



Quick Write

Think of a space-related technology that you use every day, and describe what your life would be like without it.



Learn About

- how people use satellites every day
- the uses of a global positioning system
- how NASA shares its inventions with the private sector

Sometimes the hardest part of a trip is the journey home. That was certainly true for the early astronauts in the US space program. When they returned to Earth, the process was described as a splashdown. It perhaps sounds like fun, but it could be difficult and dangerous.

The capsule would plunge through the atmosphere. Then a series of parachutes would open to slow the capsule so that it could hit the water without too much impact. A US Navy ship would be standing by. It would dispatch a helicopter to retrieve the space travelers. As the copter made its way to the astronauts, they would climb out of their capsule onto a life raft. Just exiting the capsule could be a task. Virgil I. Grissom got entangled in some lines attached to *Liberty 7*, his Mercury capsule. He could have gone to the bottom of the ocean in his flooded ship before his helicopter rescued him.

But even once astronauts were out of their capsule and into their life raft, the very aircraft that came to rescue them could endanger their lives. The problem was the rotor downdraft from the helicopters. Reaching as much as 100 knots per hour, this wind was enough to flip a flat-bottomed life raft.

NASA scientists and engineers needed a solution. They didn't want to lose their crew on the last mile of the journey. So they went to work designing a raft that was hydrodynamically stabilized. Hydrodynamics refers to the study of the motion of water or other fluids. The raft would inflate instantly and take on water. The weight of this water would then stabilize the raft, the way a heavy keel stabilizes a sailboat. This system would allow the raft to keep from tipping in choppy seas and fierce winds. But if the craft did flip, its design meant that the weight of the water would help right the raft. It wasn't a smooth ride, but NASA was sure it would ultimately prove a safe one.

The technology of these rafts has been licensed for commercial use. It's estimated that since these rafts have been introduced, they have saved the lives of 450 sailors. In August 1980, for instance, four sailors found themselves caught in Hurricane Allen, at the time the second-worst storm ever recorded on the Atlantic. Their 30-ton ketch capsized, and the crew headed for the safety of their Givens Buoy Life Raft. They spent 42 hours in it before they were rescued. The raft flipped and righted itself again and again. At times they were under several feet of water. But they made it safely to shore. As one of them said afterward, "We didn't feel comfortable, but we did feel secure."

Vocabulary



- satellite cell phone
- direct-broadcast satellite television service
- technology transfer

How People Use Satellites Every Day

Since the Soviet launch of *Sputnik 1* in 1957, satellites have transformed the way the world communicates. People once had to book overseas telephone calls through special operators. The process could take hours. Nowadays you can call most of the world directly—and fairly cheaply. Calling overseas just means punching in a longer number.

When you travel in the United States or abroad, to give another example, you can generally get the cash you need, in the local currency, just by sticking a plastic card into the slot of a bank's cash dispenser. You may take this for granted. But it hasn't always been this way. And satellite technology helps make it all possible.

The Use of Satellite Cell Phones

Satellite cell phones are an important development from satellite technology. “Satphones,” as they are known, are different from the phones that most people carry. A **satellite cell phone** is a mobile telephone that connects to a network of satellites, rather than one of land-based cell towers. This means that satphones work in remote locations where ordinary cell phones don't. For example, ships carry satphones for staying in touch on the high seas.



Air Force members operate a mobile satellite phone in South Carolina.

Courtesy of U.S. Air Force/Senior Master Sgt. Edward E. Snyder



Tweeting From Space

Not all high-tech communications take place in war zones and disaster areas. Much communication is just a matter of friends staying in touch. Social media services like Twitter are one way for people to do this. Your grandparents may remember a time when ordinary people made long-distance phone calls only in case of really big news—a birth or a death in the family, for instance. Nowadays, though, people can “tweet” messages such as “Am at coffee shop. Drinking skinny cinnamon dolce latte.” Twitter lets users send messages of up to 140 characters. People call it a “microblogging” service.

And so as NASA has worked to make life in space more “normal” for astronauts, it’s not surprising that they have learned to tweet from space.

On 12 May 2009 astronaut Mike Massimino connected with his Twitter followers from space as he was on his way to meet up with the Hubble Space Telescope. He was on an 11-day mission on the space shuttle.

