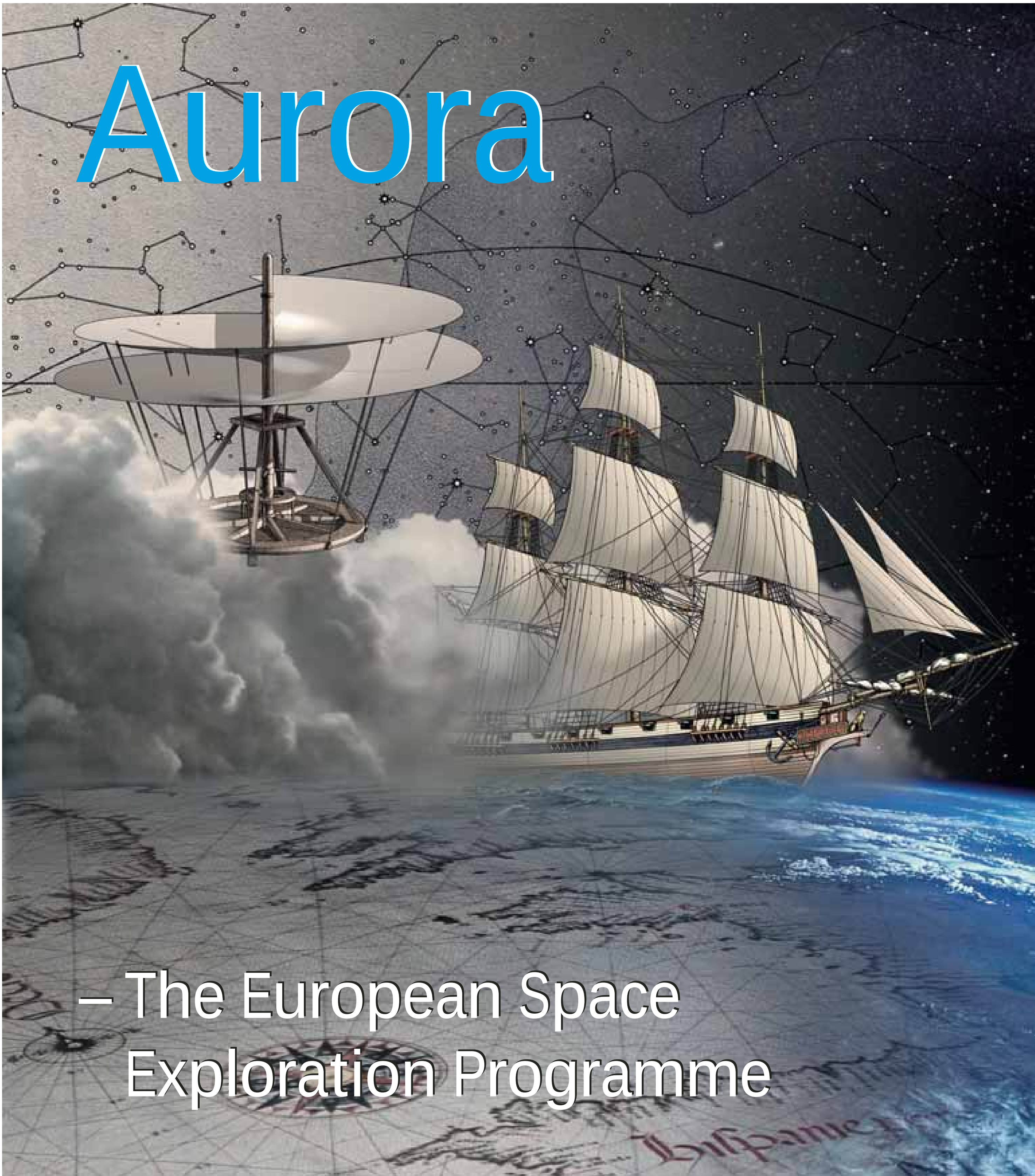
