

# MARS

## WHY GO TO MARS

For centuries, explorers have risked their venturing into the unknown for reasons that were to varying degrees economic and nationalistic. Christopher Columbus went west to look for better trade routes to the Orient and to promote the greater glory of Spain. Lewis and Clark journeyed into the American wilderness to find out what the U.S. had acquired in the Louisiana Purchase, and the Apollo astronauts rocketed to the moon in a dramatic flexing of technological muscle during cold war.

## HOW TO GO TO MARS

Going to Mars would be daunting. The planet never comes closer than 80 million kilometres to ours; a round-trip would take years. But scientists and engineers say they have solutions to the main technological challenges that a human mission would entail. The biggest obstacle is simply the enormous cost.

Cost estimates for a Mars mission boil down to one crucial number: the mass of spacecraft. Lighter spacecraft need less fuel which is the greatest single expense of a spaceflight.

Today the barest-bone mission is the Mars Direct plan, With an estimated price tag of \$ 20 billion in start-up costs, spread out over a decade, plus \$2 billion per mission (see "The Mars Direct Plan" on page 34, on review Scientific American March 2000). The National Aeronautics and Space Administration's own plan, the "design reference mission" has adopted many of the ideas of Mars Direct but costs roughly twice as much, in return for extra safety measures and larger crew (six rather than four).

In its most recent version, NASA's plan (see illustration on page 27 on review Scientific American March 2000) calls for three spacecraft: an unmanned cargo lander, which delivers an ascent vehicle and propellant plant to the Martian surface; an unoccupied habitat lander, which goes into Martian orbit; and a crew transfer vehicle (CTV), which, if the first two arrive successfully, sets out when Mars and Earth come back into alignment, 26 months after the first launches. The CTV carries the astronauts to Mars and meets up with the habitat lander. The astronauts change ships, descend to the surface, stay for 500 days and return in the ascent vehicle. The CTV, which has been waiting in orbit, brings them home. Every 26 months, another trio of space-craft sallies forth, eventually building up the infrastructure for a permanent settlement.

## **Lunch and Assembly**

In all the proposals for sending humans to Mars, the crucial first step is launching the spacecraft into a low Earth orbit (200 to 500 kilometres up). The basic problem is that any manned craft using present-day propulsion technologies will need a huge supply of propellant to get to Mars and hence will be extremely heavy: at least 130 metric tons and possibly twice much. No launch vehicle now in use can lift that much mass into orbit. The space shuttle and heavy-lift rockets such as the Titan 4B have maximum payloads under 25 tons. Moreover, with launch costs currently as high as \$ 20 million per ton, boosting a Mars spacecraft would be prohibitively expensive.

## **Propulsion System**

How can you propel a manned spacecraft from Earth orbit to Mars? Planners are considering several options, each with its own advantages and drawbacks. The basic trade-off is between the rocket's thrust and its fuel efficiency. High-thrust systems are the hares: they accelerate faster but generally consume more fuel. Low-thrust systems are the tortoises: they take longer to speed up but save on fuel. Both could be used in direct phases of single mission. High-thrust rockets can convey astronauts quickly, whereas low-thrust devices can handle slower shipments of freight or unoccupied vessels.

The options are:

- Chemical
- Nuclear thermal
- ION
- Hall effect
- Magnetoplasmadynamic
- Pulsed inductive thruster
- Vasimr
- Solar sails

## **Which Route to take**

### Conjunction class

For high-thrust rockets, the most-efficient way to get to Mars is called a Hohmann transfer.

### Opposition class

To keep the trip short, NASA planners traditionally considered opposition-class trajectories, so called because Earth makes its closest approach to Mars-a configuration known to astronomers as an opposition-at some points in the mission choreography.

### Low thrust

Low-thrust rockets such as ion drive save fuel but are too weak to pull free of Earth's gravity in one go.

## **Interplanetary cruise**

During the journey to Mars, nothing will be more essential to the crew's safety than the spacecraft's life-support systems. Researchers at the NASA Johnson Space Center in Houston have already begun an effort to improve the efficiency and reliability of current systems. Volunteer crews have spent up to threemounths in a closed chamber designed to test new technologies for recycling air and water. In addition to physical and chemical methods, the experiments included demonstrations of biological regeneration-for example, processing the crew's solid wastes into fertilizer for growing wheat, which provided the volunteers with oxygen and fresh bread.

## **Crew Compartment**

of the Mars spacecraft could resemble the inflatable Trans-Hab module that has been proposed for use on the International Space Station. The module would have four levels. The bottom level would include a kitchen and wardroom, and the upper levels would contain sleeping quarters and an exercise area.

## **Descent and ascent**

Landing a manned Spacecraft on Mars will be significantly more difficult than landing the Apollo lunar modules on the moon. Mars, unlike the moon, has an atmosphere, and its gravity is twice as strong as the moon's. Furthermore, the Mars lander would be much more massive than the lunar modules because it would live during their 500 days on the surface

## **A BUS BETWEEN THE PLANETS**

Chemical rockets have served humankind well in its first, tentative steps into space. Having ridden atop them to the moon and back, one of us (Aldrin) can vouch for technology's merits. Nevertheless, for trips beyond our nearest neighbor in space, chemical rockets alone leave much to be desired.

Even Mars, the next logical destination in space, would be a stretch for chemical rockets. To deliver a human crew to the planet would require so much fuel that essentially all scenarios for such a voyage involve producing, on the planet's surface, large amounts of fuel for return trip. That requirement adds another element of risk and complexity to the proposed mission. Much more powerful plasma rockets, on the other hand, are still probably a decade away from use on a human-piloted spacecraft.