High-Speed Trains

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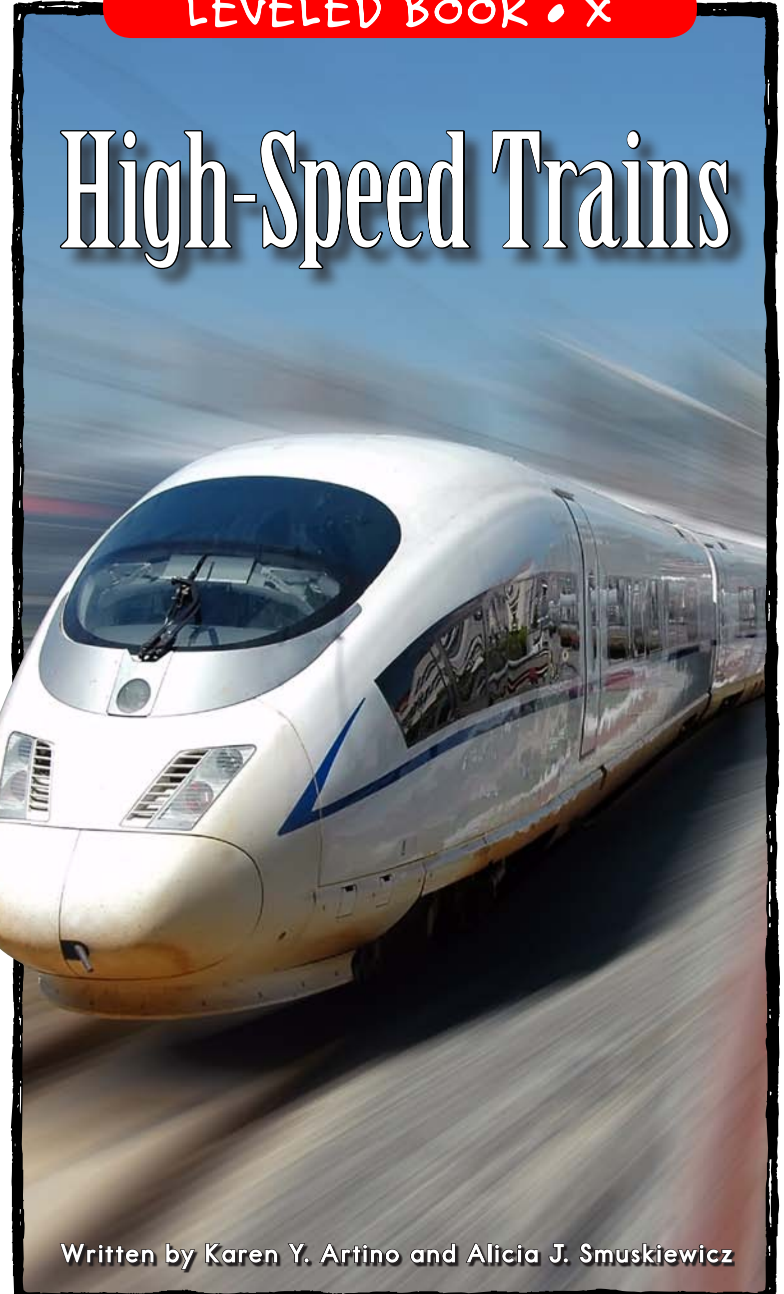

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High-Speed Trains

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Front cover: A Chinese high-speed train

Back cover: A bullet train passes through Tokyo, Japan.

Title page: Taiwan's high-speed rail system uses trains based on Japan's Shinkansen technology.

Page 3: An ICE (Inter City Express) train rounds a corner in Germany.

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Level X Leveled Book
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Correlation

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A TGV train passes a field of sunflowers in France.

Zooming Through the Countryside

It's Friday morning in Paris, and a high-speed train is leaving the station for Avignon (ah-veen-YONE), far away in the south of France. You relax in comfort on the sleek, modern train as it whisks you out into the countryside, hurtling along the tracks at speeds up to 186 miles per hour (299 kph). This journey would normally take seven hours by car, but the high-speed train will get you to your destination in just two hours and thirty-six minutes.

It may sound like science fiction, but scenes like this are happening every day in countries around the world thanks to high-speed trains. Millions of people in over a dozen countries are already using high-speed trains. Many more countries are planning or building high-speed rail systems to help them meet the transportation needs of the twenty-first century.

