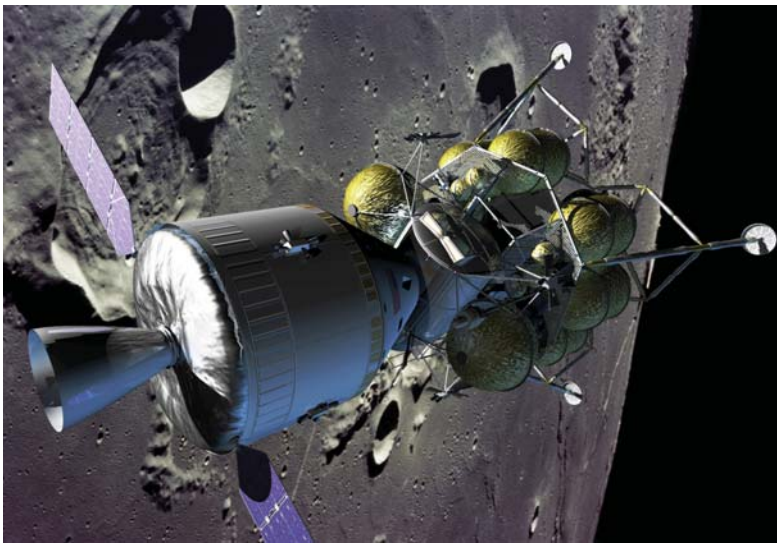
Humans in space — UK policy

A Royal Aeronautical Society, Space Group, Discussion Paper

Abstract
As the Shuttle era draws to a close and SpaceShipOne heralds the start of a new era, it is time to review the UK's options in human spaceflight. Exploration of the Moon and Mars are related topics that also need to be addressed. The roles of man in space are analysed bearing in mind the continued validity of Moore's law[1], with the provisional conclusion that lunar exploration can be performed robotically but Mars exploration may require a human on the spot. Programmes that clarify the requirements for, and address the key challenges of, human Mars missions are advocated, as is UK involvement. The creation of a radio observatory on the lunar farside operated remotely from Earth is suggested as feasible and consistent with UK interests. UK public sector support (regulatory and financial) for the emerging space tourism sector is proposed. Throughout the paper, questions and assertions for discussion are suggested to the right of the text.

This paper is the start of a Society initiative to help inform UK policy on human spaceflight to be followed by a forum in spring 2006 at which the issues will be debated. Opinions are sought on the issues raised and questions posed in this paper to help inform debate at that forum. Please send comments to **space@raes.org.uk** *preferably by 31 January 2006.*



NASA photo.

NASA's new crew exploration vehicle and lunar lander in lunar orbit.

1. What do we mean by human spaceflight?

Assertions/Questions

This is a particularly appropriate time to review UK policy on human spaceflight for two reasons. First, NASA has decided to phase out the Shuttle fleet by 2010 and to replace it with an, as yet not fully defined, successor vehicle(s). Secondly, Burt Rutan's SpaceShipOne has shown that human spaceflight may be feasible at much lower cost than hitherto demonstrated by the world's space agencies.

Is this the right time to review the human role in space?

Policy is therefore required for each of the two main strands of human spaceflight:

a. traditional government-backed national or international programmes (e.g. Apollo, Shuttle, Soyuz, Shenzhou, Hotol, Hermes) which sometimes claim to have commercial objectives but are generally seen as prestige initiatives
b. commercially initiated programmes, currently for space tourism (e.g. SpaceShipOne and its successors).

Are the two strands of human spaceflight activity identified in this paper really distinct?

Policy should also address various target orbital destinations, including low Earth orbit (LEO) flights, LEO flights to space stations, missions to the Moon, missions to Mars, beyond...

