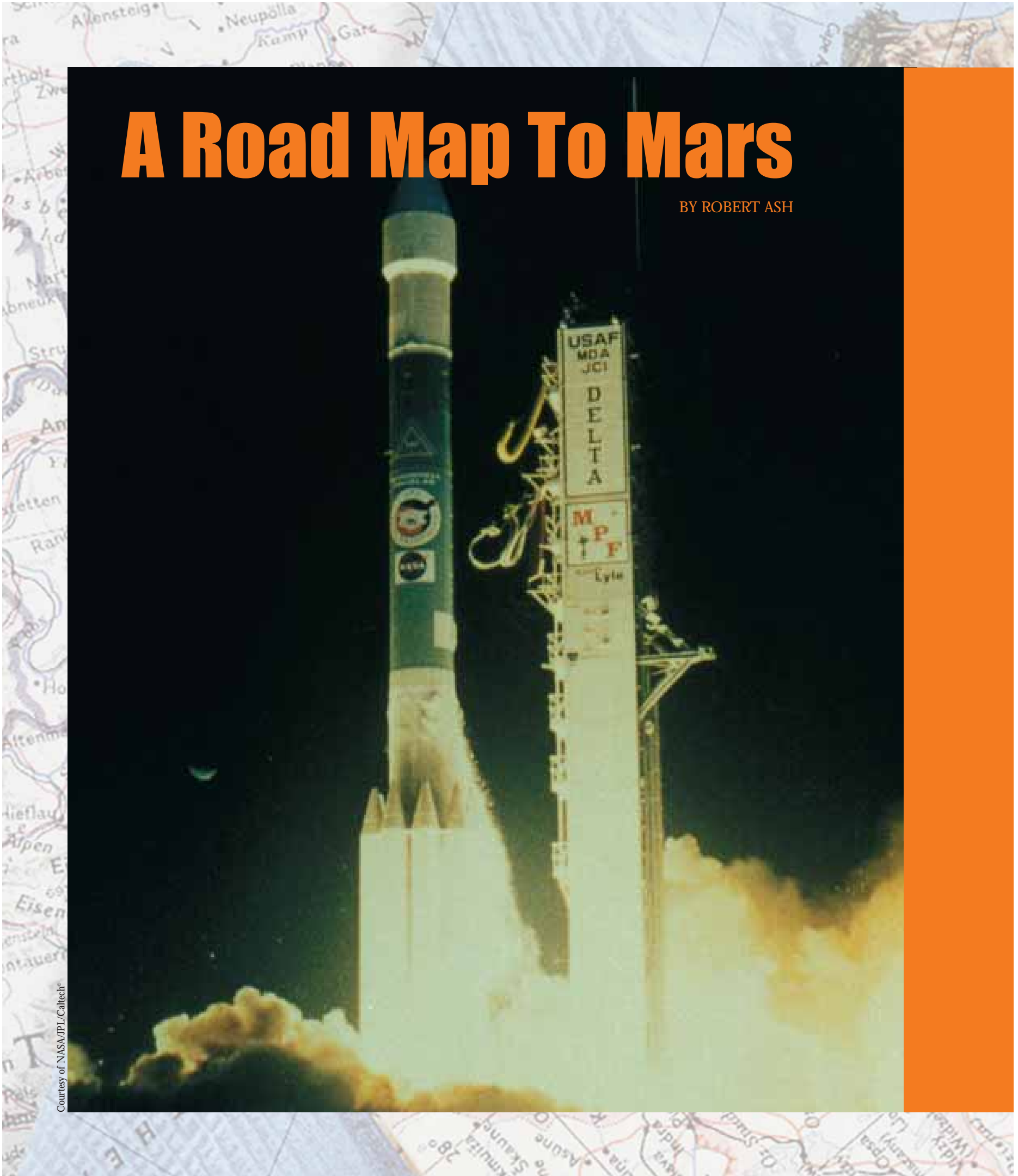


# A Road Map To Mars

BY ROBERT ASH



Courtesy of NASA/JPL/Caltech

**W**hen the lander of the spacecraft Pathfinder came to rest on the surface of Mars two years ago, humans once again had panoramic, rust-colored views of the pebbles, rocks and boulders of that body popularly known as the Red Planet. We had been there before, most famously in 1976, when Project Viking brought human cameras and scientific instruments to Mars for the first time. Now we had legs, so to speak: a little machine known as the Rover Sojourner managed a rolling exploration of its own, telling terrific science tales.

For centuries Mars has occupied a special place in the human imagination. In the earliest civilizations, Mars was considered an important heavenly object because of its red color and the peculiar path that it followed across the night sky. Between 1609 and 1610, Galileo Galilei wrote about his telescopic studies of Mars. Surprisingly, English satirist Jonathan Swift described Mars' two satellites in *Gulliver's Travels* in 1726, approximately 150 years before they were actually observed. As recently as 1964, Percival Lowell's observatory was still being used to study the seasonally varying "canals" on the Martian surface, which Lowell, in the late 19<sup>th</sup> and early 20<sup>th</sup> centuries, had claimed were the work of an intelligent civilization.

