

Destination Mars

Written by Gemma Lavender

With private space enterprises and NASA planning manned missions to Mars in the coming years, **All About Space** discovers how the world's leading space explorers will take the first humans to the Red Planet

It was former Apollo astronaut and second man on the Moon Buzz Aldrin who uttered the words, "Forget the Moon, let's head to Mars!" This is something that mankind has been working to achieve since the Sixties. Fleets of flyby missions, orbiters, rovers and landers have been sent on one-way missions to shape our understanding of the Red Planet, setting down the groundwork that will one day lead to the moment an astronaut sets foot on Martian soil.

At an average distance of around 225 million kilometres (140 million miles), Mars might not be as close to the Earth as the Moon or Venus, but the ruddy-coloured planet's potential to provide us with information to sate our appetites for knowledge as well as the opportunity to expand our species to another world, today encourages generations of scientists to overcome this distance with relative ease. However, it was not always this way.

The Soviet Union was the first country to launch robotic missions to Mars, with a number of failed launches and probes in the Sixties. By the Seventies, however, they had competition from the Americans. With two countries setting their sights on the Red Planet, the race was well and truly on, but who would get there first?

On 19 May 1971, the USSR's Mars 2 successfully raced through the last of Earth's atmosphere with the Red Planet in its sights. Russia was in with a good chance of winning this round of the Space Race. With the successful launch of Mars 3 taking place a mere nine days later, this only reaffirmed the Soviets' confidence.

However, on 30 May 1971 NASA released Mariner 9 into the skies above Cape Canaveral, hot on the heels of Mars 2 and Mars 3. It reached Mars by 14 November of the same year, beating the sluggish Mars 2 and 3 by a few weeks. Even so, Mariner 9 had to wait out months of relentless dust storms raging across Mars before it could take any of the 7,329 clear images of the Red Planet that it ultimately beamed back to anxiously waiting scientists on Earth. It saw river beds, craters, canyons, great extinct volcanoes such as Olympus Mons, as well as obvious signs of erosion from water and wind.

Following Mariner 9's successful visit, in 1975 NASA launched the twin Viking missions, each one combining an orbiter and lander. But that was it until the mid-Nineties. Since then several robots have been sent to Mars, determined to be the first to underpin the principles which will

one day allow humans to set foot on the planet's surface. Satellites have included NASA's Mars Global Surveyor and Mars Reconnaissance Orbiter, and the ESA's Mars Express, as well as the successful Phoenix and Pathfinder landers, while the Spirit, Opportunity and Curiosity rovers touched down on Mars to inspect the Martian soil for signs of life and to take a few snaps of their new home.

However, as we push for greater feats the rovers don't seem to be enough. We need something more sophisticated, according to advocate of the manned exploration of Mars and American aerospace engineer, Dr Robert Zubrin of the Mars Society. We need to go to Mars ourselves.

"I do favour sending robots to Mars and I am very happy that we're doing that," says Zubrin. "They are just the advance scouts and you know, the rovers, I love them, but there's nothing they can do that we [humans] couldn't do a thousand times faster." While the work of the rovers has provided us with an incredible amount of information, signatures of past life such as fossils could easily be overlooked by the robots. "You could

parachute 100 rovers [to Mars] and you would never find a fossil," Zubrin explains. "Finding fossils involves hiking through lots of terrain, it involves pick and pickaxing work and it involves diligent work such as carefully splitting open shells to find preserved fossils. This is way beyond the ability of robotic rovers and if you're talking about whether humans

could settle on Mars, then clearly, you have to send humans."

So to Mars humans must go. And in a change of dynamic, agencies and organisations are looking past unmanned missions and instead are focusing on landing the first man on the Red Planet in a step that makes science fiction a reality. The feat has become a race once again.

The Martian atmosphere makes landing difficult, it's too thin to provide useful deceleration like Earth's but thick enough to destroy an unprotected spacecraft



The Orion module replaces the now cancelled Constellation Program as our future hopes to send man to Mars



Zubrin thinks he knows how to win the race. In the Nineties he developed a daring plan that he called Mars Direct. "The basic idea of the Mars Direct mission is to explore Mars with a travel-light philosophy," he says. "Rather than building giant spaceships loaded with all of the food, water, air, fuel and oxygen required for a round-trip mission, we try to make the most important of these on Mars."

