LESSON 2 The Future in Space

Quick Write

How do you think Percival Lowell's promotion of the idea of "canals" on Mars might have influenced space exploration efforts?

Learn About

- the planned return trip to the Moon
- the plans for a Moon outpost
- the plans for a manned mission to Mars

Years before there was NASA, or the Apollo program, or the space shuttle, there was Percival Lowell. In Chapter 3, you read about his connection with the effort to find Pluto. But Mars was his first love. A headline in the *Boston Globe* would one day call him "The Man Who Invented Mars."

Lowell lived from 1855 to 1916. According to the *Globe*, he was a Boston Brahmin—a wealthy, well-educated businessman. He devoted much of his time, money, and energy to proving that Mars had intelligent life. He looked through his telescopes, among the best of their day, and thought he saw canals. If there were canals, there had to be canal builders, didn't there?

His fascination with astronomy began when he received a telescope as a gift when he was boy. But he was really "hooked" after he discovered the writings of the Italian astronomer Giovanni Schiaparelli. The director of the Milan Observatory, Schiaparelli described the *canali* he saw on Mars. The Italian word simply meant "channels," and referred to naturally occurring cuts on the planet's surface.

But Lowell understood them as canals, perhaps naturally so. After all, the *Globe* pointed out, he lived in a canal-building age. His family had made much of their money in the textile business in Lowell, Massachusetts, a city crisscrossed with industrial canals. The Suez Canal in Egypt had opened in 1869, reenergizing efforts to build a canal across Panama.

Lowell built an observatory in Flagstaff, Arizona. It was far from the East Coast's bright lights and often cloudy weather. This made it all the better to get a good look at Mars during the winter of 1894–95, when Mars was closer to Earth than usual.

Lowell was a tireless popularizer of his ideas. He published books and articles in prestigious magazines. And he lectured. He was a commanding presence, handsome and intense.

Lowell was never able to prove the existence of canal-building Martians. But his idea that "we are not alone in the Solar System" captured the popular imagination. Some say it has influenced space exploration efforts ever since.

Lowell died of a stroke in 1916. He is buried in Flagstaff in a domed mausoleum built to look like an observatory.

In the early years of the twenty-first century, the Mars *Opportunity* rover found evidence that at some point in the past, Mars had been "soaking wet." Where there was water, there was life, or at least potential for life.

Soon after NASA announced the *Opportunity* findings, someone left a glass of champagne, with a note, at Lowell's tomb. The *Globe* reported that the note contained a quotation from a play by the ancient Greek poet Euripides: "Far away, hidden from the eyes of daylight, there are watchers in the sky."

Vocabulary

- geodetic
- contour map
- albedo
- regolith
- volatile
- fission

The Planned Return Trip to the Moon

On 14 January 2004 President George W. Bush gave a speech in which he announced a new "Vision for Space Exploration." He said the United States would "finish what it started," by completing the International Space Station. Next, the country would develop a new manned space vehicle, a successor to the *Apollo* spacecraft. And third, America would "return to the Moon by 2020, as the launching point for missions beyond."

The speech raised far more questions than it answered. But the president was firm: "We do not know where this journey will end, yet we know this: Human beings are headed into the cosmos."

As this book was written, it was far from certain that the United States could return an astronaut to the Moon by 2020. President Barak Obama has recommended canceling the *Constellation* program—including the *Ares* launch vehicle and the *Orion* crew capsule under development. Whether Congress would go along with this or maintain the original program was also not clear. But whenever missions to the Moon and Mars take place, they will involve the issues and technologies this lesson discusses.

The Development of the 2006 Global Exploration Strategy (GES)

Sometimes when you decide to do something big—to plan a big trip, for instance—it's a good idea to sit down and think deeply about it. Your decision may be intuitive. In other words, it may be the kind of decision that comes to you all at once and just feels right. But still it can be good to flesh out your thinking about it. In the case of a trip, you may think about what you really want to get out of it, how to prepare for it, what to bring, what other destinations to include on the itinerary, and so forth.