On Halloween 1938, Orson Welles' radio company's broadcast of *War of the Worlds* had convinced a nationwide audience that Martians were attacking. By the 1960s, Martians were more peaceful and friendly: *My Favorite Martian* was visiting Earth, at least fictionally, in the television program of the same name.

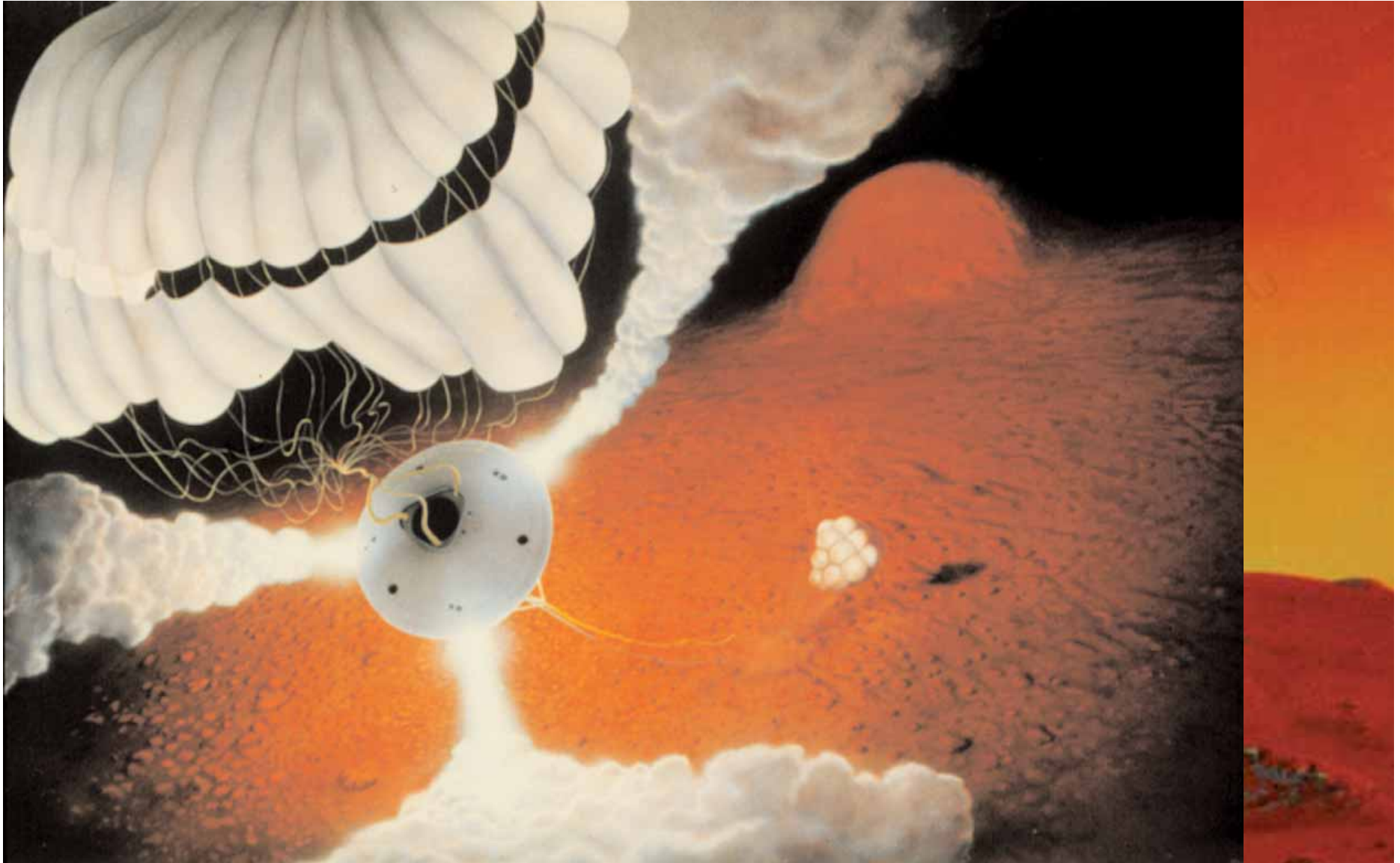
By the time NASA's successful Viking Project placed two landers on the surface of Mars in 1976, the question of whether or not humans should go to Mars began to shift from a philosophical debate to a technical question. It was no longer a question of whether, but when, human beings would set foot on the Red Planet.

So how to do it? In short: live off the land.

*Left: On a one-way mission to Mars, Pathfinder is launched at 2:11 a.m., Dec. 4, 1996. It will land seven months later on July 4, 1997. Above: In cruise stage, Pathfinder, looking like a small disk, hurtles through the atmosphere toward the Red Planet.*



Courtesy of NASA/JPL/Caltech



*Slowed by its parachute, Pathfinder descends through Mars' atmosphere toward its historic landing.*

Courtesy of NASA/JPL/Caltech®

## To And From Mars

I arrived at NASA's Jet Propulsion Laboratory (JPL) in California as a National Research Council (NRC) senior research associate in the fall of 1977. I had been encouraged to apply for the NRC appointment by chemical engineer Warren Dowler, a specialist in rocket propulsion. But (as I later discovered) while I was driving my family from Norfolk to Pasadena, NASA's funding for my proposed rocket-motor research project at the JPL was canceled. When I finally arrived I was given the opportunity to work with the Mars Mission Advanced Planning team as an alternative. That seemed like a better idea than turning around and driving back to Virginia.