For example, Zubrin proposes that an unmanned mission go ahead first, carrying with it an Earth-return craft and the ability to make rocket fuel on Mars by reacting hydrogen with the carbon dioxide in Mars's atmosphere to create the methane and oxygen rocket propellant and oxidiser. "So now you have a fully fuelled Earth-return vehicle waiting on the Martian surface," he says. "Then you shoot

the crew out to Mars and because the return vehicle is waiting on Mars, they don't need to fly to Mars on a giant spaceship, they just fly to Mars in a habitation module that lands in the vicinity of the Earth-return vehicle."

After 18 months on the surface, the astronauts then head home in the Earth-return vehicle, leaving the habitation module on the Red Planet. But then a second manned mission is launched, delivering another habitation module to the surface, and then a third and a fourth. "Before long you have the first human settlement on another world," says Zubrin. "There is nothing in this that is beyond our technology; we can do this."

Indeed, other organisations are clamouring to be the first. SpaceX's Elon Musk has already stated that he intends to go to Mars, while

"I do favour sending robots to Mars... but they are just the advance scouts"

Dr Robert Zubrin



The NDX-1 spacesuit, designed by aerospace engineer Pablo de Leon for possible use on Mars, was able to endure the icy temperatures and battering winds during tests in Antarctica



Manned missions to Mars

The leading candidates in the new race to Mars

1. Inspiration Mars

With the intention of sending a man and a woman on what has the makings of a historic mission lasting 501 days, Inspiration Mars intends to safely return its crew to Earth after they fly within 160 kilometres (100 miles) of the Red Planet, using technologies derived from NASA and the International Space Station. The plan is to use the gravitational influence of Mars to slingshot their manned vehicle onto a return course back to Earth. They will not land on Mars. The ship's inflatable habitat module will be deployed after launch and detached prior to re-entry into our planet's atmosphere.

2. SpaceX

SpaceX is the world's first privately held company to send cargo to the International Space Station and now the company's founder and CEO Elon Musk intends to send a mission to Mars. First will be a sample-return mission called Red Dragon, that will also look for signs of life. Its long-term plans, however, are to send a manned mission to Mars in a modified version of its already built Dragon capsule. The intention is for the capsule to descend through the Martian atmosphere and land on the rocky surface without the need for a parachute. The capsule's own drag may slow it down enough to allow retro-propulsion thrusters for a controlled enough descent. Eventually SpaceX wants to shuttle 80,000 people to Mars with the intention of colonising the planet.

3. NASA

The National Aeronautics and Space Administration, NASA, is the world leader in Mars exploration. Its most recent development to send humans to Mars in a 2030 timeframe is also currently under review. One possibility is the Orion Multi-Purpose Crew Vehicle that was announced by NASA in 2011. It is hoped that the Orion capsule will be able to carry between two and six astronauts sometime after 2020. It is intended that the 8,900-kilogram (19,600-pound) module will be able to return to Martian orbit using methane propellant made from Mars's soil. Image 3 shows the recent Orion drop test where scientists used a mock-up of the Orion crew module to simulate various water-landing scenarios to account for the different velocities, parachute deployments, entry angles, wave heights and wind conditions on Mars.

4. Mars One

Adamant that the technologies to land the first humans on Mars exist, Dutch start-up Mars One aims to spend an estimated \$6 billion to initially send four individuals to the Red Planet. They will be tasked with setting up a habitable outpost based on ready-made hardware that will be sent to the planet in advance. After installing their habitat, the members of the first colony outside of Earth will be expected to grow their own food, mine their own water and oxygen, perform research and, of course, explore a whole new planet.

"SpaceX's long-term goal is to colonise the Red Planet"



**1971
Mars 3**

This was the first spacecraft to achieve a soft landing on the surface of Mars but a great dust storm caused a communications failure.



