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A Brief History of American Railroading

At the turn of the 19th century, travel over land in the United States was slower than it had been in ancient Rome. The Romans had surfaced most of their roads with stone and other hard materials to make travel by horse-drawn wagon and chariots much easier. The dirt roads of Colonial America were far more primitive and filled with mud each time it rained. The lack of bridges forced people to go out of their way to cross rivers. Vehicles drawn by animals traveled about as fast as a human could walk. But the coming of the railroad changed all this.

On July 4, 1828, Charles Carroll—the last surviving signer of the Declaration of Independence—laid the foundation for what would become the Baltimore and Ohio Rail Road. Passengers could ride a horse-drawn railcar for 13 miles to Ellicott's Mills, Maryland. This was the nation's first *common carrier,* or public transportation, of freight and passengers by rail on a regular schedule.

Soon it became evident that steam was a more practical form of power than animals. Economics and the Industrial Revolution triggered and quickly stimulated the infant railroading industry. From the mines, forests, and farms to factories and markets, railroads hauled all kinds of products: coal, iron ore, timber, cattle, grain, and finished goods.

By 1830, Peter Cooper, an inventor from New York, completed work on his revolutionary invention for replacing horsepower with steam. The Tom Thumb, an experimental steam locomotive, never got beyond the test stage, but it paved the way for more advanced locomotives.

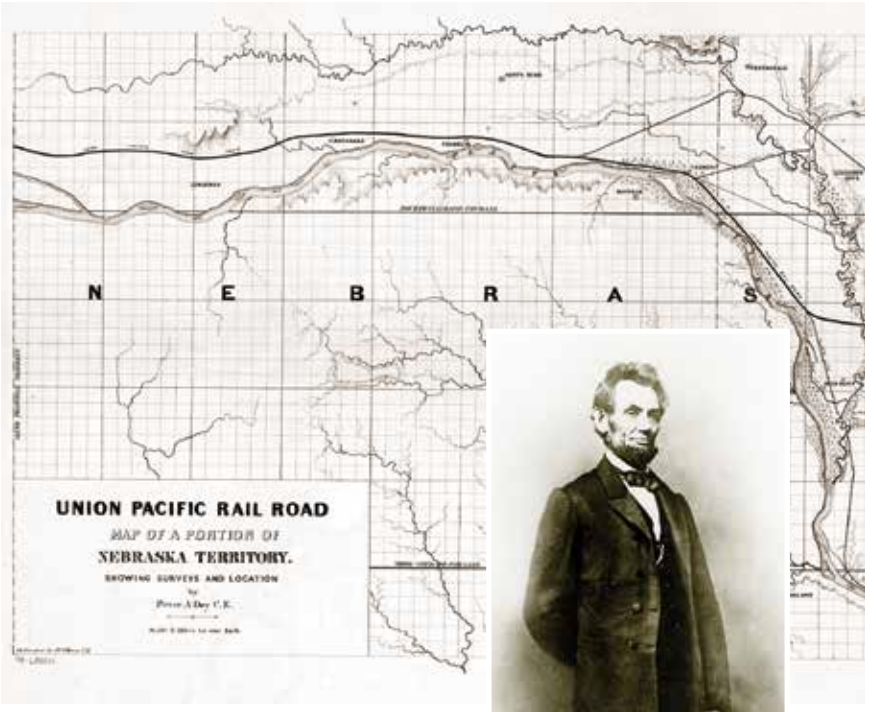
The California gold rush of 1849 increased public demand for coast-to-coast rail connections. Previously, railroad construction averaged 316 miles of track per year. But in the 1850s, the average jumped to 2,000 miles per year. By the time the U.S. Civil War started in 1861, more than 30,000 miles of track had been laid, almost as much as in all the rest of the world.

Industrialization swept through England in the 18th century. However, the Industrial Revolution did not occur in the United States until the early 19th century. This is when people began to invent and use machines to do work that previously had been done by hand, increasing productivity and efficiency.

By 1836, the Baltimore and Ohio Rail Road had reached Harper's Ferry, Virginia (there was no West Virginia until 1863), with a 37-mile line into Washington, D.C. Sixteen years later, these rails had extended to the Ohio River at Wheeling, Virginia, opening up what would soon become a trade route to the West.

During these early years the nation's rail system expanded along the Atlantic Coast from Portsmouth, New Hampshire, to the Carolina states. But it wasn't possible to ride a train or ship goods all that distance by rail. People still relied on stagecoaches, freight wagons, and coastal steamships. However, within six years of the founding of the Baltimore and Ohio Rail Road, 200 rail lines formed in America.

Some railroad companies established different *gauges* (distances between the inside edges of the rails) for their own tracks, making it impossible for railcars to pass from one railroad to another. People soon recognized the need for a uniform gauge. In preparation for the building of the Transcontinental Railroad, President Abraham Lincoln ordered that *standard gauge* should be 4 feet, 8 1/2 inches. Many think this unusual measurement, still used today, is a throwback to the width of Roman chariot wheels. Britain ultimately adopted the same measurement as its own standard gauge for wagon and carriage wheels, and later railroad equipment. Many early locomotives in America were British-built, so it made sense to accommodate this wheel width in the United States.



The Transcontinental Railroad Unites a Young Nation

In an effort to bring the nation together by connecting the East to the West, President Abraham Lincoln, on July 1, 1862, commissioned the Union Pacific Rail Road to start laying tracks westward from Omaha, Nebraska. He also commissioned the Central Pacific Railroad to lay tracks eastward from Sacramento, California. The two railroad tracks were to meet somewhere in between at an undecided location. The track would cover a total distance of 1,780 miles.

After three years, only 40 miles of track had been laid. Even though Congress had allocated $48,000 per completed mile of track as an incentive to each railroad, fighting between the North and South diverted attention. The U.S. Civil War of 1861–65 became the world's first armed conflict to use railroads, which underscored the growing importance of this new mode of transportation.

The Transcontinental Railroad was the most massive civil works project in history since the Great Wall of China. It would remain so until the digging of the Panama Canal early in the 20th century.

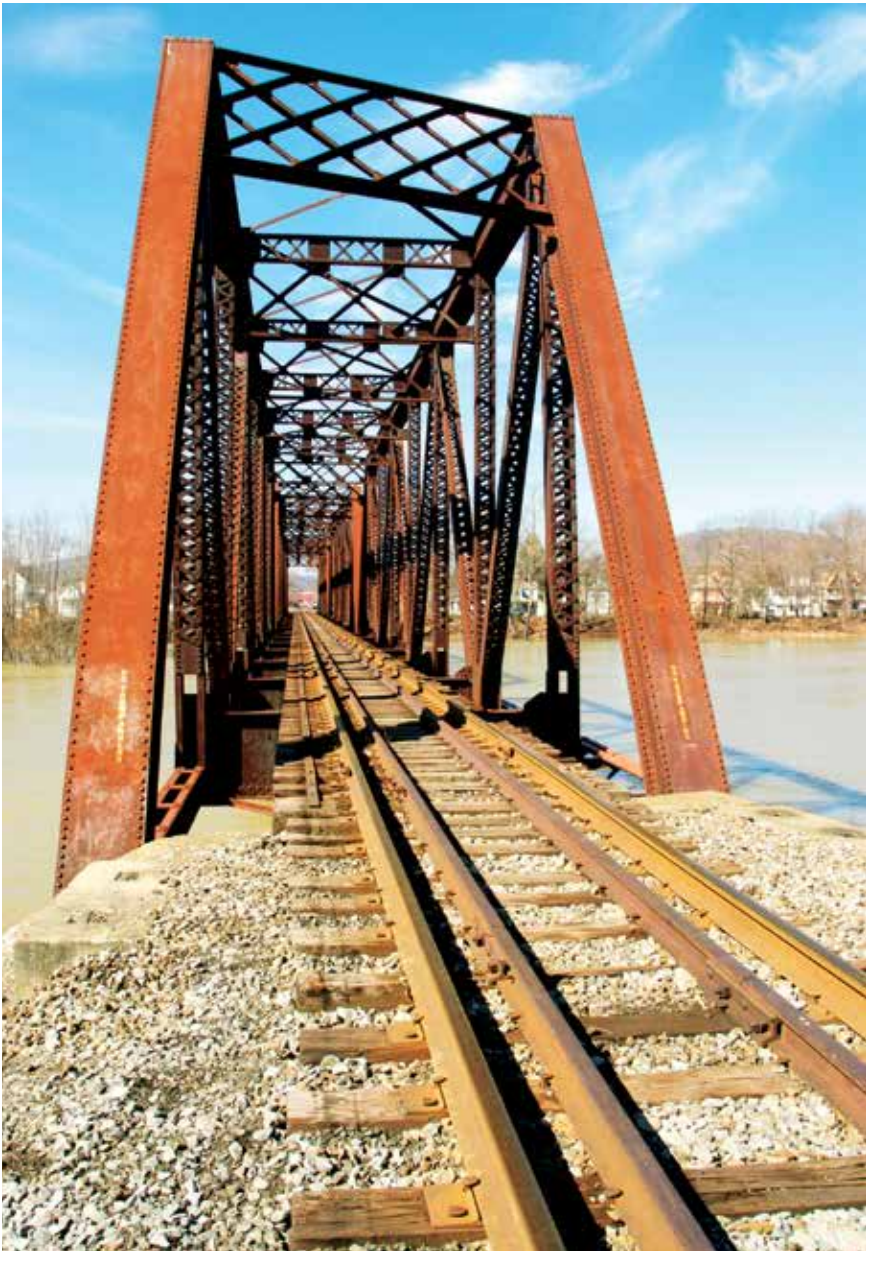
Transcontinental Railroad workers received from two to four dollars per day for backbreaking 12-hour shifts, an excellent wage for that time. Laborers' pay depended on the kind of work they were hired to do. Laborers from all over came here for the high wages, the prospect of steady work, and a chance to stay after the rail line was completed. Most came from Ireland (where the potato famine had forced many families to the edge of starvation), Germany, Great Britain, Central America, and especially China, where as many as 7,000 laborers were recruited by the Central Pacific Railroad. Many second and third generation Americans laid track as well: Mormons, Civil War soldiers returning home, freed blacks who had been slaves, and American Indians.

The construction crews worked so hard near the end of the lines that they actually bypassed each other in their haste to outperform their rival crew. During one astounding day, almost two weeks before the two crews met, the workers laid more than 10 miles of track, a record that stands to this day. After the tracks from east and west were joined at Promontory Summit, Utah, on May 10, 1869, a golden spike was driven to symbolize the now correctly named *United* States of America. While the location of the Golden Spike ceremony is no longer on the transcontinental route, a national park with operating locomotives is located at the site.

By the 1800s, with the introduction of the steam locomotive and rapid growth of railways, travel by train became more accessible to the general population.

We've Come a Long Way, Baby!

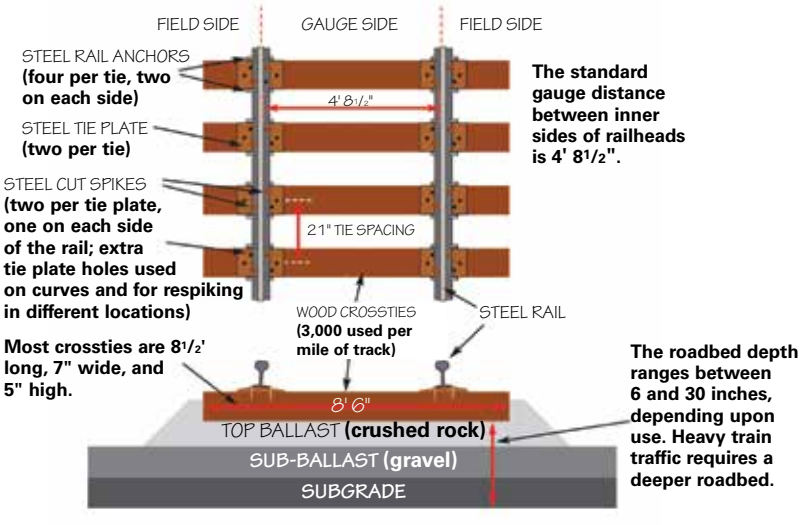
Railroad safety has come a long way since the early days of using a mounted flagman, hand and arm signaling, flags, and lanterns to direct trains. Messages for directing trains were once transmitted via telegraph and later by telephone to train operators, who wrote them on documents. At one point in history, these messages were tied with string and fastened to a stanchion or pole. The operator would then hold the pole out, and the message would be grabbed by someone from the moving train as it passed by. Today, trains have very sophisticated communication and safety systems that utilize modern technology like GPS.