Returning to the Moon is a big trip that's worth careful thought. To prepare for this mission, NASA developed a program of lunar exploration themes and objectives. The agency was trying to figure out its goals for a trip to the Moon. NASA refers to this planning program as the Global Exploration Strategy. And to put together this strategy, NASA gathered the ideas of people from all around the world and from many different stakeholder groups. (*Stakeholder* originally meant someone who owned part of a business. Nowadays people use stakeholder to mean anyone who is involved in or affected by a certain course of action.)

NASA's process for developing its Global Exploration Strategy (GES) began in April 2006 with a workshop lasting several days in Washington, D.C. As the workshop was under way, NASA sent out a formal request for information to other parties whose views the agency wanted. These included, for instance, all the NASA centers, such as the Goddard Space Flight Center and the Kennedy Space Center, as well as the Space Commerce Roundtable, a private organization seeking to develop business opportunities in space.

Space Agencies Taking Part in the GES

These bodies all contributed ideas to NASA's Global Exploration Strategy:

- The British National Space Centre
- The Canadian Space Agency
- The Chinese National Space Agency
- The Commonwealth Scientific and Industrial Research Organization (Australia)
- The European Space Agency
- The French National Space Agency
- The German Aerospace Agency
- The Indian Space Research Organization
- The Italian Space Agency
- The Japanese Aerospace Exploration Agency
- The Korean Aerospace Research Institute
- The National Space Agency of Ukraine
- Roscosmos (the Russian space agency).

After completing a rough draft of its themes and objectives, NASA sought ideas from 13 other space agencies around the world. These agencies had expressed interest in taking part in a trip to the Moon.

As it brought everyone's ideas together, NASA chose not to identify the source of each idea. Nor did the agency edit the contributions to bring them into line with its own policies or plans. The GES isn't a fixed program, either. As it moves forward, NASA will keep asking others in the global space community for their input.

The strategy, by the way, doesn't represent US or NASA policy. It doesn't commit the United States to any particular activities. But the GES does represent a global consensus as to the value of lunar exploration.