**1976
Viking 1 & 2**

The Viking programme returned hi-res images, studied the surface and atmosphere and attempted to search for life on Mars.



**1997
Sojourner**

Sojourner was the first rover to touch down on Mars. It analysed the atmosphere, climate and make-up of the planet's rocks and soil.



01



02



03



04



2004

Opportunity

The Opportunity rover has found Martian meteorites, looked into geological processes and studied surface composition.



2006

Mars Reconnaissance Orbiter (MRO)

With a suite of instruments, the MRO continues to analyse Mars's weather and surface conditions.



2012

Curiosity

Curiosity is providing information on the past and present habitability of Mars, as well as taking hi-res images of the landscape.

On the surface of Mars

No oxygen

Mars's atmosphere is a very thin envelope of mostly carbon dioxide gas, and so is not breathable. The first colonists will only be able to go out in spacesuits, but after hundreds or maybe thousands of years it might be possible to terraform the Red Planet to be more like Earth. In the meantime, oxygen can be produced from water-ice or reacting hydrogen with carbon dioxide.

Frosty nights

Temperatures on Mars can reach highs of around 20°C (68°F) at noon, at the equator in the Martian summer, and plummet as low as around -153°C (-240°F) at the poles.

Looking for life

Did Mars harbour life at some point in its long history? Is it still home to simple microbial life even today? One of the main scientific goals when going to Mars will be to answer these questions about life on the Red Planet.

A self-supporting colony

Being so far from Earth, Martian explorers will have to be able to support themselves. An inflatable greenhouse could be put up to grow crops, although nobody knows how well plants will grow in the Martian dirt.

Better than robots

Steve Squyres, principal investigator on NASA's Mars Exploration Rover Mission, has gone on record to say that what the Spirit and Opportunity rovers have accomplished in their nine years (so far) on Mars could have been accomplished by a team of astronauts in a week.

Underground water

Water-ice lies just a few metres beneath the surface of Mars down to at least its mid-latitudes, and should be easily accessible.

Weather station

When on Mars, astronauts can study the atmosphere and weather, looking out for huge dust storms that could rapidly engulf the landing site.

Longer days

The length of a Martian solar day, or sol, is 24 hours and 39 minutes. Astronauts will need special Mars watches that factor in this extra 39 minutes.

Landing craft

In Robert Zubrin's Mars Direct mission, he proposed sending habitation modules to Mars with each new crew, eventually building up to the first settlement on the Red Planet.



Geology

The rocks and dirt on Mars can tell us lots about the past climate in their local environment. Some of the first Martian astronauts therefore may well be geologists.

former private astronaut Dennis Tito has launched Inspiration Mars, an organisation that plans to send two humans - a male and female, likely married - on a flyby mission of Mars in 2018. It's a plan that Zubrin himself pitched to NASA in 1995, but they didn't take him up on the idea.

"Really the key question of whether Tito is going to pull this off is whether he can raise the \$2 billion needed," says Zubrin. "NASA is funded to a level of \$18 billion per year. Now \$2 billion is nothing to the government but it is a lot in the private world, but really if NASA had the courage of Tito we would have done this when I proposed it to them in 1995."

Dr Gernot Grömer of the University of Innsbruck and head of the MARS2013 project agrees with Zubrin. "This is a truly ambitious plan," he says. "If you look at their papers where they describe the mission profile, it is well thought through and written by experts who are very good in their subjects. However, for trajectory reasons they have to keep the 2018 deadline." That's the big problem, says Grömer. Dennis Tito is only funding the first three years of that project until the really high financial demand kicks in. Will they then