Modern Railroads

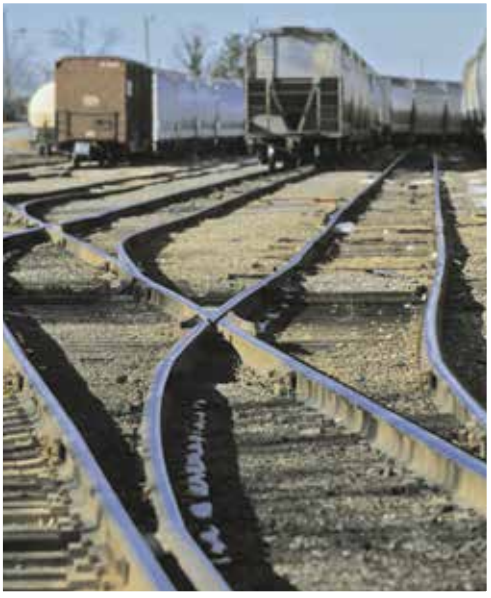
Railroads, with their low *rolling resistance,* offer the most efficient and cost-effective way to haul passengers and heavy freight long distances over land. It takes far less energy and fewer workers to operate a multicar train than the equivalent number of highway trucks. The high labor efficiency comes from the fact that numerous carloads traveling along a guideway in close order need only one "driver."

Railroads transport freight and passengers over land in steel-wheeled cars directed along fixed-guide paths. The rails, made up of two long, heavy bars of steel, each shaped like an inverted "T," may be set upon wood, concrete, steel, or composition *crossties* embedded in crushed stone called *ballast.* Or their guideways may be elevated above or buried below ground.

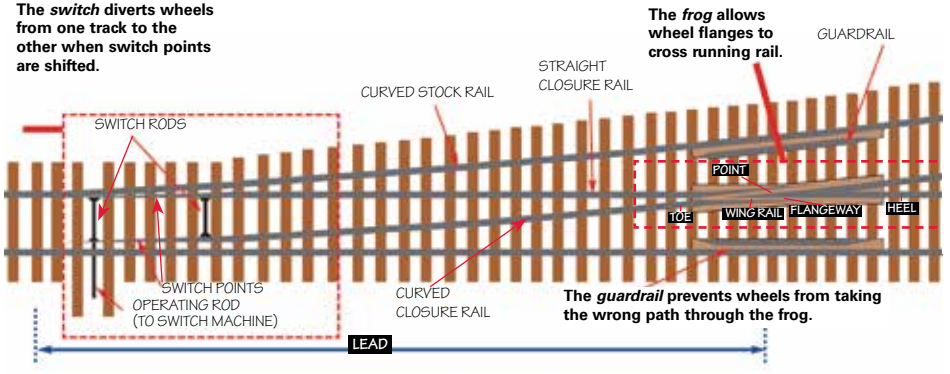


Structure of a railroad track

A simple physics principle, known as *rolling resistance,* establishes that hard wheels roll with less effort over hard surfaces than soft wheels do over softer surfaces. To test this principle, roll a golf ball over a hardwood floor. Then roll a foam rubber ball of the same size with the same force over carpeting. Which rolls easier and goes farther?



Various track configurations give flexibility to train movement. The most common include the *turnout.* At the turnout *switch* is a steel *frog,* a channeled device at the intersection of two tracks that allows the wheel flanges of a railcar to cross over from one track to another. For more information about track configurations, refer to the "Model Railroading" section in this pamphlet.



Parts of a turnout

Nearly all modern freight railroads are privately owned and operated. Unlike other transportation companies and industries, railroads must build, maintain, monitor, and pay property taxes and associated operating costs on their rights-of-way. Unlike highways and other roadways, railroad tracks and rights-of-way are not publicly funded or maintained. Railroads that lease their rolling stock, operate over another company's track, share loading facilities with another carrier, or contract with employees of another company to run their own trains may not have all these costs.

Freight Trains

Trains are categorized according to the freight they haul and the cars they operate.

Unit trains haul a single freight or commodity such as coal, automobiles, gravel, or grain. They use the same type of car to run between two points—with no loading or unloading stops in between. These trains usually deliver their freight to one destination, saving a lot of time because they don't have to be sorted in a classification yard and redirected.

Mixed trains, or general merchandise trains, carry a variety of freight in different types of railcars. The individual cars are ultimately headed for different destinations, so the mixed train usually goes through a classification yard.

Intermodal trains haul standardized, space-saving containers and trailers that are also carried on trucks and ships. This method of shipping saves shippers considerable time and handling expense while protecting the cargo from the weather, damage, and theft. Intermodal containers can move as singles loaded on flatcars, or as *double-stacks* with containers stacked two-high.

Every day a unit train of refrigerated boxcars leaves Florida, headed for New Jersey with thousands of gallons of fruit juice on board.

Refer to the timesaver switching game in the "Model Railroading" section to see how freight trains are sorted in a classification yard.

Highway truck trailers are carried in *piggyback* formation on flatcars, much like the way circus and farm wagon trains had traveled in earlier years.

Greenbrier Maxi-Stack AP®, an all-purpose double-stack car

For containerized cargo, flatcars are frequently loaded and unloaded by an intermodal crane, which straddles the train.

Centerbeam flatcar

Specialized Freight Cars

Shippers use different kinds of railroad cars depending on the type of cargo, or *lading,* to be delivered and the loading/unloading facilities available. *Flatcars* are platforms used for carrying intermodal containers and piggyback trailers. They also carry other freight, including large electrical generators and transformers, bulky pipe sections, and even military weapons. Flatcars can be unloaded by intermodal cranes or from the side by a large overhead container forklift. They come in several variations: *all-purpose,* which is flat (flush) all the way across; *centerbeam bulkhead,* with a supporting bulkhead that runs down the center from end to end; *bulkhead,* with sturdy walls at either end; and *depressed-center,* with a depression in the platform for lowering oversize loads enough to clear bridges, overpasses, and tunnels.

Flush deck heavy-duty flatcar

Enclosed railcars called *boxcars* range from 50 to 90 feet long and carry general freight in plain cars or products requiring special equipment or handling.

In 1857 a Chicago meat-packer shipped the first refrigerated car, which was cooled by placing chunks of ice at each end of the car. Today's refrigerator cars have high-tech mechanical or chemical cooling machinery.

Railcars with valuable perishable cargo often run in *express lanes,* which are given priority over other rail traffic.

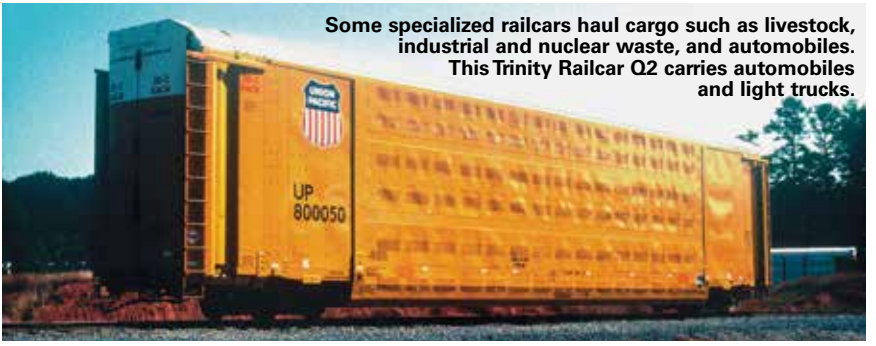
***Refrigerated boxcars* (nicknamed *reefers*) haul perishables such as fruit, beef, cheese, poultry, fruit juices, and frozen foods maintained at minus 10 degrees F.**

***Covered hoppers,* the most common kind of freight car in North America, transport loads—such as grain and sugar—that also require protection from contamination and the weather. These cars empty through the bottom.**

Open-top hoppers **are used for freight like coal, mineral ores, sand, gravel, and crushed stone for track ballast.**

Mill gondolas **provide the maximum open carrying capacity for exposed loads. For protected loads such as steel coils, gondolas are equipped with removable covers. Side-dump gondolas can unload by tilting to either side; coal-carrying gondolas unload by turning upside down.**

Tank cars **carry liquids, mostly petroleum products such as fuel oil and petrochemicals, and liquids like vegetable oil, and are sometimes pressurized. Some tank cars have special linings to contain hazardous chemicals.**



Some specialized railcars haul cargo such as livestock, industrial and nuclear waste, and automobiles. This Trinity Railcar Q2 carries automobiles and light trucks.

Starting a Train

Two main factors determine a locomotive's ability to move a train: the relationship of its *horsepower* to *tractive force*, or the amount of power produced to the amount of force exerted. Two other factors also are important: the rails' angle of incline and the adhesion (grip of the wheels to the rails). Although a single locomotive exerting a weight of as much as 70,000 pounds per axle can pull many cars, two or more locomotives—distributed throughout the train and remotely controlled from the lead locomotive—may be required to pull very long and heavy trains.

Many modern freight cars have a *gross rail weight* (GRL) of 286,000 pounds, which includes the weight of the car when empty (light weight or LT WT) plus the maximum weight, in pounds, of freight the car can carry (load limit or LD LMT). Today's railroads test railcars with a GRL of 315,000 pounds.

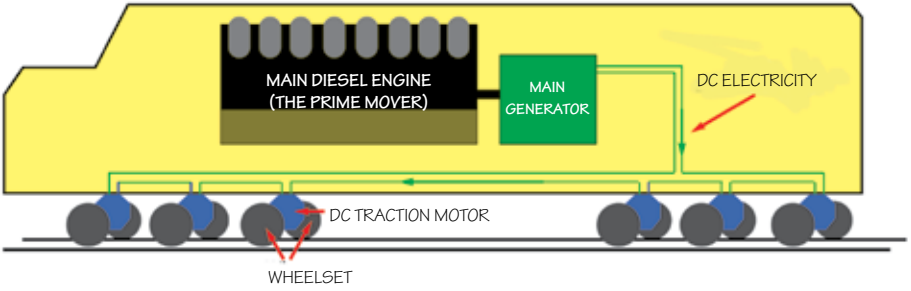
Reporting Marks

Each freight car carries on its sides a variety of stenciled letters and numbers that reveal a great deal of information about the railcar. Letters (and logos) indicate the name of the railroad or leasing company moving the freight, such as "NS" for Norfolk Southern Corporation. Each car carries a unique number so it can be identified in rail yards and directed appropriately. Another number, often preceded with "BLT," shows the date each car was built. Other numbers give you the inside dimensions of the car, its weight without load, or *tare,* and fully loaded (gross weight). The maximum capacity (CAPY) in cubic feet also is stenciled on the car.

