UK plc urged to join future

by Clive Simpson

It is arguably one of the most exciting, inspirational and expansive space projects to be touted since the landing of man on the Moon in the 1960s. And the next tentative steps on this journey into the future come at the end of September 2004, a deadline set by the European Space Agency (ESA) for member states to commit to a new round of funding for its ambitious Aurora future exploration programme. This will keep plans on track until a ministerial conference in 2005 when government ministers will be asked to approve contributions at a much higher level. The campaign for the UK to take a leading role in this project gathered momentum during the summer and was trailed heavily during the first ever Space Day at the Farnborough 2004 Air Show. Campaigners – ranging from scientists through to industrialists – were keen to turn up the heat prior to a decision by science authorities responsible for allocating the British government's science money.

The UK government was urged to take a major role in ESA's future exploration programme – known as Aurora – when leading scientists and industrialists presented their case to a high-profile audience of government officials, including representatives of the UK Parliamentary Space Committee, at this year's Farnborough Air Show.

The UK Particle Physics and Astronomy Research Council (PPARC) has to commit some £4.4 million ($6.85 million) in funding to ensure the UK maintains a significant role in the next phase starting 30 September 2004. An announcement is expected at any time.

A key member of a Task Group initiated by PPARC to evaluate the science case for UK involvement, Prof John Zarnecki, of the Planetary & Space Sciences Research Institute at the Open University, was forthright and unwavering in his approach when he spoke at Farnborough.

"Understanding how readily life can evolve in the Universe and determining how common are environments that could support life is of profound scientific and philosophical importance," he said.

"What's more, UK scientists can add real value to this programme and take a lead role in many aspects. Aurora will deliver world-class science. Not to be involved would ring the death knell for the UK's planetary space science community."

ESA sets deadline for commitment to bold exploration programme

Beyond the immediate science case for the UK's involvement Dr Sarah Dunkin, from the Rutherford Appleton Laboratory and Vice President of the Royal Astronomical Society, warned that not taking part would impact current and future generations of scientists.

"There's a real and present danger that our younger scientists would simply up sticks and move to other countries that are involved," she said.

"Perhaps of even more significance is the impact on the next generation of scientists – pupils at school right now. It's an accepted fact that space has an inspirational effect on children, enthusing them to pursue further education in science and technology and eventually full-time careers. Removing that inspiration factor would be a real turn-off."

The potential for UK industry was strongly argued by Dr Mike Healy, Director Earth Observation, Navigation and Science at EADS Astrium in Portsmouth and Stevenage.

"Like our science colleagues, UK industry can make a significant contribution to Aurora," he said. "We have acknowledged leadership in entry, descent and landing systems and these will be key technologies required for Aurora. Not to capitalise on such technology would be a complete waste of all the expertise that went into the Beagle and Cassini Huygens landers."

Dr Healy added: "We have the European lead in this area, which is not something we can normally claim. There is lots of capability and ambition within the UK and I just hope the UK government can live up to that and satisfy

"Time is not on our side, we need to decide pretty soon, otherwise our expertise will be eroded and we will be overtaken by others."
Prof Ian Halliday

the huge interest."

ESA has already conducted a 'Phase A' study programme – to which the UK contributed through PPARC – which aimed to identify the early missions and likely technology requirements of Aurora.

As a result, ESA is now requesting additional funding of $39 million from member states to sustain the programme over the next 18 months. After an interim decision on 30 September, member states, including the UK, will have to decide whether to participate in the full Aurora programme (which is optional and not compulsory) by the next ESA Ministerial meeting planned for mid-2005.

Aurora has been structured in a series of five year slices, which means the initial 'long term' commitment will cover the first period starting in 2005. The estimated total cost for this first slice is €900 million (£600 million) and a UK contribution of £25 million (€37.5 million) at this point would secure a share proportional to the UK Gross Domestic Product – equivalent to around 50p per person a year.

Commenting on the prospect of the UK becoming involved in Aurora, Prof Ian Halliday, PPARC chief executive said: "The science case for Aurora is very strong, as acknowledged by PPARC's science committee. But PPARC does not have unlimited funds and we have to tension this against other science priorities.

"To participate in Aurora at a level that would capitalise on the technology leadership we have gained through missions such as Beagle 2 will require government support. Time is not on our side, we need to decide pretty soon, otherwise our expertise will be eroded and we will be overtaken by others."