Where Did High-Speed Trains Come From?

Fast-moving trains are nothing new. Back in the 1930s, some trains reached speeds of about 100 mph (161 kph). That was before airplanes had become a common form of transportation, so most people rode trains when they needed to travel long distances. Most of these early fast trains had engines powered by diesel fuel. The diesel engine powered an electrical **generator**, which produced electricity to turn the **axles** at the front part of the train.

Japan introduced the first modern high-speed train design to the world when it hosted the 1964 Olympic Games. That train was the Shinkansen, or "bullet train." The first Shinkansen ran between Tokyo and Osaka at an average speed of about 135 mph (217 kph). One of the main breakthroughs of this train was that it was powered completely by electricity—not **fossil fuels**.

An early Japanese bullet train speeds through Kyoto.

A Eurostar train waits at a station in London.

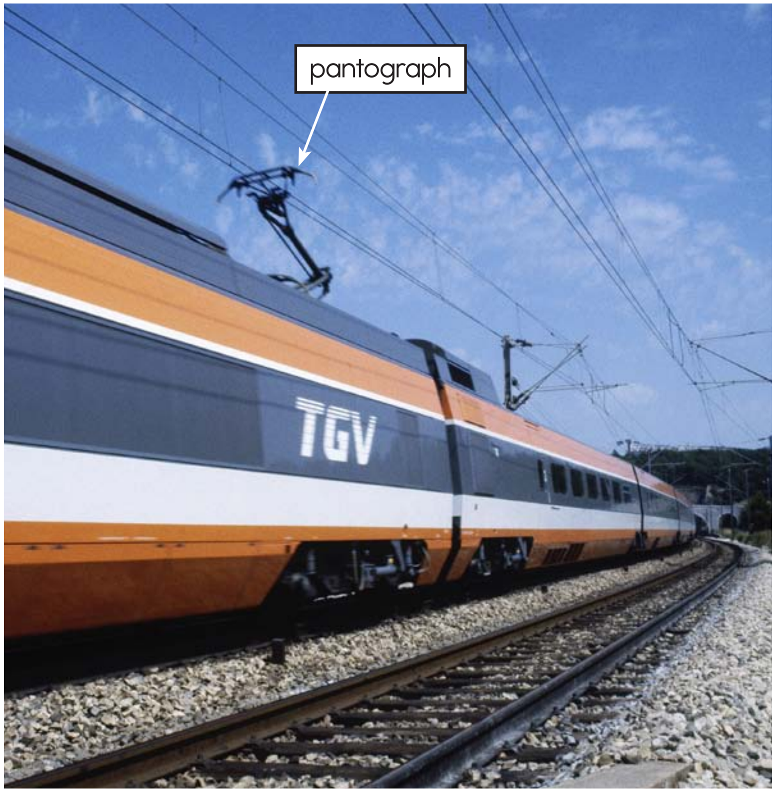
In the 1970s, European countries such as Italy and Germany began to roll out their own high-speed trains. France developed a large **network** for its high-speed trains in the 1980s, and service began in Spain in the 1990s on what has now become the longest high-speed train system in Europe. Since the completion of the tunnel—sometimes called "the Chunnel"—under the English Channel in 1994, it is now possible to travel by high-speed train from London to Paris in just two hours and fifteen minutes. All across Western Europe, high-speed trains race around at speeds of 150 mph (241 kph) or more.

The longest high-speed rail system in the world today is in China. Starting in 2004, China built its enormous high-speed rail network very quickly—adding more than 3,728 miles (6,000 km) of lines in less than six years. High-speed trains have become widely used in China. China has the largest population in the world—with more than 1.3 billion people (20 percent of all the people in the world). China also has many large cities, including its capital, Beijing. Many people in China still do not own cars, so high-speed trains give them a much-needed way to move quickly between cities.

How High-Speed Trains Work

Although there are several different types of high-speed trains, they all have certain things in common. They all have a streamlined shape, like the nose section of a jet airplane. This shape causes the air to flow smoothly over the trains, with only small amounts of drag (air resistance). The streamlined shape allows the train to use less energy to reach and maintain high speeds.

Japanese (top) and Russian (bottom) high-speed trains look different but have many common features.