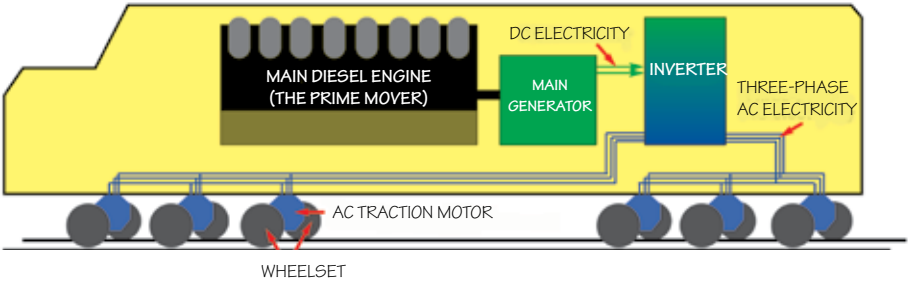
Radial Steering Trucks

A locomotive's "trucks" are the complete assemblies of driving wheels, axles, gearboxes, brakes, coil springs, and other parts—mounted in a frame. Radial steering trucks are hinged to flex and steer the wheels smoothly through curves. These trucks reduce wheel and track wear and provide better adhesion.

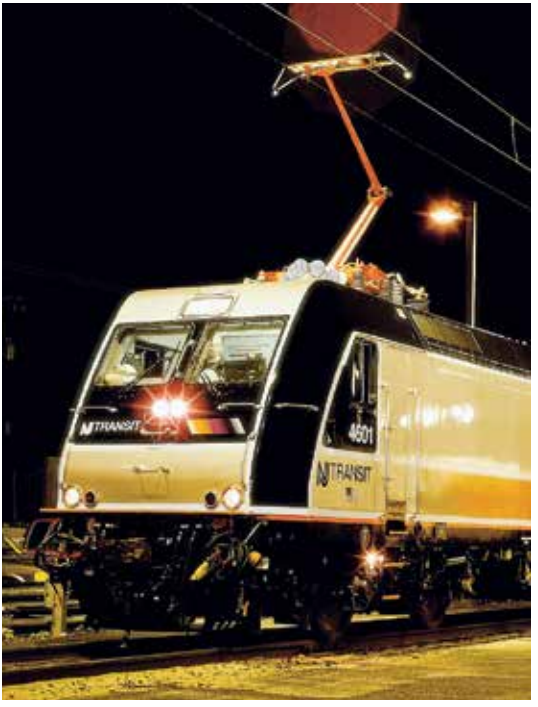
Most of today's railroad locomotives are "fired" by diesel fuel. A diesel-electric locomotive, the most common locomotive in service today, has a main diesel engine, which runs a large electric motor called a *traction alternator.* The generator produces electricity to power the electric *traction motors,* which are mounted—one per axle—on the power trucks.



Diesel-electric locomotive with DC (direct current) traction motors



Diesel-electric locomotive with AC (alternating current) traction motors



Electric locomotives (without a diesel engine) collect current from overhead wires, or *catenary,* through metal arms called *pantographs* mounted on the roof. Others use a pick-up shoe to collect current from an electrified *third rail* placed next to the running rails. The locomotive's internal equipment converts high-voltage current to lower voltage current.

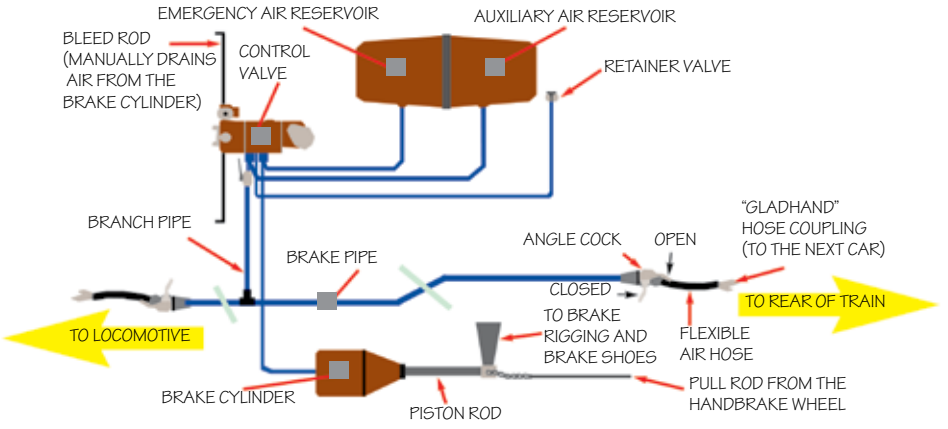
Locomotives, especially on passenger commuter trains, often push as well as pull their trains. The train has a locomotive on one end and a passenger car equipped with an engineer's cab and duplicate controls on the other end. It can be operated from either end, so it doesn't have to be turned around to make a return trip.

Electric multiple-unit (EMU) commuter trains are self-propelled; all cars (from eight to 12) can be controlled from one cab.

Stopping a Train

A train stops by using an air brake system, which allows the engineer to apply the brakes to all cars at once. An air compressor fills a main air reservoir, located in the locomotive, with compressed air. Then the air is piped through the brake pipe, which is connected from the locomotive and car to car by hoses. When the train is in motion, air passes through control valves on the brake pipe to an auxiliary reservoir in each car. When the engineer applies the brakes—releasing air from the brake pipe—the components within the brake valve change position and let pressurized air from the auxiliary reservoirs flow into the brake cylinders. The increased air pressure in the brake cylinders causes them to push against the pistons, and, through the levers and rods of the brake rigging, force the brake shoes against the wheels.

The engineer releases the brake by increasing the air pressure in the brake pipe. The increased pressure pushes the com-



The railway air brake system is fail-safe because any air loss, either from manual release or an emergency such as a car becoming detached, automatically applies the brakes.

ponents in the brake valves in a different position, allowing the pressurized air to recharge the auxiliary reservoir. At the same time, the air brake valves allow the pressurized air in the brake cylinders to escape to the atmosphere, thus releasing the brakes.

On locomotives with electric drive motors (traction motors) and most subway and other rapid transit cars, an electromagnetic system allows the motors to act as temporary generators during deceleration. The electrical current produced during braking is directed to large resistors, converted to heat, and then released into the atmosphere. This is known as *dynamic braking.*

In some electric locomotives, the electricity generated by traction motors for braking is fed back into the catenary or third rail. This is called *regenerative braking.*

At one time all freight trains had cabooses. But these special cars have been replaced with end-of-train devices (EOTDs) equipped with a bright flashing red warning light, also called flashing rear end devices (FREDs). These devices—always placed on the last car of a train—alert train crews by radio signal to problems detected in the air brake system. An engineer can also apply brakes from the rear of the train through radio contact with the EOTD.

North American Network, Class I Railroad Routes (Not all routes are shown; the ones depicted are noted in the lower left-hand box.)

Dallas Area Rapid Transit (DART) operates a light rail system along 44 miles of rail and serves an average of more than 59,000 passengers weekly.

At first, rail passenger cars were little more than stagecoaches on steel rails. Today we still refer to passenger railcars—even highway buses—as "coaches."

Railroad Classifications

Railroads in North America (including Canada and Mexico) run on approximately 200,000 miles of track and are classified by the route-miles on which they operate and on the amount of revenue (for hauling freight) they generate within one year. The nation's largest freight haulers, with revenues of approximately $490 million per year, are classified as *Class I* railroads. Although there are fewer than 10 Class I railroads, they own and maintain more than 76 percent of the track on this continent.

Next are the smaller *regional* carriers, followed by the *short lines.* These frequently handle Class I railroad trains once they leave the main lines. Lastly, there are the *terminal* railroads, which typically switch and shunt cars around rail yards or in and out of factories and terminals.

Passenger railroads are classified by their *ridership* (numbers of passengers) or by the regions they serve. They operate by what is sometimes referred to as a fixed-guide path, traveling along an established route.

Amtrak also operates the Auto Train from Lorton, Virginia (south of Washington, D.C.), to Sanford, Florida. If you are going on vacation, you can bring your vehicle, too. For shorter distances, Amtrak provides comfortable coaches, often with food service cars.

Intercity passenger trains connect major cities, with stops in between at smaller towns. An example of such a system is Amtrak, which operates rail lines in 45 states.

Commuter trains travel within a metropolitan region. The Metropolitan Transportation Authority in New York serves more than 1.3 billion riders annually in an area encompassing New York City and surrounding counties.

Rapid transit (fast public transportation, also called *heavy rail* or *metro*) serves passengers within and around the edges of cities. They usually are configured as subways that run on underground or elevated guideways. In Georgia, the Metropolitan Atlanta Rapid Transit Authority (MARTA) operates 248 railcars over 48 miles of track. San Francisco's Bay Area Rapid Transit (BART) system has a unique feature—an underwater tube that links communities surrounding the San Francisco Bay area. The largest system is New York City Transit, which carries more than 4 million riders per day over more than 700 miles of track and uses more than 6,000 cars.

Light rail transit systems—with their light rail vehicles (LRVs), the modern version of trolley cars—are generally powered by catenary and travel on smaller track. Buffalo, New York's Metrorail, which has 6.2 miles of track, is one such example. In Oregon, the Metropolitan Area Express (MAX) serves the greater Portland metropolitan area along more than 35 miles of track.

Monorail trains, also classified as rapid transit, are suspended from an overhead track or set on a single rail. They generally are used for short runs such as at airports or between other close transportation points, in amusement parks, or at other attractions.

America's Passenger Rail Service

In 1971, the U.S. Congress created the National Railroad Passenger Corporation—called *Amtrak*—to take over and operate the nation's intercity passenger rail service. This national service was established to relieve the nation's private railroads of all passenger service, which had become unprofitable because of competition from automobiles and airplanes. Amtrak operates some commuter lines under contract to local transportation authorities.

Today Amtrak carries more than 31 million passengers a year over more than 22,000 miles of track, almost all of it owned by the Class I freight railroads. The exception is the Northeast Corridor (NEC), where Amtrak owns and maintains most of this high-speed electrified rail line between Boston, Massachusetts, and Washington, D.C. Long-term plans are underway to extend this rail corridor south to Richmond, Virginia, and add other high-speed lines in California, the upper Midwest, and Southeast.

On long-distance routes, Amtrak is replacing older diesel locomotives with fuel-efficient and cleaner-burning ALC-42 locomotives from Siemens Mobility. These engines emit 89% less nitrogen oxide and 95% less particulate matter than the old diesels.

Standard Time

Before this nation's "iron network" connected communities across North America, each town set its clocks by the sun. So time varied from place to place, with the time in towns to the west running minutes behind the time in towns to the east. As travel increased on the railroads, it became obvious that passengers could no longer rely on scheduled service based upon published timetables. To make the coordination of train arrival and departure times easier, the rail industry agreed to set all its clocks along a line to one operating time. It was called *railroad standard time,* later shortened to standard time.

High-Speed Trains

The fastest timetabled start-to-stop in the world are trains G17/G39 on the Beijing–Shanghai high-speed railway, averaging 197.4 mph.

High-speed (normally 125 mph and over) passenger rail service is common throughout the world. The best known are the Japanese Shinkansen bullet train, the German InterCityExpress (ICE), and the French TGV (Train à Grande Vitesse, or "train of great speed"). These trains can reach speeds of 200 mph because they run on their own right-of-way. In the United States, however, Amtrak's high-speed Acela Express (combination of *acceleration* and *excellence*) shares its track with slower commuter and freight trains. It operates in the Northeast Corridor and attains speeds up to 150 mph from Boston to New York, and up to 135 mph from New York to Washington, D.C. Its high-speed train cars tilt, or lean in, toward the inside of curves, allowing the trains to negotiate the bends quickly and as smoothly as if the tracks were straight.

The Acela Express is called a *trainset* because the cars—electric locomotives at each end and six coaches in between—operate as one unit.

Railroad of the Future?

Today there is a kind of experimental railroad that doesn't actually touch its guideway once under power. It is called *maglev,* short for magnetic levitation. An electromagnetic field suspends the lightweight vehicles, which look like wingless airplanes, from three-eighths of an inch to as high as six inches off the rails. The guideway is called a *magway.* It can be constructed along the median center strip of a divided highway or alongside other roads much like monorail, separate from motor vehicle traffic. As with regular electric trains, there is no fuel carried on board a maglev train—and no motor. *Magports* provide the driving force for this "floating train" by means of what is called magnetic repulsion.