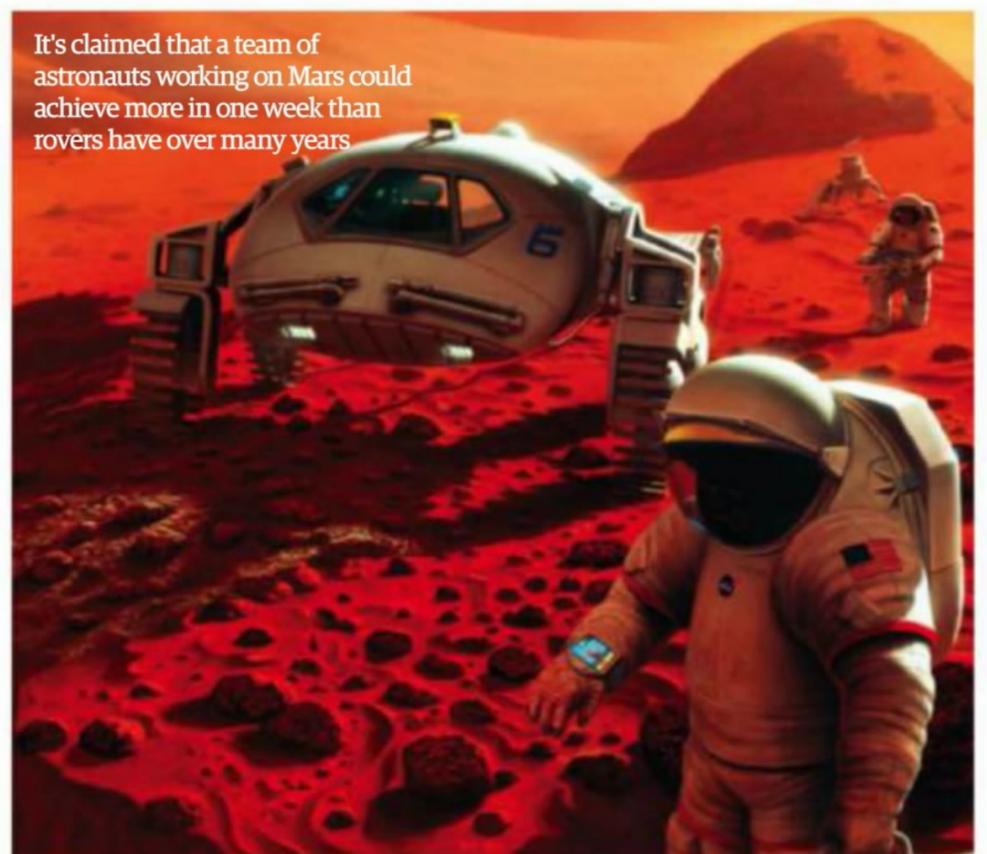
be able to get the financial backing that they need in the time required? "Developing a transportation system which brings people to Mars and back safely is something that will probably take more than the few years left to the 2018 deadline," adds Grömer. "I honestly wish them all the luck, but I am pessimistic that they can really achieve the super-tight schedule."

Another proposed privately funded manned mission is that of Mars One, a not-for-profit organisation based in the Netherlands that intends to establish a permanent human settlement on Mars by 2023, by sending astronauts there on a one-way trip. Their plan is to get funding by turning the adventure into a reality TV show. However, Grömer is less convinced by their plans than he is of Inspiration Mars's.

"Unlike the team of Dennis Tito, the Mars One team lacks the expertise and knowledge how to approach such super-ambitious programmes," he says. "Just simply recruiting and maintaining such a large astronaut corps is well beyond their capabilities, not to speak of launchers, habitats, spacesuits etc. Having big players like SpaceX [behind them] certainly helps, but there is no indication these are doing it for free. That means, that even

"The basic idea of the Mars Direct mission is to explore Mars with a travel-light philosophy" **Dr Robert Zubrin**

It's claimed that a team of astronauts working on Mars could achieve more in one week than rovers have over many years



"The first human to walk on Mars is already born"

Gernot Grömer, MARS2013 project leader

Currently standing as Europe's largest Mars simulation to date, the month-long 'Mars' expedition dubbed MARS2013, which included field tests of two experimental spacesuits, an astronaut injury scenario, tests of autonomous rovers and a cliff-climbing robot, has now been successfully completed surpassing its very own ambitious objectives. MARS2013 is led by Gernot Grömer, who was previously selected as an astronaut for a simulated Mars expedition in 2003 and 2006 at the Mars Desert Research Station in Utah. Grömer currently serves as a board member of the Austrian Space Forum managing a research programme to develop an advanced spacesuit simulator for human Mars expeditions, and he has participated in a flight team onboard the Airbus A-300 zero-gravity flight programme, where he conducted a series of medical experiments. Grömer's research interests focus on planetology and space exploration both of which he teaches at the University of Innsbruck, Austria.