Most high-speed trains are powered by electricity that flows through an overhead system of wires. Each train connects to the wires above it through a special device called a *pantograph*. However, sometimes a train disconnects from the wires, such as when it passes through a tunnel. The train then runs on battery power until the pantograph reconnects to the wires. In places where overhead wires are not used, the electric current flows through the tracks beneath the trains.

The tracks of a high-speed railway are an important part of the system. Most high-speed trains run on tracks that are welded together so that the entire length is smooth and free of joints. The tracks are also built as straight as possible so trains won't need to slow down for curves. High-speed trains often use tunnels or **viaducts** to go under or over **obstacles** rather than going around them. When the tracks do need to curve, the turns are as gentle as possible to allow the trains to keep moving rapidly. If the tracks were curved too tightly, the trains would have to slow down or risk coming off the tracks.


Some high-speed trains tilt when rounding corners.

High-speed rail systems use computerized central control systems to direct traffic safely. When a high-speed train is moving at top speed, the train **engineer** cannot read signs that the train passes along the way. All signal information, such as when to stop or when to change tracks, must be transmitted to the train engineer electronically.

Not Quite High-Speed Rail

The closest thing that the United States had to a high-speed train in 2011 was Amtrak's Acela Express service from Washington, D.C., to Boston, Massachusetts (passing through New York City). The Acela Express has a top speed of 150 mph (241 kph), though it travels at only about half that speed for most of its route. Its speed is limited because it shares its tracks with slower conventional trains.

Three Types of Fast

As high-speed trains have become more popular around the world, new technology has made them even faster. Many high-speed trains in use today run at average speeds ranging from about 150 mph (241 kph) to more than 200 mph (322 kph). Some trains can travel faster than 300 mph (483 kph), but those super-fast speeds are not usually used when carrying passengers. All high-speed trains are fast, but they don't all work the same way. The three main types of high-speed trains are the Shinkansen, the TGV, and maglev trains.

Shinkansen

One thing that makes a Japanese Shinkansen train special is that each car on the train works as a small electric locomotive. Because each car gives forward power to the train, cars can be added or taken away from the group as needed without changing the train's performance. Having a motor in each car also means that Shinkansen trains speed up and slow down very quickly, allowing them to stop more often while staying on schedule.

A Shinkansen train passes Mount Fuji in Japan.


TGV trains have been very successful in France.

TGV

TGV is short for *train à grande vitesse*, which means "high-speed train" in French. These trains were first used in France. They were originally powered by gas turbines that were similar to jet engines, but their energy source was later changed to electricity, like the Shinkansen. Unlike the Shinkansen, each car of a TGV shares axles with the cars in front of and behind it. Cars next to each other rest on the same two-axle base, called a *bogie*. Another difference is that each TGV train set is powered by just two power cars, one pulling from the front, and the other pushing from the rear. This push/pull arrangement is less expensive than the Shinkansen system in which each car supplies its own power, but it means that railcars cannot be easily added or taken away from a TGV train.

Maglev

While Shinkansen and TGV trains are largely just improvements to older train designs, maglev trains are based on a totally new technology. The name *maglev* is short for "magnetic levitation." Maglev trains use the power of magnets to fly along the tracks without touching the ground. Electromagnets are devices made of steel or iron that become magnets only when an electric current flows through a nearby coil.

