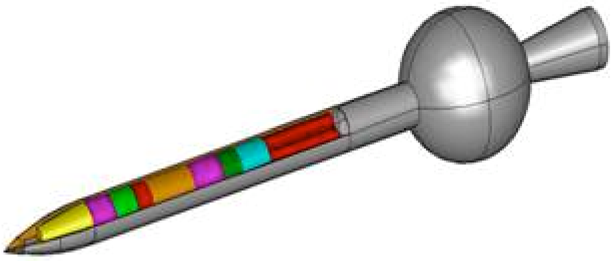
UK Lunar Penetrator Consortium

When we look at the Moon we see features as old as the oldest rocks on Earth – a Fossil of the early Solar System that retains key information about the origin and evolution of the inner planets

There has yet been no far side landing, or at the poles which could detect water and other volatiles hidden in permanently shaded areas potentially important to astrobiology and future human exploration.

UK Lunar Penetrator Consortium

This document describes the current objectives and status of the UK consortium to develop kinetic micro-penetrators for the UK PPARC initiative for a 2013 Lunar Exploration mission.



Concept for Lunar Kinetic Micro-Penetrator

History

The UK consortium grew from its beginnings in 2002, to reach a point in 2006 when its recommendations for planetary penetrometry was given a high priority by the UK planetary science community.

Also, in early 2006, PPARC initiated a study led by SSTL for feasible Lunar Exploration Mission scenarios, from which penetrators emerged as a top priority for a practical cost effective means of achieving the highest scientific research goals.

What are Kinetic Micro-Penetrators ?

Kinetic micro-penetrators are low mass probes which impact planetary bodies at high speed and bury themselves into the planetary surface.

Our consortium is aiming at a Lunar probe mass around 13Kg with an additional similar mass to decelerate and align it to survive impact at around 300m/s (equivalent to around Mach 1 on Earth). This will be the first deployment of such a probe on any airless planetary body (although two U.S. Mars Polar Orbiter Deep Space 2 (DS2) probes were released for deployment on Mars, they were lost together with the associated Lander). However, impact survivability of such probes has been ably demonstrated by ground tests of DS2, and the Japanese Lunar-A penetrator programme presently on-hold in Japan, as well as extensive defence industry trials impacting into concrete and steel.

Science & Payload

The proposed Lunar mission addresses the following key science which could be incorporated into a kinetic micro-penetrator payload :-

- **Lunar Seismology**
  A network of micro-seismometers could detect the presence and measure the size of a lunar iron core; determine crustal and basal fill thickness; the deep structure of lunar mantle; the origin and location of the enigmatic shallow moonquakes. These would benefit understanding of Moon's residual magnetism; origin of Earth-Moon system; and evolution of planetary magnetic fields.
- **Lunar Thermal Gradients**
  Passive thermometers would be capable of determining heat flow from the Lunar interior and information on inhomogeneity of crustal heat producing elements (U,K,Th). This is relevant to understanding the Moon's early history.
- **Lunar Water and other Volatiles Sensing**
  Water sensors capable of detecting the presence, extent, and concentration of water and other volatiles (organic), would provide information on Lunar evolution and future Lunar resources. If possible, an isotope discrimination capability could also provide information on the origin of the water. Such information could also be relevant to astrobiology including the highly controversial panspermic theory of the origin of life on Earth.
- **Geochemical Analysis**
  Provide ground truth for remote sensing XFA and multi-spectral imaging.
- **Far Side**
  As there has not yet been a far side landing, and there is evidence that the near and far sides of the Moon may be quite different internally, this could determine differences in regolith, lunar interior structure and composition.

Mission

- Launch: target 2013.
- Delivery and Communications Spacecraft (Orbiter).
- Orbiter Payload: 4 Penetrator Descent Probes (Maximum 13Kg penetrator + 20Kg propulsion each).
- Landing sites: To be widely spaced across Lunar surface to support seismic and heat flow network; with at least one site on far side; and one at polar region (probably South Pole Aiken basin) for water/volatiles detection.
- Duration: Surface mission to last _ 1 year (several years desirable) for seismic network. Other science do not require so long (perhaps a few Lunar cycles for heat flow and volatiles much less).
- Penetrator Support: Orbiter to provide power, pre-ejection health status, and relay communications.

Descent Phase

- Deploy descent probes from orbit, using a breaking solid rocket motor to kill orbital velocity.
- Attitude control to achieve penetration closely perpendicular into Lunar regolith to depth of a few metres.
- Camera to be used for descent to characterize landing site
- Telemetry transmission during descent for health status (technology demonstration)
- Impact accelerometer (to determine penetration depth & regolith mechanical properties)

Landed Phase

- Single body penetrator for simplicity & risk avoidance.
- Battery powered, with comprehensive power saving techniques.

Cost

There are two major reasons why the use of micro-penetrators should be relatively low cost :-

- Low mass greatly reduces launch costs.
- Given the extensive investment into impact survivability in the UK defence industry; the UK's extensive expertise in scientific instrumentation for space; and recognising that a Technical Readiness Level of 6 follows from the DS2 and Lunar-A ground trials, the development costs will be modest.

Consortium

The consortium currently consists of the following organisations who have been recognised for their appropriate expertise and track record in the particular science or developing technology for space research :-

(i) Mission: SSTL - Mission planning, delivery and communications spacecraft; Descent Probe attitude control, de-orbiting motor; attachment to spacecraft, descent manoeuvre and operations) (http://www.sstl.co.uk/

(ii) Penetrator: MSSL - Penetrator consortium lead, science requirements, instrument interface requirements, landing site selection, science operations, payload system design (http://www.mssl.ucl.ac.uk).

- **Birkbeck College London** - Lunar science (http://www.bbk.ac.uk/es/staff/Ian_Crawford)
- **QinetiQ** – Impact, power and communications technologies (http://www.qinetiq.com/)
- **Imperial College London** – Seismometers (http://www3.imperial.ac.uk/electricalengineering)
- **Open University** - Science and instrumentation (http://pssri.open.ac.uk/)
- **Surrey Space Science Centre** - Platform technologies and instruments (http://www.ee.surrey.ac.uk/SSC/)
- **Southampton University** - Optical Fibres (http://www.orc.soton.ac.uk/)
- **University of Leicester** – Geochemical sensors (http://www.le.ac.uk/physics/)
- **Lancaster University** – Lunar science (http://www.es.lancs.ac.uk/)

The above responsibilities provide a logical system partitioning of spacecraft technologies from that of the high speed penetrator which requires a closely coordinated approach. Within the penetrator, responsibilities for platform and payload have been divided with QinetiQ responsible for providing the penetrator body and a defined high gee payload environment to allow parallel scientific instruments development.

Further Information: See the consortium web site at :-
http://www.mssl.ucl.ac.uk/planetary/missions/Micro_Penetrators.php

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