Contents

Bill Darnaby's HO scale Maumee Route is a fine example of a freelanced model railroad. Bill based his layout's features, name, and paint scheme on the Nickel Plate Road and other Midwestern prototype railroads. *Bill Darnaby*

was launched in 1934. Other early magazines, including *The Model Maker* and *The Model Craftsman* (which became *Railroad Model Craftsman* in 1949), highlighted scale railroad models along with ships, cars, and other types of scale models.

The scale side of the hobby grew dramatically from the 1940s onward, with an increase in the number of manufacturers devoted to producing models and kits built to scale. Companies such as Varney, Globe, Bowser, Tru-Scale, and Walthers led the way with locomotive and rolling stock models and kits, detail parts, and structure kits.

The June 1939 issue of *The Model Railroader* included ads for companies producing scale kits and ready-to-run models in O and HO scales.

Materials have evolved since those early days, from die-cast metal, wood, and early Bakelite plastic to injection-molded styrene, resin, and laser-cut wood. Manufacturing processes and printing and painting capabilities have also improved, which has led to a dramatic increase in the quality of models.

Toy trains are still made, and many are technologically quite advanced, but collecting and operating them remains a distinctive subset of the hobby. This book concentrates on the hobby of scale model railroading, with the focus on creating accurate models and layouts that try to be as realistic as possible.

Basic hobby terms

As you get into the hobby, you'll be confronted by many terms and phrases, some of which are self-explanatory, but others that might leave you puzzled or might not mean exactly what they sound like. The rest of this book will explain many of these in detail, but here's a brief list.

In the hobby, the word *prototype* refers to real-life (full-size) railroading, helping distinguish full-size equipment from models. For example, you may read, "The HO scale model boxcar from Kadee is based on the prototype

Common modeling scales include, from front: Z, N, HO, S, and O. All are models of 40-foot cars, from the 2³⁄₁₆"-long Z scale refrigerator car to the 10" O scale stock car.

Railroading timeline

Railroading has a long, complicated, fascinating history. It can be difficult for beginners to sort out information such as when certain railroads existed or when steam locomotives ceased operations. This listing is far from complete, but it provides a rough idea of how railroads evolved from 1900 through today.

1900: Small steam locomotives (2-6-0, 2-6-2, 4-4-2, and 4-6-0 wheel arrangements) ruled main lines. Most cars were made of wood; a typical boxcar was 36 feet long and a typical freight train was 30 to 40 cars long.

1917: Railroads in the U.S. are nationalized under the United States Railroad Administration, continuing through World War I into 1920. The USRA established standard designs for locomotives and freight cars, many of which lasted through the steam era. 40-foot cars were common.

1920s: Railroad mileage peaked as railroads began abandoning light-density branch lines as highways expanded. Larger steam locomotives became common (2-8-2, 4-6-4).

1930s: Diesel switchers and passenger locomotives began entering service. Large, high-horsepower "modern" steam locomotives (2-8-4, 4-8-2, 4-8-4, 4-8-8-4) entered service. Most freight cars were steel; the 40-foot boxcar was the most common car type. Large-scale abandonment of light-density branch lines continued with the Depression.

1934: The first diesel streamliner, Burlington's stainless-steel fluted *Zephyr*, entered service. Others followed through the 1930s.

1939: Electro-Motive's streamlined FT (cab-unit body), the first successful road-freight diesel, made its debut.

1940s: Diesels began replacing steam locomotives in large numbers on both freight and passenger trains. Major builders included EMD, Alco, Baldwin, and Fairbanks-Morse.

1941: Alco introduced the RS-1, the first road-switcher design diesel locomotive.

1942-45: The War Production Board regulated locomotive production; only EMD was allowed to build road diesel locomotives. Alco and Baldwin were limited to diesel switchers, giving EMD a competitive advantage when wartime restrictions ended.

1948-49: The American Locomotive Co. (Alco) and Baldwin Locomotive Works built their last steam locomotives.

1949: EMD introduces its first road-switcher, the GP7. The road-switcher soon became more popular than streamlined cab-unit style diesels.

1950s: Diesels took over all mainline operations on Class I railroads by the end of the decade.

1955: Trailer Train (later TTX) was formed as a way for railroads to pool piggyback and intermodal equipment.

1959: General Electric introduced its first road diesel, the U25B. The company eventually became the leader in U.S. locomotive production.

1960s: Diesel locomotives and freight cars became larger and longer; six-axle road locomotives, 50- and 60-foot boxcars, and 89-foot piggyback flatcars and auto rack cars became common. Mechanical refrigerator cars took over from ice-bunker cars.

1967: The U.S. Postal Service canceled most rail mail contracts, which doomed most existing intercity passenger service.

1969: The New York Central and the Pennsylvania Railroad merged to form Penn Central.

1969: Alco exited the diesel locomotive manufacturing business.

1970s: Piggyback (trailer-on-flatcar) traffic increased, with solid trains becoming common, as did solid unit trains of coal hoppers and gondolas. 100-ton freight cars became the norm; covered hoppers took over for boxcars in grain traffic.

1971: Amtrak was formed, taking over most intercity passenger trains in the U.S.

1974: Railbox, a nationwide boxcar pool, was formed by several railroads in response to a shortage of general-purpose boxcars.

