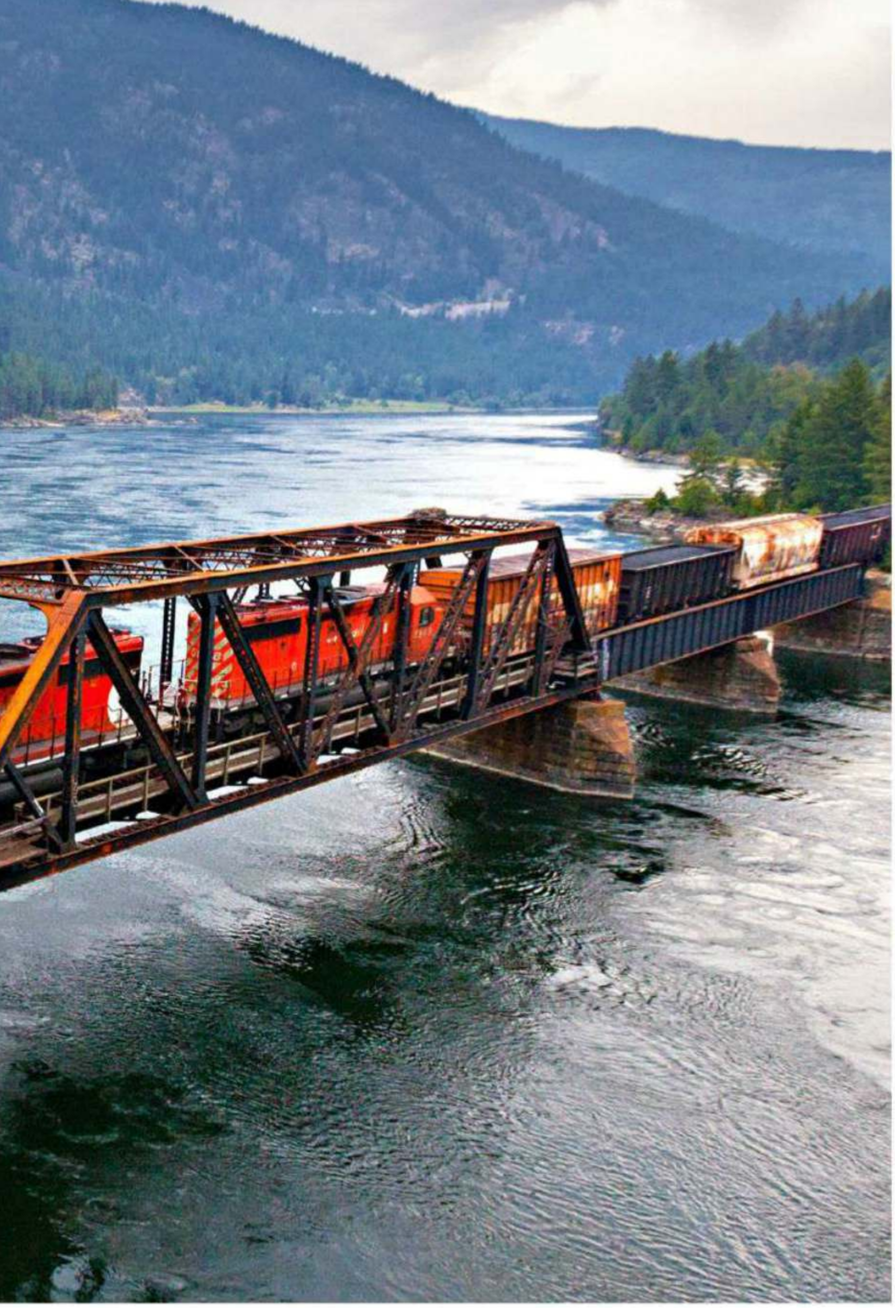
Planning for big bridges

Compression isn't always simple when it comes to these iconic structures

By Mark Dance//Photos by the author unless noted



A westbound Canadian Pacific freight from Nelson bound for the smelter at Trail, B.C., crosses the Kootenay River at Taghum. This bridge, which inspired a model on Mark Dance's N scale Columbia & Western Ry., comprises nine spans of varying styles and crosses two islands over a distance of 763 feet. Matthew Hicks photo

Canadian Pacific's Boundary Subdivision in southeastern British Columbia, the prototype for my N scale Columbia & Western Ry. [see *Great Model Railroads 2016 –Ed.*], required nine large bridges that total nearly 4,000 feet in length to ford the rivers and creeks in its path. If built full scale, that would be 25 actual feet of bridges!

