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UK lunar exploration:
Current activities and future possibilities

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Professor Alan Smith
Director, Mullard Space Science Laboratory

On behalf of:

The British National Space Centre
and
The Science & Technology Facilities Council

Content

- Role and organisation of BNSC
- The UK space science community
- UK Space Exploration:
  - current activities, plans & technology priorities
- Lunar exploration
- Conclusions

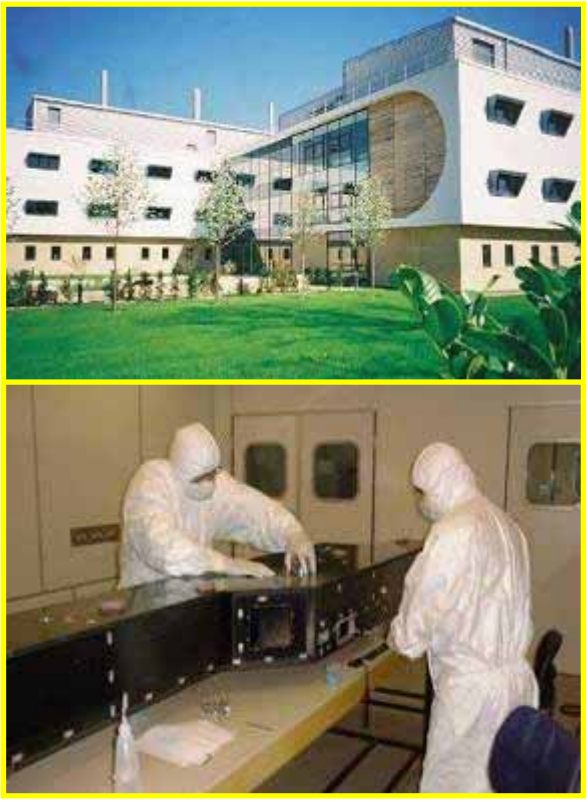
Strategic Partnership through BNSC

- The British National Space Centre (BNSC) is a partnership of Government Departments and research councils and is at the heart of UK efforts to **explore** and **exploit** space.
- BNSC HQ co-ordinates the $420M/yr UK civil space activity, provides international representation and nurtures the UK space industry.
- The research councils are a group of 'non-departmental public bodies' operating at arm's length from central government.
- The Science and Technology Research Council (STFC) is one of the core funding partners in the British National Space Centre
- In 2005/6 STFC invested $150M out of its $1billion budget in 'outwards looking' space science and technology.
- The UK space sector is worth $10 billion per annum, supports 70,000 jobs and makes an overall contribution to UK GDP of almost $14 billion per annum

The UK and Planetary Exploration

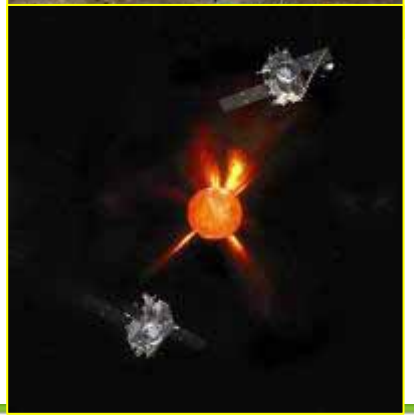
The UK space science community

- 10 university space hardware groups and 2 national laboratories (RAL & UK ATC)
- Further 31 Universities with space-related activities & undergraduate courses
- Over 100 large and small industrial companies involved in ESA programme
- Expenditure of about $150M/yr on space activities is split 70/30 between contributions to ESA for spacecraft/operations; and national work on basic R&D, instruments and science exploitation



At present, three strategic axes of UK space science and robotic exploration

- ESA Science Programme for major projects exploring Sun, solar system & universe beyond (e.g. Giotto, Mars Express, Rosetta…)
- Optional ESA Aurora Programme for robotic exploration of Mars, leading to Sample Return
- Projects with international agencies for key niche science (e.g. SWIFT, STEREO…)



• Aurora is the exploration programme of ESA and aims to prepare Europe to be a major player in exploration (human & robotic) of the solar system

• UK is the second largest contributor to the programme, having committed:

↗ more than $200M towards ExoMars mission including instruments, technology development
↗ and $10M to mission studies (e.g. MSR) corresponding technical development contracts

Space Exploration: developing a UK strategy

The UK is involved in three levels of analysis and review:

International

- Global Exploration Strategy development
- Framework Document issued by 14 agencies in May 2007
- April 2007, NASA-BNSC signed joint statement agreeing to investigate joint opportunities for lunar exploration

European

- exploration activities within the ESA Aurora programme & Cosmic Vision 2015-25

National

- Long term: BNSC Space Exploration Working Group (UKSEWG) – report published 13th September 2007 proposes actions for involvement in global space exploration
- Short term: Preparation for robotic lunar exploration

Human Spaceflight?