Under experimental conditions in Germany and Japan, maglev vehicles have traveled as fast as 375 miles per hour.

Maglevs are quiet, produce no pollution along the guideway, and can climb steeper grades and turn tighter corners than conventional trains. The only friction encountered once underway is wind resistance. Maglev trains require only one-tenth of the power needed to move a regular train. Some people think that once the high costs are resolved, maglev will replace conventional passenger railroading.

The Hyperloop is currently being developed in California and could cover the distance between Los Angeles and San Francisco in 35 minutes and cost a proposed $20 per ride. It would consist of capsules transported at high speeds through the length of low-pressure tubes that are elevated off the ground. To simplify the science, reports suggest the pods would work similarly to an air hockey table. The capsules are supported on a cushion of air and travel at average speeds of 600 mph, reaching a top speed of 760 mph. With tubes departing every 30 seconds and carrying 28 passengers each, a single tube would be able to transport 7.4 million people per year.

Signals

There is one signal that anyone, including members of the public, can use *in an emergency* to communicate with a railroad crew to stop the train: Wave any object—an arm, flag, T-shirt, etc.—back and forth when standing near the track.

The safety of passenger and freight train operations requires constant communication among train crews, employees who maintain the track and equipment, and those who control train traffic. Over the years railroads have used many methods: hand signals, flag signals, flares, whistle signals, lighted signals called block signals and interlocking signals, and telegraph, telephone, telefax, radiophone, walkie-talkies, microwave systems, cell telephones, and satellites. All employees involved with train operations must learn the signal techniques defined in their railroad's operating rules book and carry the book while at work.

Since the early days of railroading, train crew members have used hand signals. At night they signaled with lighted lanterns. The old oil- or kerosene-powered lanterns have become collectibles. Today's train crews carry battery-powered railroad lanterns as part of their standard equipment. Railroad employees rarely use hand signals and now use walkie-talkies to communicate directly with each other.

The train's engineer uses horn signals to respond to the hand signals or radio commands from train crew members, track workers, and other trains, and to make other employees aware of the train's movement. Horn signals also are used to alert the public when a train is nearing a highway-rail grade crossing as well as approaching or departing from a train station. The chart shown here summarizes the commonly used horn signals heard around a railroad.

In the past, trains left stations—one after another—on a paced schedule. Each train was expected to travel a certain distance in a certain time period before the next train was allowed to leave. But spacing the trains by time did not take into account weather conditions or other physical issues such as mechanical breakdowns. The only way to prevent a rear-end collision was to send a crew member down the track to warn an approaching train of the stopped train ahead.

To improve train control, railroads divided the tracks into sections called *blocks.* A block operator stationed at the entrance to each block would allow one train into the section. No other train could enter that block until the first train had left. Block operators communicated by telegraph and telephone to inform other operators of each train's movement in and out of the blocks. This way of separating trains by space was better than separating them by time, but it still depended too much on human intervention.

At junctions and terminals where trains may change tracks, interlocking signals give lighted commands to the trains. Originally a worker in a signal tower or a station building would set the routes and signal displays to permit the

Horn Signals

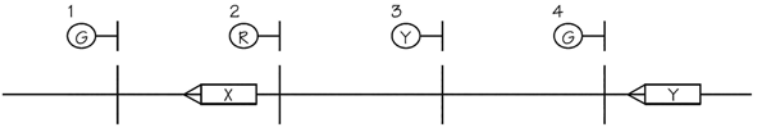
Engine Horn "O" is a short blast; "~" is a long blast.	Meaning
O	Apply brakes. Stop.
OO	Engineer's answer to any signal unless otherwise specified.
OOO	When standing, back up; when running, stop at next station.
OOOO	Engineer's request for signals.
OOOOOOOOOO, etc.	Person or livestock on track (series of short blasts).
~~, etc.	Approaching stations, junctions, or railroad crossings at grade (series of long blasts) without stopping.
~OO	A second section is following; call for other trains to signal.
~OOO	Flagman to go out to protect rear of train.
~~	Release brakes. Proceed.
~~O~	Train is approaching public crossing at grade.
~~	Flagman may return from west or south.*
~~	Flagman may return from east or north.*

*These horn signals may be followed by "O" or "OO" or "OOO" when several tracks are in use. The number of short blasts corresponds to the track number.

trains to enter the interlocking area. Complex sets of lighted signals with many aspects conveyed commands so that the train engineer would know what speed was permitted within the interlocking and what type of track change to expect.

With the invention of Centralized Traffic Control (CTC) in 1927, remote operators called dispatchers were able to control interlockings by working with lighted track diagram panels called CTC machines. Nowadays, dispatchers—hundreds or even thousands of miles away from the actual track site—control these interlockings with computer graphics displays.

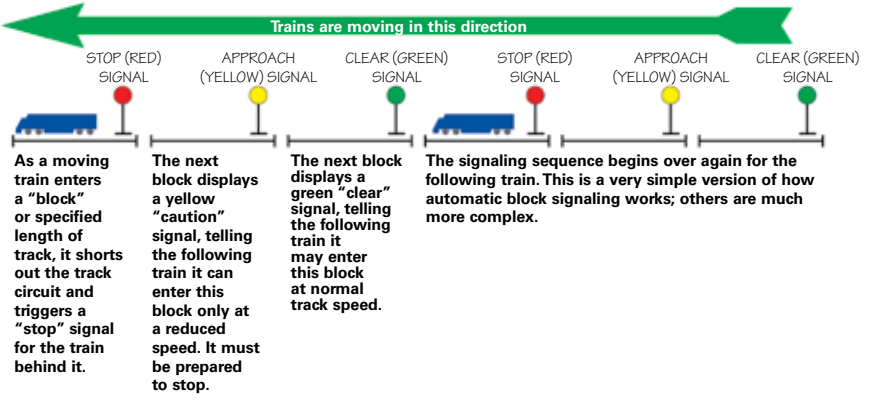
2-block, 3-aspect signaling



In this basic block layout, each signal is spaced a safe braking distance apart based on the maximum permissible speed for that section of railroad. The signals (1, 2, 3, and 4) can display three colors, called aspects, and are defined as follows: Green means "proceed at up to maximum permissible speed." Yellow means "proceed at reduced speed; be prepared to stop at next signal." Red means "stop."

In the 1870s, thanks to the invention of the closed-track circuit and track relay, railroad employees could detect the presence of a train on the rails and know whether it was occupying a block. Later, in 1911, the railroads developed a system of electromechanical devices and circuitry called Absolute Permissive Block (APB) signaling. With APB signaling, the trains themselves control the signals. As a train enters a block, which is an electrical circuit, it shorts out the circuit and activates a STOP signal, which warns other trains not to enter the block. As the train moves ahead, a signal at the entrance to the next block gives a lighted command (called a *signal aspect*) to the train indicating whether it may enter.

Automatic Block Systems (ABS), of which APB is a special type, advise an approaching train if the track ahead is clear of another train, a misaligned switch or other issues. The ABS system only informs the train of conditions ahead, but operating rules still require the train to receive permission from the dispatcher for authority to proceed from its origin to a specified location. The signals then inform the train that all is in order ahead.



How automatic block signaling works

Semaphore and Signal Lights

Over the years, railroads developed various styles of lighted signals. Originally, semaphore signals extended like arms over the tracks. In the vertical position, the signal meant "proceed at maximum permissible speed"; in the diagonal position, "restricted speed"; and in the horizontal position, "stop."

Eventually, colored lights were combined with the semaphore signals for better visibility. The *searchlight* signal, which passes a light through a moveable colored lens and then through an optical magnifying lens, is bright enough for both daytime and nighttime operations. A *position light* signals with three fog-penetrating yellow lamps in the same positions (with the same meanings) as semaphore signals. *Color light* signals use one bulb with one color lens. Locomotive engineers and other railroad workers must memorize these signals to safely operate the trains.

Trains that operate faster than 79 mph must use *cab signals.* Electronic messages transmitted through the rails are picked up by a receiver in the locomotive and displayed inside the engine cab. The engineer gets information such as speed limits along specific sections of track, rail conditions, and wayside warnings—even when the train can't be seen.

In the near future, railroads may stop using track circuits or block signals. Today, rail companies are working with the signal supply companies to develop and test two-way radio and satellite-based location determination systems such as *Global Positioning System* (GPS) to create safer and more effective train control systems.

Positive Train Control

Railway companies are now widely implementing the Positive Train Control (PTC) system in their trains. PTC is a safety system that tracks the speed and movement of trains and can automatically stop a train to prevent specific human-error accidents. In 2008, Congress passed legislation requiring that PTC be installed on tracks that carry passengers and certain hazardous materials. The law requires that the technology prevent four specific types of accidents:

- Train-to-train collisions
- Derailments caused by excessive speed
- Accidents that can occur if trains are routed down the incorrect track
- Unauthorized train movements on tracks undergoing maintenance

In order to work safely and be fail-safe, PTC systems must be able to determine the precise location, direction and speed of trains, warn train operators of potential problems and bring the train to a stop if the operator does not act.

Safety First

Railroads take extreme precautions to operate trains safely. However, the best signaling systems and state-of-the-art technology cannot prevent most of the accidents that occur on the tracks. Impatient, inattentive, or daring drivers and trespasser-pedestrians cause most railroad-related deaths.

Track Safety Basics

Be aware when you are near a railroad track:

- Freight trains don't travel at fixed times, and schedules for passenger trains often change. Always expect a train at each highway-rail intersection at any time.
- Train tracks are private property. Never walk on tracks; it's illegal trespass and highly dangerous. It takes the average freight train traveling at 55 mph more than a mile to stop. Trains cannot stop quickly enough to avoid a collision.
- The average locomotive weighs about 400,000 pounds or 200 tons; one can weigh up to 6,000 tons. This makes the weight ratio of a car to a train proportional to that of a soda can to a car. What happens when a soda can is hit by a car?
- Trains always have the right of way—over emergency vehicles, cars, the police, and pedestrians.
- A train can extend three feet or more beyond the steel rail, putting the safety zone for pedestrians well beyond that three-foot mark. If there are rails on the railroad ties, always assume the track is in use, even if there are weeds or the track looks unused.
- Trains can move in either direction at any time. Sometimes its cars are pushed by locomotives instead of being pulled. This is especially true in commuter and light rail passenger service.

- Today's trains are quieter than ever, producing no telltale "clackety-clack." Any approaching train is always closer and faster-moving than you think.
- Remember to cross train tracks ONLY at designated pedestrian or roadway crossings, and obey all warning signs and signals posted there.

Operation Lifesaver, Inc (OLI)

Operation Lifesaver Inc. is a non-profit organization and nationally recognized leader of rail safety education. OLI's mission is to provide rail safety education and public awareness materials and campaigns dedicated to saving lives. OLI is a recognized leader in providing the public with rail safety education and ending death and injuries due to trespassing and collisions on or near the tracks.

Since 1972, OLI has remained committed to preventing collisions, injuries and fatalities on and around railroad tracks and highway-rail grade crossings, with the support of public education programs in states across the U.S. Today, Operation Lifesaver offers free rail safety education programs across the U.S. They speak to school groups, driver education classes, community members, professional drivers, law enforcement officers, and emergency responders. OLI promotes the three E's—**Education, Enforcement and Engineering**—to keep people safe around the tracks and railway crossings all across the country.

- Stay alert around railroad tracks. Refrain from texting, headphones or other distractions that would prevent you from hearing an approaching train; never mix rails and recreation.