I'd never built a big bridge, but I knew that the bridges would be both significant challenges and strong and recognizable scenic features. I spent considerable time in the planning stages of my layout, first with sketches and then with computer-aided design (CAD), considering the bridges, their compression, and their support. That turned out to be time well spent, and I'd like to share with you what I learned and how things have turned out.

Planning for large bridges

Large bridges require special treatment during the design phase, especially on multi-deck layouts. The layout designer should consider not only the location and size of the bridge, but also its approach, its support elements, and the scenery that it's crossing. On multi-deck layouts, a bridge may also present construction, viewing, and access challenges.

Therefore, it's best to address two questions early in the design: How large will the modeled bridge and its approach elements be in all dimensions? (Or, if you're modeling a prototype bridge, how will the model be compressed?) Secondly, how will the bridge scene be supported?

If you're freelancing a bridge, you have more latitude in design and construction than if you're modeling recognizable prototypes. Either way, following the prototype's engineering practices and copying its look will make the scene more believable.

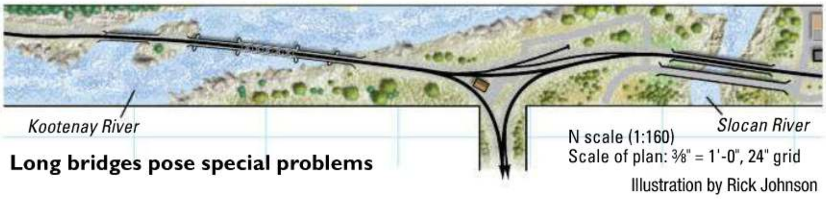
I wanted to reproduce the bridges of CPR's Boundary Sub as closely as possible. In all but one instance, however, space constraints required that I compress the bridges. In two cases, that compression was substantial. So I'll review various compression techniques and illustrate them with specific examples.

Identifying a bridge's character

The first and most important task is to identify the elements of the prototype bridge that create its character. This invariably includes the types of span that comprise the bridge – through-girder or deck-girder spans and through- and deck-trusses are examples – and any approach trestles or fills. Strong characteristic elements may also include the material that these spans and supports are made from, their color and condition, symmetry or lack thereof, the relative size and apparent mass of support members, the number of panels making up any span, and the location and construction of supporting abutments, towers, and piers.

The bridge's appearance will be strongly influenced by relative dimensions such as span depth-to-length ratios, the height of the supported track above the underlying terrain relative to its length (and thus the height of abutments and piers), and the relative height of the bridge compared to the rolling stock that will pass over or through it. These height-to-length ratios will also affect the angles of connecting diagonal elements in the scene, like riverbank slopes and diagonal trusses or links. That means that non-uniform compression –

The same westbound Canadian Pacific freight crosses high over the Slocan River at Fraine, B.C. Unlike the Kootenay River crossing, this bridge does not have a lot of repetitive spans that can be omitted. The author therefore had to use non-uniform compression to reduce the bridge to a reasonable length and height without having it dwarfed by rolling stock passing over it. Matthew Hicks photo



Long bridges pose special problems

Illustration by Rick Johnson

The Kootenay River bridge occupies a scene nearly 5 feet long and is next to an aisle only 3 feet wide, which makes photographing the entire bridge from its side challenging. This segment of Mark's track plan shows the bridges crossing the Kootenay (left) and Slocan rivers on the Columbia & Western.

compressing the length to a different proportion than the height, for example – may change the resulting angles and significantly affect the bridge's appearance.

Try sketching the prototype scene by hand or in CAD and consider what elements you draw first or emphasize the most when you are drawing. Sketching will prompt you to simplify a bridge and reduce it to its most basic elements. Note which details you haven't drawn, as these likely have the weakest impact on the overall flavor of the scene and may be candidates for omission altogether.

Selective omission

Ideally, we would just shrink all of the prototype bridge's dimensions to our scale. But in most cases, something has to give as we compress the design to fit the space available. The most dramatic and space-saving approach is selective omission – leaving entire elements out. If a bridge is made up of multiple spans, could some of these spans be omitted while still retaining its essential character? If a span is made up of multiple panels, could panels be omitted – a 7-panel span reduced down to 5 panels, for example – while still retaining the characteristic elements of the design?

As an example, my prototype's fourth crossing of the Kootenay River is a highly photographed and therefore very recognizable bridge. It stretches 763 feet and comprises one 157-foot through-truss span and eight half- and full-deck girder bridges while crossing over two islands. ("Half-deck" bridges have the track located part way up the girder sides.) This would scale out to nearly 5 feet in N scale, but I had just shy of 3 feet in which to model it.