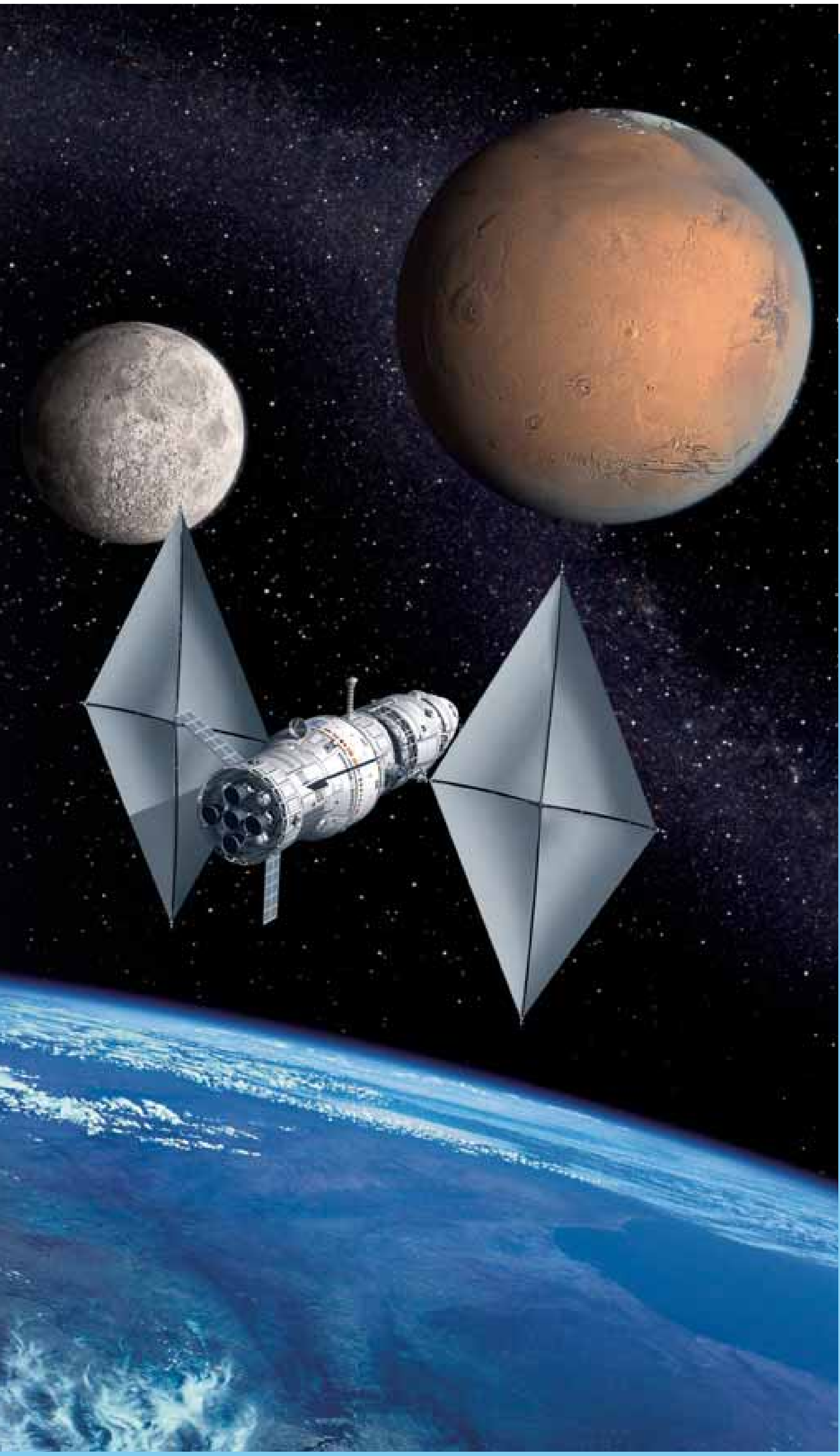
Aurora