What did the MARS2013 expedition entail?

Between 1 and 28 February 2013, the Austrian Space Forum – in partnership with the Ibn Battuta Center in Marrakesh – conducted an integrated Mars analog field simulation in the northern Sahara near Erfoud, Morocco in the framework of the PolAres research programme. Directed by a Mission Support Center in Austria, a small field crew conducted experiments preparing for future human Mars missions mainly in the fields of engineering, planetary surface operations, astrobiology, geophysics/geology, life sciences and others. We had a truly international team from 23 countries, involving more than 100 researchers and volunteers, including the United Kingdom.

What did you learn from the MARS2013 expedition?

We had 17 peer-reviewed research experiments and collected a truly large data set which we are now going to analyse in the next 12 months. We are very much looking forward to a science conference in Vienna in May where we will go into the academic discussion.

One of the major outcomes was that we have gained a lot of operational experience in conducting human exploration activities on the surface of another world. This ranges from data on instrument behaviour, biomedical data on the exhaust patterns as well as the efficiency of how to do things such as geoscience in a very efficient manner.

Do you think humans are ready for a trip to Mars?

Yes. It will be the most technically challenging journey our society has ever undertaken, but from the engineering and scientific point of view, we are almost ready. In all our research we haven't encountered a showstopper that told us 'no, you can't go'. This includes hazards such as radiation or human factors but, at the end of the day, I believe we have never been so close to human missions to the Red Planet.

What do you think the future holds for the manned exploration of Mars?

At the Austrian Space Forum we say that the first human to walk on Mars is already born. I personally believe that this generation is the first one to be able to tackle the question of life in the universe on a promising planetary surface for the first time in-situ. If you read a history book in 200 years from now, the economic crisis might only be a marginal chapter, whereas in the long run, our time will be known as the time where we left the planet to discover new worlds.



NASA is preparing for an unmanned test flight of Orion in 2014

"Inspiration Mars is a truly ambitious plan. It is well thought through and written by experts who are very good in their subjects" **Gernot Grömer**

large TV companies won't be able to afford such a multi-year programme, not to mention the challenge of keeping the public interest going for such a long time."

In the meantime, as the various companies look to find the funds to reach the Red Planet, full-blown simulated expeditions to Mars are taking place. For example, isolated for 520 days in a mock-up spacecraft in Moscow, five crewmembers got the full brunt of what it would really be like to be making their way to another planet. The Mars-500 project simulated the Earth to Mars shuttle spacecraft journey, the ascent-descent

craft and the Martian surface. Delving deep into the psychological and medical effects that long-distance spaceflight would cause, Mars-500 identified possible problems and solutions that cosmonauts were likely to encounter. Subjected to peculiarities such as a lag in communication between 'Mars' and 'Earth', rationing of food and having to live in an enclosed space with others for a long period of time, these Martian explorers were tested to their limits. While several crewmembers experienced problems sleeping, avoided exercise to counteract the effects of space travel and would hide away from



Studying the Martian landscape will provide us with clues as to whether it was once habitable

5 reasons we need to go to Mars

Why getting mankind to the Red Planet is so important



1 Testing technologies for space exploration

A manned mission to the Red Planet will involve state-of-the-art technology but Mars also offers the opportunity to test our new spacecraft and instruments to the extreme. While we have not landed any humans on the Martian soil as of yet, every mission that we have and will continue to send in the future will yield important information from their surroundings. This data will serve as a stepping stone, paving the way for human exploration and the technology that will get us to Mars.

2 Establishing human life elsewhere

At the moment, the only planet that we know of that harbours any complex life is Earth. But what if we humans could exist elsewhere? Mars has the potential, despite its hostile environment, to offer colonisation as an option.

