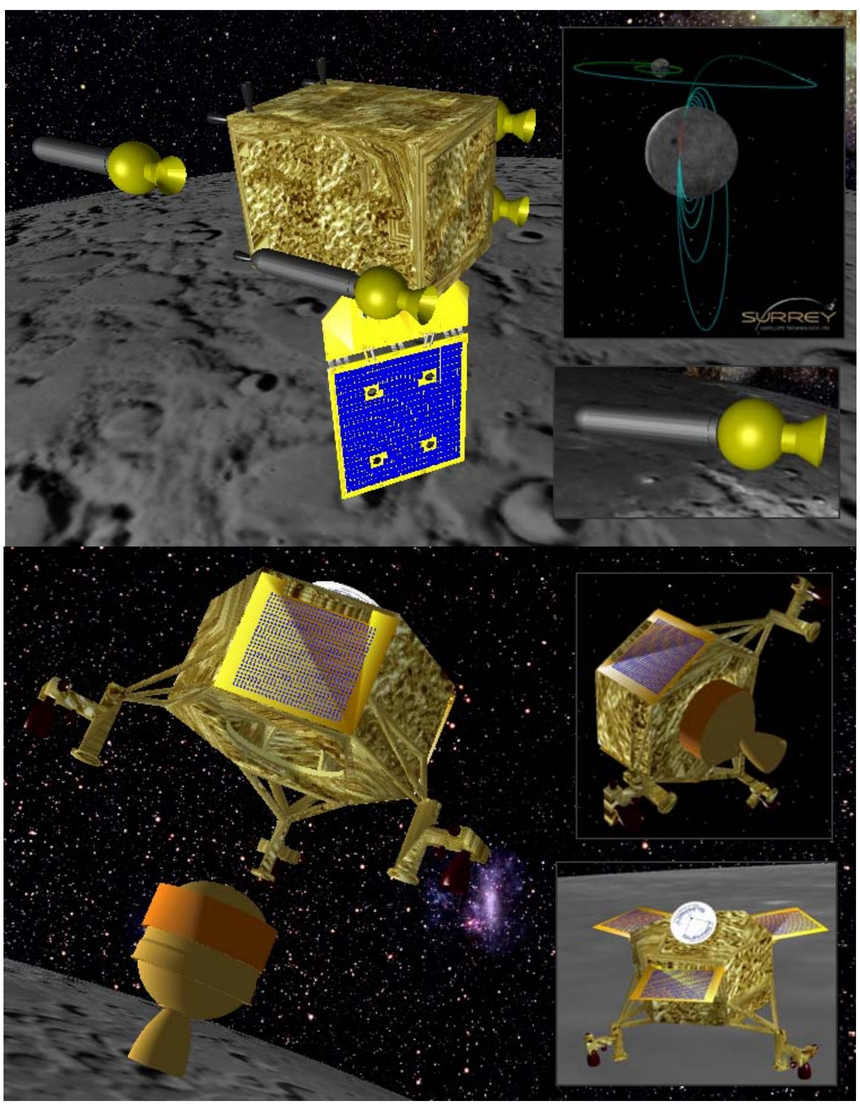
PPARC Lunar Mission Options Study

Final Report



AUTHORS

Andy Phipps (SSTL)
Dr Yang Gao (SSC)

REFERENCE

#118537

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PROJECT

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REVISION

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Surrey Satellite Technology Limited,
Tycho House
Surrey Space Centre
20 Stephenson Road
Surrey Research Park
Guildford, Surrey
GU2 7YE
United Kingdom
Tel: +44 1483 803803
Fax: +44 1483 803804
Email: sstl@sstl.co.uk

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1 EXECUTIVE SUMMARY

Returning to the Moon has been proposed by a large number of international planetary scientists in order to answer several key scientific questions. The UK too has an active lunar science community keen to support such a (robotic) lunar exploration mission. However, for several years, these interests have been eclipsed by the drive to Mars. Recently there is a renewed global interest in the Moon stimulated by the planned NASA Robotic Lunar Exploration Program (RLEP), Chang'E (China) and Chandrayaan (India) missions. The ESA Aurora programme has also broadened its focus away from just Mars to include the Moon - realising that many of the major technical challenges that are faced by Mars missions could be de-risked by relatively inexpensive and timely lunar precursors. ESA is considering a robotic mission to the Moon, but is experiencing pressure on the necessary funding to make it happen. The Surrey Space Centre (SSC) and Surrey Satellite Technology Ltd. (SSTL) have been preparing a 'smallsat' approach to achieving a low-cost lunar mission for over a decade – including various activities, such as the earlier ESA study on LunarSat and currently hardware contribution to the Chandrayaan-1 mission. With the recent successes in GIOVE, TOPSAT & BEIJING-1, alongside our participation in Aurora & AuRAC and the 695 Chandrayaan-1 OBC, SSC/SSTL have developed capabilities for providing affordable engineering solutions to space or interplanetary exploration.