Prof Zarnecki believes the UK has enormous expertise across all the scientific themes of Aurora. "As with any programme of space exploration, there are risks involved in participation but with something on the scale of this there is a greater risk to UK science by not participating," he said.

"As well as demoralising our scientists by failing to support an unparalleled opportunity in planetary sciences, we would lose our scientific leadership within Europe, and the chance to inspire a new generation of scientists, engineers, technologists, composers, writers, philosophers, and theologians."

Referring to the question of whether the UK should participate in NASA's programme instead, Prof Zarnecki added: "This would be far less effective for us. We would have no influence over programme strategy, and more specifically the selection of mission, instrumentation, landing site, operation priorities, or publicity arising from the missions. The impact of UK science would be lessened, the profile within the UK would be greatly reduced, as would its ability to inspire future scientists, and importantly, the benefits to UK industry and economy would be negligible."

The development of major space exploration programmes by both ESA and NASA means there is a unique window of opportunity for the UK to be a leading European player on this international scene.

"The UK has world-leading scientists in the necessary component elements and the scientific ability to make major advances – but this can only be achieved by working in a co-ordinated, interdisciplinary way through a targeted programme of investment," said Prof Zarnecki.

"It is imperative financial resources are made available over the next two years for technology development in order to position UK groups to win ESA technology contracts in the UK's priority areas."

Aurora is ESA's first step in human space exploration outside the low Earth orbits used for the Russian space station Mir and the International Space Station (ISS) and through it ESA intends to develop a long-term plan for human exploration of space – with Mars as its main objective and the Moon a very likely intermediate step.

Mars was chosen because it is the most Earth-like of the nine planets that make up the solar system and recent indications of the presence of water raise the likelihood of being able to find traces of life. It represents, however, a major leap for humankind.

With today's technology it would take over two years to reach Mars and to return. Depending on the orbit strategy, it is possible to either shorten the travel time – but then the crew will be obliged to stay over a year and a half on Mars to await the next return opportunity; or to shorten the stay on Mars to around two months – but then more than two years will be spent in travelling to and from Mars and the increase in velocity needed for the return trip will be much higher.

To undertake such a mission will require tremendous efforts of organisation, logistics and technological development. How will the astronauts survive for such a long period in an unfriendly environment? What will they eat, what will they drink and, more important still, how much can we recycle or grow food on Mars itself?