1975: REA Express (formerly Railway Express Agency), once the largest handler of package and express traffic, went out of business. Railroads exited the less-than-carload freight business.

1976: Conrail was formed with the merger of Penn Central and several other bankrupt Northeastern railroads.

1977: VIA Rail was formed in Canada and began operating that country's intercity passenger trains.

1980s: Most small-town depots with operators were eliminated, as railroads began to rely on radio communications instead of train orders handed to trains by operators. Double-stack container trains began appearing in large numbers.

1980: CSX was formed with the merger of Chessie System and Seaboard System (Seaboard Coast Line).

1982: Norfolk Southern was created by the merger of Norfolk & Western and Southern Railway.

1982: Cabooses were no longer required at the ends of trains, replaced by electronic EOT (end-of-train) devices; most cabooses were removed from service within a few years.

1987: General Electric passed EMD in U.S. locomotive production.

1995: Burlington Northern Santa Fe (now simply BNSF) was created by merger of Burlington Northern with the Atchison, Topeka & Santa Fe.

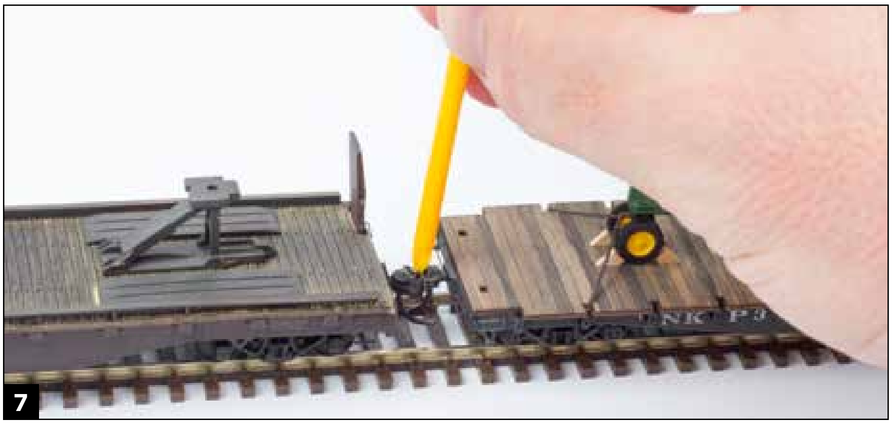
1996: Union Pacific absorbed Southern Pacific. The UP remains the longest-operating U.S. railroad, chartered in 1862 to build the eastern portion of the first transcontinental railroad.

2003: GE introduced its ES44 line of diesels, which—with design variants and upgrades, including the ES44AC—is still in production.

2004: EMD introduced its SD70ACe, which remained in production through 2014.

6

Running long cars on tight curves—in this case, Walthers 89-foot piggyback cars on 18"-radius sectional track—will result in derailments and poor operation.



7

Couplers can be manually uncoupled by placing an uncoupling tool, like this one from Accurail, or a small screwdriver between the knuckles and twisting.

8

The horn-hook coupler was standard on ready-to-run and kit-based rolling stock and locomotives into the 1990s. They look unrealistic and operate poorly.

based on specific prototypes. Older freight car kits are still available and offer potential for detail upgrades. Many buildings come in assembled versions, but kits—including highly detailed plastic models—still rule the structure market, giving modelers the chance to build and customize models.

Layout planning

Restrictions in layout planning for any scale are largely based on curves—namely, the tightest-radius curve that can be used with the equipment that you're planning to operate. In HO, the de facto standard for sectional track has long been 18" radius, making a complete loop 36" wide. Since a good rule of thumb is to allow at least 6" between track and the edge of a layout, this means a minimum 4-foot-wide table (as on a typical 4 x 8-foot layout) for HO layouts.

With 18"-radius track, short equipment works best: four-axle diesels, small steam locomotives, and 40- and 50-foot freight cars. Six-axle diesels and 60-foot cars usually work, but their ends overhang the track and do not look very realistic on curves. Longer equipment, such as modern diesels, steam locomotives with four or more driving axles, 89-foot piggyback flatcars, auto racks, and passenger cars, usually presents too many operational problems to work well, **6**. Truck rotation and car-end overhang may interfere with the couplers and cause derailments.

Broader curves look much better, and they allow you to run longer locomotives and cars. Sectional track is widely available in 22" radius; use this instead of 18" wherever possible. Ideally, try even broader curves if you can; flextrack allows you to lay track of any radius needed (see chapter 8).

As chapter 2 discusses, table-style layouts take up much more room than is sometimes apparent when you add the access space needed around all sides of any table wider than about 30". In HO, this means to look beyond a table and consider a shelf or around-the-walls style layout instead. This is especially true if your preference is toward mainline railroading, passenger operations, or modern railroads with long freight cars.

Couplers

Automatic knuckle couplers are now standard on all new HO models. These resemble and work similarly to prototype couplers, but models have a sprung knuckle that allows cars to be simply pushed together to couple. Uncoupling can be manual, by inserting an uncoupling tool or thin screwdriver between the knuckles and twisting, **7**, or automatic, by using a between-the-rails or under-track magnet. By pausing the couplers over the magnet, the magnet pulls the steel uncoupling pins (the curved pieces under the coupler) apart and opens the knuckles.