Nearly all photographs of the bridge focus on the through-truss span crossing the deepest point in the channel, so this needed to be retained. Fortunately, BLMA (www.blmamodels.com) makes a beautiful brass 150-foot through-truss bridge that, though it has four taller panels rather than the prototype's five shorter ones, makes an acceptable stand-in. I could retain the signature element of the prototype at close to full scale with this bridge, but I would have to compress the remaining 600 feet of prototype by about 50 percent to make the rest fit. Those would be some pretty wimpy spans!

What I chose to do was selectively omit one of the islands/channels altogether, along with three of the seven half-deck plate girder spans, and compress the remaining spans slightly. The result is recognizable only to those who know the prototype.

All those redundant elements in the Kootenay Bridge lent themselves nicely to compression by selective omission. A bridge just a few miles west over the Slocan River would prove more challenging; other techniques such as general and selective compression would be needed.

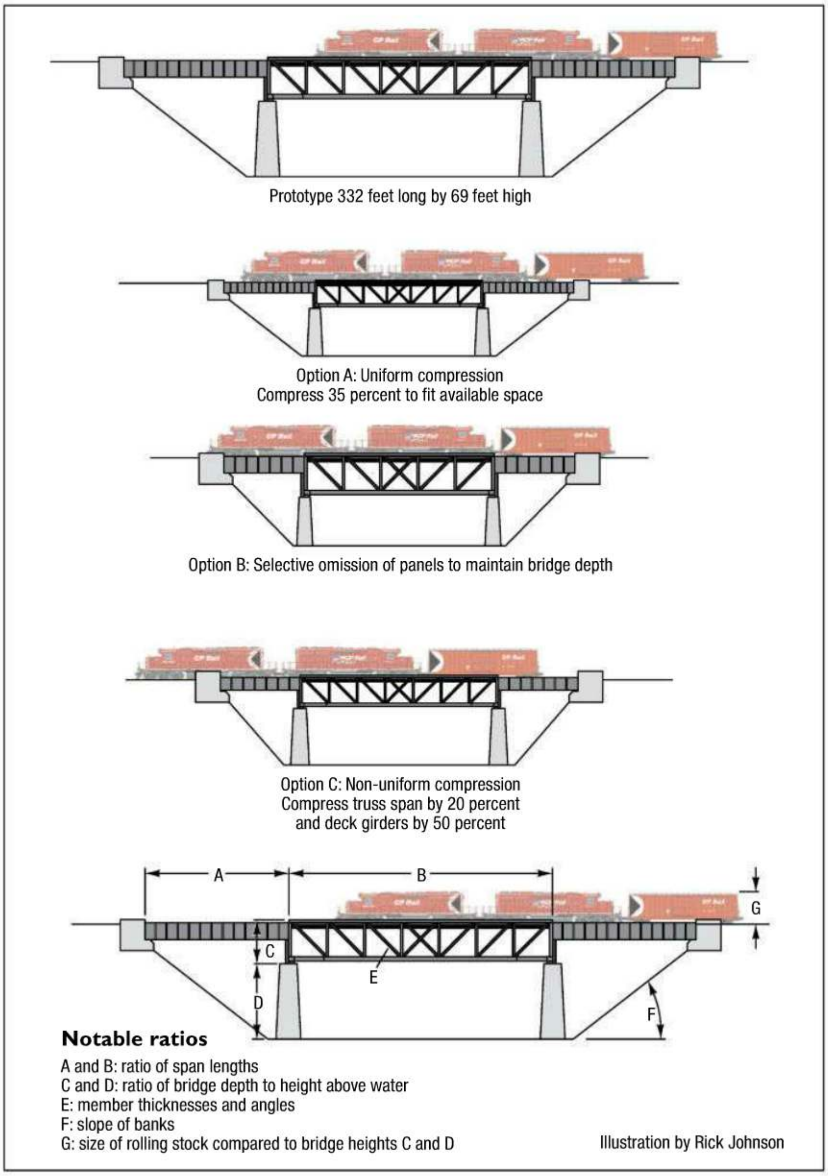
General compression is straightforward: You just scale everything in a prototype scene down by a fixed ratio. For reasons of relative proportionality that I mentioned previously, such as the bridge's height above the water, this can be taken too far and the characteristic appearance of a scene lost or rendered unrealistic. Instead, some bridge elements can be selectively compressed more readily than others. For example, the featureless lengths of a deck-girder bridge are more easily compressed than the lacy members of a through-truss.