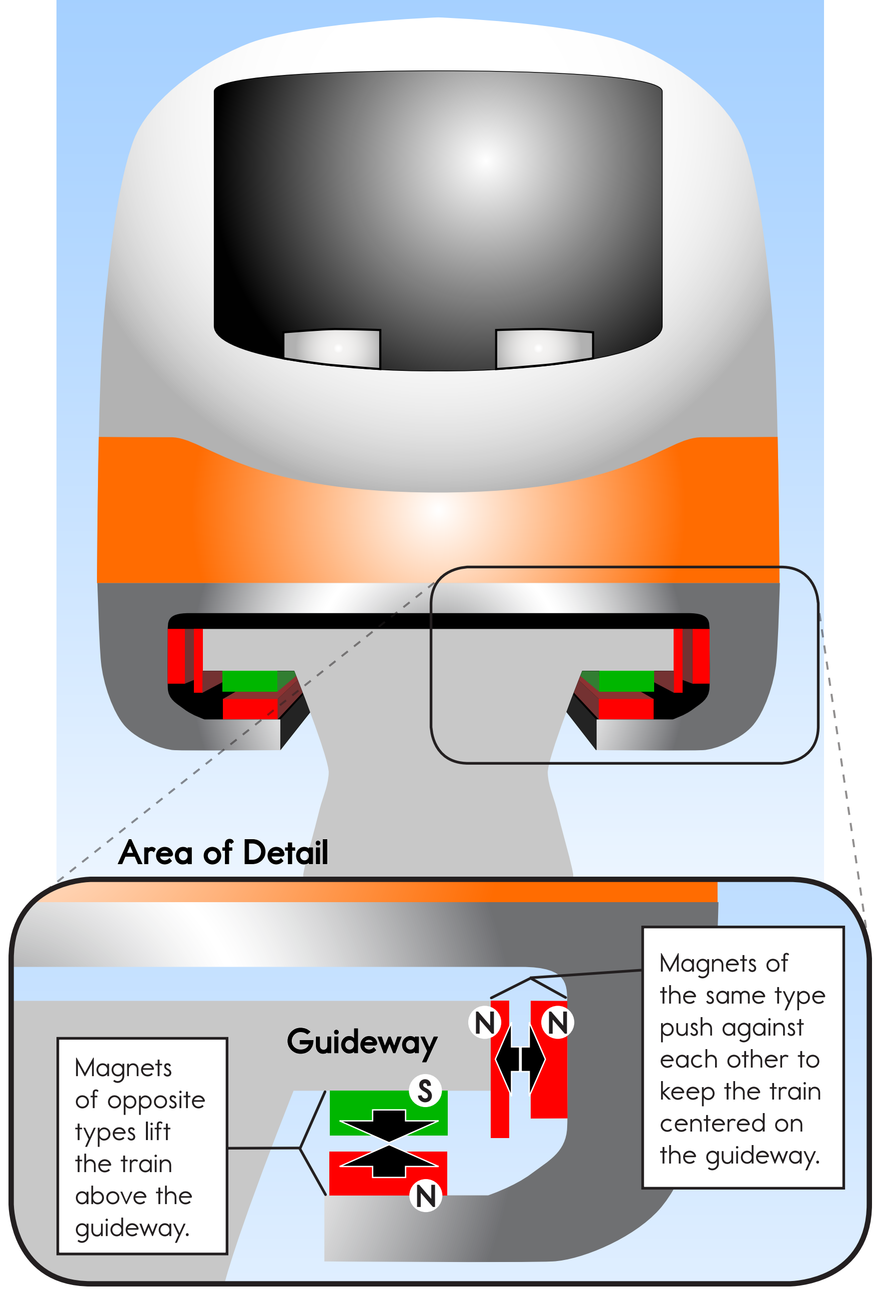

A maglev train runs along a test track in Germany.

A maglev train runs over special tracks called *guideways*, which hold the coils through which electric current flows. Just as a regular magnet can produce a magnetic force to attract or repel something, magnetic forces are also produced between the maglev and the guideway. These forces cause the train to levitate, or float, above the guideway without touching it. With the train levitating above the track, there is no friction or vibration to reduce speed or to make noise. Thus, maglevs are usually quieter and faster than other high-speed trains. Maglev trains also use magnetic force to push them forward the way an ocean wave pushes a surfer.


Maglev guideways in China

Maglev systems cost more to build than other high-speed trains, but Japan, China, and South Korea all have operational maglev trains that carry passengers in regular service. Many other countries are testing or planning to build maglev systems in the future.

How Maglev Trains Work



Safety Concerns

When trains travel at high speeds, safety is a major concern. High-speed trains are designed with several safety features built in. To reduce the chance of crashing into cars, they normally don't cross roadways at the same level as other vehicles; they either pass over the roads or under them. Many high-speed railways are fenced to keep out animals and include **sensors** to warn operators when something might be blocking the tracks.

In Japan, an early-warning system cut the power to twenty-seven Shinkansen trains that were running in the area affected by the powerful Sendai Earthquake on March 11, 2011. The trains automatically applied their emergency brakes and safely came to a stop without any injuries to passengers. Despite these safety measures, accidents can happen. In China, in the summer of 2011, a high-speed train lost power after a nearby lightning strike and was hit from behind by another train. This accident claimed many lives and was a tragic reminder that high-speed ground travel always carries a certain amount of risk.