He wrote: “From orbit: Launch was awesome!! I am feeling great, working hard, & enjoying the magnificent views, the adventure of a lifetime has begun!”

Word got around, and by the next day, he had more than a quarter-million followers. It wasn’t, however, a real “tweet,” strictly speaking. “Astro Mike’s” message was an e-mail to the Johnson Space Center, which then posted his message as a tweet.

On 22 January 2010, though, the astronaut corps took the next step into the Twitterverse. Flight Engineer T. J. Creamer, aboard the International Space Station, was the first to make a “live” post to his Twitter account, “@Astro_TJ,” from the space station. Unlike “Astro Mike,” he didn’t need an assist from ground crews.

“Hello Twitterverse! We r now LIVE tweeting from the International Space Station -- the 1st live tweet from Space! :) More soon, send your ?s”

Twitter in space may seem a bit frivolous. But NASA says that having one more way to keep in touch with people on Earth will help make space a bit less lonely for the astronauts.



Mission specialist Mike Massimino tweets from *Atlantis's* mid-deck during STS-125.

Courtesy of NASA

Satphones cost much more than ordinary cell phones, both to buy and to use. But military personnel, journalists, diplomats, aid workers, and countless others now couldn’t do without them. Satphones help cut through—somewhat—the “fog of war.” They play a crucial role in disaster relief work and in helping explorers keep in touch while on expedition in remote areas.

The Use of Satellite Images During Evening Weather Reports

Since 1975 the weather forecasts that so many millions of Americans watch every day on television have depended on a network of special satellites. These are the Geostationary Operational Environmental Satellites (GOES), which you read about in Chapter 10. They collect data used to build extensive weather maps of the whole planet. NASA launches these satellites. And then, once they're safely in orbit, the agency turns them over to the control of the National Oceanic and Atmospheric Administration (NOAA).

GOES does not come cheap. The latest in the series, GOES-P, cost nearly half a billion dollars. But they last a long time—15 years or more. GOES continuously monitors the weather of about 90 percent of the planet.

NASA is also working on a system for forecasting ocean weather. This effort draws on satellite data, computer models, and on-site measurements of the ocean. Scientists meld these data to produce “three-dimensional” forecasts of ocean conditions. The forecasts are three-dimensional in that they cover the whole ocean, from the surface down to the ocean floor. Oceangoing vessels of all kinds, coastal managers, and marine rescuers will eventually benefit from this system.



Satellite dishes on home rooftops receive TV programs directly from telecommunications satellites orbiting Earth.

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The Use of Direct-Broadcast Satellites

How do the television shows you watch at home make it to your screen? Over the air? Via cable? On your computer? What about by satellite? So-called **direct-broadcast satellite television service** (DBS) refers to *broadcasts sent via satellite directly to consumers*. The service is “direct” in that the signal goes directly to people’s homes. This is in contrast with other ways the television industry uses satellites. For instance, they also carry “feeds” from network headquarters to local stations.

DBS programming is very much like what cable television offers. But instead of getting signals over cables in the ground, satellite subscribers get their programs directly from high-powered telecommunications satellites in geosynchronous orbit some 22,000 miles (35,046 km) above the Earth. Like cable providers, DBS providers offer different packages of services or “channels” and market them to customers, typically for a monthly fee.

DBS has been one of the more successful commercial uses of satellite communications. It's become more attractive to consumers as receiving dishes have gotten smaller. Early dishes had to be several feet across. Newer ones measure less than a couple of feet. Most people attach them to their roof or the side of their home.

DBS television got started in Britain in the late 1980s. And Europeans are generally ahead of Americans in adopting satellite TV. But by 2003 a trade association claimed that 1 in 5 US households was receiving programming by DBS. And satellite TV has long been especially popular in rural areas poorly served by broadcast or cable TV.

The Uses of a Global Positioning System

When older adults tell you that the world has changed since they were your age, Global Positioning System (GPS) technology may well be one of the things they have in mind. The US Department of Defense originally developed this technology. But like satellites now supporting television broadcasts and weather forecasts, GPS has come into wide civilian use. It's changed how people everywhere find their way.