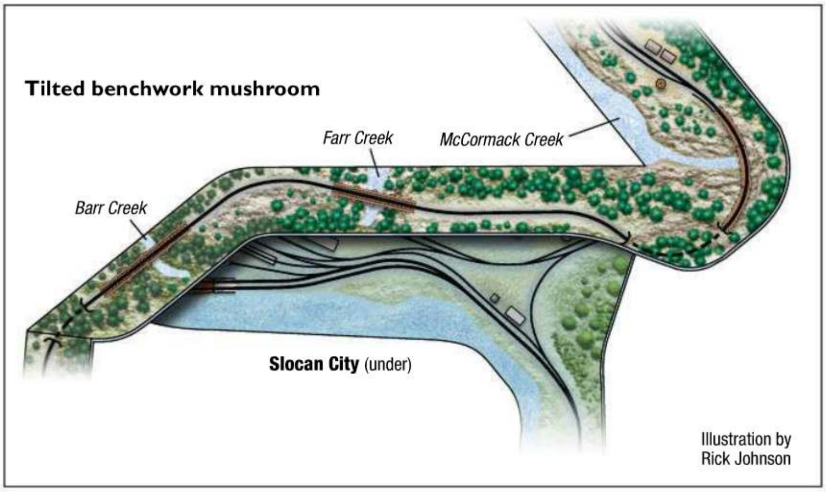
Finally, there's the believability test: Does a specific size and type of bridge make sense to the eye for the compressed distance it's spanning? When crossing a compressed distance, a bridge wouldn't need to be as strong, and its members could be constructed to lighter standards. Conversely, maintaining prototypically sized bridge members for a shorter, compressed bridge can make the bridge look more massive than would make economic sense for a bridge in that location.

The Slocan River bridge

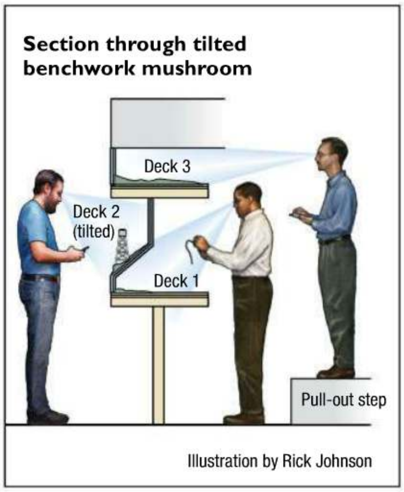
Let's turn to the C&W's Slocan River Bridge to see how these decisions unfolded. Located at milepost 14.6 of the Boundary Sub, the 332-foot-long bridge soars 69 feet above the water where the Slocan and the Kootenay rivers combine. It has two 85-foot deck-girder bridges sandwiching a 157-foot deck-truss bridge.

The finished model of the Slocan River Bridge retains specific features of the prototype: the symmetric mix of deck-truss and deck-girder spans; the number of truss panels; the combination of stone and concrete-encased piers; the recessed bridge deck; and the gradually varying truss member sizes.





This segment of the track plan shows the "negotiated air rights" over a lower deck for the Barr Creek, Farr Creek, and McCormack Creek bridges in the tilted-benchwork section of Marc's mushroom-style layout.



A cross section shows the three decks of the C&W's "double mushroom." Note how deck 2 is tilted.

I considered this bridge's most important spotting features to be the symmetric girder/truss/girder spans, the interesting depressed deck of the truss span, the single stone pier and single concrete pier, and the overall ratio of bridge height to length. As the central truss span is the dominant span, its ratios and height above the water, the number of its panels, and the mass of the truss members are very important. (Note also that the truss elements become smaller farther inward on the prototype because they carry lesser forces.)

Another important ratio to consider is the relative size of the deck truss and girder bridges to the height of the rolling stock traversing them. Too much compression will make the bridge look undersized relative to uncompressed rolling stock.

Finally, I had to consider the Highway 3A bridge, which runs parallel to, and just slightly upstream from, the CP bridge. So how would I compress this scene?

The space available was only 200 scale feet long, 60 percent of the prototype. A uniform 40-percent compression in length and height would leave the rolling stock dwarfing the bridge, while compressing just the length would mean the span's diagonal members would be much more upright. This would unacceptably change the model's appearance.

I could compress the less interesting girder bridges by 50 percent, which would mean the truss bridge would need to be compressed by only slightly over 20 percent. And if I compressed the truss bridge uniformly in depth and length by 20 percent, thus maintaining the angle of the diagonals, the rolling stock would only be 30 percent taller relative to the scale bridge. This could be further reduced by lowering the bridge deck slightly between the trusses. With the shorter distances the deck-plate girders needed to span, I could use the lightweight and readily available 40-foot Micro Engineering girders without the result looking strange.

Since I wasn't certain I was making the right trade-offs, I prepared sketches of the alternatives: uniform compression; fewer panels but prototypical depth; and a hybrid of selective and non-uniform compression. I then sent them to friends for comment. Responses came back quickly with the last alternative as the favorite.

