

18. Layout Splines

Layout Splines are a revolutionary new method to convert your digital track plan into a full scale layout. Instead of printing your layout onto paper to transfer to plywood or other roadbed material, Layout Splines can be digitally cut using CNC cutters, laser cutters or other similar digitally driven machines. They can be used to determine placement of the track and track centerline or to create spline-like roadbed. When Layout Splines are generated, they take into account all changes in elevation along the path to provide highly accurate results in all situations. CNC routers and laser cutters are becoming more accessible to the general public, or you can have El Dorado Software produce Layout Splines from your drawing file.

18.1 Varieties of Layout Splines and Materials

Two types of Layout Splines can be produced: Track Splines or Roadbed Splines. Track splines are used to help lay out your track onto roadbed material of your choice by fitting between the rails of flex or sectional track, letting you install this track and accurately match the complex curves and designs possible with 3rd PlanIt. Roadbed Splines are usually as wide as or wider than the track and ties, and can be used as actual roadbed support for the track.

18.1.1 Track Splines

Track Splines can be built with centerline slots if you choose. You place the Track Splines on your layout surface, position them as you intended, then draw centerlines on the layout surface through the slots to guide placement of cork or foam roadbed. You can also use a tool available from El Dorado Software that holds two mechanical pencils to trace both sides of the roadbed onto your layout surface. This is most useful when you're using foam roadbed that is full-width, rather than half-width cork roadbed.

After you've installed your roadbed and want to lay track, you can use your Track Splines again. This time you'll place them within the rails of the track. The Track Splines will guide you as you flex the track into its planned shape. Track Splines are fabricated using Expanded PVC (XPVC) or, in some cases, a wood product as the material. Expanded PVC is a durable, closed cell, free foam PVC sheet material that combines a rigid exterior and matte finish.

If they are made with XPVC, they have a slight flexibility that lets you smooth the track curvature and adjust its placement from your original plan, as sometimes can be desirable. You can choose Track Splines made with 1/8" or 1/4" thick XPVC. 1/4" XPVC flexes less than 1/8" XPVC. While either will provide good guidance for drawing centerlines, you may wish to have 1/4" material if you want the least accidental deviation from your plan. 1/4" material costs more than 1/8" material, so, in general, 1/8" is the best choice for most situations. To achieve the highest faithfulness to your drawing, 1/8" Track Splines made from a wood product such as Masonite or MDF (Medium Density Fiberboard) flex the least.

18.1.2 Roadbed Splines

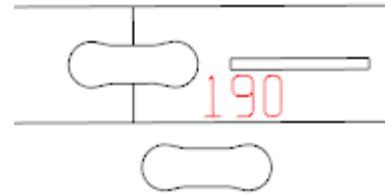
Roadbed Splines are made to support your cork or foam roadbed. They may be set to Roadbed width specified in the 3rd PlanIt Layer Properties for each track layer, or may be set to a Custom width of your choice. Roadbed splines are typically made of plywood, Masonite, or other wood products.

Roadbed Spline material may be 1/8" to 1/2" thick for most purposes. If you have changing grades in your layout, the Roadbed Spline must be able to flex vertically to make a smooth grade transition. While it is possible to cut 1" or thicker Roadbed Splines, they will not flex sufficiently to make a change in grades. For that reason, Roadbed Splines are typically 1/8" or 1/4" thick.

You may also cut Roadbed Splines into MDF (Medium Density Fiberboard) or HDU (High Density Urethane) foam. Both products offer superior temperature stability and excellent workability. HDU is a wonderful material that can be sanded like wood or trimmed with a vibrating cutter. Typical thickness is 1/4", but can be milled to 1/8" for better flexibility at additional cost.

18.2 Notching of Layout Splines

As it is not possible to cut splines of great length on either CNC routers or Laser cutters, the splines are built with Notches and matching Connectors as shown in the image to the right. The image shows a junction of two Track Splines, including the Spline Label and one of the centerline slots. A set of Connectors, one of which is shown in the image, is provided as part of the Layout Splines build process.



Notches and Connectors allow you to build Layout Splines of any length. You may glue together adjacent splines joined by Connectors until you have the spline length best for you. There are practical limitations to the longest usable Layout Spline..While it is possible to glue together your whole layout as one huge spline set, you won't be able to move it when you need to or conveniently store it. Remember that splines can be temporarily attached by unglued Connectors. If you are working with Track Splines, it's best to have one complete spline for each track path between turnouts, assuming the length is manageable.

If you are working with Roadbed Splines, you will be adding them to your layout as you build it. In this case, it works well to glue together a 4- to 8-foot section on a flat surface with wood glue or construction adhesive, and then glue that section onto the end of previously installed Roadbed Splines. A good strategy is to glue together yards or turnout groups as one section, position the most critical element on your layout, then glue additional segments to that and work your way along the track paths.