How a Global Positioning System Uses Space Technology

During the Cold War, the Defense Department needed precise navigation for the nuclear-armed aircraft and submarines meant to protect against the Soviet Union. The original concept was navigation with reference to a system of atomic clocks on satellites orbiting the Earth.

Today's GPS consists of three parts: a constellation of satellites, the ground stations that control the satellites, and then countless individual GPS devices. These devices are used by bush pilots, taxi drivers, ambulance crews, pizza delivery people, and legions of others. The 24 or more satellites orbit Earth at about 12,000 miles (20,000 km) up. Each satellite circles the Earth every 12 hours. With this many satellites orbiting, any location on Earth is usually within range of at least four of them (Figure 2.1).

A GPS device is a type of radio receiver. It calculates a position by measuring its distance from the satellites. Actually, GPS measures distance by measuring time—the time the signal takes to travel from the satellite to the device. The signal moves at the speed of light. But it goes slightly more slowly when passing through Earth's atmosphere. (Remember the satellites are thousands of miles up. This puts them well outside the thin envelope of the atmosphere. And they are moving, too. So even if a GPS device on Earth is stationary, its distance from all the satellites in space is constantly changing.)



Figure 2.1 This drawing illustrates how GPS satellites orbit Earth from 12,000 miles up. GPS consists of three parts: the constellation of satellites, the ground stations that control them, and countless individual GPS devices.

A given device communicates with typically at least four satellites at a time. By calculating the distance from each, the device pinpoints location more precisely. It's like the triangulation that navigators have practiced for centuries.

Military GPS devices, more precise than their civilian counterparts, can pinpoint locations within two inches (five centimeters). Most consumer devices promise accuracy to within about 50 feet (15 meters). A more advanced system, differential GPS, is accurate to within three feet (one meter) most of the time.

How Internet Mapping Programs Use GPS Images

All the “pings” back and forth between satellites and GPS devices are in a very specialized language. It's nothing that ordinary people can read very well. But GPS data can be turned into familiar imagery such as road maps or street maps. GPS data is behind the popular mapping programs widely available on the Internet—Google Maps, Yahoo! Maps, and MapQuest. You've probably had some experience with them. You enter the addresses of your starting point and your destination, and then they calculate a route for you.

GPS technology has led to a number of hobbies as well. For instance, it allows amateur photographers to “tag” their digital images with information about the latitude, longitude, and altitude at which they took them. This is known as GPS photo tagging, or geotagging. An individual photographer can use geotagging to organize his or her own photo collection. And when tagged photos are uploaded onto a photo-sharing Web site, others can search for and identify them by location. Tagged photos can also be displayed on interactive maps. Other specialized software lets users combine GPS data with their own interests. They can map hiking trails in remote areas, for example.

How People Use GPS Technology While Driving

People have gotten used to having GPS in their cars—their own vehicles as well as rental cars. Sales reps, repair technicians, and many others have come to rely on their devices to get around in unfamiliar parts of town. In recent years, some people have begun to list their GPS coordinates as part of their address, just as they do their ZIP code. Like the online mapping services, onboard GPS in cars relies on the same satellite data stream.

Many mobile phones also include a GPS function. These systems are not without controversy. If drivers try to program their devices while behind the wheel, this can lead to accidents because they've taken their eyes off the road. But if drivers program their devices before they leave home, this step can actually make the roads safer for everyone. A pre-programmed GPS means drivers don't have to fiddle with an unwieldy paper map with one eye on the map and one on the road, or drive around lost. When people are lost, they too often make risky moves such as turning suddenly or braking to make an exit.

Engineers have designed some new technologies that come with a GPS function to prevent risky behavior. For instance, smart phones put the built-in GPS function to work to shut down other dangerous practices: talking on the phone and texting while driving. One new program uses GPS to determine the speed at which a phone is moving. If the phone is changing position fast enough for the system to conclude it must be in a moving car, the new program automatically places all e-mail and text messages on hold. It also sends calls to voice mail until the GPS indicates the vehicle is stopped once again.

Star POINTS

A study reported by the Canadian Broadcasting Corporation found that nearly half of all drivers using GPS admitted to programming their devices while they were driving.