Walking Safely Near Tracks

Rail safety is for everyone, not just drivers. Pedestrians who choose to walk or play around railroad tracks are trespassing on private property and could be fined, seriously injured or killed. Consider the following safety considerations when walking on or near railroad tracks:

- The only safe place to cross is at a designated public crossing with either a crossbuck, flashing red lights or a gate. If you cross at any other place, you are trespassing and can be ticketed or fined. Cross tracks ONLY at designated pedestrian or roadway crossings.
- Railroad tracks, trestles, yards and equipment are private property and trespassers are subject to arrest and fine. If you are in a rail yard uninvited by a railroad official you are trespassing and subject to criminal prosecution; you could be injured or killed in a busy rail yard.
- It can take a mile or more to stop a train, so a locomotive engineer who suddenly sees someone on the tracks will likely be unable to stop in time. Railroad property is private property. For your safety, it is illegal to be there unless you are at a designated public crossing.
- Trains overhang the tracks by at least three feet in both directions; loose straps hanging from rail cars may extend even further. If you are in the right-of-way next to the tracks, you can be hit by the train.

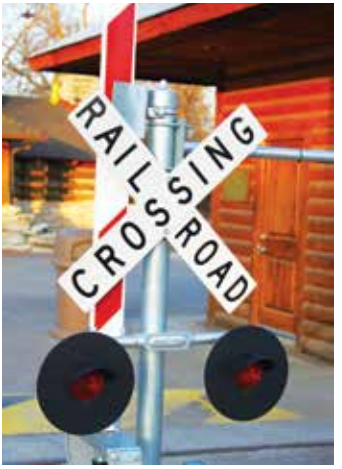
- Do not cross the tracks immediately after a train passes. A second train might be blocked by the first. Trains can come from either direction. Wait until you can see clearly around the first train in both directions.
- Flashing red lights indicate a train is approaching from either direction. You can be fined for failure to obey these signals. Never walk around or behind lowered gates at a crossing, and DO NOT cross the tracks until the lights have stopped flashing and it's safe to do so.
- Do not hunt, fish or bungee jump from railroad trestles. There is only enough clearance on the tracks for a train to pass. Trestles are not meant to be sidewalks or pedestrian bridges! Never walk, run, cycle or operate all-terrain vehicles (ATVs) on railroad tracks, rights-of-way or through tunnels.
- Do not attempt to hop aboard railroad equipment at any time. A slip of the foot can cost you a limb or your life.
- Be aware trains do not follow set schedules.

Driving Safely Near Tracks

Trains and cars don't mix. When driving near tracks, keep these tips in mind:

- Be aware that trains cannot stop quickly.
- Never drive around lowered gates—it's illegal and deadly.
- Do not get trapped on the tracks; proceed through a highway-rail grade crossing only if you are sure you can completely clear the crossing without stopping. Before crossing, be sure there is space on the other side to completely clear the tracks. Trains overhang tracks by at least 3 feet on each side. Leave at least 15 feet between the front or rear of your vehicle and the nearest rail. Do not shift gears while crossing.

- If your vehicle gets stuck at a crossing, get everyone out and far away immediately, even if you do not see a train. If a train is approaching, move away from the tracks at a 45-degree angle in the direction the train is approaching to avoid debris. Call the number on the Blue and White Emergency Notification System (ENS) sign and share the crossing identification number with the dispatcher. Using the information on the ENS sign is the quickest way to notify the railroad. No sign? Dial 911. You can also use these numbers to report any problem on the tracks including vehicles on the tracks, damaged signs or signals, obstructed views, signal malfunctions and individuals or debris.
- At a multiple-track crossing waiting for a train to pass, watch out for a second train on the other tracks, approaching from either direction.



- When you need to cross train tracks, go to a designated crossing, look both ways, and cross the tracks quickly, without stopping. Remember it isn't safe to stop closer than 15 feet from a rail. Only cross at designated public crossings with crossbuck signs. Never walk past flashing lights or lowered gates at crossings. Wait until the lights have stopped flashing and the gate is up before crossing. The only safe and legal place to cross railroad tracks is at a designated public crossing with a crossbuck, flashing red lights, or a gate. Crossing at any other location is dangerous. Always assume train tracks are in use, even if there are weeds or the tracks look unused.
- Always expect a train.

Passenger Rail Safety Tips

In America's cities and beyond, nothing connects us to work, play and each other like public transit, today's safest, most reliable way to travel. The American Public Transportation Association (APTA) estimates that 34 million times each weekday, people use public transportation. Six things to know about light rail and commuter train safety:

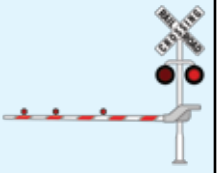
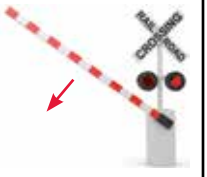
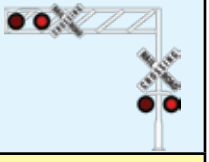
1. **Stay alert.** Trains can come from either direction at any time and can be very quiet. Obey all warning signs and signals and use caution when using headsets or cellphones.
2. **Watch the overhang.** Trains are wider than the tracks; never sit on the edge of a station platform.
3. **Stand away from the platform edge.** Pay attention to painted or raised markings at the platform edge, and stay at least three feet from the train while it is coming in or out of the station.
4. **When on board, hold on.** Hold on tight to poles or seats, and listen carefully to directions from the train operator or conductor.
5. **Watch your step.** Be careful getting on and off the train—there may be a gap between the train and platform or steps.
6. **Don't take shortcuts with your life!** Follow directional signs and markings that let you know where it is safe to cross the tracks. Crossing the tracks anywhere else is dangerous and illegal.

Rail Signs and Signals

Passive signs and active traffic control devices are installed along roads that cross railroad tracks both on the approach and at the highway-rail grade crossing to regulate, warn or guide traffic.

Passive signs alert motorists that they are approaching a highway-rail grade crossing. **Active signs** are electronic devices that warn the motorist of the approach, or presence, of rail traffic at grade crossings.

They alert drivers to the presence of railroad tracks and to the possibility of an approaching train. These signs and devices also provide a safety message and remind the driver of the laws regarding highway-rail grade crossings. The chart that follows shows some of the various signs and devices you will see.

Rail Signs and Signals At A Glance		
SAFETY DEVICES AT THE RAILROAD CROSSING		
Flashing red lights (with or without bells)	Warns of an approaching train. When the red lights are flashing, a train is approaching. Stop and wait for the train to pass and the lights to stop flashing, then proceed when it is clearly safe to do so.	
Flashing red lights and gates	Warns of an approaching train and used to close the road when a train approaches. It is only legal to drive around lowered gates if the crossing is flagged by a law officer or railroad employee.	
Lowering gates and flashing red lights	A train is approaching (even if you don't see it yet). Do not proceed until the gates go completely up and the lights turn off. It is illegal and dangerous to go around lowered crossing gates.	
Cantilever flashing lights	Warns of an approaching train. Designed to cover all the traffic lanes so the crossing warning is visible to all drivers on multi-lane roads.	
SAFETY SIGNALS ON THE ROADWAY		
Pavement marking and stop bars	On paved roads, these markings alert drivers that the road crosses railroad tracks ahead and identifies the safe place to stop and look for an approaching train. On gravel roads there are no pavement markings or stop lines, and the driver must stop no closer than 15 feet.	

SAFETY SIGNALS BEFORE THE RAILROAD CROSSING		
Advance warning	Typically the first sign you see when approaching a highway-rail grade crossing, this sign alerts drivers that the road crosses railroad tracks ahead. Reminds the driver to slow down, look and listen for a train.	
No train horn	A Quiet Zone has been established and normally the train will not sound the horn. The locomotive engineer can still sound the horn in emergency situations or if workers are near the tracks.	
Low ground clearance grade crossing	Raised crossing ahead. If you drive a low-clearance vehicle (lowboy), trailer or anything else low to the ground, you are at risk of getting hung up on the tracks. Do not proceed. All drivers need to make sure that their vehicle has cleared the tracks once they cross over.	
Advance warning for side streets	Warns that a highway-rail intersection will appear immediately after making either a right or left turn. Reminds the driver to be prepared to stop if a train is approaching.	
SIGNS ALONG RAILROAD PROPERTY		
No trespassing	If you attempt to ride an ATV or a snowmobile, or hike on the tracks, a bridge, or a trestle or even walk near the tracks, you can be arrested and fined. Most of all it is dangerous, because you never know when a train may be approaching.	

SIGNS AT THE RAILROAD CROSSING		
Crossbuck	Marks the crossing and should be considered the same as a yield sign. Most common sign at public highway-rail intersections.	
Emergency notification system	Shows the railroad's emergency phone number and U.S. Department of Transportation (USDOT) Crossing Number, both of which are different at each crossing. This is the first phone number to call if your car is stuck on the tracks; if it is missing call 911. Each crossing in the US has a unique phone number and USDOT Crossing Number.	
Multiple tracks	Indicates the number of tracks present. After one train has passed, look and listen for another train coming from either direction.	
Stop	A driver must always stop at the stop sign in advance of the railroad tracks. The stop signs mean the same as they do at highway intersections.	
Yield	Every driver must yield the right of way to a train. Yield signs mean the same as they do at highway intersections.	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KEEP OFF
KEEP OFF
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Railfanning

Many people believe there is no experience more exhilarating than standing trackside and clicking a camera as a restored steam locomotive rushes by, or flying down the rails on a high-speed train. Railfans love the history of railroading, the thrill of traveling "on the iron road," or the fun of reading the marks on freight trains. So visit a railroad museum, learn about rail preservation, attend a prototype-train event, or take a train trip and become a railfan yourself.

Planning a Rail Trip

The first question you need to ask when planning a rail trip is *Can I get to my departure point from here?* If passenger trains don't stop in your town, you will have to make arrangements to get to a station. Once you know *where* your starting point is, you can plan a destination point.

Consider these questions before you finalize your trip itinerary:

- What is the purpose of the trip? To ride a historic train? Visit a particular city? Photograph scenery?
- How much time do you have? A day? A week?
- How much do you want to spend? Food on board? Sleeper car?
- What kinds of trains depart from your starting point? Commuter? Intercity?

Westbound and southbound trains carry odd numbers; eastbound and northbound trains carry even numbers.

Now you can shape your trip. You may buy vacation planners and local sightseeing guides, but you *must* get a railroad timetable for the train you wish to take. You can pick one up at the train station or print one from the internet (with your parent's permission). Or you can request one by mail. Study the timetable carefully. It is full of information that you must understand if you want to have a good trip.

From the timetable shown on the next page, you can see that Amtrak's Crescent, Train No. 19, makes a daily departure "(Dp)" from New York, NY (designated "Mile 0") at 2:15 p.m. with an arrival "(Ar)" time of 7:32 p.m. the following evening in New Orleans, LA (designated "Mile 1377"). Reservations are required for coaches and sleeping cars. Other services available on the Crescent include flexible dining service, café service, Wi-Fi, on-board bicycle racks and checked baggage at select stations.

Most Amtrak station stops last only for the time it takes for passengers to board or debark—as little as two or three minutes. For longer stops of five minutes or more, separate arrival "(Ar)" and departure "(Dp)" times are listed.

Now that you know how to read a timetable and have decided where to go, are you ready to buy a ticket? You can make a reservation and purchase your ticket in person at the train station, by telephone, or on the internet (an adult must do this for you).

Once on board, you will give your ticket or show your boarding pass to a conductor, who will punch out your destination station on a seat check and give that to you. Your name is not on the seat check, so take it with you when you move about the train.