– The European Space Exploration Programme





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Introduction

A manned mission to Mars is bound to become a reality over the next decades. It is very likely to be an international mission carried out by those players who have developed the technologies and expertise needed to master the challenges of landing humans on Mars and returning them safely to the Earth.

Europe has been at the forefront of space endeavours for more than 30 years, with many successful missions and key contributions to international programmes. Its participation in the International Space Station, the experience acquired with the European astronauts, with leading-edge scientific missions and notably with the recently launched Mars Express and its Beagle 2 Lander, are all good examples of the degree of maturity that Europe, through ESA and its Members States, has gained as a result of its investment in space activities and the expertise developed within its work force and the scientific community.

Exploring Mars is still a risky business, however, as the low success rate of the robotic missions conducted to date is a constant reminder. Less than a third of the unmanned missions so far launched to the Red Planet have fulfilled their goal. Consequently, there is still much to be done before we can feel sufficiently confident to commit to sending humans to explore the more distant bodies in the Universe and to land on Mars.

The Aurora Programme is intended to prepare Europe to meet this challenge in a framework of international collaboration.This it to be achieved first through the formulation, and then the implementation of a European long-term plan for robotic and human exploration of the Solar System bodies, particularly those holding promise for finding traces of life.

The Aurora Programme

In order to give the Programme a sound scientific basis and appealing objectives, a Call for Ideas for Planetary Exploration was published in 2001 addressing scientists in Europe and Canada. Some 300 proposals were received and were subsequently assessed by a high-level panel of scientists. The results were presented at a special workshop at ESTEC in Noordwijk (NL) in April 2001. The responses demonstrated great interest in the further exploration of Mars, Europa, the Moon and the Asteroids and came from scientists in almost all ESA Member States and Canada.

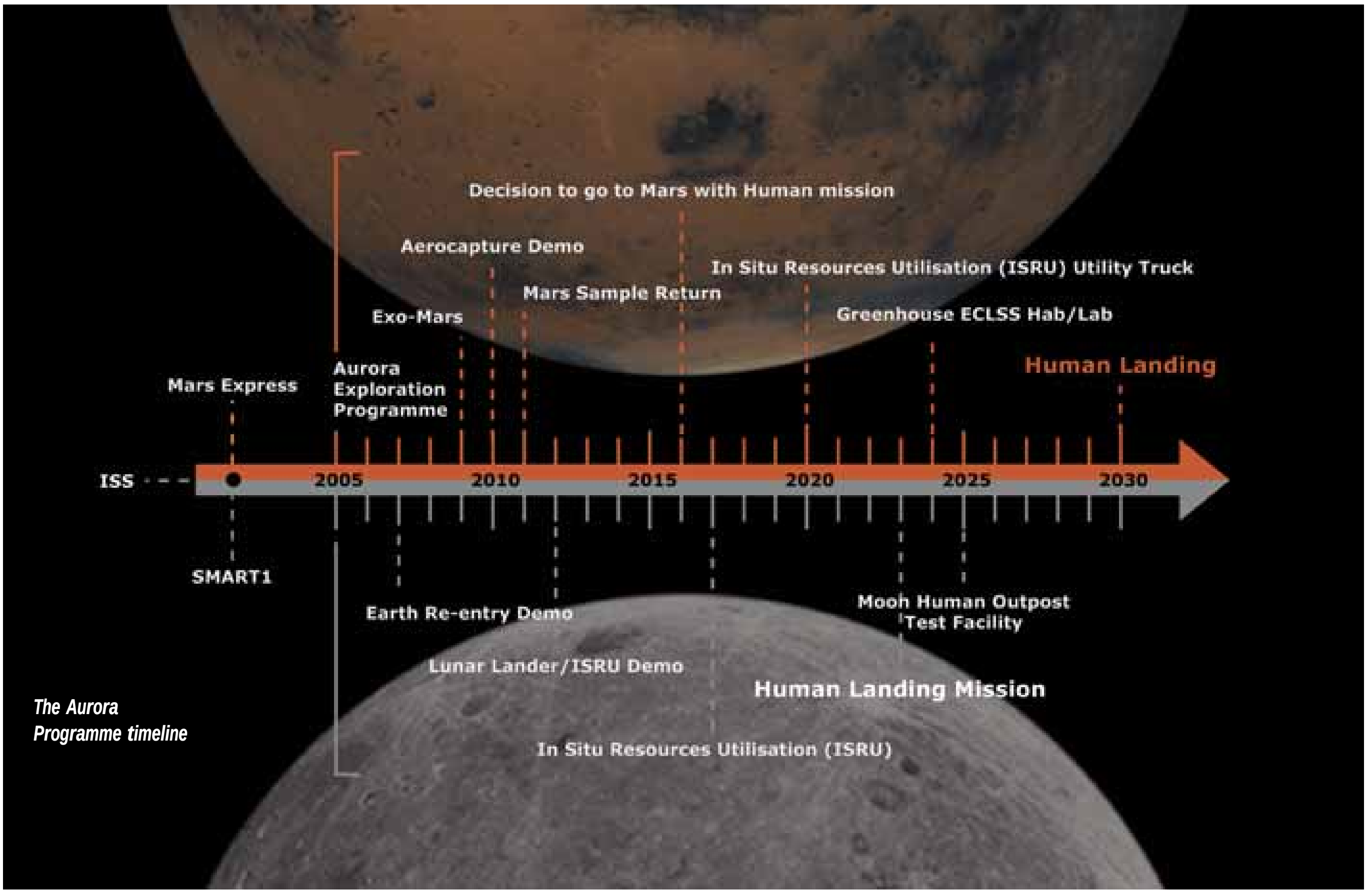
The Aurora Programme was approved, as an ESA's Optional Programme, at the Edinburgh Council at Ministerial Level in November 2001. The major ESA Member States have subscribed to the Programme and its Preparatory Period, which began in January 2002 and is due to end in December 2004. At the conclusion of the Preparatory Period, we will have an updated Programme Proposal and a comprehensive long-term plan, the European Framework for Exploration (EFE). This will build on different European activities, at national and ESA level, in order to identify interests and priorities and come up with a set of goals. It will be a living document that will be updated as the Aurora Programme and the activities connected with it move forward.