Significant selective omission and compression techniques were used on these first two bridges to fit the available spaces. Fortunately, the four remaining large bridges were simpler: Three of them – those over McCormack, Farr, and Barr creeks – required only a uniform compression of 30 percent in height and length. I modeled the final bridge, the massive fifth crossing of the Kettle River, without any compression at all.

Supporting large bridges

By definition, large model bridges are long. They may also take up a lot of vertical room. Their assembly can be tricky, so a solid, and ideally flat, base is advantageous. On a single-deck layout, or when representing relatively low bridges such as the Kootenay River bridge, the benchwork design is straightforward: A flat reference surface of plywood under the bridge scene may be all that's required, or the benchwork can be dropped in the area of the bridge to give more clearance for the scenic feature being spanned.

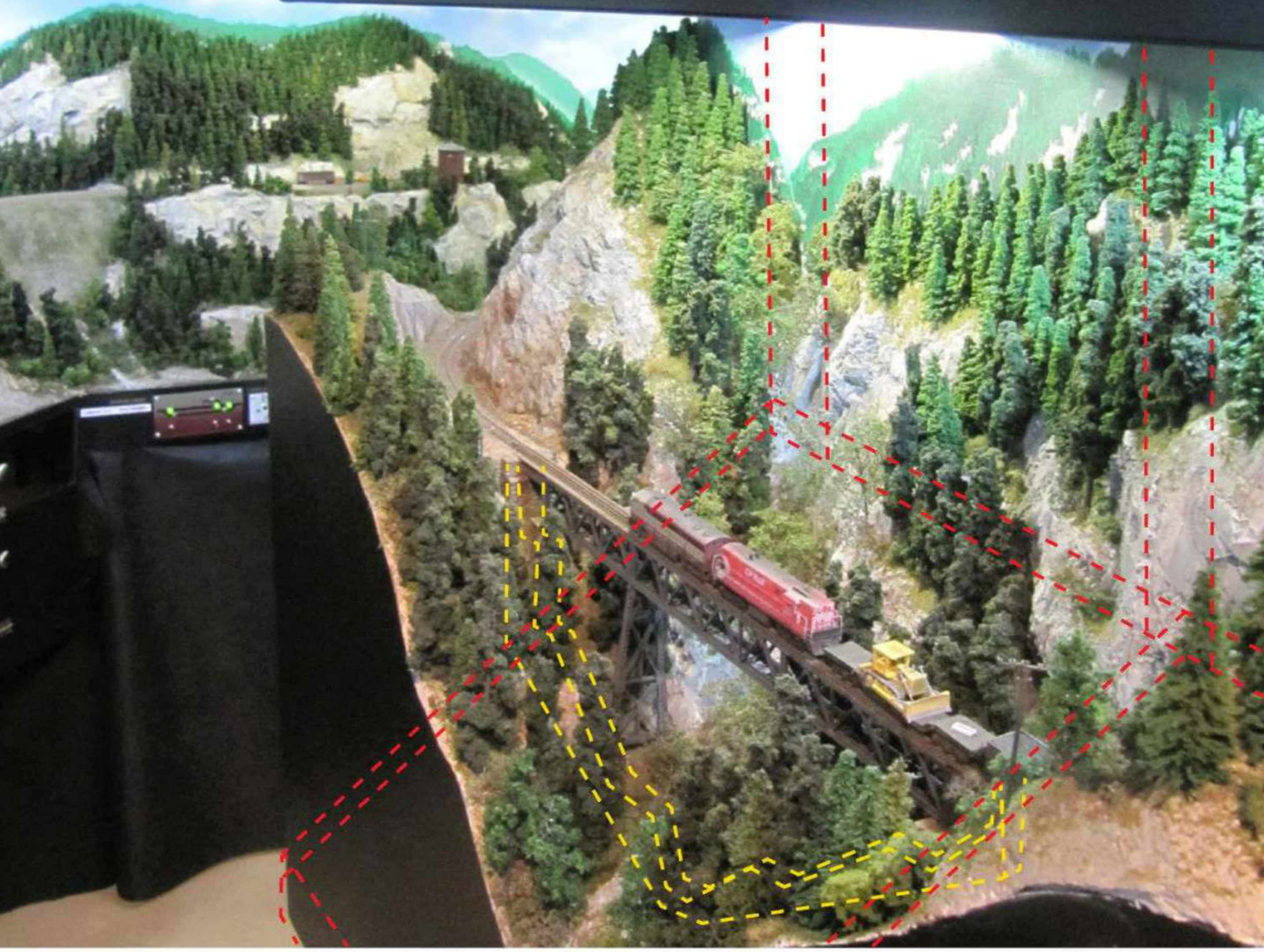
I try to extend the surface under not only the river but also the full length of the bridge so all the piers, approach trestles, abutments, and ballast walls associated with the bridge could be built up from it. While it's possible to build down from the track, most large bridges will bend without a solid surface to sit on.