Advantages of High-Speed Trains

High-speed trains offer many advantages compared to other forms of mass transportation. Although buses can be faster and more convenient for short trips, and airplanes are a better choice for very long trips, high-speed trains are perfect for trips between one hundred and five hundred miles. Over these distances, high-speed trains are much faster than buses and are just as fast as airplanes when you consider the amount of time you spend at the airport before and after a trip. They can also be more comfortable to ride in, as they often offer booths or tables to sit at and plenty of electrical outlets for powering gadgets. While airline passengers are not allowed to use cell phones or other personal electronic devices around takeoff and landing, passengers on trains are free to use them whenever they wish.

Reporters try out the seats on a new high-speed train in China.

Power for high-speed trains can come from many sources.

When carrying a normal load of passengers, high-speed trains are far more **fuel efficient** than cars, buses, or airplanes. Because they are powered by electricity instead of fossil fuels, high-speed trains do not directly release **greenhouse gases** that contribute to climate change. Although much of the world's electrical power currently comes from coal, that percentage is expected to decrease in the future as the world shifts to more **sustainable** sources of power, such as solar and wind. This means that high-speed trains will become even better for the environment as time goes on.

Another key advantage of high-speed trains is that they can help lighten the load placed on other transportation systems. Roads and airports both have a maximum number of travelers they can support at any one time. The number of travelers per hour that a transportation system can handle is called its *capacity*. When the capacity of a highway or freeway is reached, huge traffic jams can result. Traffic can slow to a crawl or even stop for hours at a time. Airports can become similarly overloaded. In many places around the world, building more roads or airports to increase capacity is not an option. However, because railroads need less land than highways, high-speed rail lines can often be added to these areas to reduce the stress on the other forms of transportation.

High-speed trains can help reduce traffic jams on freeways.

Flying Through Spain

The name of the high-speed train system in Spain is the *Alta Velocidad Española*. In Spanish, this name means “Spanish high speed.” The initials of the name—AVE—mean “bird” in Spanish.

What High-Speed Trains Need to Be Successful

Despite these advantages, high-speed rail is not always the best solution for a region’s transportation needs. High-speed rail systems can be very expensive to build. The cost of adding a new high-speed rail line can sometimes rise to many millions of dollars for each mile of track. Many countries see the building costs as an investment in the future, but other countries wonder whether such large investments are worth it.

Also, it doesn’t matter how amazing a train is if not enough people are riding it. For high-speed trains to make **economic** or environmental sense, each train needs to carry as many passengers as possible. For this reason, it only makes sense to build high-speed trains in places where large numbers of people travel frequently. Areas with high population density pack many people into a limited amount of space. One of the reasons that high-speed trains have been successful in areas such as Europe, Japan, and China is that these countries all have many areas with high population density.

Riders wait to board a high-speed train in Germany.

High-speed rail could change the way people travel in California, as shown in this artist's rendering.

Racing Into the Future

High-speed rail is growing by leaps and bounds as new lines are added in new countries and on new continents. Europe plans to link together its many separate high-speed rail systems to form a gigantic trans-European network by 2025. Morocco is building Africa's first high-speed rail system. In the United States, the first true high-speed rail network is being developed in California. If completed as planned, it will allow people to go from Los Angeles to San Francisco in under two hours and twenty minutes while traveling at speeds up to 220 mph (354 kph). As world population increases and concerns about energy sources and the environment grow, high-speed trains will play an important part in helping the world meet its transportation needs.

Glossary

axles *(n.)* bars around which wheels revolve (p. 5)

economic *(adj.)* related to buying and selling of goods and services (p. 22)

engineer *(n.)* a person who is responsible for the safe operation of a train (p. 10)

fossil fuels *(n.)* energy sources, such as coal, oil, and natural gas, that are taken from the ground (p. 5)

fuel efficient *(adj.)* making good use of fuel as measured in miles per gallon (p. 19)

generator *(n.)* a machine that turns motion into electricity (p. 5)

greenhouse gases *(n.)* gases in Earth's atmosphere that trap heat and contribute to global warming (p. 19)

network *(n.)* a group of things or computers that are connected to each other (p. 6)

obstacles *(n.)* things that get in the way, preventing progress or movement (p. 10)

sensors *(n.)* devices that sense and react to a signal or a change in conditions (p. 17)

sustainable *(adj.)* able to be used in a way that does not completely use up or cause permanent damage to a resource (p. 19)

viaducts *(n.)* low bridges over dry land or long valleys (p. 10)