Some modelers use the magnetic uncoupling feature, especially on spurs and secondary tracks where cars are typically dropped off and picked up, but generally not on main lines, where cars can accidentally uncouple if a train slows down over a magnet. Many modelers today remove the pins for greater realism; others paint them dark gray or black to represent air hoses.

Kadee was the pioneer in developing realistic knuckle couplers, and its Magne-Matic line of couplers has been available since the 1950s. Into the 1990s, it was virtually the only brand of knuckle couplers available, and they were only available as aftermarket items.

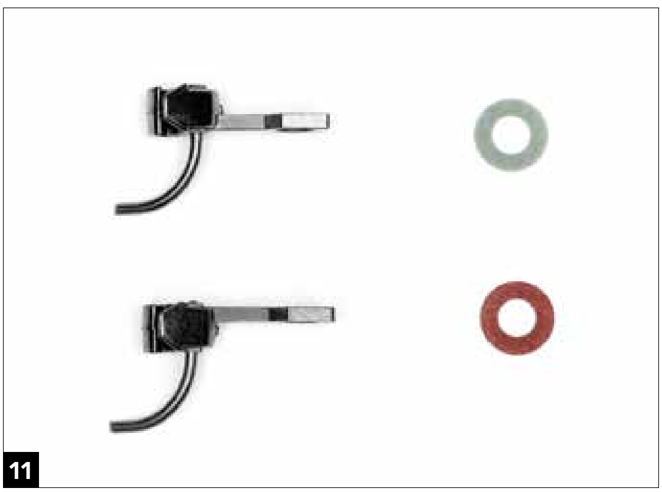
Until that time, all cars were factory equipped with the horn-hook coupler, **8**. These couplers operated as poorly as they looked. Horn-hook couplers coupled easily but were difficult to uncouple, and because of their design, pushing strings of cars

9

Remove the coupler box lid to replace the couplers. This is a Kadee no. 158 whisker-spring coupler (left) and no. 5 coupler with separate bronze spring (right) in Accurail boxcars.

10

Kadee's coupler height gauge is invaluable in ensuring that all cars on your layout are mounted at the same height. The uncoupling pin should clear the base on the gauge.



11

Several manufacturers offer couplers with overset or underset shanks. *Jim Forbes*

12

Replacement metal wheelsets include Kadee code 110 with scale 36" wheels (in an Accurail truck, left) and narrow-tread Reboxx code 88 (33") wheelsets (right).

with horn-hook couplers could lead to derailments.

By that period, most serious modelers had adopted the Kadee coupler as standard. Kadee continues to offer a full line of knuckle couplers, including smaller, scale-size versions that have become very popular. After Kadee's original patents expired in the late 1990s, other companies began offering knuckle couplers, including Accurail Accumate, Athearn (McHenry), and Bachmann E-Z Mate II. Couplers are available with a variety of shank lengths to fit specialized installations.

Many modelers simply keep the couplers that come with equipment; others standardize on a specific brand. Most operate well, but you may notice occasional cross-compatibility issues with couplers from different manufacturers, where they balk at coupling or uncoupling.

Most cars are now equipped with body-mounted couplers, and longer cars often have some type of extended draft gear that allows the coupler shank to rotate on sharper curves. Many older HO cars (especially low-quality models) had truck-mounted couplers. Although truck-mounted knuckle couplers generally operate well, they aren't realistic—they make it difficult to add uncoupling lever and air hose details.

Changing couplers is usually just a matter of removing the existing coupler box lid, which is held by a small screw, clip, or press-in pin, and placing a new coupler and spring in place, **9**. Make sure the coupler shank moves freely from side to side with no binding. If it binds, check for stray plastic or other material, or find a different coupler to drop in.

To operate properly, all couplers on your layout must be mounted at the same height. Mismatched couplers will uncouple, especially on hills or uneven track, and the uncoupling pins on low-hanging couplers can snag on turnouts and crossings, which can derail cars and damage equipment.

Kadee makes a coupler height gauge that should be a standard tool for any HO scale modeler, **10**. Before placing any car or locomotive in service, check it against the gauge on a test track. The

10

Alco's 1960s Century line wasn't enough to save the company. This is the four-axle, 2,400-hp C-424. This HO Canadian National model is from Atlas, part of its Classic Gold line.

11

EMD's GP38-2 was its most popular late-model four-axle diesel, with more than 2,200 sold from 1972–1987. This is an HO model from Walthers Proto 2000.


12

The SD60 was front-line power in the 1980s, as EMD built 537 of the six-axle, 3,800-hp engines from 1984–1991. This is an N scale model from Atlas in Oakway Leasing colors. *Bill Zuback*

13

EMD's F40PH passenger diesel was very successful, with various versions in production from 1976–1992. This HO scale F40PH-2D from Rapido wears VIA Rail's Canada scheme.

Alco kept pace with succeeding RS models (and six-axle RSDs) and then introduced its Century line around 1960, producing the four-axle C-420 (2,000 hp) and C-424 (2,400 hp) and the six-axle C-628 (2,800 hp), C-630 (3,000 hp), and C-636 (3,600 hp) before exiting the locomotive market in 1969, **9** and **10**.

In the 1960s, GE entered the road diesel market with its Universal line, starting with the U25B (four-axle) and U25C (six-axle; middle numbers indicate horsepower in hundreds), followed by the U28, U30, U33, and U36 models into the 1970s (see sidebar on page 22).