The Moon and Earth from space

Courtesy of NASA

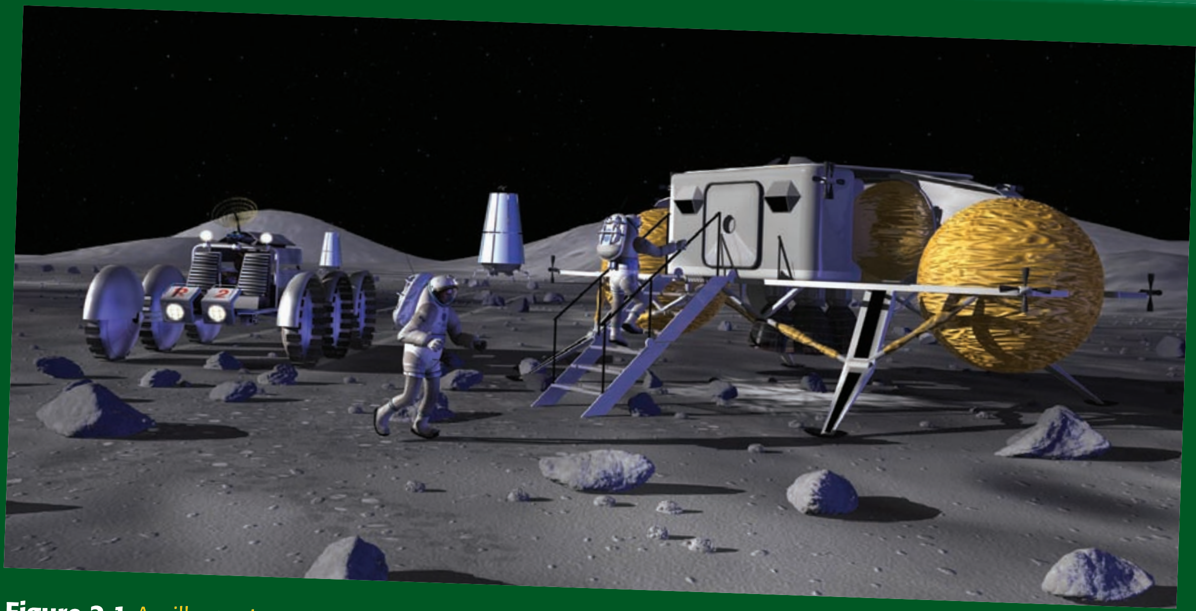


Figure 2.1 An illustration of a futuristic human base camp on the Moon
Courtesy of NASA

Benefits Expected From Lunar Exploration

Nearly 200 lunar exploration objectives emerged from this idea-gathering process. They represent answers to the question, "Why should people return to the Moon?" NASA grouped the answers into six broad themes. These areas of pursuit define, in the world's eyes, the value of going to the Moon. Here they are, with a little explanation of the benefits lunar exploration could provide (Figure 2.1):

- ***Human civilization:*** The human presence should be extended to the Moon to make eventual settlement there possible.
- ***Scientific knowledge:*** A return to the Moon will help answer fundamental questions about the history of the Earth, the Solar System, and the universe, and humanity's place there.
- ***Exploration preparation:*** The Moon is a logical "base camp" for further manned spaceflight throughout the Solar System, notably to Mars. Trips to the Moon will offer opportunities to test new techniques and technologies close to home, too.
- ***Global partnerships:*** Space exploration can provide a challenging, but peaceful, shared activity among different nations.
- ***Economic expansion:*** The exploration of the Moon should lead to economic growth at home, including quality-of-life improvements.
- ***Public engagement:*** A vibrant space exploration program can capture the public imagination. It can also help develop the high-tech workforce needed to face the challenges of tomorrow. Not everyone will be an astronaut. But a strong space program can draw bright students into the study of math, physics and other sciences, engineering, and technology.

Suni Williams

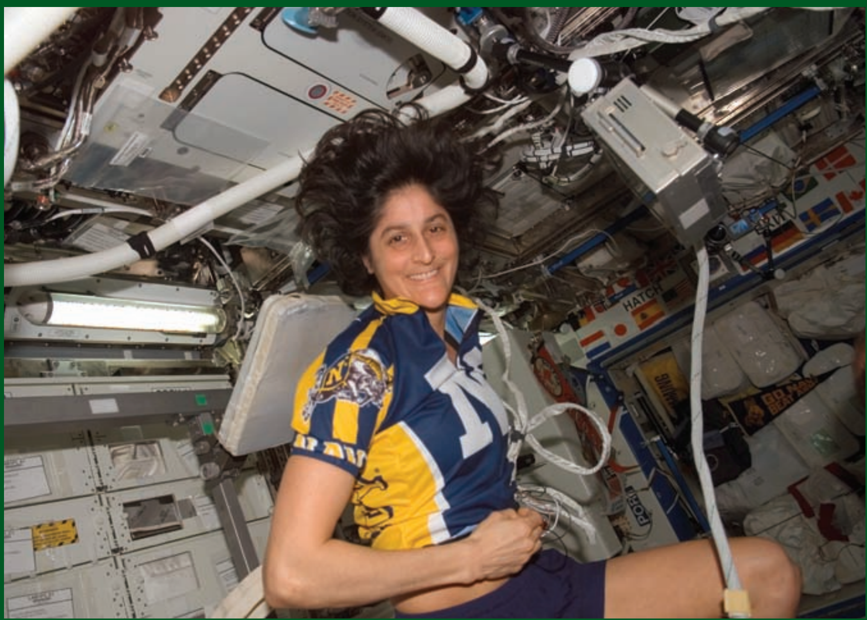
People take many different routes to NASA's astronaut corps. Sunita Williams, you might say, arrived by helicopter.