While building your layout with Roadbed Splines, you will want to support it with Risers as typically found for hand-made splines (see www.TrackPlanning.com/splines.htm). It's far faster to build a layout with Roadbed Splines than to hand-craft splines from poplar and glue or hand-cut them from sheets of plywood, yet gives you the same freedom of placement with built-in accuracy. It's good practice to leave an occasional Connector/Notch junction without glue until you've positioned the Roadbed Spline end-to-end, in case you need to slightly adjust the path along the way. However, make sure all Connector/Notch junctions are glued prior to installation where a change in grade is found, or the grade change may not have a smooth vertical transition.

18.3 Building Layout Splines from your Track Plan

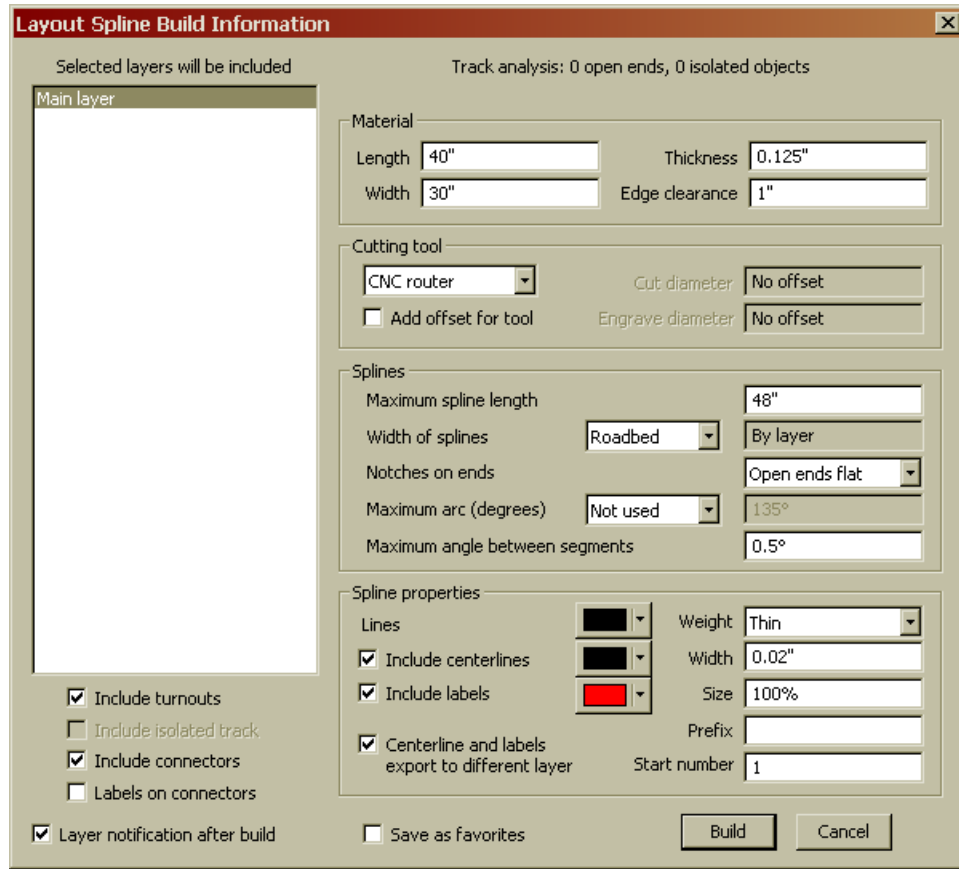
Now that you have some background in the use of Layout Splines and various materials, it's time to build a set of splines from an existing track plan. We'll use a simple point-to-point example made from SoftTrak as well as individual track objects (curves, easements, tangents and a turnout).



All track objects are in the Main Layer, as typical of many small track plans. However, Layout Splines can be built from more than one layer in a complex design. Before building your Layout Splines, make visible any layers for which Layout Splines should be built.

It's always good practice to save your file before generating Layout Splines, especially when you are first learning how to generate and edit them. You can easily revert to your known-good document should something go wrong during the process.

To begin, select Tools / Build Layout Splines or use the shortcut F12. If the shortcut is not active, select Tools / Shortcuts and click Reset All. After issuing the Build Layout Splines command (F12), the Layout Splines Build Information dialog appears:



While there is a lot of information presented, it is broken down into related fields that do not change frequently. Let's review each area, starting on the right side.

18.3.1 Track analysis

This is perhaps the most important field in the dialog. If you have open ends, you really should not build Layout Splines without reviewing your plan in **View / Display style / Questionable track** (Alt+Q). You'll often come across a mismatch in elevation at ends that appear connected in 2D, or an open connection that is only apparent if you zoom in deeply. To get good Layout Splines, start with a good track plan!

If isolated objects are detected, decide whether they are intentionally isolated, such as the radial track around a turntable. They may also be hidden lines underneath other lines and other drawing errors that should be resolved prior to building Layout Splines.