On the Kootenay bridge, I used ⅜" plywood under its full length, which allowed for simple alignment of the six spans and eight piers or abutments, resulting in level track. On the Slocan Bridge, however, I extended the plywood under the river and the two piers, but neglected to provide a surface for the abutments. Though I was able to fit the abutments to the ends of the roadbed approaching the bridge, the work would have been considerably easier had I been able to place the abutments on the same flat surface as the piers. A bit more planning in this regard would've saved time and headaches later.

A further benefit from planning and installing a solid reference surface for large bridges is that scenery can be finished well in advance of the construction of the bridge. The C&W was operated for years with scenery mostly complete but with only mock-up bridges, because I was confident that when the bridges were built I knew how they would be supported.

Coping with multiple decks

Planning support for any large bridge early in a design process is



The Farron Hill side of the mushroom shows the tilted benchwork (red lines) and a profile board (yellow lines). Multi-deck designs of mountainous terrain can use tilted benchwork and negotiated air rights to allow tall scenes without needing to resort to adding helix turns or increasing grades in a quest for adequate between-deck clearances.

helpful. But if the layout is multi-deck – either conventional or, like mine, a mushroom (where multiple decks face opposite directions on either side of a backdrop), this planning may be crucial. Multi-deck layouts need not be limited to high, narrow benchwork with deck-to-deck clearances of a foot or less. Although easier to construct, simple stacked decks are unlikely to provide the depth necessary to adequately model tall bridges.

Conversely, simply increasing the deck separation may waste the layout's vertical space, place decks at awkward heights, and increase the real estate required for the track to attain vertical separation. An alternative approach for multi-deck layouts is impinging upon the vertical space of the deck below to make room for a feature above.

In his book *Designing and Building Multi-Deck Model Railroads* (Kalmbach Books, 2008), MRP editor Tony Koester described a situation on his HO railroad where the lower deck track is temporarily hidden from view as it makes its way beneath a key bridge scene that projects downward from the deck above. This "air rights" approach, while allowing vertical space for signature scenes, brings its own challenges, notably restricting access to the scene below and limiting the lower deck's usefulness in that area.

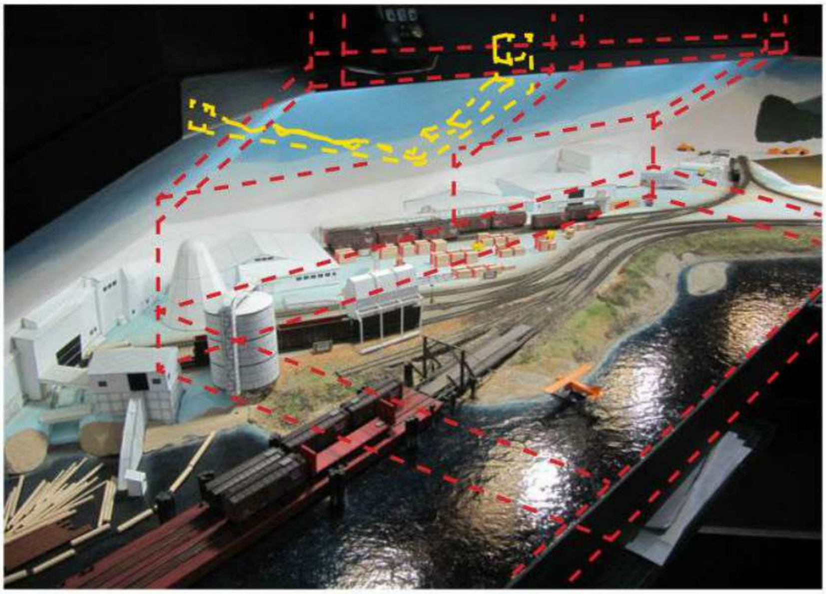
This restriction can take a number of forms, including reduced access for construction, maintenance, photography, and, most importantly, operation. I'll describe two approaches used on the Columbia & Western to mitigate these limitations.

As the Boundary Subdivision winds and climbs out of the Columbia River valley along Lower Arrow Lake to the Monashee Mountain summit at Farron, it crosses three tall steel trestles: the McCormack Creek, Farr Creek, and Barr Creek bridges. Although difficult to view, the prototype trestles are accessible from the rails-to-trails roadbed, which now exists where the Boundary freights once roamed. I wanted my N scale models to do justice to their engineering.

