Penetrators as a deployment tool for Mass Spectrometer instrumentation

Conference or Workshop Item

Penetrators as a deployment tool for Mass Spectrometer instrumentation

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Abstract

We discuss penetrator deployment systems and Mass Spectrometer (MS) based instrumentation that offer the potential for future characterization and understanding of the volatile content at the surface and near-surface of airless bodies in the Solar System. We review previous penetrator missions, systems and instrumentation, before considering future options to bodies such as the moon and small solar system bodies.

1. Introduction

Solar system exploration is currently in a phase where in-situ analysis is playing an increasingly important role. A number of mission opportunities are arising, and are under consideration that may provide the opportunity to gain access to surface and sub-surface material through deployment of either high-speed penetrator platforms [1], or low-speed sub-surface penetrating mole devices deployed by soft landers [2].

1.1 Penetrators

Penetrators (Figure 1) are small probes that offer the opportunity to gain access to surface and sub-surface material without the need for complicated drilling or excavation equipment. Multiple penetrators further offer geographically spaced investigations and mission redundancy. However, despite previous attempts penetrator technology has yet to be proven in flight. The Russian Mars 96 penetrator probes, launched in 1996 to investigate Mars was lost when the space-craft failed to leave Earth orbit. The NASA's Deep Space 2 (DS2) mission successfully reached Mars orbit however the probes never made contact with the orbiter. Despite these setbacks penetrators are seen as a viable concept with possibility to accommodate a wide range of target bodies.

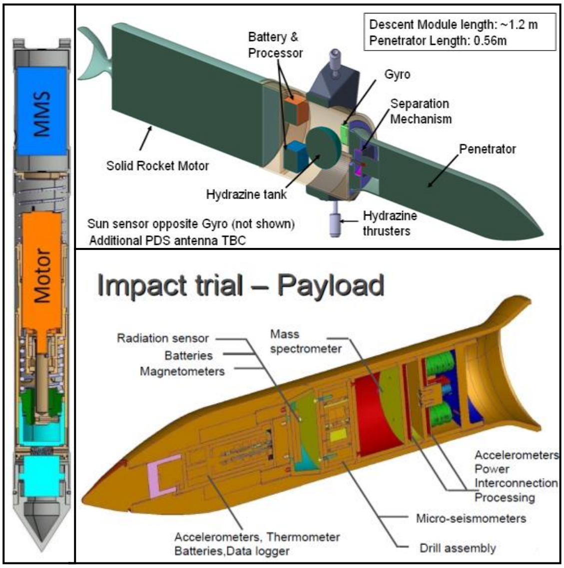

Figure 1: (left) low-speed Mole deployment (top-right) High speed penetrator system (bottom-left) Instrumented penetrator

1.2 Mass Spectrometry

Mass spectrometry is regarded as a "gold standard" analytical technique in terrestrial laboratories and is used for the determination of the elemental, isotopic and molecular composition of sample material. A high-speed deployable (Figure 2) and a low-speed deployable version of the Ptolemy MS [3,4], instrument on-board the Rosetta lander been developed. These instruments will allow in-situ volatile characterisation following penetrator deployment from either high-speed or low speed platforms.

Figure 2: (left) High-speed (right) low-speed deployable Mass Spectrometer instruments

2. Instrument testing

High-speed testing of the MS has been performed under a UK-led penetrator testing programme [5]. The objective of these tests was to demonstrate survivability of the penetrator shell and to assess the impact on instrument sub-systems. The impact tolerant MS was part of the payload. An Impact speed of 310 ms^{-1} was achieved with the use of a rocket propelled sled (Figure 2)

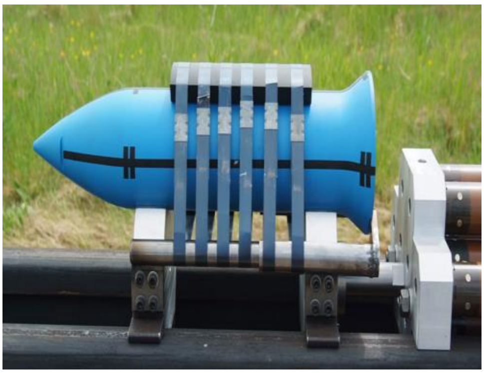

Figure 3: Instrumented penetrator prior to impact testing

3. Future missions opportunities

3.1 Lunar Penetrator mission

The L-DART mission concept [6], is currently under consideration and consists of one or more penetrators being released from lunar orbit into a targeted permanently shadowed region. The penetrator deployed MS would measure the rise and decay of volatiles released during and after the impact event. The results obtained by L-DART will provide ground truth for the numerous orbital measurements that provide indications concerning polar volatile deposits and their concentrations [7,8,9,10].

3.2 Deep space Penetrators

Conceptually similar to the ESA-China proposal for Marco-Polo at the ESA M4 call, a proposal from the China Academy of Space Technology would see a mission visit a NEO, return a sample to Earth, and then send the main spacecraft on to a Main Belt Comet (MBC) [11]. If selected it would arrive at the MBC which is currently expected to 133P in the late 2020s. Discussions with international partners are ongoing and a penetrator deployed MS is under investigation to allow access the subsurface and measure its volatile composition [3].

4. References

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