From June to October 2006, PPARC funded SSTL/SSC to carry out a pre-phase A study on a UK-led low-cost lunar mission. The study investigated various mission options, their feasibilities and identified a number of suitable mission concepts. The scope of the study included:

- Mission architecture
- Mission science & technology interface
- Lunar orbiter
- Small lunar landers (hard/semi-hard/soft)
- Low-cost lunar sample return to Earth

The study firstly assessed the scientific and technological requirements of three baseline mission options, namely orbiter, lander and sample return. The first iteration of system design was performed for each for the three options. Design and cost drivers in terms of science performance and required technology were identified.

The study showed that the moon remains scientifically appealing and has generated revived interest in recent years. The large number of intended future missions demonstrates the international community's desire to return. However, despite the large number of planned missions, there still remain significant gaps in the data to be collected that can be the focus of a low-cost UK-led lunar mission. The two main areas worthy of investigation are dating of the young basalts and additional seismology experiments. Two mission concepts MoonLITE and Moonraker were established by SSTL / SSC, a science working team and PPARC and prioritised for further investigation. In addition, the mission concepts were found valid for demonstrating technologies required for large future missions.

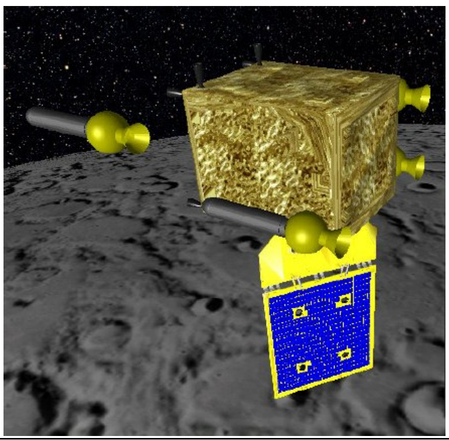
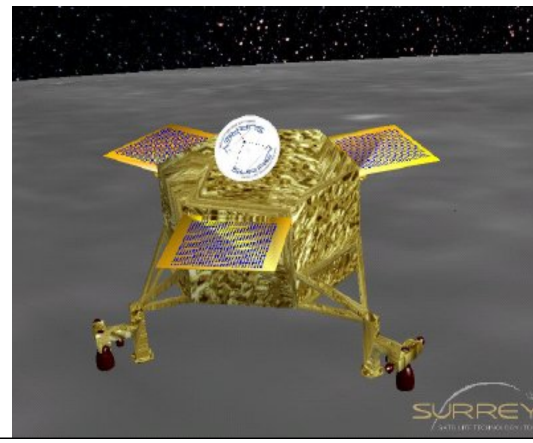
- **MoonLITE (Moon Lightweight Interior and Telecom Experiment)**

This mission concept comprises a small orbiter and multiple (~4) penetrators. The scientific goal is to emplace a network of seismometers and heat flow experiments (including at least one on the lunar far side) in order to investigate the seismic environment and deep structure of the Moon, including the nature of the core. The penetrators are designed for a one-year lifetime with the orbiter providing the data relay back to Earth for this period. The four penetrators would be widely distributed over the surface, with a preference for one being in the same area as an Apollo landing site. If possible, one penetrator would be targeted at the South Pole Aitken Basin and equipped with a sensor to detect water or other volatiles.

In addition, the orbiter shall carry a Ku-band transponder to perform a high data rate communications experiment with any landers that may be operating on the lunar surface during the mission lifetime (e.g NASA/ESA/JAXA/China Space Agency). While several areas of development have been identified, much of the orbiter is derived from the successful SSTL GIOVE-A spacecraft with other flight proven hardware used where required.

- **Moonraker**

This mission concept comprises a single propulsive soft-lander, directly targeted to the lunar nearside (similar to NASA's Surveyor from the 1960s). Constrained to a near-side landing site to allow direct communications to Earth, science data is transmitted directly to ground stations on Earth. The mission would have a primary goal of attempting in-situ dating of the young basalts at northern Oceanum Procellarum and other geophysical experiments for a mission lifetime of approximately 3 months. The Moonraker lander will offer greater scientific return than MoonLITE but it is worth mentioning that significant development by UK industry and academia will be required.

	
MoonLITE orbiter shown deploying first of four lunar surface penetrators	***MoonRaker low cost lander during terminal descent, after separation of deceleration motor***
▪ A polar lunar orbiter for communication, navigation plus orbital remote sensing ▪ Multiple penetrators for both far-side and near-side deployment and in-situ geophysics & geochemistry ▪ Launch in 2010	▪ Small soft lander for northern near-side geophysics & geochemistry ▪ Precision landing, surface autonomy and multiple sites sampling ▪ Launch in 2013

Both mission concepts MoonLITE and Moonraker have been investigated in detail. The report made to PPARC elaborated a design solution to the level of preliminary mission definition and ROM cost, and showed that a lunar orbiter could be demonstrated for considerably less than the cost of ESA's recent SMARt-1 mission, and a lunar lander for a comparable cost. A science dossier was provided to explain and assess potential science goals for the different mission options and associated scientific instruments. In addition, the PPARC mission proposals were compared with current and upcoming international lunar missions in terms of science benefit and technology development.