Like all other ESA programmes, Aurora has its own Programme Board (the Aurora Board of Participants) and an Exploration Programme Advisory Committee (EPAC), which brings together a balanced group of European experts in the various scientific and technological fields associated with the Aurora objectives.

Having set a clearly defined goal – to safely land humans on Mars by 2030 – Aurora will provide the roadmap of how to get there, as well the technologies that need to be developed and the knowledge that needs to be gathered in the meantime. A series of space missions, technology developments and other scientific work will provide the answers and lay the foundations for a European manned mission to the Red Planet, or for Europe's participation in an international endeavour with the same goal.

The Aurora Programme is structured into consecutive 5-year 'Periods', the first of which is due to start in 2005, subject to the results of the Preparatory Period and to a positive decision by the Participating States. Each 'Period' will include a Definition Component as well as a Development Component. The former represents the programmatic and forward-looking part of the Programme, while the latter covers the actual development of the technologies identified and their demonstration through space missions.

Robotic missions and new technologies wll pave the way for safe human missions to Mars



The Aurora Programme timeline

The Preparatory Period includes only a Definition Component. The Development Components of all subsequent Periods will cover the Phases-B/C/D/E of technology development and missions.

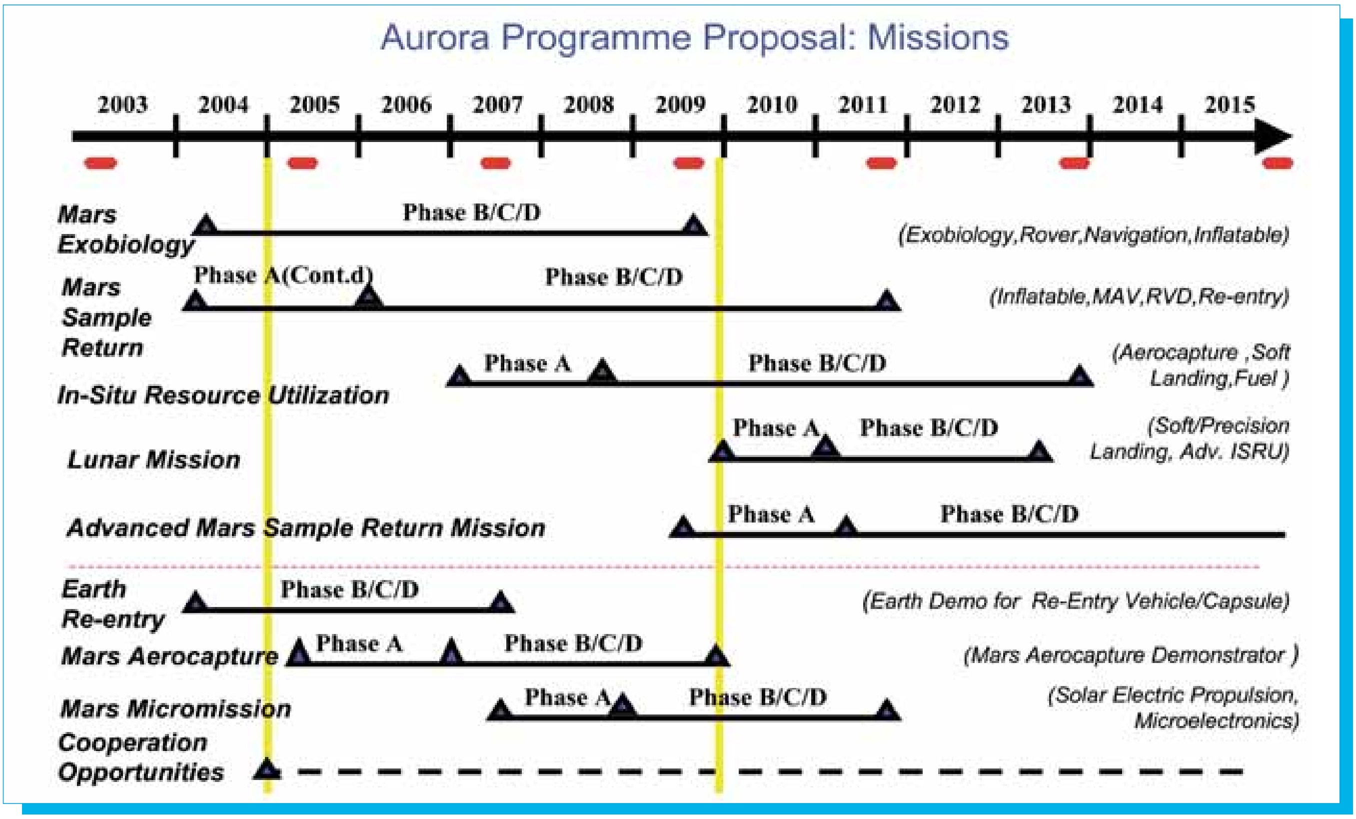
Preparing for Human Missions

The primary goal of the missions detailed below, and the further robotic missions to come, is to gather knowledge about the Martian environment and the risks that are associated with it and with the long interplanetary journey to and from the planet, as well as to develop and validate the key enabling technologies.

In parallel, the preparation of human exploration scenarios has started, always within the Definition Component of the Aurora Preparatory Period. While several years ago NASA developed its own ‘Reference Mission’, ESA has followed the path of entrusting European industry with a series of parametric studies to assess the requirements and constraints of various scenarios. Many different parameters are currently being studied, including: mission philosophy (surface outpost, multiple landing sites, orbital base), crew size (3, 6 or 12), duration of stay (30, 100 or 600 days), mass in low Earth orbit (LEO), etc. Working meetings are held regularly with