19	‹ Train Number ›					20
Daily	‹ Normal Days of Operation ›					Daily
R	‹ On Board Service ›					R
Read Down	Mile			Symbol		Read Up
2 15P	0	Dp	New York, NY (ET) –Penn Station		Ar	1 46P
2 37P	10		Newark, NJ			D1 25P
3 18P	58		Trenton, NJ			D12 41P
3 55P	91		Philadelphia, PA –Gray 30th Street Station			D12 08P
4 20P	116		Wilmington, DE			D11 44A
5 12P	185		Baltimore, MD-Penn Station			D10 55A
5 59P	225	Ar	Washington, DC		Dp	D10 18A
6 30P		Dp	–Union Station		Ar	D9 53A
6 49P	233		Alexandria, VA			D9 32A
7 22P	258		Manassas, VA			8 35A
7 55P	293		Culpeper, VA			8 01A
8 52P	337		Charlottesville, VA Richmond—see page 2			7 09A
10 00P	398	Ar	Lynchburg, VA (Roanoke)		Dp	5 56A
10 06P		Dp			Ar	5 52A
11 14P	461	Ar	Danville, VA		Dp	4 43A
12 15A	512	Ar	Greensboro, NC (Winston-Salem)	N	Dp	3 44A
12 22A		Dp		N	Ar	3 37A
12 39A	524		High Point, NC	N		3 16A
1 17A	559		Salisbury, NC	N		2 32A
2 20A	601	Ar	Charlotte, NC	N	Dp	1 46A
2 45A		Dp		N	Ar	1 21A
3 12A	623		Gastonia, NC			12 39A
4 14A	678		Spartanburg, SC			11 39P
4 54A	709	Ar	Greenville, SC		Dp	10 58P
5 01A		Dp			Ar	10 53P
5 39A	739		Clemson, SC			10 16P
6 15A	773		Toccoa, GA			9 40P
6 58A	810		Gainesville, GA			8 59P
8 13A	859	Ar	Atlanta, GA (ET)		Dp	8 04P
8 38A		Dp			Ar	7 35P
10 00A	959	Dp	Anniston, AL (CT)		Dp	3 59P
11 50A	1023	Ar	Birmingham, AL		Dp	2 24P
12 08P		Dp			Ar	2 15P
1 07P	1078	Dp	Tuscaloosa, AL		Dp	12 44P
2 58P	1175	Ar	Meridian, MS		Dp	11 07A
3 04P		Dp	Dallas—see page 2		Ar	11 02A
4 01P	1231		Laurel, MS			10 05A
4 38P	1260		Hattiesburg, MS			9 30A
5 42P	1324		Picayune, MS			8 22A
6 07P	1342		Slidell, LA			7 57A
7 32P	1377	Ar	New Orleans, LA (CT) –Union Passenger Terminal		Dp	7 00A

SCHEDULES EFFECTIVE 3/16/20

Remember that your behavior reflects on yourself—and all Scouts—so be a courteous traveler.

Remember to bring a map and timetable along so you can figure out where you are and recognize prominent geographical landmarks along the way. Amtrak partners with the National Park Service for a "Trails and Rails" program. During certain months, interpretative guides talk to the passengers about the areas through which the train passes.

Railroad Expressions

If you are a true railfan, you will want to know the history of some of the railroad expressions used today.

Full steam ahead—Go forward at the greatest speed possible, or with as much energy and enthusiasm as possible. The expression comes from an instruction to the engineer to power up a steam locomotive.

Highball—A signal for a train to proceed. This term comes from an antique signal design that had a large ball on a rope, which hung from the top of a pole by a pulley. When positioned at the top of the pole, the ball was an indication to proceed.

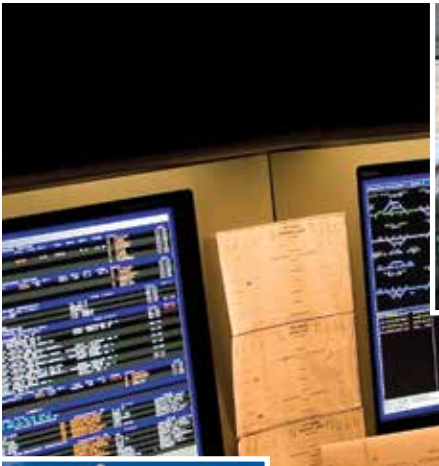
Jerkwater town or one-jerk town—Insignificant or out-of-the way. Often along main lines but where train crews gave only one jerk on the tower spout to top off locomotive tender water tanks.

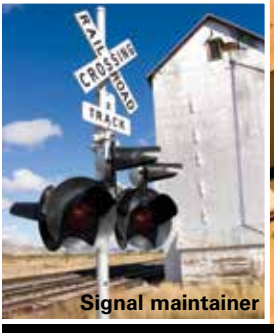
On the right track—Going the right way, following the right assumptions. This phrase comes from a train ready to go on its assigned track.

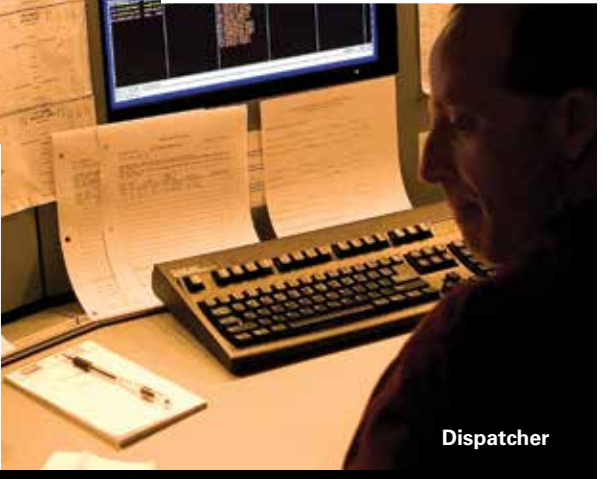
One-track mind—A mind that thinks about only one subject, like a train that follows one track and never switches to other tracks.

Railroaded—Pushed through hastily (as a law) so there is no time to consider objections. This dates back to a time when farmers and other rail shippers felt they were being taken advantage of by high railroad freight rates.

Sidetracked—Distracted from the main subject or forced off one's intended course. In railroading, it means a car moved off the main track to an auxiliary track.







Some of the departments within a typical railroad include:

- Executive and management
- Operations, which manages the trains, other rolling stock, and roadbed
- Transportation, which schedules trains
- Mechanical, for repairs and inspections
- Engineering, for planning, layout of tracks and other facilities, and signaling
- Sales, to market and sell the railroad's services
- Legal, to handle all such matters
- Finance, to track revenue and expenses and the purchase of needed supplies and equipment
- Human resources, to handle employment and benefits
- Public relations

Careers in Railroading

If you want to be a railroader, you can follow many career tracks. It is much like entering a classification yard, with certain rails leading to railroad operations, others to management, purchasing, engineering specialties, even public relations and corporate communications. Most Class I railroads have more than 100 classifications for positions including mechanic, signal and communications worker, marketing and sales representative, lawyer, accountant, surveyor, track foreman, and transportation supervisor. All are important for the smooth operation of the railroad.

To work for the railroad, you must be in good physical shape and have a high school diploma (at the minimum, although a college diploma is preferred). You will have an edge if you have work experience in railroading or other related fields of transportation, mechanical talent, and the ability to think straight in an emergency situation.

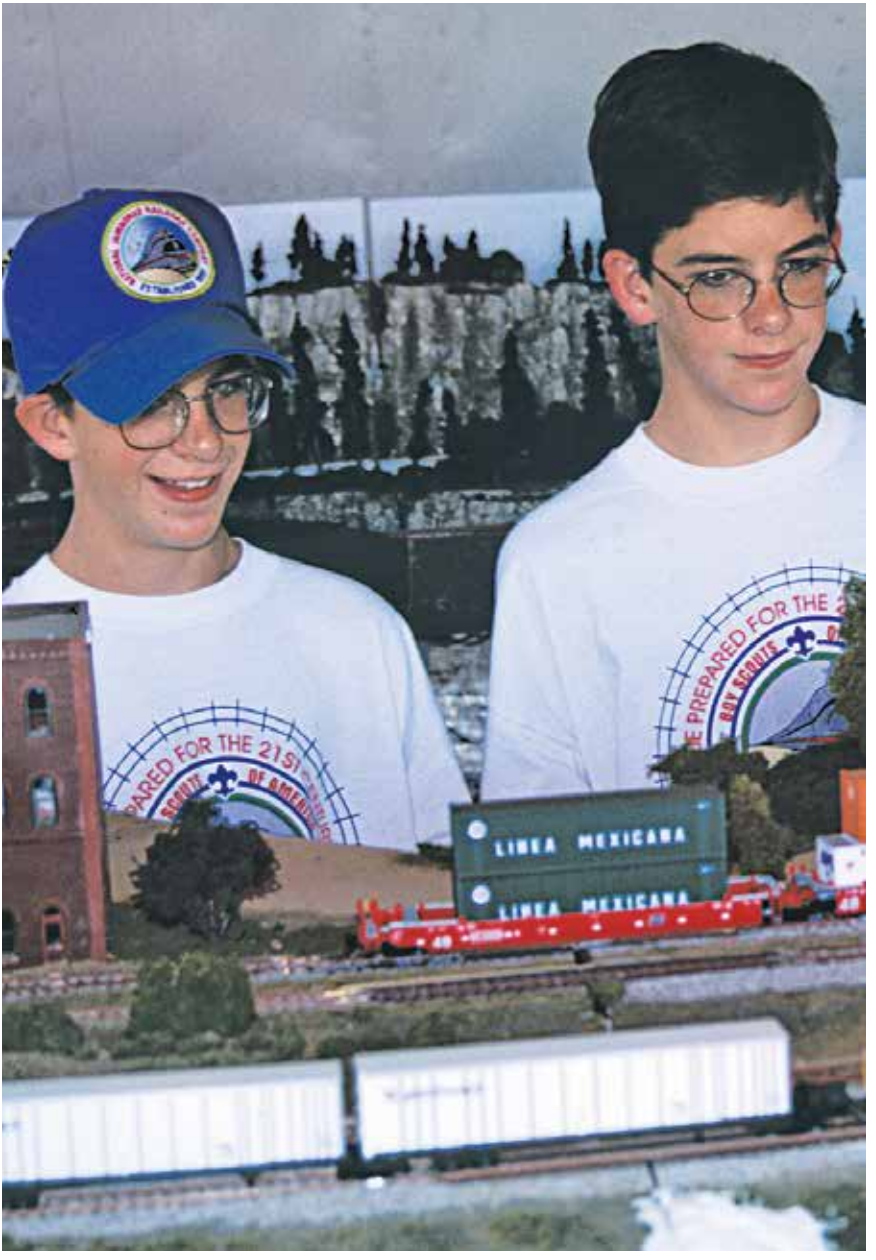
The Association of American Railroads maintains a webpage that hosts links to other pages where career information can be found. Go to www.aar.org/about-us/careers.

Railroad Organization

Railroad companies have five basic components.

1. **Fixed plant**—track, track bed, supporting structures like bridges and trestles
2. **Rights-of-way**—strips of land for track, stations, and other buildings
3. **Rolling stock**—locomotives, freight cars and passenger coaches, sleeper and dining cars, work trains, and track inspection equipment
4. **Financial structure**—capital funds for the purchases of large items as well as operating funds for day-to-day expenses
5. **Human resources**—employees in the ranks of labor and management who make it all work

All these different components give any individual who is interested in the railroad industry a variety of career opportunities from which to choose.


LINEA MEXICANA
LINEA MEXICANA

Model Railroading

Model railroading is an educational hobby whose popularity is growing. Model railroad clubs exist worldwide and the number of individuals operating their own model railroads is increasing. Model railroads often have amazingly realistic scenery and frequently these modeled scenes represent portions of actual railroads. Many are now operated in the same way that real-life railroads are run.

Your local model railroad clubs and hobby shops can help you plan your layout. As you proceed, you may find that you are more interested in operations, in building cars or structures, in building scenery—or all of these. Attend public train shows in your area or conduct research on the Internet. Often, you will be able to buy secondhand items and sometimes complete layouts to save money. Model railroading has so many options that it is easy to learn about those areas that interest you most.