2. Human utility in space

In the Earth–Moon system (except perhaps on the lunar far-side), almost all activities can be undertaken via interactive control from Earth because the round-trip delay is less than three seconds. Hence human-in-the-loop can be achieved, in principle, without the need for human-in-space. Even in the depths of the lunar farside, relay satellites in lunar orbit can provide human-in-the-loop, while close to the nearside, cable or microwave relay links to the nearside can do the same.

Robots are more cost effective for all activities on or around the Moon.

Given the long radio time delay between Earth and Mars, exploration of Mars involving substantive human-in-the-loop requires the physical presence of a human on Mars or in orbit about Mars — the current NASA Spirit and Opportunity missions illustrate the limitations of what is possible using Earth-based controllers: able to adapt operations to circumstances on Mars but with significant delays (days and weeks) in responding to unplanned scenarios.

Assertions/Questions

How important is human-in-the-loop for science or exploration?

However, the argument is not black and white. A human trip to Mars is likely to cost hundreds of billions of Euros and a proportion of the funding directed at developing clever robotic technology might enable the vast majority of the objectives of a human Mars mission to be achieved. So, one might achieve 95% of the objectives for 25% of the cost, for example. This trade-off needs to be investigated objectively and thoroughly before committing to the expense of a human Mars mission.

If it is important, human spaceflight is a prerequisite for Mars science or exploration.

Funding of better robotic technology needs to be traded off against funding of human spaceflight.

A programme of robotic missions to both the Moon and Mars should enable this trade-off to be quantified — the lunar robotic missions can identify the objectives that unambiguously require human-in-the-loop, as opposed to those that could be performed robotically given an identified amount of development work in robotic technology.

Appropriate robotic missions to the Moon and Mars are needed to test the human versus robot trade-off.

A possible outcome of such a programme of experimentation and analysis is that human spaceflight is demonstrated to be a cost effective way to achieve mankind's Mars science and exploration objectives.

As concerns science or exploration of the Moon itself, human spaceflight appears intrinsically less cost effective than robotic technology.

Robotic exploration is the cost effective option for the Moon

[1] "The complexity of integrated circuits doubles about every two years." For its continuing validity, see for example *Scientific American*, July 2005, pp 54-57; available to purchase at www.sciam.com.

Tourism or extreme adventure holidays to the Moon and Mars would of course be perfectly legitimate reasons for sending humans to the Moon or Mars, or indeed any other destination in space. Public sector funding for such missions seems unlikely to be forthcoming.

Public funding of space tourism is inappropriate.

3. Moore's Law and cost of launch

Since the Apollo missions, computer technology has improved by more than a factor of a million (Moore's law), and will continue to do so for a decade or more[2]. Many aspects of robotic technology benefit directly from improved computer technology, so robotic performance has been increasing steadily over the past 30 years while requiring less power, weighing less, becoming smaller and reducing in cost. Humans, on the other hand, require the same resources for the same output. The value for money of launching a human *versus* a robot therefore continues to decline.

Robotic technology can already out-perform a human in space in most situations.

Will robotic technology continue to improve?

4. Shuttle and ISS

Neither the Shuttle nor the International Space Station (ISS) has objectives that address mankind's long term future role in space (see point 2 above). Instead of addressing such objectives, the world's space powers have been focusing their funding since the early 1970s on a vaguely defined and politically oriented objective.

The much publicised commercial return from the Shuttle and the ISS has long been recognised as political window dressing. As the total through-life cost of the ISS creeps nearer and nearer to the $100bn mark, the science and commercial returns gets smaller and smaller (e.g. due to reduced crew size).

Shuttle and ISS primarily address political objectives.

ISS is wildly expensive for its likely commercial return.

If human Mars missions are the long term objective, then our human spaceflight activities should address the two main technical barriers to human Mars missions identified many years ago by NASA (and others): (1) artificial gravity for the cruise phases, (2) extraction of rocket fuel from the Martian surface. Both of these technical objectives could have been addressed by a combined human and robotic spaceflight programme, but have not been addressed by Shuttle or ISS.

