Measure While Drilling Development Plan

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This presentation describes the concept and experimental test plan for the development and preliminary validation of an intelligent substrate identification and hardness estimation system for planetary drills. The proposed technology is part of a larger project involving a TRL 5 prototype of a rover-based drill that can also be mounted on a fixed base (e.g. lander), capable of acquiring and transferring clean, unheated, uncontaminated, intact subsurface samples. This technology will demonstrate Canadian expertise in planetary drilling for future exploration missions and will be used in the context of NASA's next generation RESOLVE mission.

This work builds on previous experiments at NORCAT that demonstrated how the measured response of a working drill can be correlated to changes in the drilling substrate. The results from instrumented drilling operations and preliminary analysis indicate that the proposed approach could lead to the ability to identify geotechnical characteristics and estimate substrate hardness during the drilling operation. The goal of the final system will be to perform two functions based on data collected from transducers and the drill control system during the drilling process. The first function of the system will be to extract and identify key geotechnical characteristics for mission decision support. The second function of the system will be for data collection, enabling the drill to be used as a scientific instrument. In particular, the system will be used to estimate substrate hardness during the drilling operation.

The objective of the preliminary experimental data collection phase is to obtain a dataset characterizing the response of the modified NORCAT RESOLVE EBU2 drill penetrating a range of substrates under controlled conditions. Data will be collected from drilling of both consolidated and unconsolidated material encompassing a range of moisture content using an instrumented drill (Figure 1). This dataset will then be used to develop, train and validate the intelligent Measure While Drilling (MWD) pilot system. A sensitivity analysis will also determine the cost versus benefit of specific parameters for accomplishing the end objective.

Sample preparation for the initial data collection phase will consist of compacted Chemically Enhanced OB-1 (CHENOBI) lunar highlands regolith physical simulant at 0%-10% moisture content by weight and dolomite, at cryogenic temperatures and standard temperature pressure. CHENOBI at 0%-10% moisture content will be prepared as follows for this testing. The CHENOBI will be oven dried and compacted prior to use. Multiple thermocouples will provide data to estimate temperature at the drill contact zone. The prepared vessel containing the sample

will then be placed in the cryotemper and cooled to -175°C. The instrumented drill will be placed on top of the cryotemper and the drill bit and auger assembly will access the frozen CHENOBI within the chamber by means of the top port in the cryotemper. Drilling depth will range between 10 to 90 mm.

The data collection will be triggered by the control system of the drill. The measured parameters will include rotational speed, thrust, rate of penetration, vibration, motor current and motor voltage. The instrumented drill will penetrate the sample under specified operating conditions regulated (PID control) by the MWD control system. The core sample and potentially surrounding material for consolidated substrates will then be collected and logged, linking linear position with core location. Collected samples will be preserved and measured for hardness at specified depths along the sample. Finally the ground truth and instrumented parameters will be combined into a common synchronized dataset.

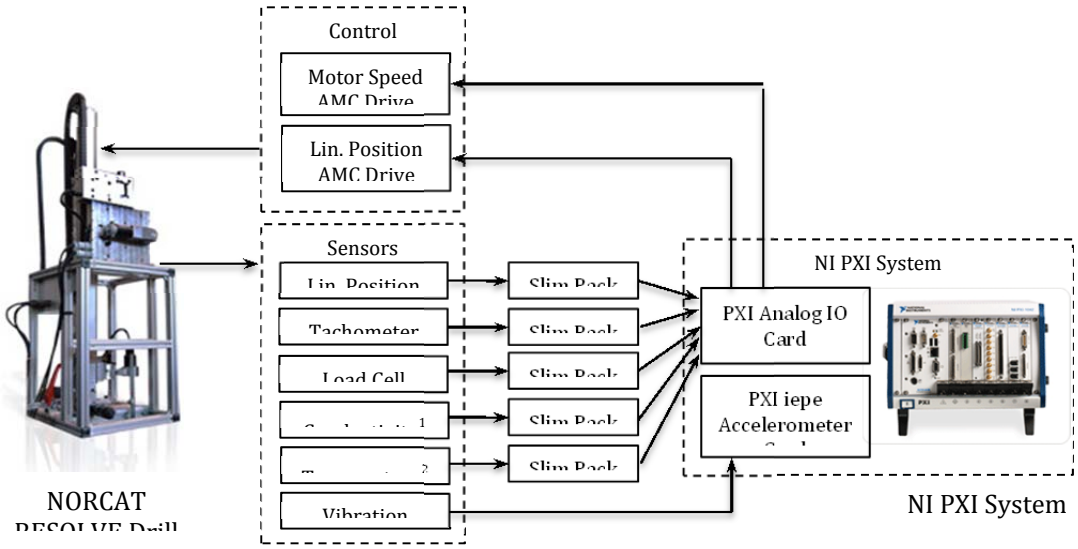

Figure 1. Hardware setup for data collection system