Born in Ohio to parents who had emigrated from India, Williams considers Needham, Massachusetts, her hometown. She went to the US Naval Academy and graduated in the middle of her class. But she didn't do well enough to train as a diver, as she wanted. So she went for her second choice: flight school. Again, she did well, but not quite well enough to get one of the spots for a female jet pilot. So she opted for a third choice: becoming a helicopter pilot instead.

Once Williams tried it, she loved it. She became the test pilot for her squadron, and then went on to test pilot school. That's how she got her first glimpse of NASA. She visited the Johnson Space Center. There she heard former astronaut John Young speak.

"He talked to us about landing on the Moon and told us that they had to learn how to fly helicopters to do the lunar landing," Williams said in an interview. Up to that point, she didn't know much more about space travel than what she'd picked up from TV shows she'd watched as a child. "So that was the first time I was really like, 'Wow—maybe if I really want to do this, I should apply. Maybe we'll go back to the Moon.' "

NASA picked her for its astronaut corps in 1998. She has served as a flight engineer on the International Space Station (2006–2007), setting records for the longest time in space for a woman (195 days), and greatest number of spacewalks by a woman (four—a record broken in 2008).



Expedition 15 flight engineer Sunita Williams exercises aboard the International Space Station in 2007. She attended the US Naval Academy and eventually learned how to pilot a helicopter.

Courtesy of NASA

The Plans for a Moon Outpost

Important parts of any plan to return to the Moon are the *Lunar Reconnaissance Orbiter* (LRO) and the work of the Lunar Architecture Team.

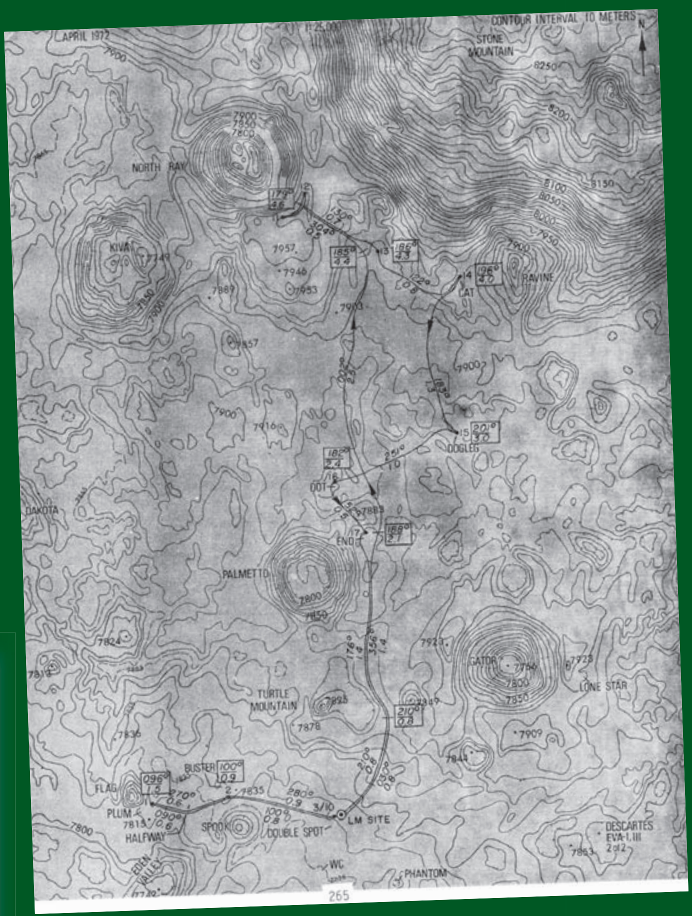


Figure 2.2 A contour map of the Moon used for *Apollo 16*

Courtesy of NASA

The *Lunar Reconnaissance Orbiter* (LRO)

The LRO was the first mission in the Vision for Space Exploration. NASA launched it on 18 June 2009 from Florida aboard an *Atlas V* rocket for a yearlong exploration of the Moon. The LRO's objective is to conduct the preliminary surveys that will make a human return to the Moon possible.

