**TRIDENT lunar drill with PlanetVac pneumatic sample delivery: a new paradigm in sample acquisition and delivery.**

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**Introduction:** Future missions to the Moon will require regolith samples from below the surface for either in situ analysis or sample return. These samples would be analyzed to answer specific science questions as well as provide information related to volatiles (and specifically water) resources for the purpose of In Situ Resource Utilization (ISRU).

To enable sample acquisition and delivery to instruments or sample return container, we combined high Technology Readiness Level (TRL) technologies: TRIDENT for sample acquisition and PlanetVac for sample delivery [1, 2, 3].

**TRIDENT and PlanetVac:** TRIDENT is a rotary-percussive drill designed to capture samples from approximately 1 m below the surface. Depending on the mission requirements and the lander size, TRIDENT could be modified to drill deeper or shallower. The 1 m version of TRIDENT weighs approximately 16 kg and can be mounted on the side of the lander or along one of the legs or in various locations on a rover. Smaller version of TRIDENT could weigh as little as 2 kg and penetrate 10 cm below the surface.

Drilling below the surface is the first step in sample acquisition. As important, however, is the sample delivery. Typical sample delivery options include mechanical approach – a scoop at the end of a robotic arm. This approach, however, has significant flaw – it requires that the arm can reach both the drill and the instrument. This significantly constraints where the two payload elements (drill and instruments) can be placed on the lander (or the rover). PlanetVac is a pneumatic sample delivery system that uses compressed air to fluidize and transport the sample directly into an instrument (Figures 1 and 2). The transport occurs inside a pneumatic tube which can be routed in any way to reach the instrument. As such, the drill and the instruments could be placed in different locations. This significantly simplifies the payload integration. The drill will be mounted where it's best for the drilling, while the instrument can be placed in a location that's most optimal for sample analysis (e.g. within thermally controlled box).

TRIDENT is at TRL6; the drill has been matured through a series of the lunar vacuum chamber tests (100 K and 10^-6 torr) in water doped and compacted lunar soil simulant NU-LHT-3M [4]. The tests were performed at VF13 facility at NASA GRC. The drill has also underwent vibration tests at NASA KSC.

PlanetVac is at TRL5/6; the system has been tested in a vacuum chamber and successfully delivered samples of JSC-1a lunar simulant into a cup [3]. PlanetVac has also been integrated on a footpad of a Masten Xodiac lander and tested under actual flight scenario in Mojave, CA. The lander took off, traversed, and landed on the bed of MSS simulant, PlanetVac was triggered to capture the sample, and the lander took off again and landed in its initial location. In each of the three tests, approximately 300 grams of sample was acquired [2].

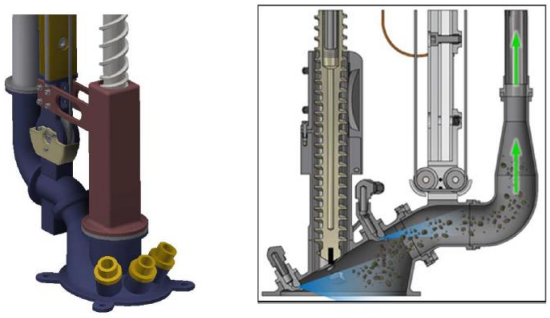

**Figure 1. Details of the TRIDENT and PlanetVac system.**

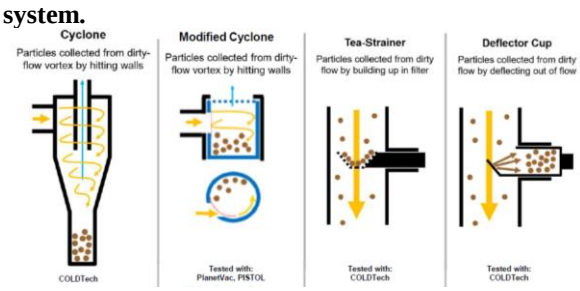


**Figure 2. Details of the PlanetVac sample delivery to instruments.**

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