- The UK remains content with its decision not to participate in the International Space Station…
- …but the role of humans in space exploration is today being examined on its own merits
- The considerable cost implications will have to be weighed against the potential benefits

UK Planetary science and technology heritage

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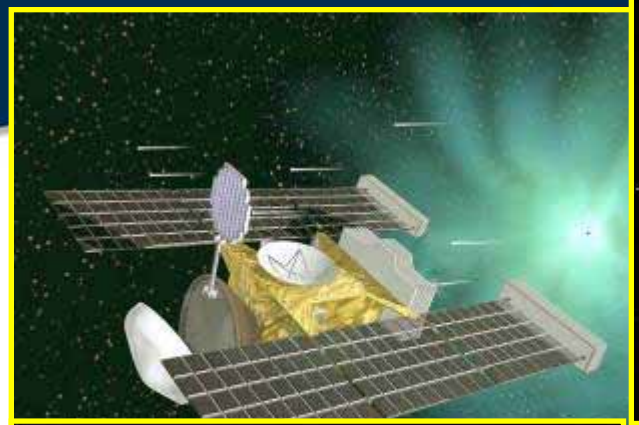
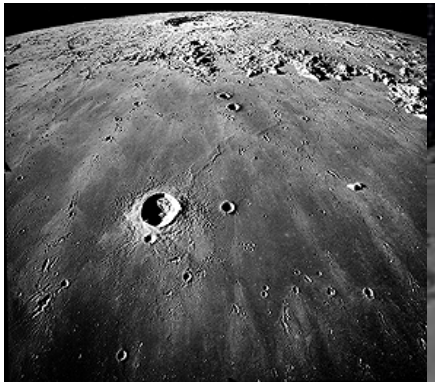
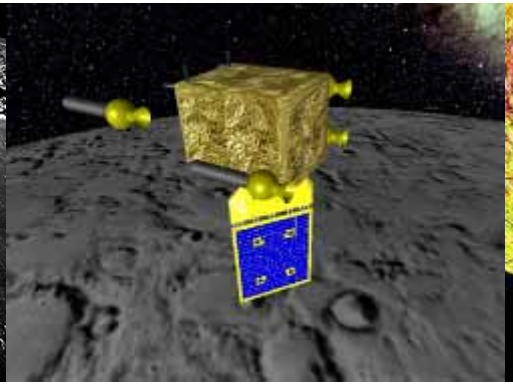
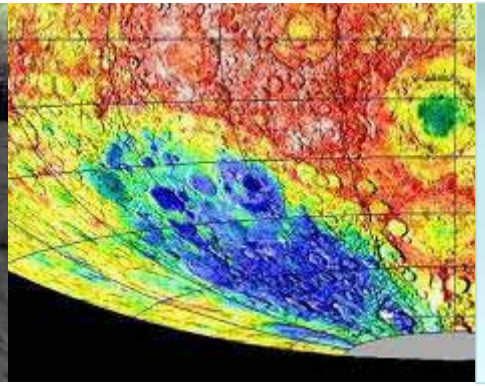


Lunar Exploration:

- **UK heritage stretches back to analysis of lunar samples in 1970's**
- **D-CIXS demonstration x-ray spectrometer on ESA SMART-1 spacecraft**
- **C1-XS x-ray spectrometer for ISRO Chandrayaan-1 due for launch in 2008**


UK Involvement in Lunar Science (i)

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- ***Aberystwyth University:*** ***lunar crustal composition using X-ray fluorescence spectroscopy from orbit (D-CIXS, C1XS)***
- ***Birkbeck/University College London: Lunar petrology; crustal evolution using lunar meteorites and orbital X-ray data (D-CIXS and C1XS); multi-spectral imaging***
- ***Imperial College: Lunar seismology/geophysics***
- ***Natural History Museum: Petrology and mineralogy of lunar meteorites***
- ***Open University: Lunar petrology and mineralogy; instrumentation for surface science (e.g. penetrometers, moles); polar volatiles***
- ***Rutherford Appleton Laboratory (part of STFC): lunar crustal composition using X-ray fluorescence spectroscopy from orbit; instrument development (e.g. D-CIXS, C1XS)***