18.3.2 Material

In these fields you select the **Length** and **Width** of the material based on the capacity of the machine which will be used to fabricate the Layout Splines. The **Thickness** field is used to set the engraving depth for labels when the splines are fabricated on a CNC router. Make sure to set Thickness to match the material you plan to use. **Edge Clearance** allows you to provide enough "wobble room" for positioning the splines for fabrication.

18.3.3 Cutting tool

You may choose **CNC router** or **Laser cutter**. A CNC router needs to use two cutting tools to fabricate Layout Splines: one to cut the edges and another to cut centerline slots for Track Splines and labels if selected. The field **Add offset for tool** provides a basic tool path for the chosen cutting tool. For example, a CNC router using a 1/8" (0.125") diameter end mill needs to run the center of the tool offset outside the

spline by half its diameter (1/16" or 0.0625"). You will not need to use this field if you submit your job to El Dorado Software or another commercial vendor. In-house CAM (Computer-Aided Manufacturing) software generates the optimal tool path for the cutting machine from the edge outlines provided in the exported DXF file generated in your final step to production.

If you have access to a machine that does not have CAM software to generate the necessary tool offset, **Add offset for tool** will be handy. If you select **CNC router**, two diameter fields become active: **Cut Diameter** and **Engrave Diameter**. The end mill discussed above is entered as the Cut Diameter, and will typically be either 1/8" or 3mm. If you select Laser cutter, only one size field is active: **Cut diameter**. This will be the beam width at the least focused extent. The default value is 0.003" as found on a commercial laser cutter. Hobbyist laser cutters will typically have a beam width of 0.006" or a bit more, depending on the optics of the system. Although a laser cutter has only one diameter available, it also can engrave material as well as cut. Isolating lines to engrave from lines to cut is discussed in **Spline properties**, below.

18.3.4 Splines

These fields control the specifics of how Layout Splines are built by 3rd PlanIt. **Maximum spline length** helps you control the length of the splines in concert with other limitations. Above all, Layout Splines are limited by the specified size of the material less the specified edge clearance along each side. In the 40x30" example with 1" edge clearance, the size of splines is constrained to 38x28". You can further reduce the maximum spline length to a chosen value if you wish.

Width of splines determines whether you are building Track Splines or Roadbed Splines. The example builds Track Splines because its width is set to **Rail Spacing**. The value field shows **By gauge**, because the width of the spline is computed from the gauge information in the **File / Settings / Track** dialog and the model scale set in **File / Settings / Units**. Similarly, if you choose Roadbed for Width of splines, the roadbed defined in each objects layer is used (**Action / Modify Layers / (Main layer) / Ballast and Roadbed**). You can also select **Custom** width and enter a specific value.

Notches on ends lets you choose **All ends flat**, **Open ends flat**, or **All ends notched**. This is typically set to Open ends flat. Unless you select All ends flat, turnouts are built with notches on open ends as well as connected ends. This lets you add track in the future and easily connect it to the existing turnout end.

Maximum arc helps you control spline length in special situations, such as a helix. You want to make best use of the available material, and later in the process you will position Layout Splines within a material outline. If your helix spline is generated until it would intersect itself, you'll have a few very large round splines that don't pack nicely onto material. This may be OK – you may choose to have fewer junctions and give away some excess material. If you prefer to use material more efficiently, try setting **Maximum arc** to 120-180 degrees. You'll find it much easier to arrange splines on the available material.

Maximum arc (degrees) controls the accuracy of cut compared to the curvature of the track. Curves are provided to the cutting machine as a sequence of lines that approximates the curve. The value of 0.5 degrees keeps the lines within 0.005" and 0.25 degrees keeps the lines within about 0/002". The smaller the value, the larger will be the generated data file sent to the cutting machine.

18.3.5 Spline properties

Here you can control the content of your splines and provide information to the cutting machine to fabricate them properly. The **Lines** color field is often used to control the beam power of a laser cutter, and could be used to select a tool on a CNC router. The **Lines / Weight** field controls the thickness of the Layout Splines in the 3rd PlanIt view.

You can choose to **Include centerlines** if you wish. If so, you can select a color appropriate to what you are making and the fabrication machine. If you are making Track Splines, you'll want to trace a centerline with a 0.6mm mechanical pencil. If a laser cutter will be used, this should be set to the same color as the Lines color. If you're making Roadbed splines on a laser cutter, the color should be appropriate to engraving, as you want to lay roadbed direction on the spline. You can also choose the width of the centerline, which in the example is a value appropriate for the mechanical pencil.

Include labels generates a numbered sequence of labels with a chosen **Prefix** and **Start** number. You'll almost always want to generate labels – it is far more difficult to recognize a specific spline than you would expect! Labels help greatly by showing you what connects to what. Along a path of splines, the sequence number always increments by one until reaching the end or a turnout. Since labels will always be engraved, you can set the color as appropriate for power setting or bit selection on the cutting tool.