Star POINTS

On 1 September 1983, when a South Korean airliner strayed into the airspace of the Soviet Union, Moscow responded by shooting the jet down, killing 269 passengers and crew. This was widely seen as a horrifying overreaction to an innocent mistake by the Koreans. The episode prompted President Reagan to order that GPS data be made freely available to civilian users such as airlines. The idea was that this could reduce navigational errors like the one responsible for the Korean tragedy.



Many people from truck drivers to vacationers mount GPS devices on their dashboards to guide them to their destinations.

Courtesy of Garmin International Inc.

How NASA Shares Its Inventions With the Private Sector

Ordinary people benefit from space programs in many other ways as well. As one of NASA's reports says: "Space exploration acts as a lens that sharply focuses the development of key technologies through the rigorous scientific demands that arise from pursuit of the near-impossible." In other words, the space program fosters the invention of new devices and technologies.

Once NASA has developed them, the agency shares them with the public. The term for this is **technology transfer**—the movement of new technology from its creators to secondary users. GPS is an excellent example of this. A technology developed for the military—using the military's considerable budget—ultimately enters civilian life.

Technology transfer has been part of NASA's mandate from the start. The act that established NASA in 1958 required the agency to share its discoveries as widely as practicable and appropriate. And the agency saw the need to do this in a structured, orderly way. Otherwise, technology transfer can be too much a matter of luck, chance, and happy coincidence.

After 1980 Congress spoke even more clearly on the need to share products of government-funded research. At that point, Americans had begun to worry they were losing their competitive edge to other countries, especially Japan. And so Congress required NASA and other federal agencies to take an even more active role in sharing new discoveries with the business community. But, as you will read, NASA not only shares new technologies that it develops. It also seeks to buy new technologies it needs from the private sector.

The Goals of NASA's Innovative Partnerships Program

NASA creates new technologies to meet the challenging goals of the aeronautics and space programs. Once these technologies are proven, they often turn out to be useful in many different fields, often very different from aerospace. Making the connections between aerospace and health care, or environmental engineering, or transportation, or whatever field, and then getting the technologies to the public is a primary goal of NASA's Innovative Partnerships Program, or IPP.

It works the other way, too. IPP helps find answers to problems NASA hasn't solved yet. IPP seeks solutions to some of NASA's technical challenges by, among other things, funding small-business research. The goal is to create new technologies by joining up with small businesses and sharing the cost of developing something new.

How the NASA Publication *Spinoff* Contributes to Technology Transfer

Not too many years after the space program started, new products began to emerge from NASA. These were known as *spinoffs*; you'll read more about them later in this lesson. Soon people at NASA began to think about producing an annual report on these spinoffs. NASA could then present this report to members of Congress at each year's budget hearings.



Cowboys Stadium in Arlington, Texas, sports a Teflon-coated fiberglass dome inspired by astronaut spacesuits.

Courtesy of Richard and Cindy Krauss

And so in 1973 NASA published a black-and-white document with a not terribly exciting title: “Technology Utilization Program Report.” The next year, a sequel came out. Even in black and white, it created some buzz. NASA decided to recast the report in full color, with the more energetic title *Spinoff*. Every year since 1976, *Spinoff* has highlighted the transfer of NASA technology to the private sector.

The report goes to elected officials, corporate executives, scholars, and specialists in technology transfer, as well as to the public and the press. Since its first black-and-white effort, NASA has published nearly 2,000 stories of technology-transfer success.

Spinoff accomplishes several goals:

- It helps justify NASA’s budget
- It helps educate the press and the public by telling them about what NASA is accomplishing
- It helps dispel the myth of “wasted taxpayer dollars”
- It builds public interest in space exploration
- It shows how aerospace technology can be applied in other environments, such as health care
- It spotlights American inventors, engineers, and entrepreneurs
- It also spotlights the willingness of a government entity to assist them
- And it helps ensure that the United States keeps its global edge and its technological leadership.

How NASA's Direct Research Has Benefited Society

So far in this lesson, much of the discussion has been about practical applications of science, and specific products. But you may be wondering about the role of NASA's own direct research and its effect on society.

