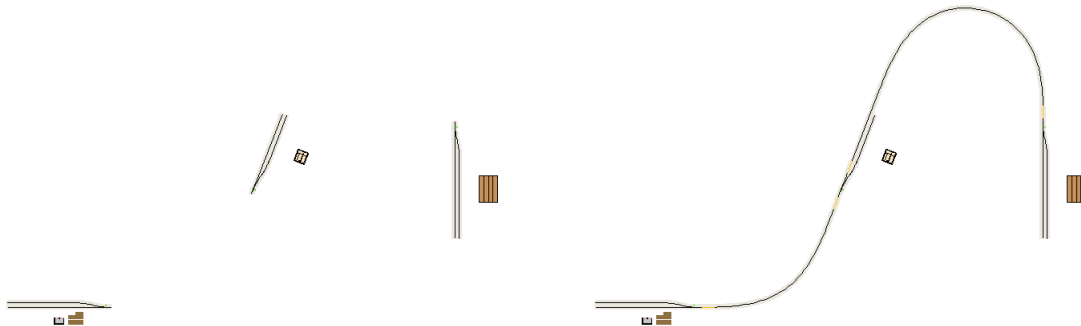# 1.   SoftTrak

SoftTrak is the most powerful design tool ever introduced to track planning. It lets you focus on the track routing, rather than the details of curves, easements and tangents that form the basis of track design. In addition to SoftTrak, 3rd PlanIt now offers Quintic Easements that allow smooth transitions in all three dimensions at the same time.

1.1   SoftTrak Basics

When working with SoftTrak, it is helpful to think about track design as the task of connecting a number of straight track segments with curves. Prototype railroads use straight track as much as possible to minimize energy consumption and wear of track and wheelsets. Thinking this way when you design your model railroad helps keep it in tune with the prototype, and SoftTrak works naturally in this paradigm.

We will therefore start with a design example that looks first at the elements of the layout, and second at the position of the track. In the image below-right, you will see a track plan that has a freight house and a corner café at the lower left, a packing house near the center, and a freight house on the right.

A few simple sidings were placed by the industries, made in the manner described in the tutorial. To connect them using SoftTrak, select the Connect SoftTrak tool as shown on the right. First, connect the lower-left turnout to the middle turnout, by clicking on the open entry legs of each turnout. The two will be connected by a SoftTrak curve that completes the connection without any other additional track.

The same process is repeated for the remaining connection. In this example, the radius of the resulting curve came out to 33 3/8", using SoftTrak with a Maximum Radius of 60", as shown in the Object Data Window. To see one benefit of SoftTrak, we select the upper-right curve; then click on the "Maximum Radius" field in the Object Data Window.

The field will change to "Fixed Radius" after you click on it, with a default value of 30". As a result, the curve is recomputed using a fixed radius rather than the maximum radius of 60" previously in use. Compared to the previous image, the curve is now longer and the radius has become smaller.

In this view, the curve's internal structure is visible. You can see this by using command **View / Display Style / Type** (Alt+Y) twice. As you can see in this example, SoftTrak is comprised of tangents, easements and circular curves. All of the internal detail was generated by the program, and changed automatically when you changed the curve from "Maximum Radius" to "Fixed Radius".