a number of European experts to monitor the progress of the industrial studies and prepare inputs for the European Framework for Exploration. These inputs generate further questions and comments that are injected into the subsequent reflections. This iterative process will be consolidated in a series of scenario trade-offs that will eventually lead to a baseline human-exploration scenario that will be a key element of the Aurora Programme strategy and the European position in upcoming negotiations with international partners.

Technologies and Instrument Development and Demonstration

Within the Development Component, the mission-specific technologies will have to be developed and brought to a degree of maturity that will allow a Phase-B/C/D programme to be started with an acceptable level of risk. A ‘Technology Dossier for Robotic and Human Exploration’ has been produced, which also takes into account the outcome of a dedicated Workshop held at ESTEC in spring 2001. A roadmap for enabling technologies has been worked out, with a series of key milestones. All such technological development work will be conducted taking into account the existing ESA and national technology programmes (e.g. TRP, GSTP), to avoid duplication of effort and to maximise the return on investment for Europe.



Robotic Missions

These Robotic Missions are intended to pave the way for human exploration and for the establishment of a manned outpost on Mars. On 7 October 2002, the Aurora Board of Participants approved the start of assessment studies for the first four Robotic Missions in the Programme. These missions were selected by the EPAC from the 300 proposals mentioned earlier, and then recommended to the Member States for endorsement.

Flagship Missions

These Flagship Missions will enhance the European capability for undertaking human planetary missions, whilst also providing significant scientific return in their own right. Within the agreed cost of a Flagship Mission, the Aurora Programme will nominally fund the development of the complete spacecraft, the ground-segment development (spacecraft operations and data processing), the launch, and a nominal period of operations. The payload funding mechanism will be decided by the Participants during the Preparatory Period. The mission's payload will be selected by the Aurora Board of Participants, taking into account the EPAC's recommendations.

Those elements identified so far are: Mars Exobiology, Mars Sample Return, In-Situ Resource Utilisation, a Lunar Mission, and an Advanced Mars Sample Return Mission. The first two selected for industrial Phase-A studies are ExoMars and Mars Sample Return.