Michael DeBakey, the famous heart surgeon who worked on projects with NASA, had this to say about the kinds of research that NASA carries out: "NASA is engaged in very active research. It has as its goal to explore space. But to do so, you have to do all kinds of research—biological research, physical research, and so on. So it's really a very, very intensive research organization. And anytime you have any type of intensive research organization or activity going on, new knowledge is going to flow from it."

Dramatic space missions may get more attention than the quieter story of NASA's tangible impacts on Americans' daily lives. But the return on investment for society from NASA is significant. *USA Today* recently offered a list of the "Top 25 Scientific Breakthroughs" that have occurred since that newspaper's founding in 1982. Nine of them came from space exploration. Of these nine, eight came directly from NASA.

Star POINTS

NASA has received more than 6,300 patents in its history.

At NASA's 50th anniversary, administrator Michael Griffin said, "We see the transformative effects of the space economy all around us through numerous technologies and lifesaving capabilities."

How Products Developed for NASA Have Benefited Society

NASA spinoffs have improved people's quality of life as well as their economic growth. These spinoffs have been in the areas of:

- health and medicine
- transportation
- public safety
- consumer goods
- environmental and agricultural resources
- computer technology
- industrial productivity.

Here are some concrete examples of spinoffs from NASA research:

- In the 1970s NASA developed a new space suit out of Teflon-coated fiberglass. This new "fabric" has since been used around the world on roofs for stadiums and other buildings.
- In 1986 a joint project by NASA with the National Bureau of Standards led to a new lightweight breathing system for firefighters. Every major manufacturer of these systems now uses some form of the new technology. Using the new equipment, firefighters suffer significantly fewer smoke-inhalation injuries.

- In 1991 a Chicago company used three different NASA technologies in the design and testing of its school bus chassis. The result was a safer, more reliable advanced chassis. With this new product, the company captured nearly half the market within its first year of production.
- In 1994 a firm in Santa Barbara, California, used technologies created for servicing spacecraft to develop a mechanical arm for use in advanced laparoscopic surgery (procedures that call for a medical utensil that helps examine organs).
- In 1995 David Saucier of NASA's Johnson Space Center and Michael DeBaKey of the Baylor College of Medicine developed a device that supplements the heart's pumping capacity. It can stabilize a patient in need of a heart transplant for up to a year. In some cases it can even make a transplant unnecessary.

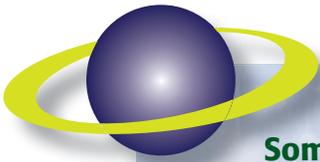
NASA spinoffs have worldwide applications. In Pakistan, the Dominican Republic, and Iraq people are using a portable water filtration device based on technology developed for the space shuttle and the International Space Station. Scientists have used space-suit technologies to make balloons that serve as low-cost "satellites" to provide cell phone coverage in remote parts of Africa.

In Kosovo and Jordan, a technique using surplus NASA rocket fuels is in use to defuse land mines. A device developed to monitor astronaut health is now in use to track water quality in Vietnam and public health information in Ethiopia. Charities shipped "space blankets" in mass quantities to Pakistan in 2005 after earthquakes there. Scientists have used techniques developed to clean up



Runners wrap themselves in space blankets while cooling down after a 10K run. Space blankets are a spinoff of NASA technology.

© Martin Cameron/Alamy Images



Some NASA Myths

A fair bit of what people “know” about NASA simply isn’t so. Many people think NASA developed Tang, a sweet, orange-flavored soft drink. Not so. General Foods developed Tang in 1957. It first went onto the supermarket shelves in 1959. But Tang was on the menu when John Glenn performed eating experiments as he orbited Earth in *Friendship 7* in 1962. This got Tang noticed by the public, and led to much improved sales.

Likewise, NASA didn’t invent Teflon, the nonstick coating widely used in cookware; DuPont did, in 1938. But NASA has used lots of Teflon in such things as heat shields and space suits.



STS-90 astronaut Richard Searfoss prepares a meal for the crew by attaching food packets to trays with Velcro.

NASA often uses Velcro to deal with microgravity, but the agency didn’t invent it. A Swiss engineer did.