Centerline and labels export to different layer can help the operator of either style cutting tool. Some CAM packages work most naturally if the mill or power setting is made by-layer rather than by-color. Choosing this option creates a DXF export file with a layer named **Layout Splines** and an extra layer named **Layout Splines Ext**. Spline outlines export to the Layout Splines layer, while labels and centerlines are exported to the Layout Splines Ext layer.

18.3.6 Selected layers will be included

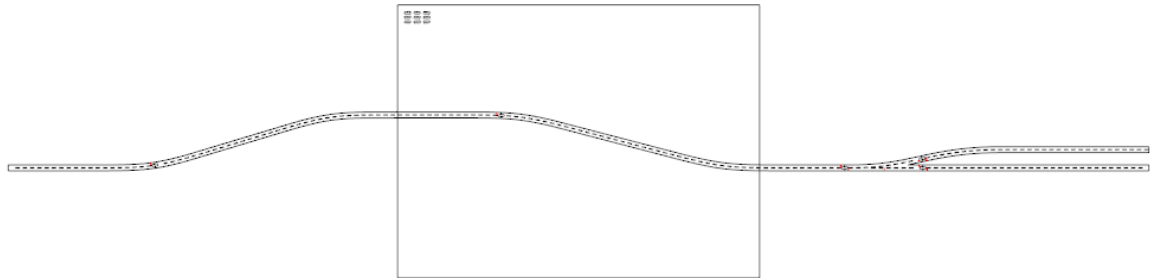
This list box will be populated with all layers in your track plan that contain track. Layers holding terrain, rolling stock and other non-track objects are not included. All layers selected in this list will be included in the Layout Spline build list.

18.3.7 Checkboxes

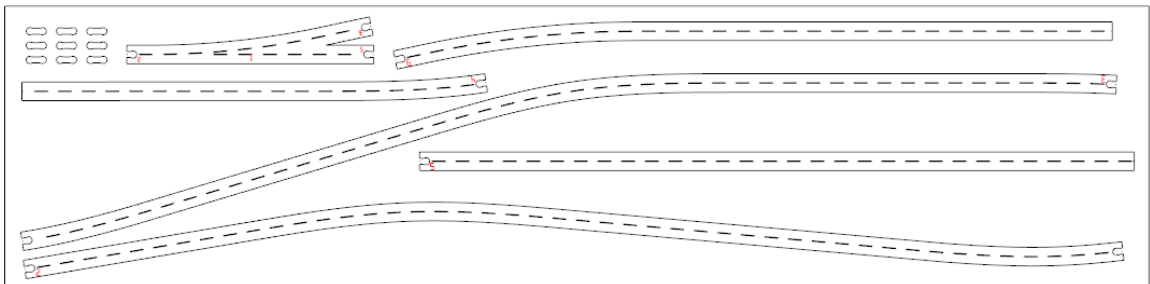
Include turnouts is almost always checked, but you may want to generate splines for turnouts separately from the rest of the track. **Include isolated track** is disabled if the drawing contains no unconnected track objects. You have the option of making splines for these “outlying” pieces if you check this box. **Include connectors** should always be checked if you are building splines with notches, although you might want to disable it for initial attempts to save time in the build process. You can have **Labels on connectors** to help you sort them if more than one size is used, an option best saved for the final build. **Save as favorites** stores the values in this dialog to be your default values in newly created documents. You can also disable a notification window displayed after the build process once you get comfortable building Layout Splines.

18.4 Building Layout Splines

With all the values set appropriately, press the **Build** button. Here's the output for the example settings.



The large box is the size of the material that can be handled by the cutting tool. A set of connectors is in the upper-left of the material box, grouped so they can easily be relocated as a set. We also see the Track Splines that have been built. Note that only the Layout Splines layer is active and displayed. It's easy to toggle **Layout Splines Only** mode: View / Show / **Layout Splines Only** (Ctrl+F12). With the select tool, move the splines into the material box in a compact arrangement.

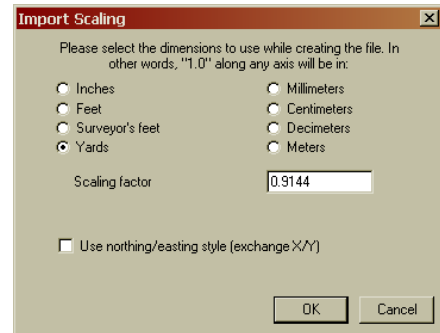


This is a nice, efficient arrangement of the pieces. The bottommost spline was rotated about 160 degrees from its original position to make good use of material. The less material you use, the less you'll pay for your Layout Splines. Make sure to leave at least 1/8" between adjacent splines for the cutting tool.

18.5 Exporting to DXF

If you will be submitting your file to El Dorado Software for fabrication, you can save your file as it is. We'll open it with 3rd PlanIt and create the DXF file. While still in 3rd PlanIt format, we can easily make small changes that may make production more effective. Once the file is in DXF format, the locations are more-or-less fixed. If you are submitting this to another vendor or using your own machine, you'll need to have the Layout Splines stored in DXF format.