The LRO is to provide data for day-night temperature maps of the Moon. It will capture data for a global geodetic grid. (Something that's geodetic is *related to measuring the Earth's shape, or the shape of another celestial body*.) That is, the LRO will take the measurements needed to produce a contour map—*a map that shows an area's different elevations*—of the entire lunar surface (Figure 2.2). This map would include a grid for navigating on the Moon. The LRO will also gather data for high-resolution color imaging and information on the Moon's ultraviolet albedo—*its reflecting power, expressed as a ratio of reflected light to the total amount falling on the surface*.

The LRO's particular emphasis, though, will be on the Moon's polar regions. NASA scientists suggest that sunlight shines on these areas all the time. Water may also be present.

The Work of the Lunar Architecture Team

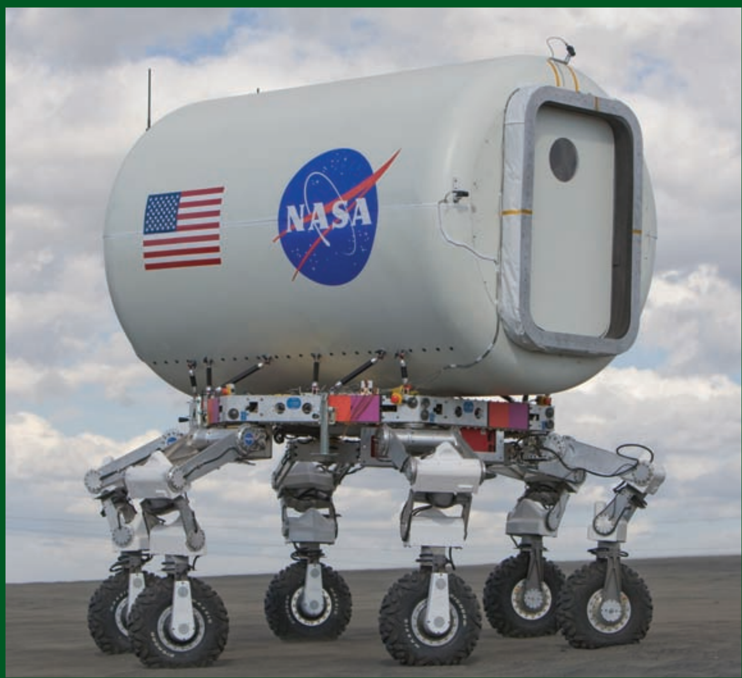
The next logical phase in NASA's return to the Moon is for engineers to come up with ways to make extended stays possible once the new space fleet gets there. "Architecture" usually suggests buildings. But the Lunar Architecture Team isn't charged with designing just a Moon dwelling for space travelers. To this team, architecture includes designs for rovers—the wheeled vehicles that you first read about in Chapter 3 that can travel around the surface of a moon or planet. The team's job involves spacesuits as well. There's plenty of engineering that has to go into those suits. They're not what the salesclerks at your local clothing store would call "unstructured" garments!

NASA planners have their eye on a site known as Shackleton Crater, near the Moon's south pole, as a possible location for their lunar outpost. The rim of this crater is near both permanently shadowed regions and peaks that are in sunlight for much of the year. This would be a good location for solar power arrays to provide electricity to the outpost. The crater may also harbor water ice, which could be an important source of water for a base there. Planners don't intend to limit their options, though. And so the architecture team is designing hardware that would work at any of a number of locations on the Moon.

The original idea for building an outpost on the Moon was to send up smaller elements and have the astronauts assemble them on site. But the Lunar Architecture Team has found that sending up larger elements—more preassembled modules—would help get the outpost up and running more quickly. The architecture team is also considering a mobile habitat module—a sort of lunar RV. This would let a couple of astronauts move away from base camp, for instance, to explore other places on the Moon as mission needs dictate.