UK Involvement in Lunar Science (ii)

- ***University College London (Mullard Space Science Laboratory):*** ***Instrumentation for lunar landers (e.g. seismometers, penetrometers, PANCAM)***
- ***University of Lancaster:*** ***Lunar volcanism, magma ocean evolution and structure of the lunar crust***
- ***University of Leicester:*** ***Instrumentation for lunar landers, building on the Beagle-2 legacy (especially lunar applications of the PAW instruments/in-situ age dating)***
- ***University of Manchester:*** ***Geochemistry and dating of lunar materials (e.g. lunar meteorites)***
- ***University of Oxford:*** ***Infrared mapping of the lunar surface (LRO); isotopic studies of lunar evolution***
- ***University of Surrey (SSC/SSTL):*** ***Lunar mission definition, technology development***

Vision

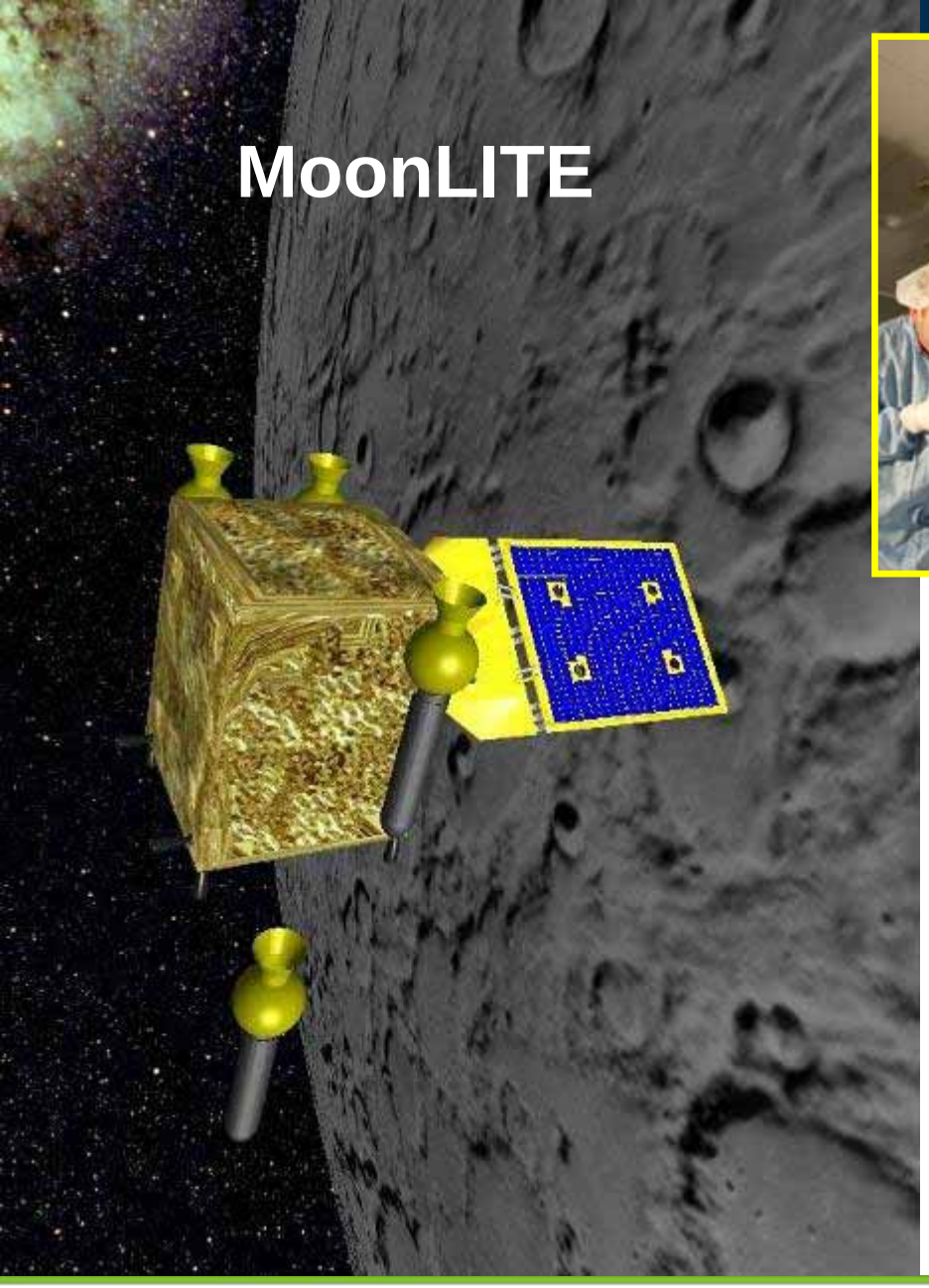
↗ In 2006, STFC funded study of small, low cost robotic lunar missions (MoonLITE and Moonraker)