EMD continued with its Dash-2 line from the 1970s into the '80s, which were upgraded versions of earlier diesels, and then moved to its SD50, SD60, SD70, SD75, SD80, and SD90 models from the 1990s into the 2000s, with horsepower moving to 4,000 and then 4,400 hp (with a brief effort at 6,000-plus hp), **11** and **12**. EMD also produced the popular 3,000-hp F40PH line of four-axle passenger diesels, **13**.

During that period, GE brought out first its Dash-7 line, then the Dash-8 and Dash-9 line of 3,000 to 4,400-hp locomotives, followed by the 4,400-hp AC4400CW. GE also offered the P40 and P42 passenger engines, **14**.

Today, GE dominates locomotive production, making versions of its six-axle ES44 (4,400 hp), while EMD offers its SD70ACe (see photo 3 on page 29), **15**.

Trends included a shift to six-axle diesels for freight service in the 1960s, with freight engines exclusively six-axle by the 1990s, and a move to AC traction motors for heavy-haul service by the mid-1990s. Both builders offer AC and DC versions of their current models.

Prototype locomotives often varied in appearance through their production runs (some were in production 10 or more years). In addition, each prototype railroad tended to prefer different features or options, such as the type of horns, headlights, brakes, and bell. This was especially true through the 1960s, when 100-plus railroads were ordering locomotives.

You'll find entire books dedicated to individual locomotive models, manufacturers, locomotive series, and locomotive rosters of individual railroads. Don't overlook early builders, such as Baldwin, Lima, and Fairbanks-Morse, all of which produced comparatively few locomotives. All were out of the locomotive business by the mid-1950s, but they remain popular among railfans and modelers.

Steam models

Steam locomotives have always been popular with modelers, and rightly so—they are fascinating machines with many moving parts on display. The design of model steam locomotives leaves less space inside the boiler than does a comparable diesel, meaning manufacturers have to cram more things into a tight space. Many models use the tender for electronic gear, such as a decoder and speaker (as shown in photo 16 on page 33), and use tender wheels for electrical pickup. This means many steam models have a plug-and-socket connection between the locomotive and tender.

14

General Electric's P42 4,250-hp passenger diesels, built from 1995–2001, can still be found leading Amtrak trains across the country. This is an HO model from Kato.

15

General Electric's 4,400-hp ES44AC, or GEVO (GE Evolution Series) diesel, debuted in 2005 and remains in production. This HO model is from MTH.

16

The 2-6-0 Mogul, although bumped from mainline service just after 1900, remained a popular branchline engine through the end of the steam era. This is an N scale model from Bachmann.

17

The USRA version of the 4-8-2 Light Mountain steam locomotive was operated by several railroads. This N scale version is a Bachmann Spectrum model.

Historically, it's always been more of a challenge to get steam locomotives to operate as smoothly as diesels. This is a function of the complex mechanism (as with the real thing) involving side rods and valve gear, and finding a good way to couple the drive shaft with the drivers.

Today's steam locomotive models feature outstanding details and much better operation compared to older models. Many newer offerings are based on specific prototype locomotives and include details to match specific versions or eras. More details are separate, including bells, whistles, pumps, and piping, and most models have detailed cabs that feature figures and backhead detail. Valve gear and rods are more accurately represented, and rods are typically blackened metal (many older models have shiny stamped metal pieces).

The biggest improvement is that steam models are now available with DCC and sound. Adding DCC to older steam locomotives is certainly possible, but it can be very

Common steam locomotive types

Whyte Class	Name	Service	Primary era
0-6-0	Switcher	Yard service	1800s to early 1900s
0-8-0	Switcher	Yard service	1900s to 1950s
2-6-0	Mogul	Freight	late 1800s to early 1900s
2-6-2	Prairie	Freight	late 1800s to early 1900s
2-8-0	Consolidation	Freight	1900 to mid-1900s
2-8-2	Mikado	Freight	early 1900s to end of steam era
2-8-4	Berkshire	Freight	1920s to 1950s
2-10-0	Decapod	Freight	1920s to 1950s
2-10-2	Santa Fe	Freight	1920s to 1930s
4-4-0	American	Freight and passenger	mid- to late 1800s
4-4-2	Atlantic	Passenger	late 1800s to early 1900s
4-6-0	Ten-Wheeler	Freight and passenger	late 1800s to early 1900s
4-6-2	Pacific	Passenger	early to mid-1900s
4-6-4	Hudson	Passenger	late 1920s to 1940s
4-8-2	Mountain	Freight	early 1900s to 1950s
4-8-4	Northern*	Freight and passenger	1920s to 1950s
2-6-6-2	Mallet	Freight	early 1900s to 1950s
2-8-8-2	Mallet	Freight	1910s to 1950s
4-6-6-4	Challenger	Freight and passenger	1930s to 1950s
4-8-8-4	Big Boy	Freight	1940s to 1950s