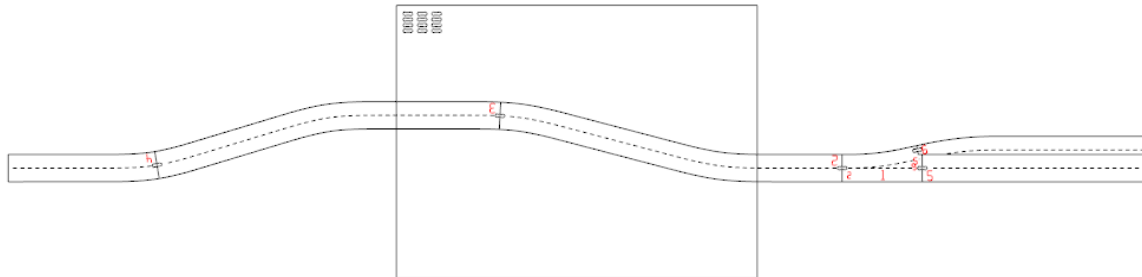
Choose **File / Export / DXF** from the main menu. You must be running the 32-bit version for this option to be active. Choose the location and name for the export file and press Save. You will see the dialog shown at the right. In America, you will almost always select **Inches** for units. Elsewhere, you'll choose **Millimeters** or **Meters**, depending on your vendor's preference. The **Scaling factor** field will be updated to reflect your choice of output units.



Press OK to complete the process.

18.6 How to Work with Wide Splines

There is a significant difference between Track Splines and Roadbed Splines: their width. Consider for a moment that Track Splines always fit within the rails. They can never overlap each other. On the other hand, Roadbed Splines can be any chosen width. If you have track spaced at 2" and generate Roadbed Splines at a 3" width, the overlap is apparent. Here is the sample layout again, this time with Roadbed selected for the Spline Width.



The difference in width is obvious when compared with the Track Splines built previously. The splines in the open area on the left are fine, but the area around the turnout needs attention. What should be done?

18.6.1 Connect / Add Polygons and Connect / Subtract Polygons

Two new editing tools are part of 3rd PlanIt to support Layout Splines. They are not limited to Layout Splines, however; they can be used on any polygons in the drawing. Let's take a look at their operation using two simple rectangular polygons.



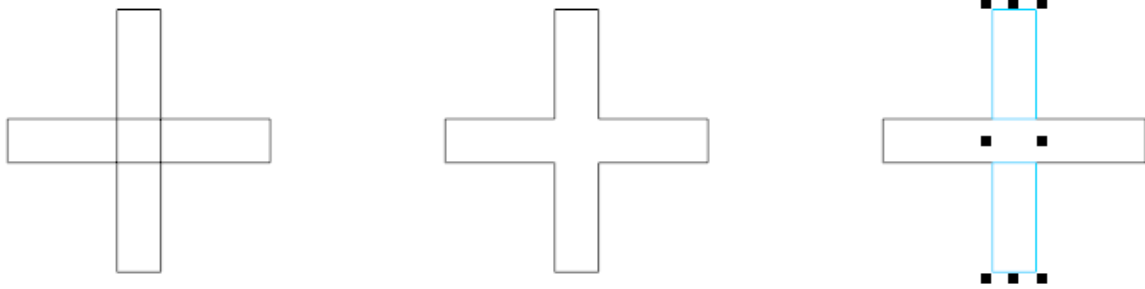
The **Connect / Add Polygons** tool joins two polygons or polylines that overlap each other. The result is one polygon or polyline whose outline is defined by the union of the two original objects. It doesn't matter which order you click the two objects when connecting.



The **Connect / Subtract Polygons** tool subtracts the second polygon or polyline you click from the first polygon or polyline you click. Sometimes this can result in the first object being divided into two or more pieces.



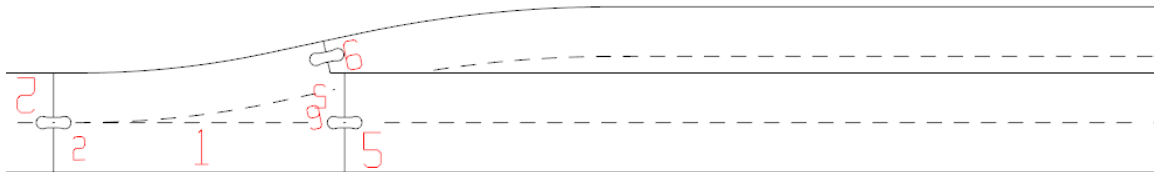
The operation of the tools can be understood by using them on two crossed rectangular polygons.



The original pair of polygons is shown on the left. It was copied twice to the right before using the Connect tools. The center example shows the result of **Connect / Add Polygons**. Only one polygon remains after the operation, shaped like a thick Plus sign (+). The right example shows how the **Connect / Subtract Polygons** tool can produce more than one result polygon. The vertically oriented polygon was clicked first, followed by the horizontal polygon. Think of it as “subtract the second polygon from the first. The result shows two highlighted polygons, made from the top and bottom portions of the vertical polygon.