3 Conquering frontiers

Despite being the closest planet to us which bears some similarities to Earth, experts have not let the fact that a manned mission to Mars would be difficult escape their notice. However, for the first time in history, a species on Earth has the knowledge and technology to make the journey to another planet possible. Making the journey to Mars and landing on its

of a lifetime.

Mars's past and present to look into the future

Clearly expanding our knowledge about Mars is very important, especially if we hope to set foot on the Red Planet sometime in the future. Learning from past and current missions has broadened our horizons immeasurably giving us the confidence to start thinking about what to expect when the first crew touches down on the ruddy soil. Important information that we have discovered is that Mars may have supported life in its past - according to the damp soil that Curiosity found recently. Of course, rovers are not as dextrous as humans which means that they have several limitations when it comes to looking for clues. This is another reason why we need to go to Mars.

4 Looking for life

When asked to envision what life might look like on other planets, it is easy to imagine humans or even sub-human beings roaming their world. Another misconception is that for a planet to be habitable it must have exactly the same characteristics as our Earth. A frozen planet harbouring something as small as a single organism surviving comfortably under an icy planetary crust means that world is habitable no matter the differences in comparison to our home. Mars is similar, while it is unable to support humans without the aid of spacesuits and technology, it can provide clues on the conditions for life both under its surface and on other planets in the Solar System and beyond.



Road map to Mars



Author of *Mars: A Cosmic Stepping Stone*, Kevin Nolan speculates on how he thinks Mars exploration will develop in the next seven decades

First manned fly-by 2020-2029

"A European Union-driven sample return mission by around 2025. Human astronaut programme for Mars will be ramped up by the European Union, the United States of America and potentially China. A manned flyby of Mars will occur before 2030 and will be initiated by Dennis Tito but in co-operation with NASA. By contrast, the Netherlands-driven Mars One project for a one-way mission to Mars is notional, impractical and bares no basis on reality."



2010

2020

2030

2040

New Rovers and Landers 2010-2019

"Missions will include NASA's Mars Atmosphere and Volatile Evolution (MAVEN), a planned space exploration mission to send a space probe to orbit Mars, as well as ESA's ExoMars, a new Mars Science Laboratory-type rover. Additionally, plans will be firmed up for an international sample return mission. In reality, Dennis Tito's Inspiration Mars, if it is to actually happen, could not happen before 2025."

Deimos mission 2030-2039

"If we stay on course, we could see a human mission to Mars's furthest moon Deimos and serious Chinese human activity at Mars by either flyby or landing on Deimos."



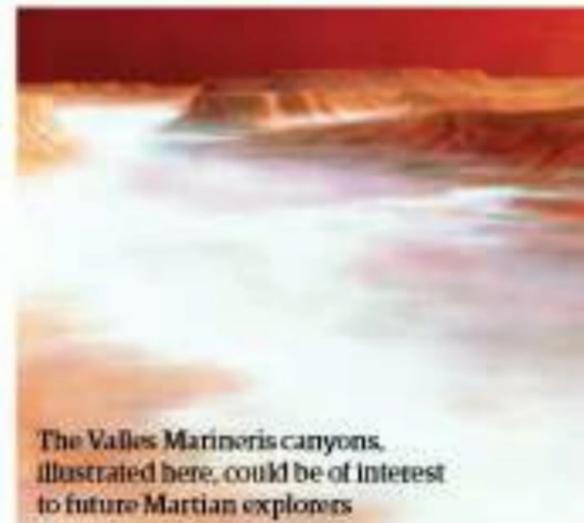
their crewmates, Mars-500, which ran between 2007 and 2011 and admitted three separate crews, proved a success, with most volunteers reportedly being in good physical and psychological condition. However, with simulated missions to the Red Planet far from over, experts want to put potential astronauts to the test even more. How

would they deal with completing actual scientific experiments and walking for miles across the tough Martian terrain?