Are the two challenges to human Mars trips identified here the main ones?

The UK has been in the forefront of exploration of the Earth since the 16th century and has led many of the most imaginative recent European initiatives in astronomy and solar system science. This is part of the background that underpins recent evidence of public support for the UK to play a role in a world initiative that is carefully targeted at affordable human exploration of Mars and that avoids the pitfalls of prestige space programmes.

Is the UK's heritage in exploration and space innovation important?

Would the UK public support well targeted human spaceflight initiatives?

5. Lunar science

NASA has declared 'return to the Moon' as a new high priority human spaceflight objective. Although previous such assertions over the past 35 years have withered in the cold light of funding realities, it would be churlish to dismiss this statement out of hand. But could robotic missions achieve the required results at cheaper cost? The new NASA administrator, Mike Griffin, has confirmed[3] that the arguments for human presence on the Moon are essentially prestige: "The value of humans on the Moon I think is quite significant. I've never heard it put better than Norm Augustine in his report in 1990, where he pointed out that an instrument[ed] payload on the top of Mount Everest simply did not have the same value as Tenzing and Hillary ascending that mountain."

NASA's 'return to the Moon' initiative should be treated seriously.

NASA photo.

The International Space Station.

Science of the Moon is a reasonable subject for scientific research. Science from the Moon is more than that — it is a unique way to undertake radio astronomy. A radio astronomy observation on the lunar farside (and only there) would be shielded from Earth's radio emissions, thus allowing much more sensitive and comprehensive radio astronomy.

Radio astronomy from the lunar farside is a high priority scientific objective for lunar missions.

Human spaceflight is not essential to creating and operating such an observatory. A lunar farside observatory could be located just over the lunar north or south pole out of sight of Earth, with relatively short (<100 km) cable or radio relay links to Earth. A programme of experimentation to verify the feasibility and cost of building such an observatory robotically would be the first step.

Robotic installation and operation of a lunar farside radio observatory is possible and more cost effective than using humans on the Moon.

The UK is a world leader in operating observatories remotely, so a UK role in such a lunar farside radio observatory would be a natural evolution of one of our current strengths.

UK has expertise in remote observatory operation.

6. Mars science

Mars is a particularly interesting destination for *in-situ* research because, besides the Earth, it is the only known body in the universe whose surface could support life (Europa is tbd, Jupiter/Saturn/etc. atmospheres are tbd). More generally, it is

Scientific exploration of Mars is a high scientific priority.

[2]See footnote 1.

[3]Testimony to the House Committee on Science Hearings on the Future of NASA, 28 June 2005 — http://www.nasa.gov/pdf/119619main_Griffin_Hil_testimony_062805.pdf.

the most Earth-like of the planets.

Extensive scientific exploration of Mars requires either human-in-the-loop techniques (and therefore human spaceflight) or major advances in robotic technology.

7. Commercial developments

SpaceShipOne represents a major step towards affordable human spaceflight.

Recent developments in human spaceflight from the commercial space tourism sector have opened up dramatic new opportunities — particularly the SpaceShipOne technology developed by Burt Rutan's Scaled Composites Inc. While this capability still falls considerably short of orbital flight, it is foreseeable that a large commercial market for space adventure holidays can be tapped in the near future providing considerable revenue for further developments.

The millionaire extreme adventure community will make sub-orbital flights a commercial success.

Evolution of Rutan's technology seems likely to deliver affordable orbital access for humans within a few years. Other technical approaches to the same objective are also likely to emerge.

Human orbital flights will soon become available at affordable cost.

The UK can play an important role in this initiative. First and most important, Richard Branson has set up Virgin Galactic to operate five enlarged versions of SpaceShipOne (Scaled Composites has been contracted to build them) to target the sub-orbital space tourism market. Second, over the past 25 years, a number of UK teams have promoted advanced launcher concepts and technologies, resulting in a core, albeit small, of technical competence in the UK in the general area of innovative launch vehicles.

