Introduction: The Regolith and Ice Drill for Exploration of New Terrains (TRIDENT) is an ice mining drill under development for two exploration/ISRU missions to the Moon: Volatiles Investigating Polar Exploration Rover (VIPER) and PRIME1 (Polar Resources Ice Mining Experiment) – see Figure 1 [1]. The primary goal of TRIDENT is to deliver volatile-rich samples from up 1 m depth to the lunar surface [2]. Once on surface, the material would be analyzed by Mass Spectrometer Observing Lunar Operations (MSolo) and the Near InfraRed Volatiles. Spectrometer System (NIRVSS) to determine volatile composition and mineralogy of the material.

TRIDENT is a rotary-percussive drill which enables it to cut into icy material that could be as hard as rock. The drill consists of the following subsystems: rotary-percussive drill head for providing percussion and rotation to the drill string, deployment stage for deploying the drill to the ground, feed stage for advancing the drill string 1 m into subsurface, drill string for drilling and sampling, brushing station for depositing material onto the surface (Figure 2).

TRIDENT drill is designed to capture and deliver samples in so-called bites. That is, the drill penetrates 10 cm into subsurface, and then it is pulled out and deposits the 10 cm worth of material onto the surface for analysis by MSolo and NIRVSS instruments. Once the analysis period is complete, the drill penetrates another 10 cm (i.e., from 10 cm to 20 cm depth), and brings up fresh material for the analysis. The 10 cm bite is a nominal drilling depth, however, the drill could also use shorter bites, if requested.

The bite operation allows for stratigraphy to be preserved in at least the 10 cm bites, though, it is highly probable that MSolo and NIRVSS will be able to provide information at a much higher depth resolution, provided the subsurface material is cohesive and dense. If subsurface material is highly porous, it is likely that some of the material, instead of being captured, will be pushed sideways into the borehole wall.

Drilling power comes from two major sources: power needed drill and power needed to remove cuttings. As the drill penetrates deeper, the power required to remove cuttings can be significantly higher than the power required to drill. As such, drilling in 10 cm bites, has a major advantage of keeping drilling power to minimum. This in turn, reduces the need for more powerful drive electronics and simplifies power distribution.

TRIDENT will be able to provide in-situ density by measuring the size of the cuttings cone on the surface. Integrated heater with co-located temperature sensor could be used to determine subsurface temperature and thermal conductivity. The temperature sensor at the drill bit, will be directly exposed to the regolith. As such, this sensor will be able to determine more accurate subsurface temperature. TRIDENT drilling power and penetration rate would be used to determine regolith strength and together with data from MSolo, NIRVSS and Neutron Spectrometer System (NSS), we would be able to determine structure of ice – whether it’s mixed with regolith or cemented with regolith grains.

Figure 1. VIPER (left), PRIME1 (right).

Figure 2. TRIDENT subsystems.