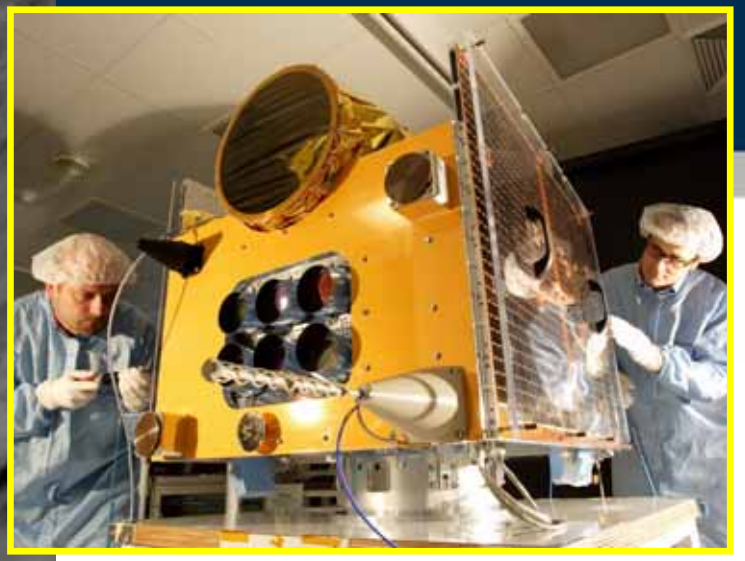
↗aspiration is to develop a rolling programme of international missions building on UK scientific, technical & commercial strengths

↗sustainable and cost effective;

↗flexible missions with rapid development cycles using incremental technology development

MoonLITE



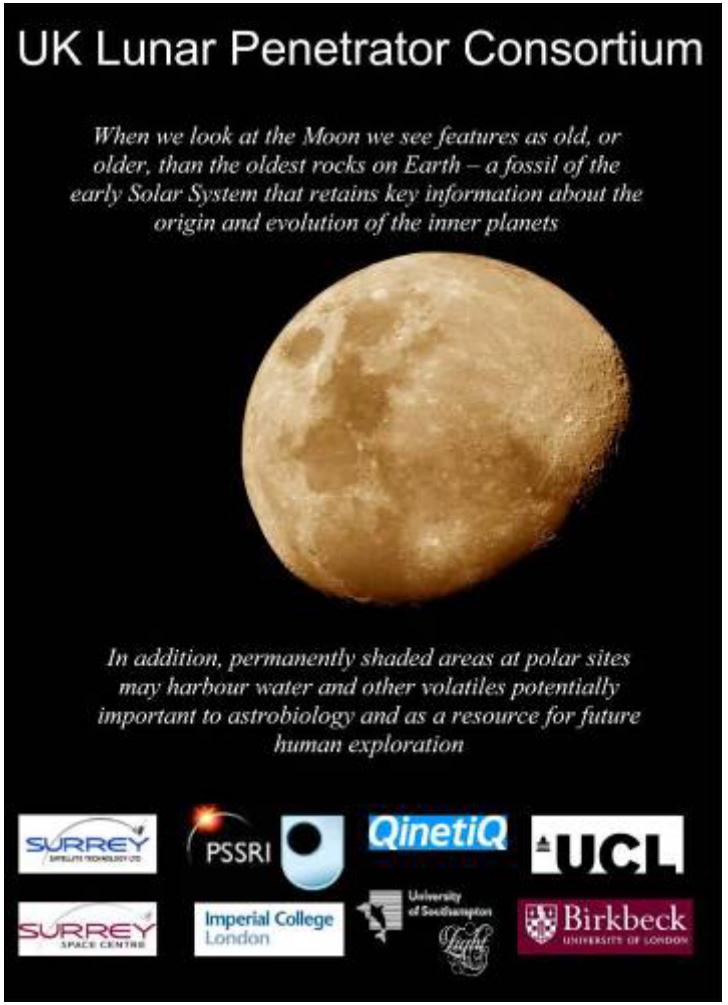


Moon Lightweight Interior and Telecoms Experiment

Combining technological and scientific goals in a mission exploiting the UK's strengths in affordable spacecraft