Small pressurized rovers are another idea NASA is considering. These would go out in pairs, two astronauts in each, and could venture nearly 125 miles (200 km) from the main outpost for research or other purposes. If one rover broke down, astronauts could ride "home"—back to the outpost—in the other.

NASA says that the rovers should provide a "shirtsleeve environment." That means that astronauts don't have to wear spacesuits inside them. Rather, they would "step in" to spacesuits attached to the rovers' exterior. Do you see why NASA calls this "architecture"?



The Lunar Architecture Team's lunar rover

Courtesy of NASA/Sean Smith

The Plans for a Manned Mission to Mars

Current thinking is that once NASA sets up its lunar outpost, it will turn its attention to Mars. At a workshop entitled "Why Mars," held in August 1992 in Houston, Texas, a team of consultants laid out six arguments in favor of human exploration of Mars. You may find them similar to the arguments for a return to the Moon:

- ***Human evolution:*** Mars is the next step toward expanding the human race into the stars.
- ***Comparative planetology:*** Understanding Mars will help us understand Earth better.
- ***International cooperation:*** A joint effort to explore Mars could help the cause of global unity.
- ***Technological advancement:*** New technologies would inevitably come out of a mission to Mars. These will improve the lives of people on Earth and encourage high-tech industry.
- ***Inspiration:*** A mission to Mars will test human capacities to the limit. A population mobilized in service to such a mission would be an inspiration to later generations.
- ***Investment:*** The cost of a mission to Mars is reasonable in comparison with other social spending.

Building a New Fleet of Spacecraft

NASA's Web sites and other public communications are full of excitement about future missions to Mars. But there's not much discussion about building a new fleet of spacecraft to get there. It's likely that whatever spacecraft eventually goes to Mars will be adapted from whatever program NASA uses to return to the Moon. NASA compares these much shorter missions to using a brand new car to run errands in town before taking it out on a long road trip.

Star POINTS

One of the arguments for sending people to Mars, and not just more robots, is that the red planet is a very complex environment—much more so than the Moon, for instance. And so it would be worth it to bring the greater intelligence of human explorers to bear. What NASA's robotic rovers take all day to do, a human explorer could accomplish in about a minute.

The Greatest Challenges of a Manned Mission to Mars

The challenges of a trip to Mars would include the concerns you read about in Chapter 5. These include the physical effects of long-term exposure to high-energy cosmic rays and other forms of radiation. The low-gravity, low-light environment of a long space mission would also pose some problems for astronauts.

Some of the trials would be psychological: a sense of isolation from Earth and from loved ones back home during the two and one-half years it would take to get there and back. On the other hand, astronauts bound for Mars would also face the test of too much company of people they couldn't get away from: their crewmates. (Even your best friend can get on your nerves sometimes.) A Mars-bound crew would surely include at least one physician, but the astronauts would have to face the reality of having only limited medical facilities.

Other challenges to a mission to Mars would be political and economic. A journey to another planet would take a long time just in terms of actual space travel. It would also take time in terms of planning and budgeting. But the US Congress—which ultimately has to approve NASA's budget every year—can change course every two years. The space program has always been at the mercy of the changing political winds. A mission to Mars will require sustained political and financial support.

Star POINTS

The orbits of Earth and Mars produce a 15-year cycle divided into seven launch windows. About every 26 months, when the two planets get closer to each other, a launch window opens up. A roundtrip mission to Mars would take about two and one-half years—six months to travel to Mars, about 500 days on Mars, and then six months to return home.

Endeavour's crew is hard at work in the onboard Spacelab-J module. This photo shows the types of crowded conditions astronauts would face on a long journey to Mars.