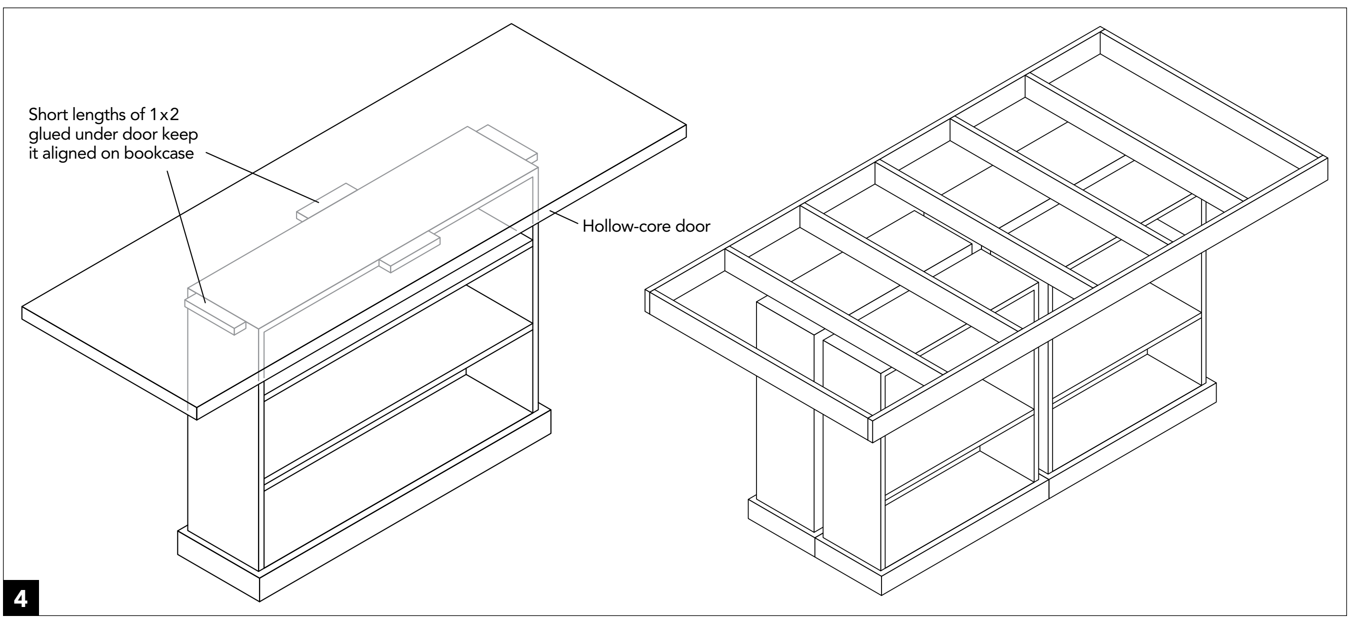
*Also known as Dixies on several Southern railroads

2

Among the simplest designs for table-style benchwork is a hollow-core interior door using either a frame with legs or folding legs. Folding legs can be extended with lengths of PVC pipe, metal pipe, or conduit. *Jim Forbes*

3

Glue and screw 1 x 4s across the door to provide a solid base for the folding legs. The screws must go into the door's outer frame. *Jim Forbes*



4

Bookcases can support hollow-core doors or standard benchwork grids.

Benchwork is the full support structure for a model railroad. It includes the basic framework, legs, bracing, and table—everything below the scenery and track. As you'll see, benchwork can be very simple and utilitarian, or it can be quite fancy. The approach is up to you.

Benchwork can be freestanding, attached to walls, or a combination of the two. Construction style falls into two types: grid or L-girder, with the top surface either open or covered (tabletop). Most benchwork uses a combination of dimensional lumber and plywood, but extruded foam insulation board is also popular.

The type of benchwork you choose depends on the size and style of your layout: Is it an around-the-walls design, with or without peninsulas? Is it a freestanding, island-style layout? Do you want to be able to move it at some point?

Let's look at the advantages and disadvantages of various types of benchwork, and examine a few examples. You can adapt these techniques and styles to your particular situation.