For such an occasion there was the aforementioned MARS2013 project, which took place in February 2013. The month-long simulation was initially based at Camp Weyprecht

in the Mars-like Moroccan desert, before a three-day excursion collecting rock samples on the way to a second 'landing site' called Station Payer that had been established by four of the ten-member team of analog astronauts. Led by Gernot Grömer, MARS2013 was the biggest Mars simulation ever performed by a European organisation,

"The Mars One team lacks the expertise and knowledge how to approach such super-ambitious programmes" **Dr Gernot Grömer**



The Valles Marineris canyons, illustrated here, could be of interest to future Martian explorers

500 day stay 2040-2059

"If we're to set people on the surface of Mars then it most likely cannot happen before 2040 (with current forecasts). The notion of placing people on the surface (for a required 500-day stay there) would need significant resources, such as supply missions two years in advance, landing mining nuclear power stations on the surface, return fuel in-situ manufacturing facility. All of these are decades away, so a 20-year interval time period is most likely for actual human missions to land on the surface of Mars."



2050

2060

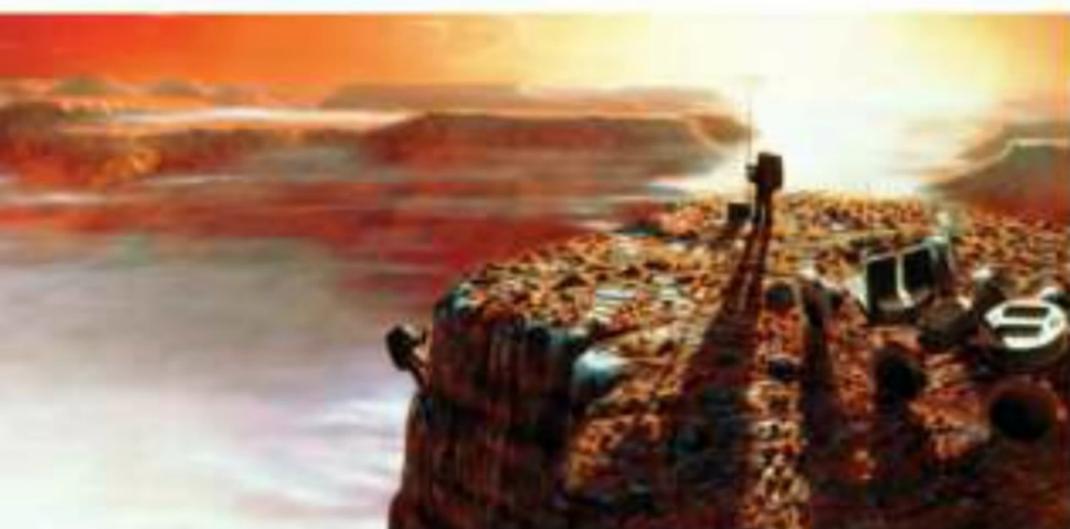
2070

2080



Long term presence 2060-2079

"When you consider we've been in space for over 50 years and what we've done in that time, one can sense the lengths of time needed, the commitment by countries and governments and the readiness of people. These issues, coupled with the extraordinary technology and budgets required, pushes a long-term human presence on Mars well into the second half of this century in my opinion. An en masse migration of people to the surface of Mars will be another entire agenda well into the next century. Of course, these are speculations, and one multimillionaire could propel all of this forward by decades!"



involving 23 nations and more than 100 scientists. The team performed 17 scientific experiments, as well as field-testing new spacesuit designs and deployable shelters, acting out an astronaut-injury situation and testing cliff-climbing robots. Like Mars-500, a 20-minute 'time delay' was included in all communications with Earth, simulating the wait as radio waves travel at the speed of light from Mars to Earth and then back again. Data collected from such simulations is important in planning and preparing for the real thing.

And when is that 'real thing' likely to occur? The Mars enthusiasts at Inspiration Mars, Mars One, the Mars Society and SpaceX would argue that it could happen by the end of the current decade, or the beginning of next. Others, however, are playing it safer, and suggesting 2030 or later as the most likely date for mankind to reach the Red Planet. In the end it will be decided by who can raise the necessary money and have the courage that Zubrin says is essential to make history by being the first to send people to Mars. ■