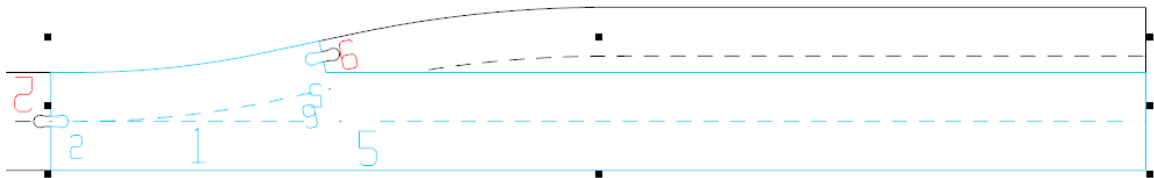
18.6.2 Adding Adjacent Layout Splines

Let’s look closely at the results of the Roadbed Splines build on the right side.

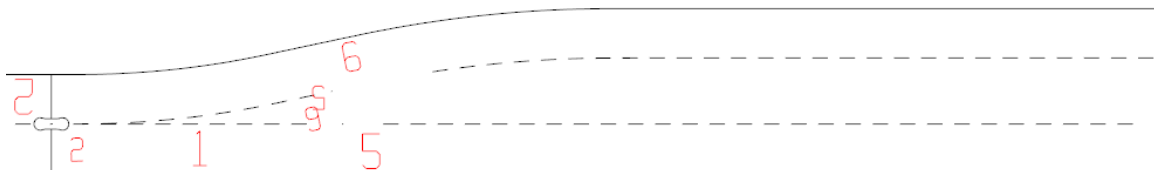


The build process recognized the two splines attached to the turnout overlapped. It trimmed the splines so that the spline proceeding from the non-routing side of the turnout was left intact at its assigned width of 3”. During the build, the turnout spline (Spline 1) and Spline 5 were subtracted from Spline 6. While this could be built with connectors by gluing the three pieces together, it is possible to make a composite Roadbed Spline that simplifies building.

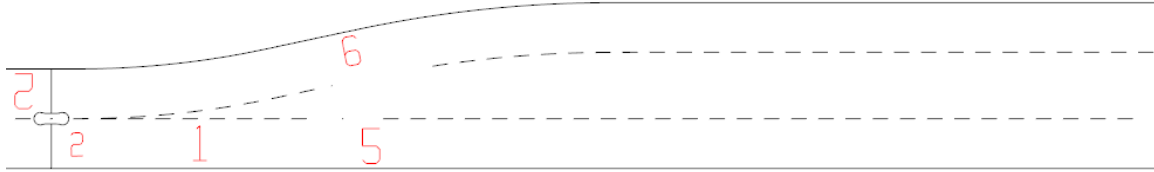
By selecting the Splines 1, 5 and 6, we can see their overall length is slightly less than 34”. This can easily fit on either CNC or Laser material as one piece. We’ll choose **Connect / Add Polygons** and click Spline 1 followed by Spline 5.



A merged Roadbed Spline results from the Add operation. We can do this again to include Spline 6.



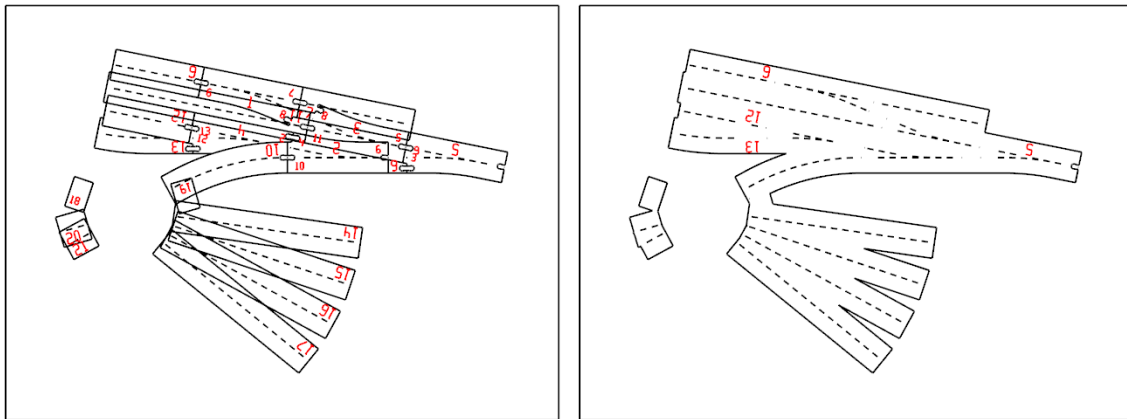
This composite spline can easily connect to Spline 2 at the left, but does not need to be glued together as an assembly while building. It is easily fabricated on either cutting device. We notice that two labels are now unnecessary – the 5 and 6 that originally indicated which splines were adjacent to the routing and non-routing turnout endpoints. Layout Splines are groups that contain the cutting outline as a polyline, as well as optional labels and centerlines. It's easy to double-click the Roadbed Spline group to “drill-down” edit its contents and delete the redundant labels.