Technological goals

1. First ‘affordable planetary spacecraft’ building on UK heritage of 25 small satellites for customers worldwide
2. Demonstrate polar orbital telecoms for exploration missions
3. Demonstrate use of penetrators for planetary exploration (Mars, Europa…)
4. Provide platform for exploration technology demonstrations



MoonLITE: Science Objectives

- Improve understanding of the origin, differentiation, and internal structure of the Moon;
- A better understanding of the origin and history of the volatile flux in the Earth-Moon system;
- Obtain ‘ground truth’ geochemical data for the calibration of orbiting remote-sensing instruments;
- Obtain *in situ* surface data that will help in the planning of future lunar exploration activities.

Instruments:

To be emplaced by four widely-spaced penetrators deployed from low orbit (40-100km):

(a) Seismometers:

- Size and physical state of lunar core
- Deep structure of the lunar mantle
- Thickness of the far-side lunar crust
- Studies of natural moonquakes
- Constrain natural seismicity of proposed lunar base location, which will feed into engineering constraints on habitat design.

(b) Heat-flow probes:

- Perform heat-flow measurements at sites distant from the Apollo 15 and 17 measurements (e.g. polar localities and the far-side)
- Constrain models of lunar mantle thermal evolution
- Constrain the distribution of KREEP in the lunar crust and mantle

(c) X-ray spectrometer:

- Determine abundances of the major rock-forming elements (e.g. Mg, Al, Si, Ca, Fe and Ti) at sites far from previously sampled areas
- Provide geological context of penetrator landing sites to aid interpretation of other instruments
- Provide additional ground truth for orbital remote-sensing instruments.

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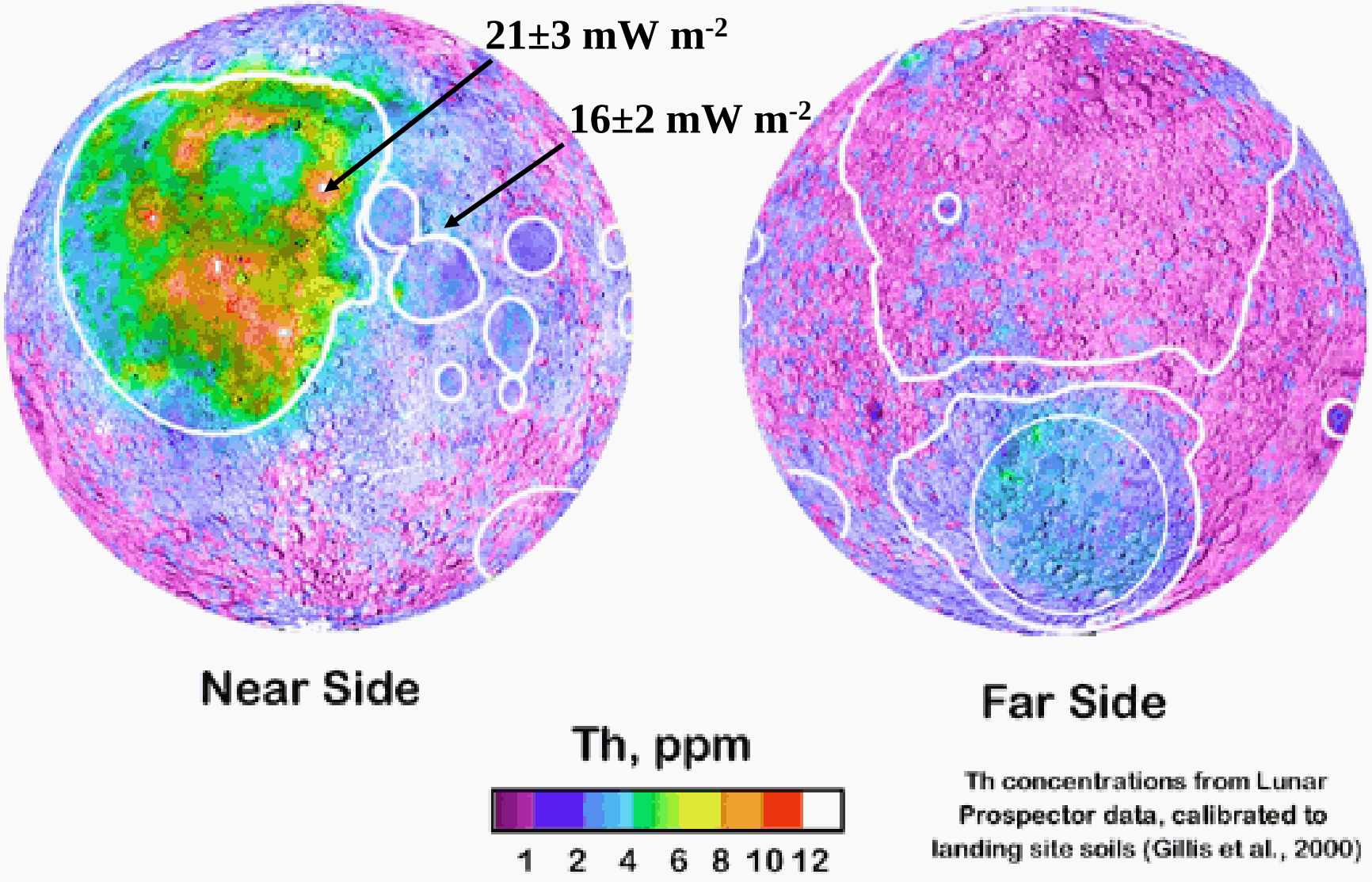
Importance of new heatflow measurements