Courtesy of NASA

New Technologies to Support the Mission

NASA says that sending humans to Mars "currently lies on the very edge of our technological ability." A successful Mars mission would be a milestone achievement, and a testament to the possibilities that technology presents to civilization. Here are some of the technologies under development at NASA to support missions to the Moon and ultimately to Mars:

Structures, Materials, and Mechanisms

This NASA project develops technologies to build lightweight vehicles and dwellings. The project team is also working on low-temperature devices—equipment that works where it's very cold. Technology for Mars will rely on lightweight composites and inflatable structures to reduce the amount of mass that has to be launched into space.

Protection Systems

This team focuses on heat and dust. It's developing a heat shield to protect the next crew vehicle, as well as protection systems for equipment that will land on the Moon and Mars. Both these bodies are full of dust—dust that is essentially tiny bits of broken glass. Regolith is the term for this *top layer of silt-fine dust*. NASA is working to figure out how to protect astronauts and their equipment from this threat.

Nontoxic Propulsion

Fuels are usually dirty or even poisonous. But NASA has a team looking for nontoxic—nonpoisonous—propulsion systems. The idea is that nontoxic propellants may take some effort to develop but will be much easier to handle.

Energy Storage and Power Systems

If you've ever had a flashlight fail on a camping trip, you have some flicker of an idea how important batteries will be on future space missions. NASA has a team working on advanced lithium-ion batteries and regenerative fuel cells for energy storage. These systems will make it possible to store solar energy during the day for use at night, and provide power for mobile systems such as rovers, too.

Thermal Control for Surface Systems

This project is developing heat pumps, evaporators, and radiators to make sure the capsule stays the right temperature at all times. Scientists are also working on thermal control for systems for use on the lunar surface, and eventually on Mars, too: habitats, power systems, and spacesuits.

Avionics and Software

In Chapter 5 you read about the danger that radiation poses to electronics, including the computers that would guide spacecraft to their destinations. This project concentrates on "radiation hardened" electronics and reliable software. It's also working on systems that will function in extreme cold.

Environmental Control and Life Support

This project works on ensuring that astronauts have enough air to breathe and water to drink, as well as safe ways of handling their wastes—including the carbon dioxide they breathe out. The team also designs systems to ensure safe and comfortable "room temperatures" for astronauts. It's developing special monitoring instruments for testing on the International Space Station.

Crew Support and Accommodations

This project is at work on an advanced extravehicular activity (EVA) suit. Astronauts will need such a suit for walking around on the Moon or Mars. The current suit used on the space shuttle and the International Space Station is too heavy and constrictive to allow astronauts to move freely.

ISS Research and Operations

This project conducts basic microgravity research in biology, materials, fluid physics, and combustion aboard the International Space Station. It takes advantage of the ISS as a specialized lab in space.

In-Situ Resource Utilization

"In-situ resource utilization" means, essentially, "making the most of what you've got on the scene." "In situ" is a Latin phrase that means "in place." Up to now, space travel has required astronauts to bring everything with them—even the bacteria-free "space kimchi" that you read about in Chapter 6. But now NASA is beginning to work on technologies that would let astronauts draw on resources available on the Moon or on Mars. These include producing oxygen from regolith, and collecting and processing lunar ice and other volatiles. A volatile, or volatile chemical, is *a substance that readily changes from solid or liquid to a vapor*. Scientists expect use of in-situ resources to help cut the amount of water, oxygen, and rocket fuel that NASA must ship in from Earth to the Moon or to Mars.

Robotics, Operations, and Supportability

Whatever the advantages of human over robotic exploration, robots will certainly be part of the program. Robots can move over rough terrain and can help astronauts build and maintain their lunar outpost.