SoftTrak may be used without easements, as well. Simply select the curve and click the field in the Object Data Window that displays "Easements". It will changes to "No Easements", and recalculate the track.
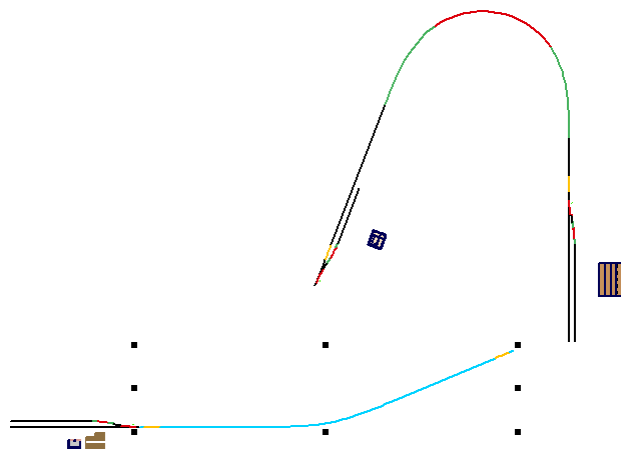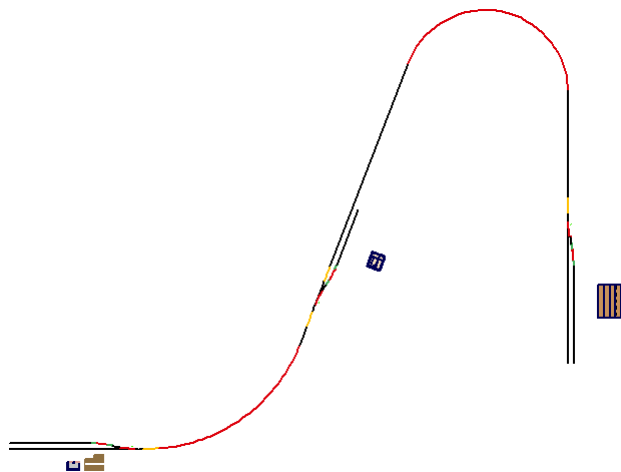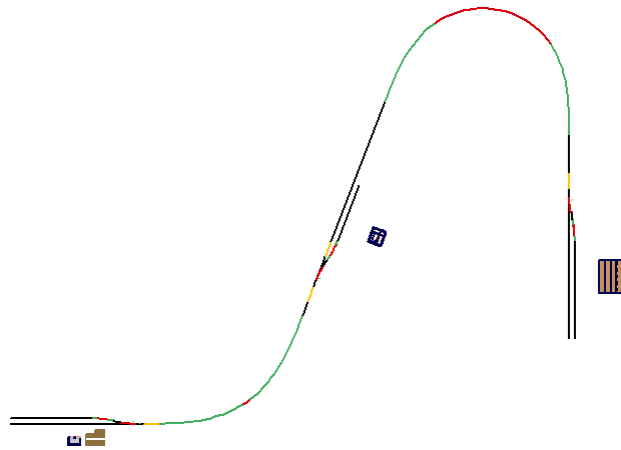
At the right we can see the result of this change. The upper curve, with a fixed radius of 30", now extends a bit further to the north. The lower curve has no easements, and was set to have a fixed radius of 30" also.

Note how the SoftTrak extends from turnout to turnout. SoftTrak is defined as:

1. An entry segment of tangent track
2. An easement
3. A circular curve
4. An easement
5. An exit segment of tangent track

In any given piece of SoftTrak, one or more of these elements may not be present. Easements are optional, at the user's choice. The circular arc may become very short or non-existent, depending on the angle of the connection and the spiral length settings. Finally, the entry and exit segments complete the track from the curve to an existing object.

SoftTrak is dynamic by its nature. Because you control characteristics of the curve and not the specific geometry of the objects, you may change a curve's connection quite easily. Looking carefully at the examples above, you can see a yellow "tip" at each end of every SoftTrak object. Point your cursor to one of the tips, such as the top tip of the lower curve. Press the Left Mouse Button, then drag the tip around. It will flex as you move it, much as a piece of flex-track. Note that easements have been turned on again.

