The Search for Life on Mars

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For centuries, humans have been fascinated by the possibility of life on other planets. Recent robotic spacecraft have given us tantalizing hints that primitive life may have existed – or, perhaps, still exists – on our neighbouring planet, Mars. The European Space Agency set up the long-term Aurora Programme in 2001 (see Box 1) and its first mission, ExoMars, will be presented for approval to the ESA Ministerial Council in November 2008. The main scientific objective of ExoMars is to establish whether life on Mars has ever existed or is still active today. The technological and scientific developments required to make ExoMars possible have already started to deliver commercial benefits for the UK with the promise of many more to follow. This note provides an overview of ExoMars and discusses the benefits of the UK's involvement.

What is the Aurora Programme?

The Aurora Programme is part of Europe's strategy for space which was endorsed by the European Union Council of Research and the ESA Council in 2001. This strategy calls for Europe to:

- explore the Solar System and the Universe
- stimulate new technology
- inspire the young people of Europe to take a greater interest in science and technology

The primary objective of the Aurora Programme is a European long-term plan for the robotic and human exploration of the Solar System. ExoMars is the first in a series of Aurora missions that will lead to the return to Earth of a sample from Mars. The UK is playing a leading role in ExoMars and the Aurora programme.

Background

The origins of ExoMars go back to 2000 when ESA began studies for a mission which would land a rover on the surface of Mars. This rover was to carry a sophisticated automatic laboratory capable of detecting and analysing traces of life, both present and past. In 2006, ESA awarded a design contract for the ExoMars mission to Thales Alenia Space, Italy, with a major subcontract for the rover going to Astrium UK. In the same year, a provisional selection of scientific instruments was made which, in addition to life detection instruments, included instruments to measure the Martian environment. UK scientists are leading four of the 23 scientific instruments and are heavily involved in the design of seven others. The design phase is well advanced and it is expected that manufacturing will start early in 2010.

The Mission

ExoMars will be ESA's second mission to Mars and will build on the expertise gained from its 2003 predecessor, Mars Express Orbiter which itself has been spectacularly successful but carried the ill-fated Beagle 2 lander. It will be launched on an Ariane 5 rocket from ESA's spaceport in French Guiana in November 2013, followed by a landing, using parachutes and airbags, on Mars in late 2015. The exact landing date will be chosen after ExoMars goes into orbit around Mars in order to avoid Martian dust storms.

Why look for life underground?

During the Martian day, the surface of Mars is exposed to intense ultraviolet light from the Sun which passes easily through the thin Martian atmosphere. During the Martian night, the surface drops to -100°C or even colder. These conditions are not conducive to life.

However, there is a more benign environment a few centimetres below the surface where ultraviolet light cannot penetrate and the temperatures are less extreme. More importantly, data from instruments on board spacecraft in orbit around Mars strongly suggest that large quantities of water ice exists in the porous layer of soil some 30 to 60 centimetres beneath the surface in some areas. It is known that some types of organisms live successfully in very similar conditions on Earth.

The ExoMars drill is mounted on the rover and will deliver samples from below the surface to the rover's life detection and characterization instruments.

Getting to Mars

Mars is a 'near neighbour' of the Earth but, even at its closest, it is 35 million miles away and landing a spacecraft on its surface is not at all routine. To date, there have been 10 attempts to land spacecraft on Mars and only 5 have been successful – including 3 since 2003. Just 2 carried rovers. So far Europe has made only one attempt at landing on Mars.

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In addition to the rover with its cameras, exobiology laboratory and drill for collecting samples from up to 2 metres below the surface where life is thought most likely to be found, the ExoMars lander will carry an environmental and geophysics science station.

The rover and lander instruments are designed to collect scientific data for at least 6 months after landing and may last much longer depending on the severity of the conditions encountered on the Martian surface.

The Science

ExoMars is expected to answer important questions including:

- Has there ever been life on Mars?
- What is the present day environment on Mars?
- Has Mars ever had an environment that could support life?
- How has the Martian environment changed over time?
- How do planets form and evolve?

Answers to these questions will increase our understanding of the uniqueness – or otherwise – of life on Earth, within our Solar System and in the Universe.

The Technology

UK industry and scientists are working in partnership to deliver commercial benefits for the UK from ExoMars and the Aurora programme. Examples include:

- Unmanned vehicle technologies that can be applied to situations here on Earth in remote, unstructured or hazardous environments.
- 3D multimedia technologies that will create new virtual reality experiences of planetary exploration for research, outreach and commercial exploitation.
- Highly innovative miniaturised instrumentation using low-temperature catalysts that are needed for the future biotechnology industry.
- New solvent systems that provide flexible, safe and economic extraction procedures so that industries of the future can operate in a clean environment.
- Advanced fluid dynamics simulations of ExoMars' entry into the Martian atmosphere that will improve operational tools for modelling high-speed flight on Earth.

Key parts of the mission including the rover are being built by UK industry. The rover will be the most sophisticated exploration vehicle on Mars and the first to use a drill and radar to explore beneath the planet's surface.

The Skills

In the UK, over 16 companies and 18 research institutions are presently involved in ExoMars. It is anticipated that over 250 UK engineers, technicians and scientists will be employed on this mission. A wide range of high-level skills are needed including electronic engineering, mechanical engineering, thermal engineering, robotics, software design, materials science, microbiology, contamination control, systems engineering, product assurance and international project management. These are applicable to many other industries.

At least 100 scientists will study the data collected by ExoMars which, in addition to answering the key scientific questions, will be used to plan future Aurora missions.

The Future

ExoMars is the first in a series of missions that will lead to the return to Earth of a sample from Mars and, in the more distant future, perhaps a manned mission. The instruments and technologies which are being developed for ExoMars are stepping-stones for these later missions.

The People

ExoMars' ground-breaking science and engineering will inspire and encourage the next generation to become the highly skilled scientists and engineers which Britain will need in the future.

In support of this, an outreach programme involving schools, colleges and the general public is being planned with some pilot work already under way.

The Funding

The UK's involvement in ExoMars is funded by the Science and Technology Facilities Council, one of the UK's seven research councils, and a partner in the British National Space Centre, which co-ordinates the UK's civil space activities. As Aurora is an optional programme of ESA, the level of return (industrial and science) to the UK is dependant on the level of funding. Currently the UK is the second largest contributor after Italy.

Further information about the Aurora Programme and ExoMars can be found at :
http://www.scitech.ac.uk/SciProg/Aurora/auroraHome.aspx
http://www.esa.int/esaMI/Aurora/
Further information about water ice on Mars can be found at:
http://news.bbc.co.uk/1/hi/sci/tech/7294767.stm
http://news.bbc.co.uk/1/hi/sci/tech/2009318.stm
http://news.bbc.co.uk/1/hi/sci/tech/120270.stm
http://www.sciam.com/article.cfm?id=mars-odysseys-measurement