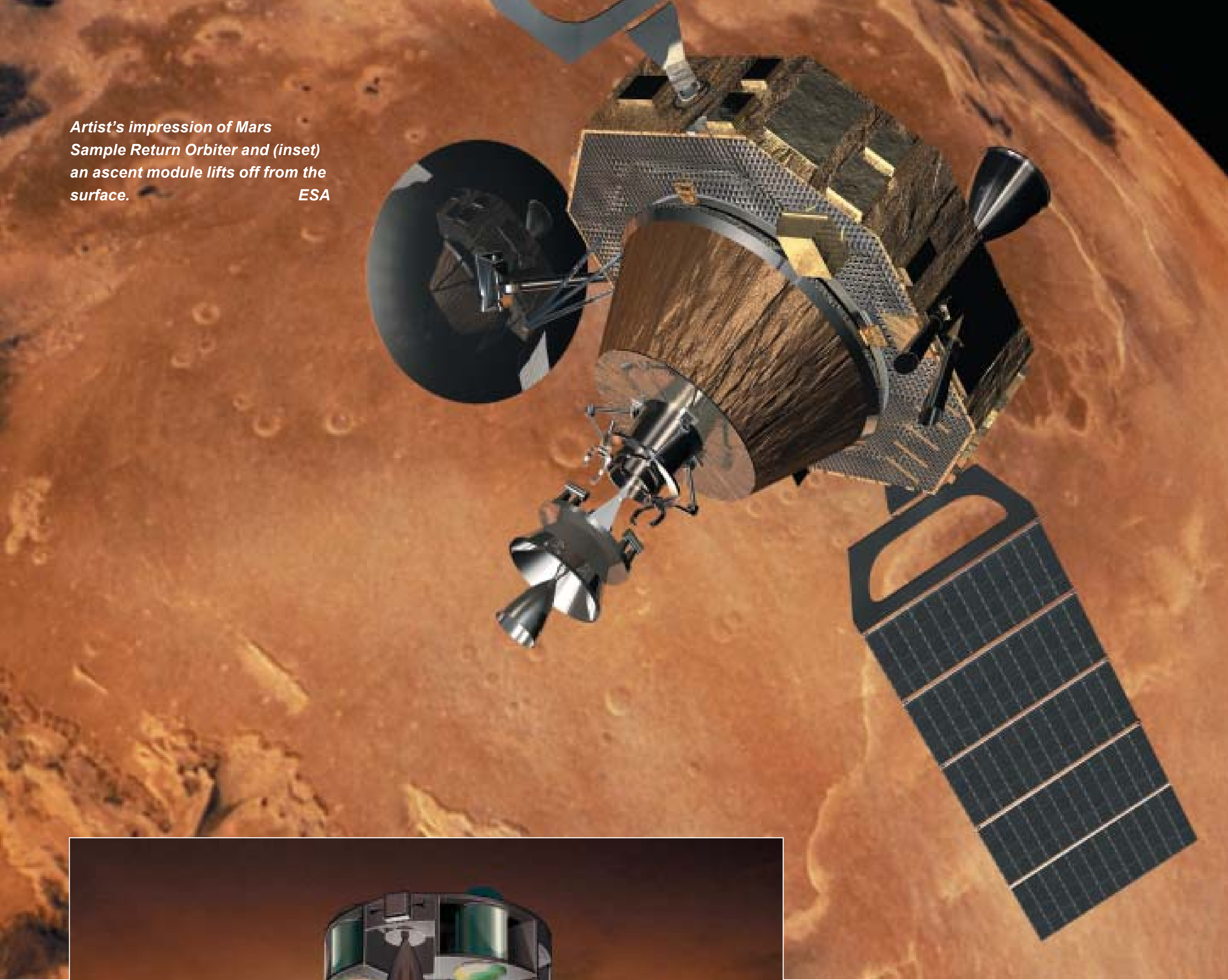
Not least of the problems will be learning to cope with the psychological pressure and stress of living in a confined space, for a long period of time, with a small number of colleagues.

Research and simulation on the ground, as well as experience gained from working on the ISS will all help to meet and overcome these difficulties.

But although a human exploration mission is the ultimate goal, no one will be visiting Mars until as much information as possible has been gathered about Mars and its environment – and a return vehicle has been fully tried and tested.

A number of successively complicated robotic missions will be needed to test the technology needed for a human mission, to establish the conditions under which human presence is possible, and to see how

Artist's impression of Mars Sample Return Orbiter and (inset) an ascent module lifts off from the surface. *ESA*



EADS/Astrium

automation and robotics can assist human exploration.

ESA has defined a series of 'Arrow' missions – essentially technology demonstrators – intended to reduce the risks of more sophisticated 'Flagship' missions that would follow on. The Arrow missions will be flexible, relatively low cost, technically less complex and have shorter development times. The first two to be approved for study under the Aurora programme are an Earth re-entry vehicle/capsule and a Mars aerocapture demonstrator.

Aurora's origins

Aurora is part of Europe's strategy for space – endorsed by the European Union Council of Research and the ESA Council in 2001 – which calls for Europe to explore the solar system and the universe, stimulate new technology, and inspire the young people of Europe to take a greater interest in science and technology.

ESA set up the Aurora programme with the primary objective of creating and then implementing a European long-term plan for the robotic and human exploration of the solar system – with Mars, the Moon and the asteroids as the most likely targets.

The interdependence of exploration and technology is the basis of the Aurora programme – on the one hand the desire to explore provides the stimulus to develop new technology while, on the other, the introduction of innovative technology will make exploration possible.

Exploring space

Many exciting and innovative ideas for future exploration have been proposed by industry and scientific establishments since the Aurora programme began in 2001. ESA received more than 300 replies when it asked the space community to put forward suggestions for future exploratory missions.

All proposals were accompanied by a preliminary time schedule and an assessment of feasibility and cost. The ideas received were

Artist's view of the ExoMars descent module and (inset) a European rover on the surface of Mars. ESA

wide and varied, and included an investigation of Pluto, the smallest and outermost planet in the solar system, establishing a launch site on the Moon, and the human exploration of Mars.