(From Jolliff *et al.*, 2000.)

(d) Polar volatiles package:

Principal science objectives are:

- Determine whether or not scientifically and operationally valuable deposits of volatiles exist at the lunar poles.
- Determine nature and composition of volatiles if present (with implications both for improved scientific knowledge and possible ISRU)
- Volatile detectors at non-polar sites will constrain the background level of volatiles in the lunar regolith (if any), which is needed to determine the significance of any detections which may be made at the poles.

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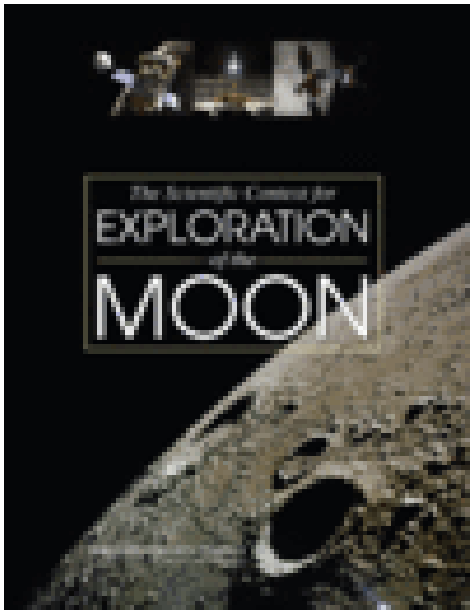
Linkage to top-level lunar scientific concepts identified by SSB/NRC Report



(1) The bombardment history of the inner solar system is uniquely revealed on the Moon [requires in situ dating or sample return]

(2) The structure and composition of the lunar interior provide fundamental information on the evolution of a differentiated planetary body [seismology, heatflow]

(3) Key planetary processes are manifested in the diversity of lunar crustal rocks [XRS -- *in situ* geochemistry]

(4) The lunar poles are special environments that bear witness to the volatile flux over the latter part of solar system history [volatile detector/MS]

Status

MoonLITE mission as potential first project of programme

– targeting 2012 launch (50th anniversary of first UK satellite)

Current activities:

- Refinement of system design (industry)
- Optimising launch and orbit analysis (industry)
- Penetrator technology work (Labs/industry)
- Preparation of science case for formal review (scientists)
- Possible call for an international Science Working Team
- Under consideration within the NASA/BNSC joint study of possible collaborative opportunities

Mission approval depends on national budget decisions and tensioned against other activities in the STFC programme

Conclusions

The UK has an active, dynamic space and planetary programme

- **UK strategy envisages a major role in Solar System exploration**
- **We are familiar with collaboration on the international scene**

expressions of interest re. MoonLITE should be advised to:

NASA HQ (Mr. Garvey McIntosh)

Further information can also be obtained from:

alan.smith@mssl.ucl.ac.uk

See also:

www.bnsc.gov.uk

www.scitech.ac.uk

www.mssl.ucl.ac.uk