Tables and islands

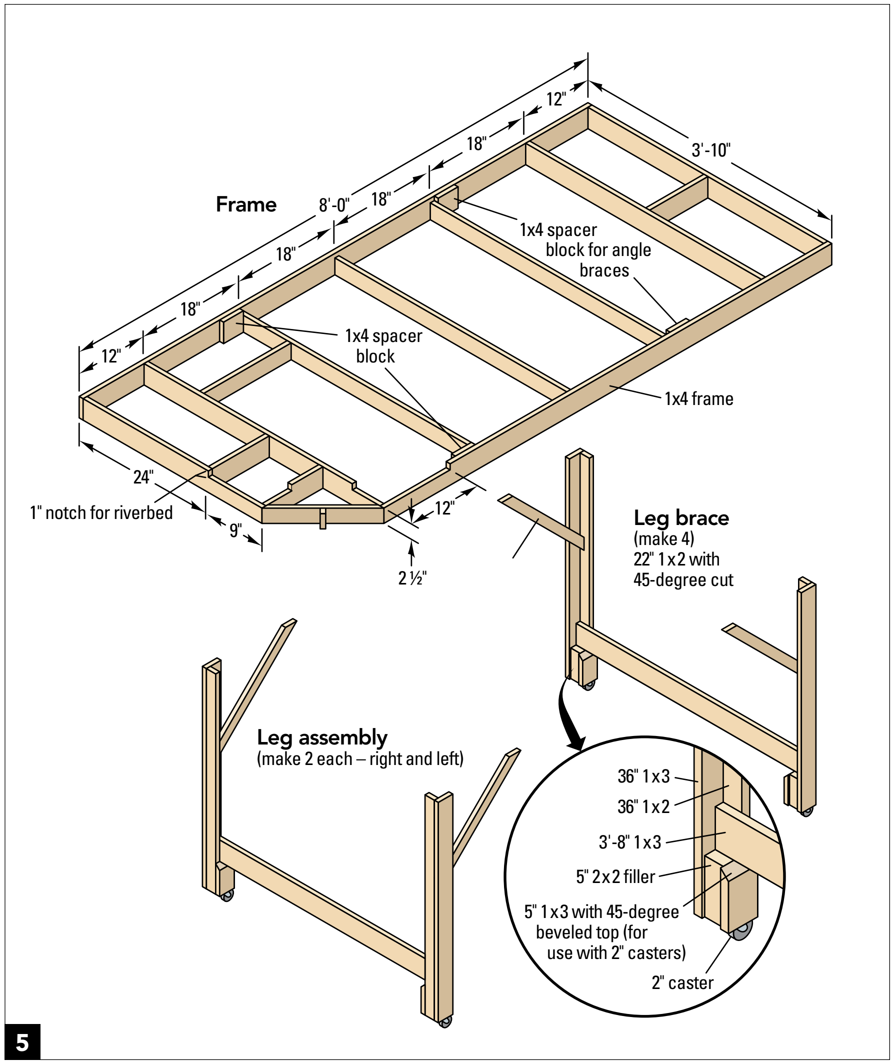
As explained in chapter 2, many modelers start out with small table-style layouts (and many never go beyond that point). An advantage of a freestanding table is that you don't need to drill holes in walls or block anything along a wall.

Among the easiest types of tables to build uses a common hollow-core household door. These doors are lightweight compared to plywood, yet they're strong and relatively inexpensive. They're 80" long (6'-8") and available in 18", 24", 28", 30",

Layout height

Layout height is a much-debated topic. The overall trend is toward tall layouts, where viewers see scenes at or near eye level while standing for realistic views that replicate what we see in real life. Layouts that are too tall, however, make it difficult for working on scenery and track (especially far from the layout edge) and can make it a challenge for shorter people to reach in to uncouple cars or throw turnouts.

For shelf or around-the-walls layouts where operators walk or stand with their trains, consider a height around 46"–50". For a table, consider that same height or one a few inches lower if operators will sit on stools. You should, of course, adjust the height to suit your own preference.



Open-grid benchwork works well for tables and around-the-walls layouts.

32", and 36" widths. They're typically 1¼" thick, made of two thin sheets of lauan plywood, with solid dimensional lumber around the outside of the door.

They are especially handy for N scale, where you can do a complete loop on a 28"- to 36"-wide table, or for HO or larger layouts where you don't need a turnback loop (such as an industrial switching layout). You can also put two loops end to end, in an L shape, or side by side to expand the space.

The basic idea is shown in photo **2**. You can build dimensional-wood framework with legs, or you can mount two pairs of folding table legs under the door, **3**. (You can buy them from home centers and websites, or scavenge a set from an old folding table.) Since these doors are hollow, the backing plate needs to be screwed to the outer edge where the solid wood is located.

Table layouts (hollow-core doors or grids) can also be placed atop bookcases, **4**. A single bookcase will support a door, and two bookcases back to back will support a 4-foot-wide layout. Multiple bookcases can be placed side by side for along-the-walls layouts. Bookcases look good, are solid, eliminate a lot of framework construction, and provide storage space.

Frame and grid

The traditional option for table and larger layouts is an open-grid design, with framework and legs for bracing. There are a number of ways to do this, but a good basic grid design is shown in figure **5**. The principle is simple: a grid of 1 x 3s or 1 x 4s supports the table, with legs made of an L (a 1 x 2 glued and screwed to a 1 x 3) and braced by 1 x 2s.

You can also use 2 x 2s for legs. An advantage of L-design legs is having increased stability in both directions, so they require less angle bracing. This design works for tables to 6 feet wide and 10 feet long; larger tables will need additional legs.

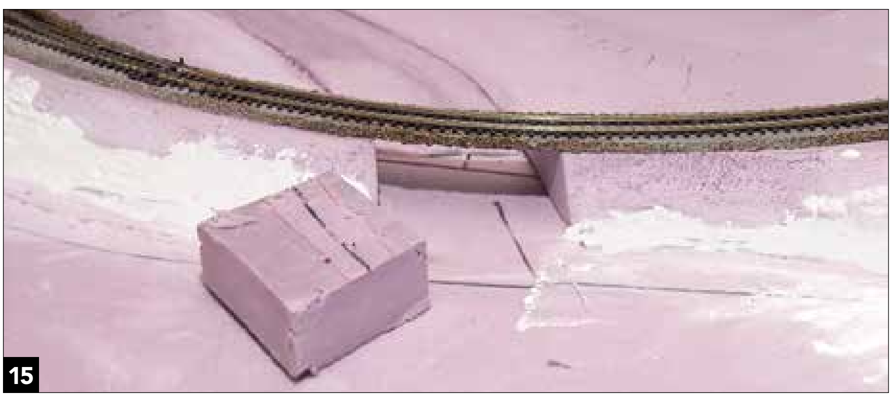
The benchwork built from the drawing shows why the various small cross members were added to the grid, **6**. You'll have to do this based on where you need various components to match your track plan design.