The Aurora programme carefully assesses the feasibility – both technical and financial – of all the ideas received and European industry is then encouraged to develop the technology needed to bring these ideas to fruition.

Advanced technology

Each phase of exploration on the way to the human exploration of Mars will require increasingly complex technology. In some cases existing technology can be further developed or adapted but in many cases European industry will be asked to come up with new innovative technology to make future exploration missions possible.

Technological studies to be carried out under the Aurora programme will enable Europe to select which of the many technologies on offer should be given priority for development within Europe, as well as the value of the technologies offered by possible partners.

Among the technologies needed to make a human mission to Mars possible are aerobraking, precision navigation and landing, propulsion systems that offer cheaper, faster travel, and life-support systems to enable humans to live in hostile space environments.

International cooperation

Although Aurora is an ESA programme and will promote European industry, many missions will involve international cooperation. For instance Canada, which has a cooperation agreement with ESA, is already participating.

International cooperation is vital because it spreads costs and allows the countries involved to benefit from one another's expertise. ESA wants to ensure that the Aurora programme will maximise benefits from joint enterprises with international partners.

Aurora's step-by-step approach means that missions will increase in complexity over time, culminating – if all goes well – in a human expedition to Mars by the year 2030. Steps on the way to Mars will probably include exploration of the Moon, as well as remote sensing of the Martian environment, robotic exploration and surface analysis, Mars sample return missions and a robotic outpost.

ExoMars is the first Aurora flagship mission to be assessed. Its aim is to further characterise the biological environment on Mars in preparation for robotic missions and then human exploration. Data from the mission will also provide invaluable input for broader studies of exobiology – the search for life on other planets.

This mission calls for the development of a Mars orbiter, a descent module and a Mars rover. The Mars orbiter will have to be capable of reaching Mars and putting itself into orbit around the planet. On board will be a Mars rover within a descent module.

After their release and landing on the surface of Mars, the orbiter will transfer itself into a more suitable orbit where it will be able to operate as a data relay satellite. Initially, it will act as a data relay for the ExoMars rover but its life may be extended to serve future missions.

The Mars descent module will deliver the rover to a specific location by using an inflatable braking device or parachute system. Either system would be robust enough to survive the stresses of atmospheric entry and their landing accuracy will be sufficient for a mission of this nature.

Using conventional solar arrays to generate electricity, the proposed rover would be able to travel a few kilometres over the rocky orange-red surface of Mars. The vehicle will be capable of operating autonomously, using onboard software, and will navigate with optical sensors. Included in its approximately 40 kg exobiology payload will be a lightweight drilling system, a sampling and handling device, and a set of scientific instruments to search for signs of past or present life.

In order to be successful, ExoMars will require advanced technology in rover and landing systems, an inflatable braking device, power supply, and autonomy and navigation. Although this presents a considerable technological challenge for European and Canadian industry, it has the potential to bring to fruition many years of technological development both at ESA and national level.

Following this, a Mars sample return will be a complex flagship mission calling for five spacecraft – an Earth/Mars transfer stage, a Mars orbiter, a descent module, an ascent module and an Earth re-entry vehicle. When the orbiter is in low-altitude orbit around Mars the descent module will be released and descend to the surface of Mars. On board the landing platform will be a device to collect samples and an ascent vehicle.

Once samples of Martian soil have been collected they will be loaded on to the Mars ascent vehicle which be launched into orbit around the planet to rendezvous with the Earth re-entry vehicle. After rendezvous the Earth re-entry vehicle will return to Earth on a ballistic trajectory with the precious samples which will be recovered and isolated in a 'curation' facility to prevent contamination and to allow scientists to analyse them in safety.

An inflatable braking device will probably be used for the descent through the Martian atmosphere, similar to that proposed for the ExoMars mission. For re-entry into the Earth's atmosphere a parachute or inflatable device system is envisaged.

More new technologies will be required to carry out such a pioneering mission, including the landing system, an ascent vehicle, the rendezvous system in Mars orbit and the Earth re-entry vehicle or capsule. In principle all of these can be tested in a near-Earth environment except for the final qualification of the rendezvous and docking system, which would preferably be carried out in a Mars orbit.

The technology required for this Flagship mission will be developed during a series of technology-driven arrow missions and, if all went to plan, such a challenging and complex mission could be launched as early as 2011.