ExoMars

This mission, to be launched in 2009, will study the Martian environment and search for evidence of life, past or present, on the planet's cold and arid surface. The large spacecraft will take advantage of the planet's thin atmosphere to aerobrake it into Mars orbit. A descent module will then deliver a large rover to the Martian surface using an inflatable braking device or a parachute system.


Artist's impression of the ExoMars mission

The autonomous roving vehicle, powered by conventional solar arrays, will spend many months exploring the hostile terrain. The 40 kg payload, called 'Pasteur', will include a drill and a sampling and handling device that will enable it to analyse soil from sites that may be hospitable to primitive Martian life forms. The rover navigation system, including optical sensors, onboard software and autonomous operational capability, and the life-detecting payload will constitute a significant technological challenge for European and Canadian industry. Testing of rendezvous and docking techniques for the ExoMars mission will pave the way for the second Flagship Mission, namely Mars Sample Return.

A recently launched Call for Ideas for experiments to be included in the Pasteur payload attracted a very large response, with over 580 investigators from 30 countries having expressed the desire to participate in the ExoMars mission.

Mars Sample Return

Scheduled for launch in 2011, this mission will bring back the first sample of Martian soil for analysis in laboratories here on Earth. After braking into Mars orbit, a descent module will be delivered to the planet's surface. A robotic 'scoop' will collect a soil sample and place it in a small canister on the ascent vehicle. The latter will then lift off from the surface and rendezvous with the mother spacecraft in Martian orbit. An Earth-return vehicle will bring back the capsule and send it plummeting into the atmosphere. Slowed by a parachute or inflatable device, it will make a gentle touchdown before recovery teams retrieve the precious sample from the Martian landing site.

Arrow Missions

The Arrow Missions will follow a flexible selection approach and allow fast response to upcoming opportunities, in the form of:
- small exploration missions
- technology demonstration missions, to demonstrate new technologies and mission techniques
- participation in another programme, for instance another international programme, a European national programme or another Agency programme, within an agreed co-operation framework.

Arrow Missions will be cost-capped and have a set development time limit. The first two to be studied are:

• *an Earth Re-entry Vehicle / Capsule*
This mission will place a small spacecraft in a highly elliptical (egg-shaped) orbit around the Earth. The re-entry vehicle will then be fired Earthwards in order to test the performance of its heat shield and other onboard technologies under conditions similar to those experienced by a capsule returning from Mars. This mission is a necessary forerunner of the first Mars Sample Return mission.

Artist's impression of the Mars Sample Return mission's ascent module lifting off from the Martian surface with its soil samples

• *a Mars Aerocapture Demonstrator*
Aerocapture is a means of slowing a spacecraft through friction in a planet's upper atmosphere. By avoiding the use of onboard propulsion, the spacecraft can be considerably smaller and less expensive to build. The Mars Aerocapture Demonstrator is a small mission that will be sent to Mars in order to validate the technology before it is applied to larger, more ambitious Flagship, and eventually human, expeditions.

Conclusion

Just as the image of the first man to stand on the Moon remains an icon of the 20th Century, so human exploration of the Solar System, most notably Mars, is likely to be a lasting symbol of the 21st Century. The strategic and political drivers that led the USA and the Soviet Union to engage in the space race have dramatically changed, but both space and exploration retain their strategic importance as sources of inspiration, innovation, economic development, and lasting spin-offs for daily life. The coupling of the two concepts in a single initiative like the Aurora Programme represents a unique opportunity for Europe to show its scientific, technical as well as industrial maturity and to be regarded as a key player in future international co-operative space ventures.

As a consequence of the technological developments needed to fulfil the Programme's goals, Aurora will quickly become a true source of innovation and spin-offs that will contribute to raising the living standards of Europe's citizens. At the same time, it will allow European industry to retain its present workforce and further enhance its skills, and it will offer European academia and research centres unique opportunities for first-class science and research.

Europe has set itself ambitious goals both in global terms (the Lisbon Declaration includes: '*being the most dynamic knowledge-based economy*'), and more specifically for its space policy. The Aurora Programme is a comprehensive and coherent response to both challenges. The vision embedded in the Aurora Programme is the continuation of Europe's historical tradition of exploration and discovery and an essential element of any European space strategy.