An around-the-walls grid works in similar fashion, and peninsulas can easily be added at any point, **7**. Simply keep extending the grid and add pairs of legs every 6 to 8 feet.

These designs show legs with rolling casters, a good choice for a table design that makes it easily portable. Another option for table layouts is adding adjustable feet to the bottoms of the legs, **8**. The feet make it easy to adjust leg height to compensate for uneven floors. For permanent layouts, you can just cut and adjust each leg to the exact height needed.

A good rule-of-thumb with grids is to make sure the table or subroadbed is supported every 14"–16". Add additional cross members if needed (you

Extruded foam boards can be used as table surfaces, either by themselves or atop a hollow-core door or sheet of thin plywood. *MR staff*



By using two or more layers of foam, it's easy to carve contours for details below track level. *MR staff*

This fascia is cut from ⅛" tempered hardboard. Fascia can be attached with screws into the edge girder (open grid) or the joist ends (L-girder).

Make sure web and flange joints are staggered.

As with open-grid, the L-girder design can be adapted to around-the-walls designs (even wall-mounted), including peninsulas.

Layout tops and subroadbed

Whether you use grid or L-girder as a framework, how you proceed with the layout surface and track base (subroadbed) is a matter of personal preference and the type of scenery you're modeling. If you're modeling a large urban area with no grade changes, or relatively flat territory, you can simply use plywood or foam as a table across the entire benchwork surface.

Cookie-cutter tops are an excellent option, and very versatile, **12**. For this, cut sheets of material (plywood or foam) to allow for raising or lowering the track grade and to allow features placed below the surface, such as lakes and rivers. The elevated portions are supported by vertical wood risers (lengths of 1 x 2s, 1 x 3s, or 1 x 4s) screwed to the grid or cross members.

You can also leave the benchwork open and add just the subroadbed atop the grid, using ½" or ⅝" plywood cut slightly wider than the cork roadbed, **13**. This works well for mountainous areas or rural areas with lots of hills, as the scenery would cover up a tabletop anyway. You can merge this with a cookie-cutter style at town and city areas.

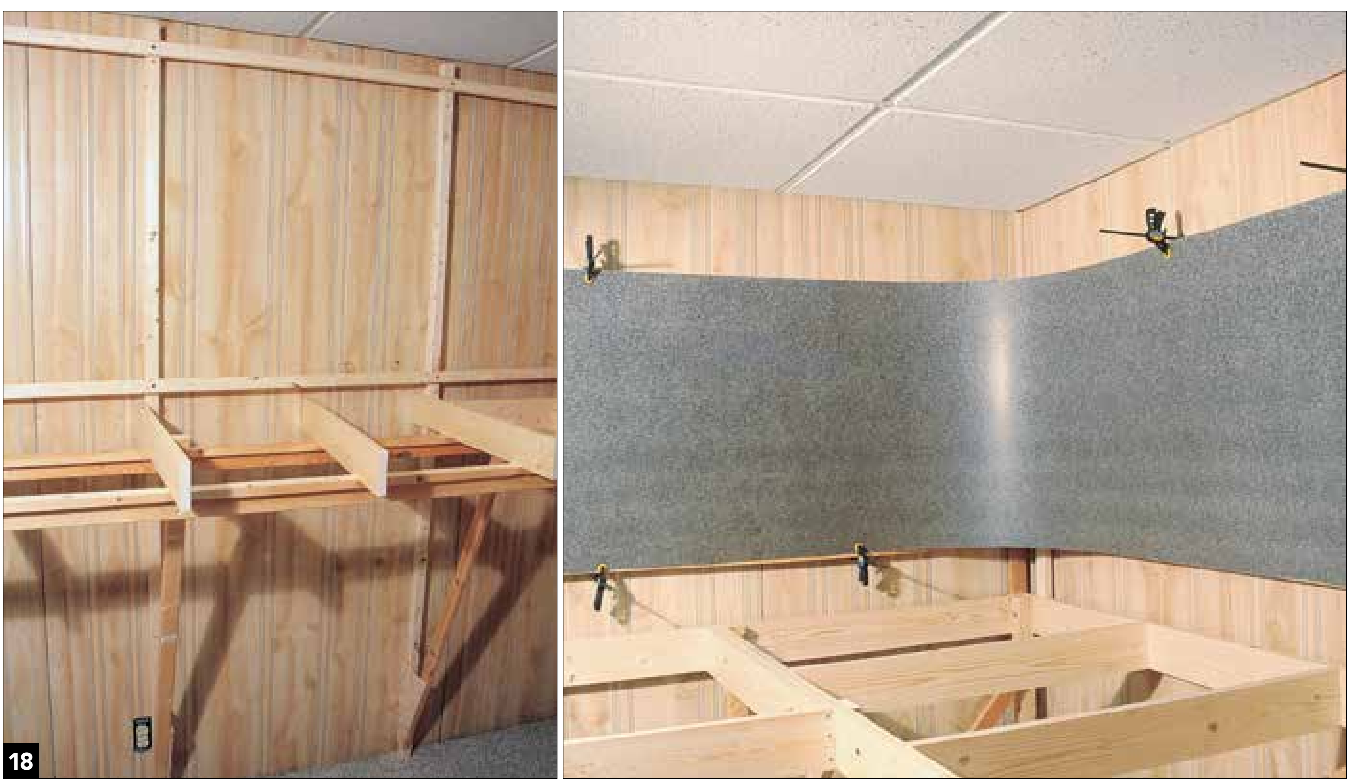
Foam and plywood

Foam and plywood each have their advantages and disadvantages as layout surfaces, and both have their dedicated fans and followers.