Fission Surface Power Systems

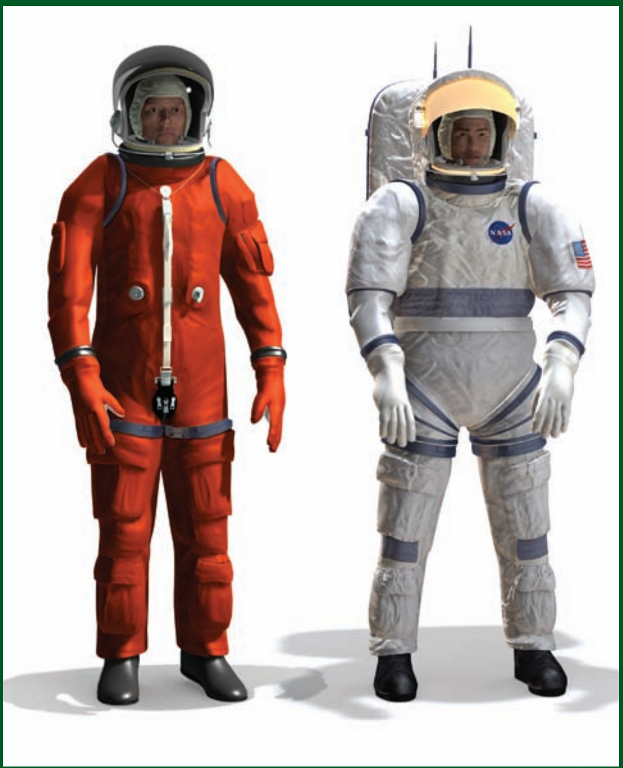
Solar power can be an effective source of energy on the Moon and on the way to Mars. As pointed out earlier, that's what makes the Shackleton Crater such a prime location. But Mars is a different story. The farther you get from the Sun, the less effective solar arrays are. Mars is 1.5 times farther from the Sun than Earth, and the intensity of sunlight there is only about half that on Earth. This means you need bigger solar arrays to generate the same amount of power you get near Earth. Solar power works on Mars, but nights there are very long and require storing energy in batteries. In addition, dust in the atmosphere can degrade solar cells' operation.

By the time you get to Jupiter, the intensity of sunlight is only 1/25th that in Earth orbit. For this reason, spacecraft traveling away from the Sun to the Jovian planets and beyond—such as the *Voyagers*—need nuclear power.

Star POINTS

Fission is the opposite process from what you read about in Chapter 3, which explained that the Sun generates massive amounts of energy from nuclear *fusion*, the combining of atoms.

Likewise, space scientists have long thought in terms of nuclear fission to meet the energy needs of long stays on the Moon or Mars. Fission is *the splitting of an atom's nucleus*. It creates huge amounts of energy in the form of heat. This heat is then converted to electricity, much as happens in a nuclear power plant here on Earth. NASA is working with the Department of Energy on what the space agency calls "affordable nuclear fission surface power systems" for its Moon and Mars missions. For Mars in particular, fission would be a better power source—if engineers can find a way to transport the equipment there in a cost-effective manner.



Engineers designed these suits for a future Moon mission.

Courtesy of NASA

While human beings have already achieved tremendous technological leaps that nineteenth- and twentieth-century science fiction writers only dreamed about, scientists have even greater steps ahead—some of them as yet unimagined by even novelists and filmmakers. NASA takes the process a step at a time. That's why the US space agency is first calling for a return to the Moon. Then a lunar outpost. And only then a journey to Mars. Just as you must master the subjects in one grade before you may advance to the next, so science gathers knowledge in increments. This is how to build a solid foundation—or a launch pad—to the next phase of exploration.

CHECK POINTS

Lesson 2 Review

Using complete sentences, answer the following questions on a sheet of paper.

1. From whom did NASA seek ideas after it had completed a rough draft of its Global Exploration Strategy?
2. Why is a return to the Moon a logical first step toward further exploration of the Solar System?
3. NASA launched the *Lunar Reconnaissance Orbiter* on 18 June 2009 with what mission objective?
4. How has the original idea for building an outpost on the Moon changed?
5. From what program will the rocket to go to Mars likely be developed?
6. What two kinds of psychological challenges would astronauts on a mission to Mars probably face?
7. What is in-situ resource utilization and how does it represent a change in space travel?

APPLYING YOUR LEARNING

8. Do you find the arguments for the exploration of Mars presented in this lesson persuasive? Why or why not?