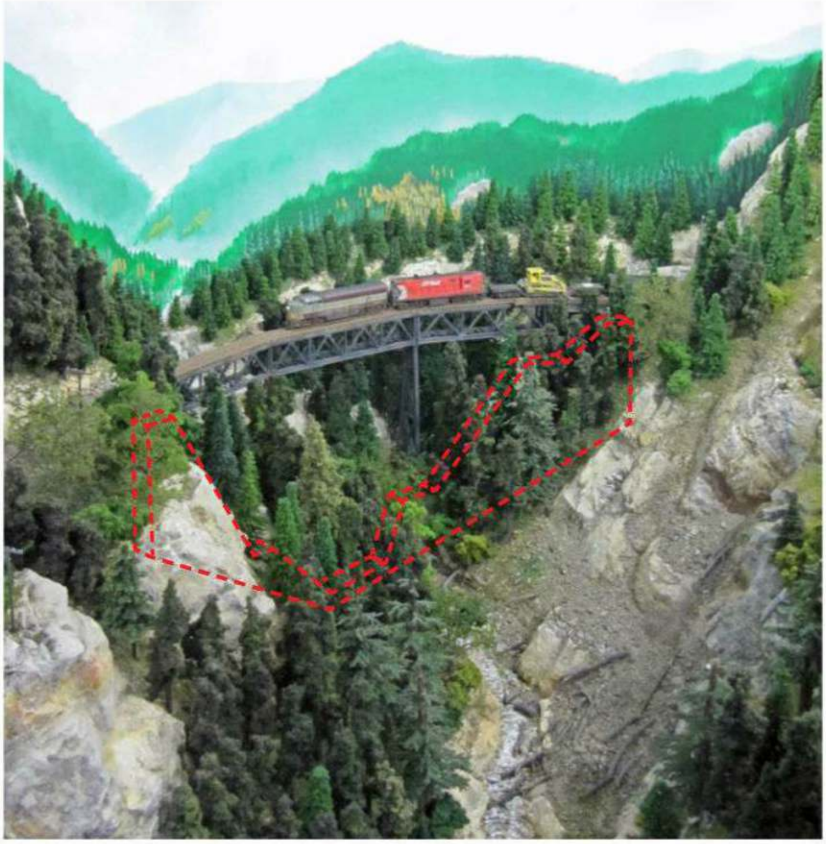
Another signature feature of the CPR's operations in the area was the rail barge operation between the isolated Slocan and Kaslo subs. These parts of the layout occupy a central, inward-facing 8 x 8-foot area in the layout room with the Kaslo Sub stacked over the Slocan Sub. Rail barges are used to transport entire trains between the decks, just as on the prototype.

A "double mushroom"

Sandwiched between these decks, but facing outward, is the lonely climb to Farron summit, resulting in a "double mushroom" configuration. If



The Slocan City side of the mushroom shows tilted benchwork (red lines) and a profile board (yellow lines). A compromise Mark accepted in the negotiated air rights was a slanted backdrop behind the Slocan City sawmill. The backdrop is made from thin hardboard fastened to the underside of the tilted middle deck.



McCormack Creek is deep at the end of a turnback curve. The track to staging is located directly beneath this deep scene, and the profile board installed when the track was laid is marked in red. Scenery and operations preceded the bridge construction by many years, but when this complex curved trestle was finally installed, the profile board beneath the scenery allowed the piers and abutments to sit at a fixed, known height, greatly simplifying installation.

the outward-facing middle deck were narrow but otherwise of conventional level construction, then the sawmill town of Slocan City beneath it could be fully accessible. However, there wouldn't be enough depth in the middle deck to reproduce the soaring heights of the three steel trestles.

So I made a compromise. By tilting the open girder framing of the middle deck so it was lower at the front and higher at the back, enough depth became available to model the three bridges with a uniform 30 percent compression. Adequate access remained above Slocan City for switching the mill. The sky backdrop behind the mill was angled for a large portion, but this was a compromise I deemed acceptable.

About 20" of vertical scenery was made available for the bridge scenes by tilting the benchwork, versus 9" if the middle deck were conventionally flat. So the added complexity of the benchwork bought an additional 150 scale feet of height, enough to accommodate those 190-foot-high trestles compressed by 30 percent.

To provide a reference support for these bridges, I used CAD to draw the eventual scenery profile under each bridge with flat surfaces for the piers and abutments to sit on. This was transferred to ¾" plywood profile boards, which were hung below the roadbed to provide a surface to support the piers and bridge above.

I completed the scenery, including trees, around all three bridge sites, and the layout was operated for years before the bridges were installed. When they were completed, I simply cut small holes into the scenery above the profile boards, dropped the abutments and piers through the scenery, and secured them to the profile boards.