Sheets of extruded foam are sold as insulation in thicknesses from ¾" to 2". As a stand-alone table surface, use at least a 2" sheet, or layer two or more sheets atop a ¼" plywood table, **14**. By layering boards of various thicknesses, foam allows you to combine benchwork with scenic contours (see more in chapter 10), **15.**

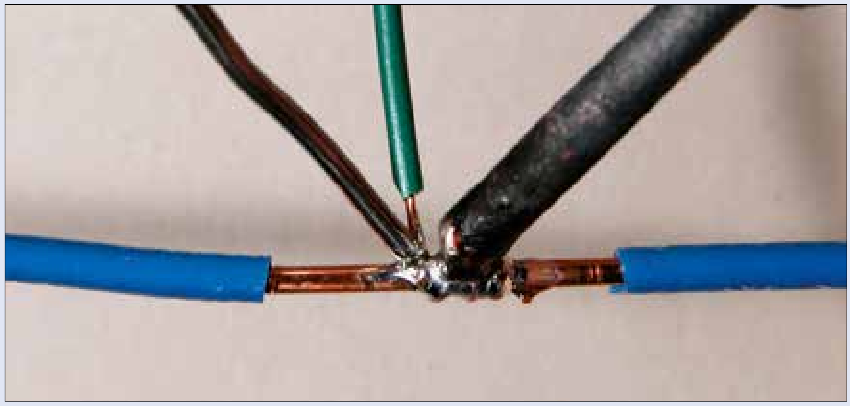
Foam's big advantage is that it's easy to cut without power tools, using a serrated knife or hot-wire foam tool. Disadvantages are that it

17 A simple black curtain hung behind the fascia creates a very clean, neat look on Larry Nast's HO layout. *Dave Rickaby*



18 A simple bracket of 1 x 2s or furring strips supports a backdrop (hardboard in this case). The bracket can be wall-mounted or mounted to the layout itself.

Soldering



Soldering is a basic skill that you'll need to learn for installing many types of wiring, and you'll also need it for some trackwork. Get a good pencil-type soldering iron with a 30-watt or higher rating. Avoid the heavier trigger-style soldering guns.

Use stranded rosin-core solder. A 60-40 tin/lead content works well. The rosin in the core is a flux, which helps clean the joint to make the solder adhere firmly. You can also use lead-free solder. (Do not use acid-core solder, as the acid will cause joints to corrode with electrical contact.)

To solder a connection, you first need a solid wire joint. Strip the wire from the mating pieces of wire with a wire stripper. You can also use a knife, but be careful not to nick the wire, as this can weaken the wire, especially with small wire sizes.

Make sure that the wire is twisted securely; with stranded wire, make sure no stray strands are poking out. Hold the hot soldering iron so that it firmly contacts both wires. Apply the solder to the wires—not to the iron. When the wires become hot enough, they will melt the solder and it will flow into the joint. Remove the iron and then let the joint cool.

Cover the joints with electrical tape or heat-shrink tubing to protect the joints and eliminate the risk of short circuits from bare wires contacting each other. If using heat-shrink tubing, make sure you add the tubing before soldering the joint. After soldering, slide the tubing in place and hold the edge of the iron (not the tip) against it. It will shrink and secure itself firmly to the wire.

22 Hold the tinned wire against the rail with the soldering iron, adding more solder away from the iron.

23 With an insulation displacement connector, slip the connector over the main wire and the feeder wire in the slot. Use pliers to clamp the metal conductor in place.

24 Flip the cover in place and you're done. IDCs work best for track feeders branching off the power bus.

Mechanical connectors are also popular for many types of wire joints. Insulation displacement connectors (IDCs), also known as *suitcase connectors*, are handy for joints where a smaller wire branches from a main wire. They are quick to install, as no stripping of wire is needed. Their main use on layouts is for track feeders from the main power bus.

These are available from several manufacturers and in a variety of sizes (the wire sizes are listed on packaging and often the connector itself). I prefer 3M brand because the metal internal connector is U-shaped, which provides two connection points instead of one as with many other brands, **23**.

To use one, slip an IDC over the main (bus) wire and put the end of the stub (feeder) wire in the appropriate slot. Use square-jaw pliers to press the metal connector in place (the metal tab cuts through the insulation of the wire and just into the wire itself). The plastic hinge is then folded over the top of this tab and snaps in place, **24**.

Keep it simple

Wiring can be intimidating, but for small layouts, it's generally not a complex process. I recommend getting a copy of *Wiring Your Model Railroad*—it's a great reference book for both DC and DCC layouts, and it will help you troubleshoot any problems you might encounter.

More information

The DCC Guide, Second Edition, by Don Fiehmann (Kalmbach, 2014)

DCC Projects and Applications, Vol. 3, by Mike Polsgrove with Cody Grivno (Kalmbach, 2015)

Wiring Your Model Railroad by Larry Puckett (Kalmbach, 2015)