UK can play a role in the development of affordable human spaceflight.

UK public sector support for this opportunity is worthwhile.

Burt Rutan has been successful by avoiding public sector involvement. UK public sector initiatives could help to ensure the best possible environment for innovative human spaceflight initiatives, as well as providing R&D and seed corn funding, e.g. for joint academic-industry projects.

8. UK national ambition and pride

Is human spaceflight a necessary part of being a major world power?

Should the UK, as the fourth largest economy in the world, invest in human space programmes, whether supporting large national projects or backing commercial ones? Notably it is the only country among the G8 that does not fund launch vehicle development or support an astronaut programme. The other G8 members, with the addition of China, support human spaceflight for their own reasons. The Cold War fuelled the USA–USSR competition that underpinned the Apollo programme, and national ambition and pride play a role for example in China[4]. France points to the importance of having both a launch vehicle and a human spaceflight programme in order to protect national or European sovereignty.

Prestige space programmes were a 20th century phenomenon and are not appropriate for the 21st century.

To many people, the national prestige argument seems naïve, simplistic and slightly archaic. In contrast, the small is beautiful approach championed by Beagle 2 (and arguably by Huygens) and by SpaceShipOne seem more in keeping with the times. Meanwhile, the military dimension of space has evolved to the point where a quarter of all launches are currently military — all robotic — and the nuclear détente between East and West, and between regional powers in South, East and West Asia, depends heavily on military robotic satellites. Hence, the arguments for soldiers in space seem to be diminishing.

Military space will remain robotic.

Thus we consider that UK involvement in prestige-type human spaceflight programmes would be widely seen as a poor use of taxpayers' money, whether it was diverted from other space programmes or not. However, evidence to rebut this comes from a June 2005 poll of views on human space exploration by the BBC website that elicited more positive than negative views. An October 2005 report by the Royal Astronomical Society was also broadly supportive of human exploration of the Moon and Mars[5].

There is little public support for funding UK involvement in prestige human spaceflight missions.

Has the UK public an appetite for prestige human exploration missions?

Furthermore, NASA continues to argue that society benefits many times over from space programmes — $7 return for every $1 spent according to one NASA report. If this assertion is valid, the UK is missing out on an important opportunity by not participating in human spaceflight programmes.

Are NASA's cost benefit figures valid?

9. Provisional conclusions

Until human spaceflight is shown to be necessary to address agreed objectives, the UK should avoid involvement in large government-funded programmes. On the other hand, UK should encourage European partners plus USA, Russia, China, etc. to analyse the robotic versus human trade-off for addressing those objectives and be ready to play a role. The NASA assertion that space benefits outweigh costs seven times over should be assessed.

Use of the lunar farside for radio astronomy is an intriguing scientific objective. Robotic techniques for establishing such a facility should be initiated, with substantial UK involvement.

Robotic exploration of the Moon and Mars should be continued with a view to clarifying what can and can't be done robotically, thus providing inputs to a scientific business case for human Mars missions.

The commercial human-in-space sector is an area where the UK has much to offer. Government support of realistic programmes should be encouraged, both by creating a supportive regulatory environment and by R&D and seed corn funding.

In summary, human spaceflight for exploration or research is extremely expensive, and its commercial benefits are difficult to quantify or justify. A major new programme, such as a return to the Moon or a mission to Mars, requires a clear objective and a political justification such as was the case with Apollo. On the plus side, we are seeing clear signs that our sense of adventure is leading to developments that will make human spaceflight more accessible and affordable within the next decade. This is where the next big strides will be taken, and the opportunity is there for the UK to help write this new chapter in the history of space travel. ◆

[4]Illustrated by the picture of the first Chinese astronaut, Yang Liwei, on the wall of nearly every restaurant and shop in Chinatown.

[5]http://www.ras.org.uk/index.php?option=com_content&task=view&id=847&Itemid=1