In the same manner, you can drag the tip to an existing track object, so that the object highlights to confirm your aim. The SoftTrak will align to the existing object, while maintaining alignment with the object at the other end. The track elements within the curve will change accordingly.
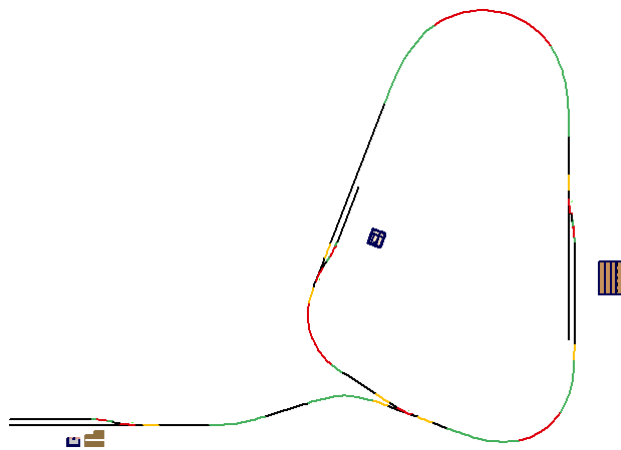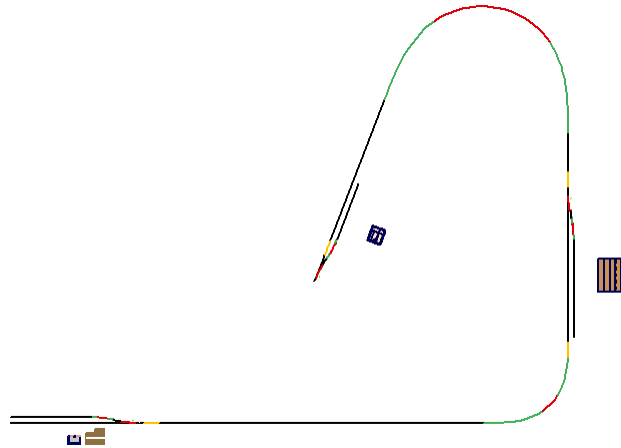
Changes to complex track are just that simple. For example, we can easily add a turnout and a branch route to the drawing at the right.

After placing the turnout, we drag the tip of the bottom curve from its present location to align to the new turnout. We use the Connect SoftTrak tool once again to connect each turnout to the other.

The image on the right shows the details of the design so far. Examining the lower curve, we can see that it is, in fact, an S-curve. Each part of the curve is made of a pair of back-to-back easements – the most efficient track design for shallow angles. They are nicely balanced, providing room and similar geometry for each part of the S-curve.

It's worthwhile to look back through the last few paragraphs. The track design has been changed substantially through the course of the discussion – but each change was simple and fast. If you want to change the location of an industry and it's siding, just select the objects by rubber-banding (or group them temporarily), move them to the new location, then drag each track tip into alignment as you wish after the change. SoftTrak takes the drudgery out of layout changes, so you feel more free to "work the plan" into the best design possible.
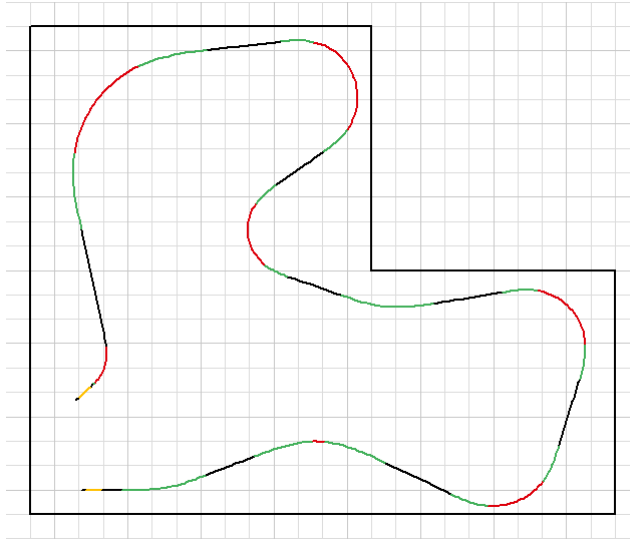
1.1.1   Changing SoftTrak to Objects

3rd PlanIt gives you many powerful tools that work with individual track objects: straight lines (or tangent track), curves (arcs of circles), and easements (transition track from curved to tangent). You can easily change SoftTrak to its constituent pieces so you can fine-tune the route, such as providing vertical easements. Select the SoftTrak you want to change, then issue the **Edit / Transform / SoftTrak to Objects** command, or right-click on the SoftTrak and select **Transform / SoftTrak to Objects** (or use the shortcut **Ctrl+2**). The resulting objects are exactly the same as those within the original SoftTrak.

