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Micro-Penetrator Applications for Europa and Mars

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Abstract

We present the current status of the penetrator consortium and of the opportunities being pursued for Europa and Mars.

1. Introduction

We consider kinetic penetrators in mass range (~5-15kg) which impact at speeds of up to ~300m/s to embed themselves a metre of so under the surface, to then perform key scientific investigations for durations of around a week to ~1year.

Because of their low mass, they offer the ability to provide a low cost method of providing a wide variety of science which include high priority astrobiological investigations requiring access to potential astrobiological material, and seismic investigations of the deep structure of planetary interiors.

A wide range of potential scientific instruments have been proposed which can support the above and other major scientific investigations, of which key sensors have already survived impact trials, and together with others are

Geophysics Ocean/interior	*Geophysics Surface/chemistry*	*Environment*
Astrobiology habitat	*Astrobiology biosignatures*	*Astrobiology relevant*
Seismometer (engineering tiltmeter)	*Mass spectrometer*	*Light level monitor*
Magnetometer	*Thermo gravimeter*	*Radiation monitor*
Radio beacon	*X-ray spectrometer*	*Thermal sensor*
Gravimeter	*Raman, IR, or UV-Vis-NIR spectrometer*	*Atmospheric sensors (gas, humidity)*
Geophysical tiltmeter	*Microscopic imager*	
Heat flow probe	*Astrobiology Habitability Package*	
Microphone	*Descent camera*	
	Accelerometer	
	Dielectric/permittivity	

Table-1: Candidate Penetrator Instruments

currently under development.

2. Candidate Instruments

A wide variety of candidate instruments for potential penetrator implementation are shown in **Error! Reference source not found.**, which depicts instruments with astrobiology potential *italicised* in shaded boxes. This table is focused particularly on Europa where a subsurface ocean could be a potential astrobiological habitat, though also includes potential inclusion of instruments which could sense atmospheric gases on Mars which have permeated into the near subsurface.

It is anticipated that for a particular mission that selection criteria for an appropriate subset of the candidate instruments will include scientific merit, resources and TRL (Technical Readiness Level).

3. ESA System Study

Results from an ESA system study of penetrators which has just completed will be reported. This study focused primarily on application to the Jovian moons, though also included an initial assessment of application for Mars.

This study included assessment of payload instruments, impact environment, delivery systems, and the penetrator including shell, subsystems and instrument accommodation. It also included assessment of radiation environment, and planetary protection.

3. Europa

There is strong interest in provision of penetrators for a surface element to the proposed NASA/ESA EJSM mission to Europa. In particular, penetrators could address many key science aspects which are not possible from orbit which include seismic determination of the depth of the posited subterranean ocean, and also the thickness of the upper ice crust should it be too thick for orbiting ground penetrating radar to determine. This would provide important astrobiological habitat information, and in addition penetrator instruments could determine the basic chemistry of the surface materials and search for astrobiological signals therein, as well as directly determine the habitability characteristics of the frozen water.

4. Mars

Despite many previous successful Mars space missions, and those in current preparation, there are none which address the major missing element of firmly establishing the basic inner geological structures of Mars. For this a network of 3 or more seismometers would be required, for which penetrator deployment would be an ideal and potentially low mass and cost solution. In addition an ancillary payload could address other science issues which include the exploration of additional geological sites on Mars. This could include astrobiological investigation using relatively deep implantation of penetrators to several metres.

5. Penetrator Consortium

In the last year the UK penetrator consortium has expanded to include a relatively large number of European contributors in response to a penetrator surface element to the proposed EJSM mission, and some potential U.S. contributors also. The consortium incorporates contributors to the science, potential instruments, and penetrator and delivery system elements.