The bottom edge of the profile boards also helped to protect the air rights above the Slocan Sub, since I knew I couldn't go below these planes without impinging on the scenes below. In fact, I used the bottom edges to fasten the angled backdrop behind Slocan City. Using CAD early in the process to plan the layout and benchwork saved me a lot of calculations, and probably errors, and the actual benchwork construction and the scenery and bridge installation went very smoothly as a result.

The last big bridge

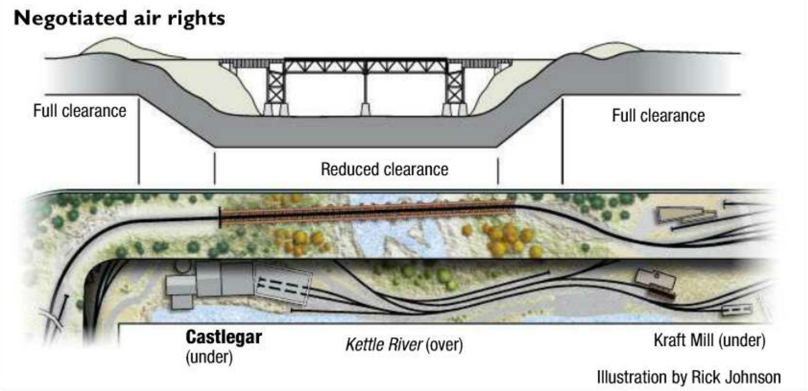
This brings us to the last big bridge on the Columbia & Western, the fifth crossing of the Kettle River at the western foot of Farron Hill. The prototype bridge stands 80 feet tall and stretches 505 feet long. When originally constructed as a wooden trestle/bridge combination, this bridge was nearly three times as long. But when that wooden trestle was replaced with steel around 1910, the approach trestles were filled in, creating the massive approach fills visible today. The prototype bridge has three deck-truss spans interspersed by deck-girder spans, all supported by a unique pair of angled steel towers.

Having biked the trail across this trestle, I was determined to find room for this model in all of its uncompressed glory. The problem was that this bridge was located above a complicated switching area, including Castlegar Junction and its yard, as well as the Celgar Kraft mill. Multiple trains would meet here, and the busy Kraft Switcher would ply its trade, adding congestion to the aisle and requiring unimpeded access to the lower-deck tracks for uncoupling.

I found a solution through "negotiated air rights":

- The upper deck benchwork where the bridge would be located was narrowed to 12" while the lower deck was broadened to 24".
- The upper benchwork was dropped by 5" at the location of the bridge and approach fill, thus permitting a full-scale model of the bridge. This benchwork was framed with 1 x 2s and covered with a ¼" sheet of plywood, thus reducing the clearance under the depressed bridge scene to a bare minimum 8" but retaining a minimum 14" deck-to-deck clearance in other areas.
- Low-profile fluorescent light fixtures augmented with white light-emitting-diode strips fit nicely between the 1 x 2 framing to light the lower deck in this area.
- Tracks on the lower deck, especially turnouts and logical uncoupling locations, were routed forward and around the low-clearance area as much as possible.
- It was important to have a large 4'-6" wide alcove adjacent to Castlegar Junction to allow the engineer of the Kraft switcher to stand relatively unimpeded for much of the session.

The result, while a compromise, works. The full-scale bridge and its approach fill are displayed in all their glory, the lower-deck track is accessible, and – by and large – crew members politely manage the operator traffic jam caused when multiple meets occur at Castlegar.



One of the most active switching areas on the layout sits directly below one of the most prominent scenic features, the Kettle River Bridge. In such situations, benchwork clearance and track location is critical to the viability of operations. The lines on the diagram above and the arrows in the photo below show where the upper-deck benchwork was dropped on a thin frame to permit a full-scale rendition of this signature bridge. This reduced clearance here to only 8", an acceptable compromise, since most track is routed away from this area.

The Kettle River Bridge/Castlegar scene illustrates the trade-offs between the air rights required to make the lower deck operationally viable while not compromising the space available for Mark's full-scale rendition of the bridge.

Lessons learned

Years of frequent work travel provided the time to plan not only the signature bridges on the Columbia & Western, but also the entire layout well in advance of construction. Did I make mistakes? Absolutely, but I think I would have made more without the planning. The result is admittedly a complex design, but it's simpler to operate because of the tilted mushroom and the negotiated air rights. And I believe the many large bridges do justice both to their prototypes and to the remarkable engineers who constructed the Boundary Sub. MRP

Mark Dance and his wife, Christiane, live in Vancouver, B.C., with children Carys and Isaac. Mark has a degree in mechanical engineering (robotics) and spent 20 years as a product designer/inventor and manager. He has modeled in N scale for 42 years.

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A video walking tour of Mark's N scale Columbia & Western layout can be seen on our website. Look in the Online Extras box at **www.ModelRailroader.com.**