Warren and I were assigned to investigate some of the alternative Mars

surface-exploration concepts, including a robotic airplane; an inflatable, wind-blown ball; and a free-flying, weather-balloon-like concept. We were also asked to investigate the possibility of making rocket fuel required for an Earth return directly from local materials processed on the Martian surface. At this point, a human mission to Mars wasn't part of our thinking.

After looking at some rather ridiculous robotic mining concepts, and even studying the possibility of digging a one-kilometer-deep hole into Mars' surface and filling the hole with hydrogen and oxygen slush to make a large rocket-launching cannon, we made up our minds that Mars-based rocket-fuel production wasn't feasible. However, we decided to look a little deeper before we reported back to the study team. It was

during this one-week exercise that we had a conceptual breakthrough.

Our "eureka" was that man-made machinery could "breathe in" martian air and "drink up" available Mars water to make methane rocket fuel on site, without prospecting or mining. We could use very simple chemical processes. Methane fuel is nearly as energetic as hydrogen fuel and it could be kept in liquid form at temperatures that were no colder relative to the Mars environment than temperatures maintained in a home freezer on Earth. A tiny factory could stockpile an impressive volume of methane during the 100 days or so that explorers would wait for the orbital window to once again open for the return to Earth.

Even before departure of the first manned Martian expedition, a small



*After disconnecting from its parachute, the Pathfinder pod bounces to a resting place, making it the first spacecraft on the surface of Mars in more than 20 years.*

Courtesy of NASA/JPL/Caltech®

chemical processor could be built and sent to Mars, along with solar- or nuclear-power generating equipment, to slowly convert on-planet materials (such as water and carbon dioxide) into oxygen and fuel for surface exploration, life support and the return trip to Earth. By the time the astronauts completed a 100-plus-day transit from Earth and entered orbit around Mars, an Earth-return spacecraft (included with the other equipment in one or more pre-landing packages) could be fully fueled and waiting. In addition, our explorers would have in place a power plant that would be used to provide the electricity for their base, as well as a supply of breathable air and drinkable water.

Our ideas made a round trip to

Mars practical and affordable.

Furthermore, our approach removed the hazards associated with carrying large additional quantities of rocket propellant inside a human-occupied spacecraft.

Our initial results were published in 1978, but we could not convince mission planners at NASA headquarters that this was the logical approach for sending humans to Mars. After numerous trips to Washington, where our requests for funding were passed from division to division, I decided in 1979 that it would be easier for me to do my part in keeping this idea alive by returning to Old Dominion University than by accepting a permanent JPL position.

## **Where Do We Go From Here?**

In 1987, a team of Old Dominion students successfully designed, built and tested a stabilized zirconia cell which converted simulated Mars atmosphere into oxygen. During the past decade, others have suggested that transporting liquid hydrogen from Earth, allowing some of it to boil off during the trip to Mars, and then combining the remaining hydrogen with carbon dioxide to form either methane or any number of other hydrocarbons, may have advantages over our original concept.

Since the first publication of our proposal in 1978, such areas of research



*On Earth, television stations and Internet sites carried pictures generated by Rover Sojourner, the small wagon-like robot used to maneuver around the surface. Weighing less than 25 pounds on earth (nine pounds on Mars,) it was designed to travel no more than three meters a day, not venturing more than 10 meters from the lander (at left).*

Courtesy of NASA/JPL/Caltech®

have become known as “in situ resource utilization,” or ISRU. In 1997, as part of their *Human Exploration and Development of Space* (HEDS) initiative, NASA published a “Manned Mars Mission” design that incorporated ISRU as the preferred approach. Not only does ISRU reduce the mass and cost of the missions, but it also represents a major shift in contingency planning.

Early unmanned missions could leave behind surface-transportation vehicles, power-generation equipment, fuel and oxygen processors, water-processing equipment (eventually) and so on. Also, by selecting specific base-camp locations on Mars where successive missions can land and leave equipment for re-use, it would be possible to build up the infrastructure needed for an outpost that would be similar to the site maintained at McMurdo Station,

Antarctica.

The parallels between a human voyage to Mars and Columbus’ first voyage to the New World are remarkable. Length, cost, supply and resupply, communications lag time: all are quite similar. Columbus’ voyage was thought to be impossibly long and too dangerous to undertake. His voyage was motivated by an incorrect assumption: that he would open up additional commerce with Asia, rather than gaining access to the wealth of a new continent.

A future voyage to Mars might be undertaken solely for scientific reasons. Yet it is likely that after setting foot on the Martian surface we, like ancient terrestrial explorers, will discover undreamed-of opportunity on a planet that has so long dominated our hopes and dreams.



Jason Waitunas

*Robert Ash is an Eminent Scholar and professor of aerospace engineering.*