When you are working with Roadbed Splines or Custom Width Splines larger than the Rail Spacing, it's always important to review the output and simplify sections that can be joined as one piece and still fit on the material size determined by the cutting tool.

If you're building splines near a roundhouse, yard or other complex and closely-spaced set of track, the Connect / Add Polygons tool can save a lot of build time. We'll examine an excerpted set of track from a complete layout design to learn how.

This example was set to a Custom width of 2.25" to allow roadbed to fit nicely on the Roadbed Splines while leaving room for terrain to be attached along the sides. The wide splines look like quite a mess at first glance.

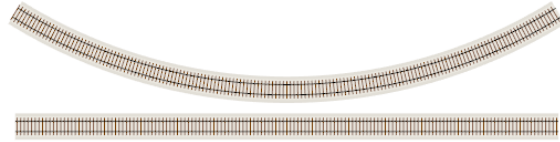


It's obvious that these splines can't be assembled as they stand. Notice that the whole group of Roadbed Splines fit within the material box – they can be joined together and still fit on the cutting tool. The **Connect / Add Polygons** tool was used in several successive operations to create the more pleasing, easily fabricated and constructed spline group on the right. There are only two pieces of material at the end of the process, and the unnecessary labels within the two spline groups were removed. Less than 60 seconds of editing saved about 60 minutes of gluing and alignment while building the layout.

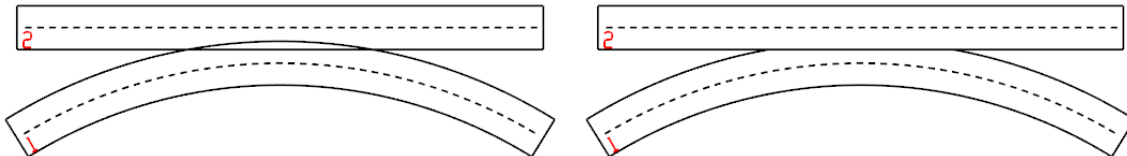
It's important to note a certain drawback to the result. There are several places where a narrow V-shaped cut is required; in particular, between the radial track segments extending from the turntable. If this shape is cut on a CNC router, the Vs cannot come to a sharp point. Even with a 1/16" end mill, there will be a 1/32" radius at the point of each V. This may not be an issue in many situations, but depending on your needs and preferences, you might want sharp points on the Vs. In that case, you want to cut the splines on a Laser cutter. With a typical beam width of only 0.003" or so, the effective radius is only 0.0015" – as close to a point as can be achieved. Due to the lifespan of the expensive CO2 laser in a Laser cutter, production will always cost a bit more than with a CNC router. This is a good example of the trade-off between the two.

18.6.3 Subtracting Adjacent Layout Splines

The **Connect / Subtract Polygons** tool is used in many situations. Here's one that commonly occurs on model railroads. The track snippet at the right shows a curve passing near a tangent track. We see this all the time, often planning for track to be as close as reasonable to make the most of our space.



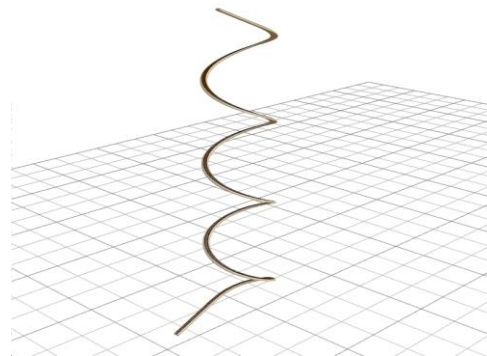
But what happens if we build Roadbed Splines? Here, the width setting **Roadbed** was chosen, using the Main Layer roadbed width of 3" as the spline width. The output of the build is shown in the left image.



As generated by the Layout Spline Build operation, although the track spacing was quite sufficient, the 3" wide Roadbed Splines overlap. They could be joined together as in the previous example, but these are only portions of what might be quite long splines. If added, they may not fit on the available material. In this case, it's better to subtract the top spline from the bottom. With **Connect / Subtract Polygons**, click the bottom piece first, then click the top piece to subtract it from the bottom. They can both be positioned in the material box, as both splines fit the material box when first generated.

