDH cannot operate alone, but is intended to be mounted in front of a drilling system to enhance its capabilities to penetrate through rocks enclosed in loose sand. This tool therefore presents a valuable concept for mission scenarios like deep surface drilling into unknown soils such as Mars.




## The Shutter:




A shutter mechanism is integrated into the core sampler that allows sawing through rock cores and also to retrieve loose sand samples. This system is based on spring foils in order to reduce as much as possible the wall thickness of the core sampler and thus the energy necessary to cut rocks.

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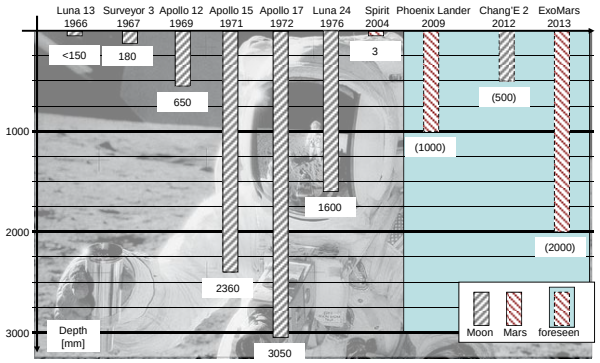
## Deep soil sampling, state of the art:

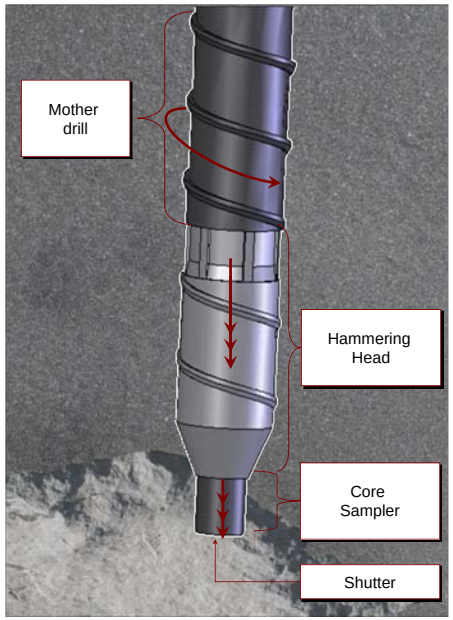
The figure below shows the state of the art in planetary deep-soil sampling. The figures illustrate the difference between samples taken by the Apollo astronauts (over 3 meters depth) and samples taken by robotic means (Luna 24 with 1600 mm depth).

The planned future missions are shown on the right side with the intended respective depths. The here presented *ISDDH* is dedicated to such kind of mission, where samples need to be taken from depths below 500 mm in unknown terrain and the presence of hard rocks enclosed in loose sand.

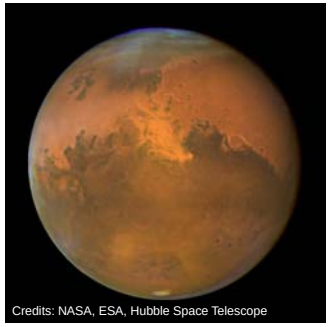



## A concept for hard rock and soft sand.

With its internal hammering mechanism the ISDDH is able to penetrate through different kinds of terrain. The system is integrated in front of the mother drill string.




## Possible applications




Possible applications of this device are the coming Mars missions with deep drill capabilities (i.e. ExoMars) but also the Chinese lunar mission Chang'E 2 where a drill is needed to penetrate into the soft lunar soil to retrieve samples.