Courtesy of NASA

You might think of Velcro as the opposite of Teflon. After all, Velcro is about sticking, and Teflon is all about not sticking. But like Teflon, Velcro is an invention mistakenly credited to NASA. A Swiss engineer invented Velcro in the 1940s. But the space program has used it so much—notably for anchoring equipment aboard spacecraft in low-gravity environments—that people think NASA invented it.

groundwater near the Kennedy Space Center’s launch sites to reclaim other badly polluted industrial sites. And the list goes on.

The economic effect of NASA’s technology has been enormous. In 2003, the agency’s Inventions and Contributions Board report estimated that since 1958, NASA technologies have contributed more than *half a trillion dollars* in wealth to the world economy. And this is only part of the positive impact NASA has had on people’s lives.



This textbook has introduced you to humanity’s efforts to learn about space and noted the landmarks along the way. In the last 2,000 years, humanity has gone from thinking that the Sun revolves around the Earth to sending space probes

beyond the Solar System. Its understanding of the universe has grown from the work of deep thinkers—people who understood the relationship of mathematics and physics here on Earth to what happens beyond Earth’s atmosphere. These scientists made careful measurements and observations that others could use to further advance understanding.

Travel into Earth orbit seems so routine today that it’s hard to remember the time in which Alan Shepard’s and John Glenn’s flights riveted Americans to their black-and-white TVs. Yet as the *Challenger* and *Columbia* tragedies showed, getting safely into orbit and back again is not as simple as it sometimes seems.

Space exploration has greatly increased scientists’ understanding of the universe around us. It’s raised new questions as well. But as you’ve read in this lesson, it has also brought many direct benefits to people around the world. They include inventions that improve people’s health, the quality of their water, their ability to navigate, and their ability to predict life-threatening storms. Space exploration has also increased people’s understanding of Earth, humanity’s home planet. For example, satellites orbiting Earth allow scientists to observe significant changes in climate and the ozone layer.

When will people return to the Moon? Will it be possible to journey to Mars? What new discoveries await mankind regarding the nature of the universe? The answers to these questions lie with you and your fellow students. You are the voters of the future whose representatives will decide the space program’s goals and funding. You are the engineers and technicians of the future who will create and build the technologies to travel and live in space. You are the scientists of the future who will interpret the data from probes that go “where no one has gone before.”

If you are interested in space, now is the time to start thinking about a possible career in space exploration. In addition to astronauts and scientists, careers with NASA include engineers, mathematicians, technicians, accountants, historians, writers, computer support personnel, project and public relations managers, artists, educators, human resource personnel, physicians, lawyers, doctors, and many more. To learn more about these and other careers in exploring space, the NASA website is a good place to start. It contains information about the qualifications you need for various jobs with the agency. You can also find information about NASA’s many programs and internships for students. In any event, you’ll want to prepare by studying one of the sciences (chemistry, physics, biology, astronomy, and so on), mathematics, or technology and engineering. Most importantly, in preparing to find a job at NASA, take the necessary courses in high school as recommended above. Study what you’re interested in, pursue your goals, and work very hard to achieve those goals. You’ve already started your journey by completing this course.

The future of space exploration will soon be in your hands. Like Newton, you stand on the shoulders of giants. Are you ready to take up the challenge?



CHECK POINTS

Lesson 2 Review

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

1. What is the difference between a satellite cell phone and the phones most people carry?
2. What is the mission of GOES?
3. What specific development has helped make satellite television more attractive to consumers?
4. How precisely can GPS pinpoint exact locations?
5. What are some examples of Internet mapping programs with GPS data behind them, beyond just simple driving directions?
6. How do GPS devices make the roads safer for everyone? How do they increase risk?
7. What is a primary goal of NASA's Innovative Partnerships Program?
8. What became of the NASA publication originally titled "Technology Utilization Program Report"?
9. Space exploration and NASA accounted for how many of the "Top 25 Scientific Breakthroughs" that the newspaper *USA Today* listed at its own 25th anniversary?
10. How did a joint project by NASA and the National Bureau of Standards benefit firefighters?



APPLYING YOUR LEARNING

11. Of all the adaptations of space technology to daily life that you've read about in this lesson, which seems most interesting to you? Why?