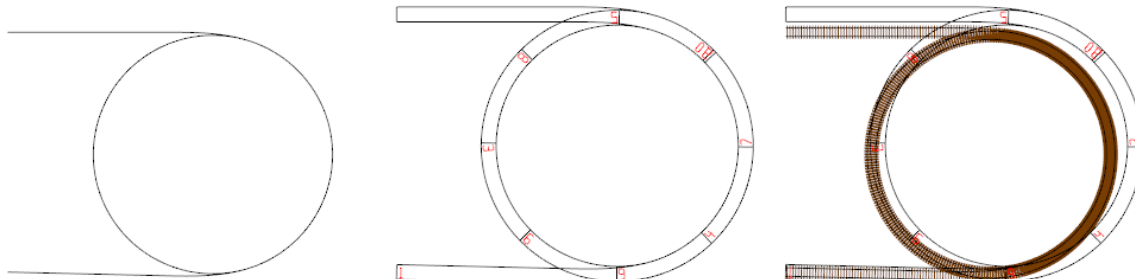
18.7 Grade Changes with Layout Splines

Layout Splines are built to compensate for changes in grade along the spline. Simply projecting an outline of the 2D view of track will not suffice – it's important to remember that a spline will need to be longer than its 2D appearance if it climbs a steep grade. One of the easiest places to see this is in a helix.



This example uses a helix with a grade that could not possibly work on a model railroad, as shown at the right. The purpose of the example is to show the grade compensation performed when building Layout Splines and the appearance of splines built on grades when viewed in 3D. With typical grades, the differences will be far less pronounced.

The next sequence of images demonstrates the "grade stretching" resulting from the example track.

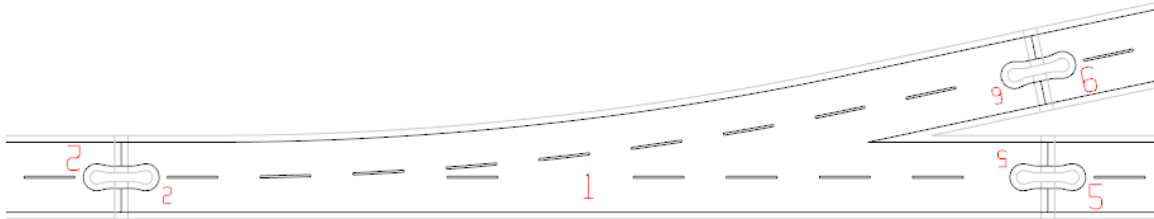


The original track centerlines are shown on the left. The center image shows 3" Roadbed Splines built from the track and the right images shows the track with rails and ties superimposed on the Roadbed Splines. Note now the splines do not overlay the track as one might expect. That's because the very steep grade had to be accounted for when building the splines. Without compensating for grade, the splines would be too short and serve no purpose.

Despite the apparent incorrectness of the result, when you build your layout with Layout Splines, you can be assured that they will be the correct length considering the grade. They will also end up with proper X/Y alignment, even though the image suggests the splines do not end on the track endpoints. After you work with Layout Splines for a while, this will become second nature.

18.8 Tool Offsets

During the discussion of the Layout Splines Build Information dialog, the field **Add offset for tool** was reviewed. Since it's necessary to position the Layout Splines on the material with some knowledge of the tool location, 3rd PlanIt presents splines with tool offset as shown.



The light gray outlines show the tool path. When you position splines in the material box, ensure that tool paths do not overlap each other.

18.9 Where to Order Layout Splines

You may order Layout Splines directly from El Dorado Software. We can produce splines made from any of the listed materials using on-site equipment. You can submit your 3PI file directly (almost always the best choice) or you can export the Layout Splines to a DXF file for submission. Simply send an email to 3pi@TrackPlanning.com to ask questions or submit a file.

El Dorado Software can provide Layout Splines on material up to 40x30" on the CNC router, or 36x24" on the Laser cutter. If your project requires larger material, we can use equipment and services from partner vendors, but be aware that larger material is considered "oversize" by shippers and costs quite a bit more. Splines made of XPVC must be run on the CNC router, as PVC gives off hydrogen chloride gas when heated. Splines made from wood products (plywood, MDF, etc.) and HDU may be run on the CNC router or the laser cutter. Although laser-cutting is a bit more costly, its accuracy and ability to engrave labels in highly visible dark letters often outweighs the slight increase in cost. If your design has a large number of V-shaped corners in the Roadbed Splines, you may wish to have them laser cut to avoid sanding required to mate splines against V-shaped corners.

You may also use an exported DXF file to work with a vendor of your choice or on a CNC router or Laser cutter you can run yourself. If you choose an independent vendor, make sure to discuss the job carefully, as vendors are not familiar with Layout Splines. If you choose to do the job yourself on a machine you own or rent time on, always make sure that your material choice is compatible with the chosen tool! Both tools can be dangerous if not used properly! If you are new to these tools, seek guidance from a knowledgeable friend or published guidelines. *El Dorado Software assumes no responsibility for results, problems or complications resulting from personal use of any manufacturing tool.*

The Notches and Connectors have been designed for cutting with a 1/8" or 3mm end mill on a CNC router. A larger tool will not fit within the Notch of a Layout Spline, while a smaller end mill can break more easily. Carbide mill bits are almost always the best choice – they are strong and keep their edge longer than hardened steel. It is generally best to process engraves before cuts.