You can begin as a model railroader with a small layout. Expand it as your time and money permit. Be patient and do your best on each model so that it will give you a lifetime of service.

As your interest in this hobby grows, consider joining the National Model Railroad Association. Currently, there are more than 25,000 members worldwide. Your BSA local council can put you in touch with qualified NMRA members who are willing to serve as counselors for the Railroading merit badge.

Scales and Gauges

Scale, in model railroading, refers to the proportion of a model as it relates to the size of the real object. For example, a 1:48 proportion means the model is $1/48^{th}$ the size of an actual train. Scale may also be expressed as a length measurement on the model (in fractional inches or millimeters) that represents one foot of length on a life-size (or prototype) train. While model trains come in many scales and gauges (some are large enough

Gauge is the distance measured between rails. The terms *scale* and *gauge* are often confused.

Toy or "tinplate" trains are not true ¼-inch scale because they are shortened to run on sharp curves; a tinplate passenger car may be only 6 inches long. Tinplate trains also run on three-rail track.

to carry passengers!) the most common sizes are referred to as No. 1 (G), O, S, HO, N, and Z.

- The *G* scale, or No. 1, is the largest scale and is most often used in garden or outdoor model railroads.
- The *O* scale dates back to the 1920s when mechanical or windup toy trains were common. Each ¼-inch on an O scale model represents one foot on a full-size train, so the model for an 80-foot passenger car will be about 20 inches long.
- The *S* scale is about halfway between the O and HO scales.
- The *HO* scale is currently the choice of the majority of modelers. This scale takes about half as much space as O scale.
- *N* scale equipment is made to accurate scale, yet its small size takes only about half the space required for the HO scale. Reducing the space requirement allows modelers to use broader, more realistic-looking curves.
- The *Z* scale is the newest and smallest scale and was made possible by the development of precision subminiature motors.

North America's railroads operate on standard gauge track with rails spaced 4', 8½" apart. Some tourist railroads in places such as scenic areas or at amusement parks operate on narrow gauge track with rails spaced only 3 feet apart. Model railroaders add a letter "n" and the track gauge to the scale name (On3, Sn3, or HOn3) when they refer to narrow gauge models. ome rideable outdoor models with locomotives actually operated by steam have gages ranging from 2½" (64 mm) to 15" (381 mm).

Scale and Gauge Chart

Name	Scale (In inches)	Relationship (To actual size)	Gauge (In inches)
G (No. 1)	.375	1/32	1.766
O	.250	1/48	1.250
S	.188	1/64	.875
HO	.138	1/87	.649
N	.075	1/160	.353
Z	.055	1/220	.250

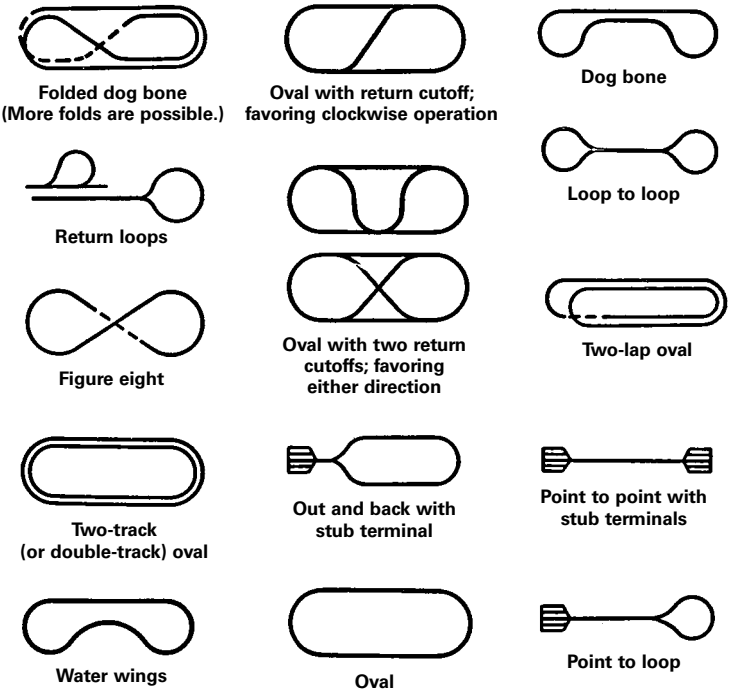
Layout Design

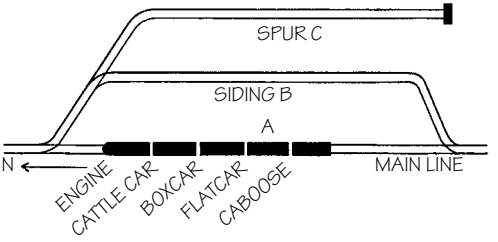
Planning a layout is a lot of fun, but you need to think about how much space you have before you choose your scale. Modelers build layouts in basements, attics, and garages. If you don't have much space, consider building a layout design on a low folding table with casters so it can be stored under a bed. Although a smaller scale allows you to build more railroad, it might be wise to select the scale you like the most.

Use a pencil to sketch your layout on graph paper, roughly to scale. As you draw your layout, consider several points: What kind of railroad do you like? What sorts of things will the cars haul? How much money can you spend?

If possible, try to design a layout that you can expand on later. The drawings shown here depict some common track planning ideas you may want to try.

Layouts





Local switching

Local freight trains deliver cars to customers along their route. Suppose your train is traveling north on the main line at A. How can you deliver the cattle car on siding B and the flatcar on spur C? Now, suppose your train were traveling south. This would make it necessary to use siding B as a runaround track to get the engine to the other end of the flatcar. You will find at least one runaround track in most industrial areas.

Much of the fun in operating model trains comes from solving switching problems as the freight cars are delivered or picked up at points around the layout.

Layout Construction

To ensure reliable operation, build your layout on a solid structure or table called *benchwork*. With your layout off the floor, you will keep the tracks and motors cleaner and avoid accidental damage. You also will find working on benchwork is easier than working on the floor.

Many layouts begin on 1/2"-thick plywood fastened to a 1"-by-4" framework. Using plywood thinner than 1/2" is not wise as it tends to sag between the supports, creating problems with your trackwork.

Ready-to-use track comes in standard straight, curved, and flexible sections with a variety of switches, crossings, and other components. Sectional track offers a lot of advantages for the first layout. If you change your mind, you can easily change your trackwork before fastening it to the plywood with scale spikes. You could use white glue for permanent fastening, but it is difficult to change track later. To make your trackwork more realistic, add finely graded gravel (scale ballast).

When you are ready to test the layout, watch how a train passes over every inch of the track. Fix any bumps or rough spots until the train runs smoothly. Now you are ready to add scenery.

Scenery

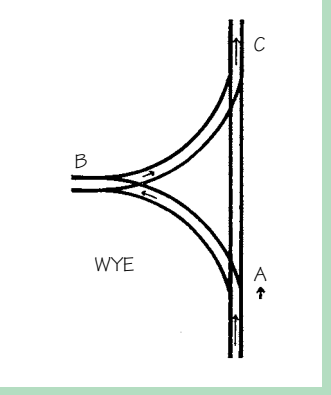
Building scenery provides a setting for your trains. For a good starting point, assemble a few of the simple plastic building kits and set them in appropriate places on the benchwork. Use a pencil to sketch in roads, rivers, and other landscape features.

Add a bi-level track to lengthen the run and allow for more bridges and mountainous scenery. However, you will have to test your locomotive to see how many cars it can pull up the grade, or ramp, between the levels. As a general rule, a grade should not exceed 3 percent (the track rises 3 inches in height per 100 inches of length).

Use a concealed-from-view track to hide the train in a tunnel beneath a mountain or behind a backdrop. This lets you stop the train for a few moments to give the effect of a longer trip and a larger layout.

Install a crossover, made up of two facing track switches, to allow a train to leave one track and move onto a parallel line. The term "crossover" is sometimes confused with a *crossing,* where one track crosses another at an angle.

Incorporate a *wye* (pronounced "Y"), an interesting track arrangement made up of three turnouts (see the wye diagram). It is used to turn a train or locomotive. Throw switch A and proceed through one leg of the wye until the train is clear (or past) switch B. Throw switch B behind the train and then reverse direction to back through the adjoining leg of the wye to clear switch C. Throw switch C in front of the locomotive so you can return to the starting point (switch A) heading in the opposite direction. A wye arrangement often needs special wiring, so be sure to get advice from an expert.

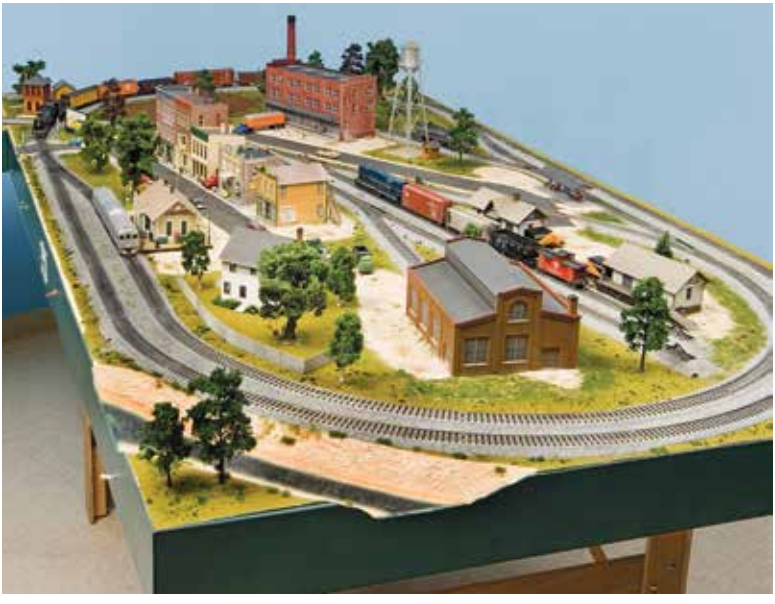


Add a group of switch tracks to make a classification yard where freight cars are sorted and connected to form trains. Arriving trains often have cars for several destinations mixed together. The yard crew sorts these cars into groups headed for one destination and then puts the groups in order for delivery.

You can create a rolling landscape by taping crumpled newspapers, paper towels, or bags to the plywood. Dip strips of paper toweling in soupy plaster and drape them over the newspapers in several layers. After the plaster sets, paint your landscape and add details.

You can buy model trees, or you can make your own from dried weeds, twigs, and fibers from old furnace or air conditioner filters. For extra texture, use commercial products such as ground-up foam rubber or dyed lichen.

Notice details in your neighborhood like signs, sheds, people, telephone poles, and animals. Think about how adding similar items to your scenery will make your layout come alive. While you are looking around, pay attention to how nature has weathered buildings, cars, fences, and equipment. If you want your models to look more realistic, "weather" them yourself. Tone down bright plastic buildings by spraying them with a light coat of clear dull finish, or apply a wash of thinly diluted India ink.



A good-looking layout doesn't have to be big to be fun to build and operate. This HO layout is built on a 4'-by-8' sheet of plywood.

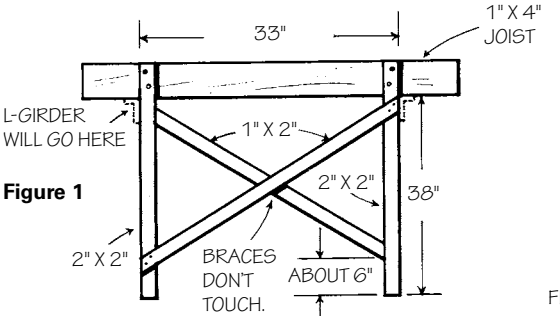


Figure 1

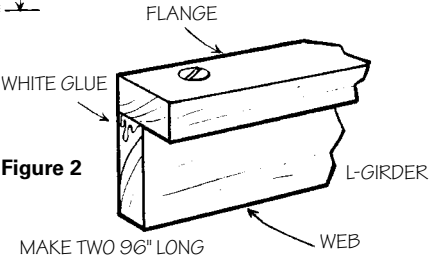


Figure 2

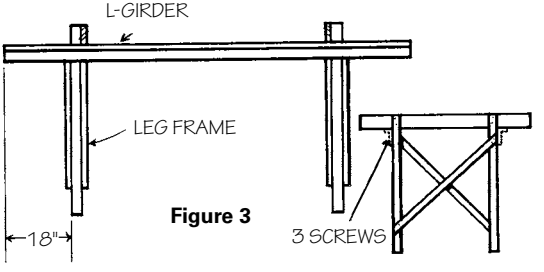


Figure 3

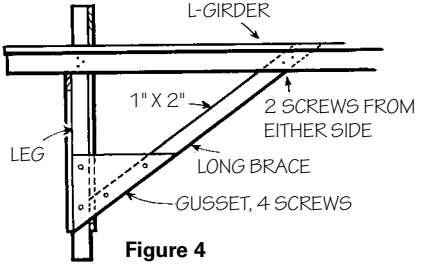


Figure 4

Benchwork plan

No screws should ever be driven down through the top. See figure 7.

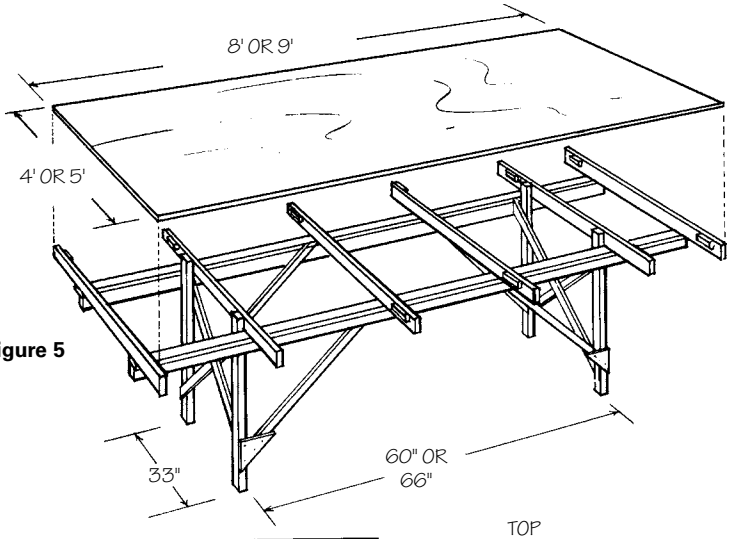


Figure 5

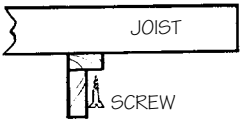


Figure 6

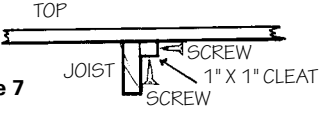


Figure 7

Sometimes it's fun to build models of historic trains that ran in the western mountains.

Here is a layout built to look like it's in the north woods, with trees made out of weeds.

Rolling Stock

You can buy locomotives and rolling stock for your railroad "ready-to-run." Or you can buy kits, which come in various levels of difficulty and detail, from easy-to-assemble with simple details to difficult with elaborate features. Some people like *kit-bashing,* or combining parts from two or more kits (along with items found around the house) to build an item that is hard to find, unavailable, or original. Kit-bashing allows you to use your imagination *and* take advantage of premade parts.

You can build rolling stock from plans, parts, and materials—a practice called *scratch building.* This requires following well-detailed plans and studying prototype photos to make the needed parts. Many model railroad magazines feature such plans and make parts available for cars and locomotives.

Because tinplate trains operate on AC current, they use a transformer that has variable speed control.

Some modelers build urban structures to create a city scene.

Power and Control

For many years, two-rail scale layouts have been run by DC (direct current) power packs plugged into a wall outlet. Power packs include a transformer to reduce the 110-volt AC (alternating current) house voltage to about 18 volts before a rectifier in the circuit converts it to 12 volts DC. A rheostat adds variable resistance to the circuit to control the voltage (speed) while the DC polarity determines the train's direction. Many accessories operate on AC, so most power packs have extra wiring terminals labeled for this purpose. With DC power, depending on the arrangement of the layout, you might want to break the track into more than one segment to allow the operation of more than one train.

Digital Command Control (DCC) is a new system for controlling two-rail layouts with simplified wiring. Each locomotive contains a decoder that can be linked to a specific throttle control or cab through the system's minicomputer. Throttle settings and other commands from the cab are broadcast as high-speed digital signals that travel through the entire layout. The locomotive's decoder responds only to signals from its assigned cab to operate the locomotive. Thus, DCC allows many locomotives to operate under individual control at the same time on a layout.

Care of Equipment

You may need to clean your equipment occasionally. Use a clean, dry paintbrush to remove dust and any hair or lint that is caught in the moving parts. Clean the track with a dry abrasive block, which works better than applying cleaning fluids to a cloth pad.

The instruction sheet that accompanies most model locomotives explains how and where to lubricate the train cars. Be sure to get plastic-compatible lubricants and use them sparingly as too much oil is worse than too little. Rolling stock axles seldom need lubrication unless they are actually squeaking. Many good lubricants are available, so seek recommendations from a friend who has a model railroad or from someone at your local hobby shop.

Cars that frequently derail may need minor adjustments. You can buy a gauge to check wheel spacing and other standard dimensions from the National Model Railroad Association or a hobby shop. You may need to add weight to certain cars to improve performance. Consult printed guides (such as those published by NMRA) for correct car weight based on car length and scale.

The Timesaver

The timesaver is a switching game that tests your problem-solving skills to see who can deliver all of the freight cars to their proper destinations in the shortest time. It is played on the standard HO layout shown in the drawing. Here is the list of the sectional track and other components it takes to build a timesaver using Atlas parts, which are widely available at hobby shops and online (only with your parent's assistance).

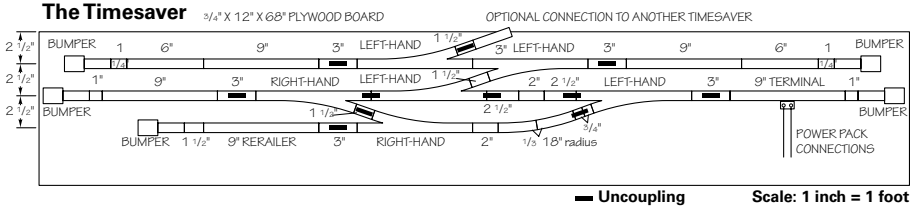
- 4 Atlas left-hand manual Snap-Switches®
- 3 Atlas 9" straights
- 1 Atlas 9" terminal section
- 6 Atlas 3" straights
- 1 Atlas short section assortment
- 11 Kadee No. 321 uncoupling magnets
- 1 power pack
- 5 40-foot freight cars: boxcar, gondola, hopper, refrigerated boxcar, and tank
- 2 Atlas right-hand manual Snap-Switches®
- 1 Atlas 9" rerailer

Timesaver hint: Think ahead and carefully plan your switching moves to avoid extra moves that take more time.

2 Atlas 6" straights
2 Atlas 1 ½" straights
5 Atlas bumpers
1 ¾" x 12" x 68" plywood board
1 diesel switcher (40-foot or smaller)

The game begins with the cars and locomotive positioned as shown in the diagram labeled "starting car positions." Set the throttle to a slow speed and then use the power pack's reversing switch to change direction as you switch the cars. The game ends when all of the cars have been delivered to the positions shown in the diagram labeled "finished car positions." The elapsed time is your score and the best time wins.

The Timesaver ¾" X 12" X 68" PLYWOOD BOARD

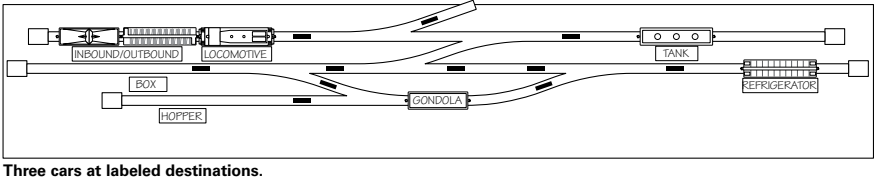


▬ Uncoupling magnet location

Scale: 1 inch = 1 foot

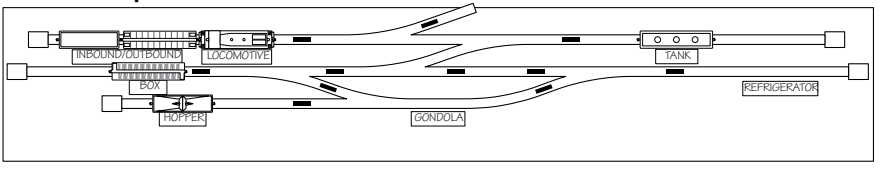
Starting car positions

Add destination labels on the layout for each car type.



Three cars at labeled destinations.
Two cars are marked with tags for removal.

Finished car positions



Resources About Railroading

Scouting Literature

Engineering and *Model Design and Building* merit badge pamphlets

With your parent's permission, visit the Boy Scouts of America's official retail website, www.scoutshop.org, for a complete listing of all merit badge pamphlets and other helpful Scouting materials and supplies.

Books

Ambrose, Stephen E. *Nothing Like It in the World: The Men Who Built the Transcontinental Railroad 1863–1869.* Simon & Schuster, 2000.

Armstrong, John H. *The Railroad: What It Is, What It Does, The Introduction to Railroading,* 5th ed. Simmons-Boardman Books, 2008.

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Kelly, Jim, and Michael Emmerich. *HO Railroad From Start to Finish (Model Railroad Handbook, No. 36).* Kalmbach Publishing Company, 1993.

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Solomon, Brian. *The Heritage of North American Steam Railroads: From the First Days of Steam Power to the Present.* Reader's Digest, 2001.

Stover, John F. *The Routledge Historical Atlas of the American Railroads.* Routledge, 1999.

Vantuono, William C. *All About Railroading,* 2nd ed. Simmons-Boardman Books, 2006.

Magazines

Classic Trains
Model Railroader
Trains
Kalmbach Publishing Company
P.O. Box 1612
Waukesha, WI 53187-1612
Toll-free telephone: 800-533-6644
www.trains.com

Model Railroad News
Telephone: 877-787-2467
modelrailroadnews.com

Passenger Train Journal
Toll-free telephone: 877-787-2467
passengertrainjournal.com

Railfan & Railroad
White River Productions
Toll-free telephone: 877-787-2467
railfan.com

Railroad Model Craftsman
White River Productions
Toll-free telephone: 877-787-2467
rrmodelcraftsman.com

Railway Age
345 Hudson St.
New York, NY 10014
www.railwayage.com

Trains & Railroads of the Past
Toll-free telephone: 877-787-2467
trpmagazine.com

Organizations and Websites

Amtrak
Toll-free telephone: 800-872-7245
www.amtrak.com

Association of American Railroads
425 Third Street SW
Washington, DC 20024
Telephone: 202-639-2100
www.aar.org

Federal Railroad Administration
1200 New Jersey Ave. SE
Washington, DC 20590
railroads.dot.gov

National Model Railroad Association
P.O. Box 1328
Soddy Daisy, TN 37384
Telephone: 423-892-2846
www.nmra.org

National Railway Historical Society
505 South Lenola Road, Suite 226
Moorestown, NJ 08057
Telephone: 215-557-6606
www.nrhs.com

Operation Lifesaver
425 Third St. SW, Suite 915
Washington, DC 20024
Toll-free telephone: 800-537-6224
oli.org

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Notes