1.2   SoftTrak as a Spline

Designed specifically to be used in railroad or thoroughfare planning, SoftTrak let you design long stretches of track as though they were a spline – a traffic spline, if you will. They are made of one or more SoftTrak curves, joined internally to form a contiguous track with multiple curves.
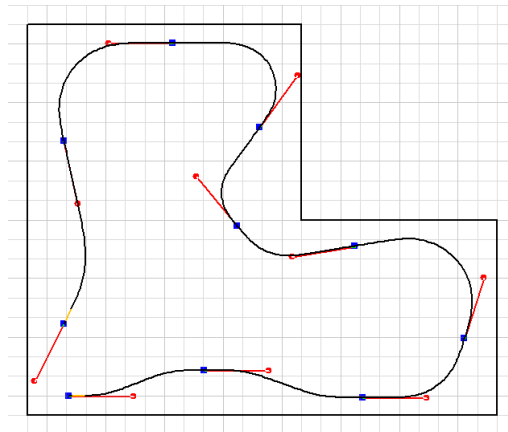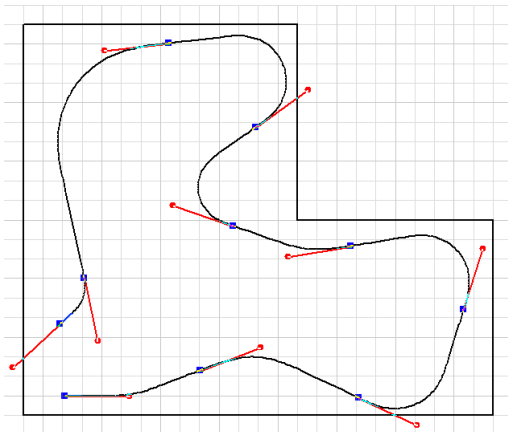
In this case, we will start with an L-shaped room and try to find a mainline for it. Our room has a door at the lower-left, so there must be an opening to allow people to enter the room. Select the tool **Draw / Spline / SoftTrak with Easements**. Point to a reasonable location near the lower left, then press the Left Mouse Button. Drag the mouse away from the starting point in the direction it should head, in this case, to the right. After a while, move the cursor north a bit, and a natural bend will form, in the same manner as adjusting SoftTrak by its tip. If you haven't released the Left Mouse Button, do so now.

This is the time to focus on the straight segments. Review the image on the left; each black segment is straight track, and each has a vertex associated with it. (Note that S-curves can form between two vertices, but there is no vertex associated with the tangent track between the two curves.)

To see and manipulate the route's vertices, double-click the route. As you can see below-left, each vertex has a location and a direction, from blue to red.

Using the same technique as for editing a polygon, you can point to a blue vertex, press and hold the Left Mouse Button, and drag the vertex to a new location. Each vertex also has a red direction pointer with a diamond head. If you drag the red handle around its blue vertex, you adjust the direction of the track through the vertex. Note how the track parallels the walls at the top and bottom. By holding down the Ctrl key while adjusting a red direction diamond, you can "snap" the direction every 15 degrees to aid in establishing typical directions such as horizontal and vertical.

1.2.1   Changing SoftTrak to SoftTrak Segments

While you can transform SoftTrak to objects, you might also find occasion to transform SoftTrak into its constituent SoftTrak segments. Select the SoftTrak, choose **Edit / Transform / SoftTrak to segments** (Ctrl+F2), and it will be transformed to a number of SoftTrak segments.
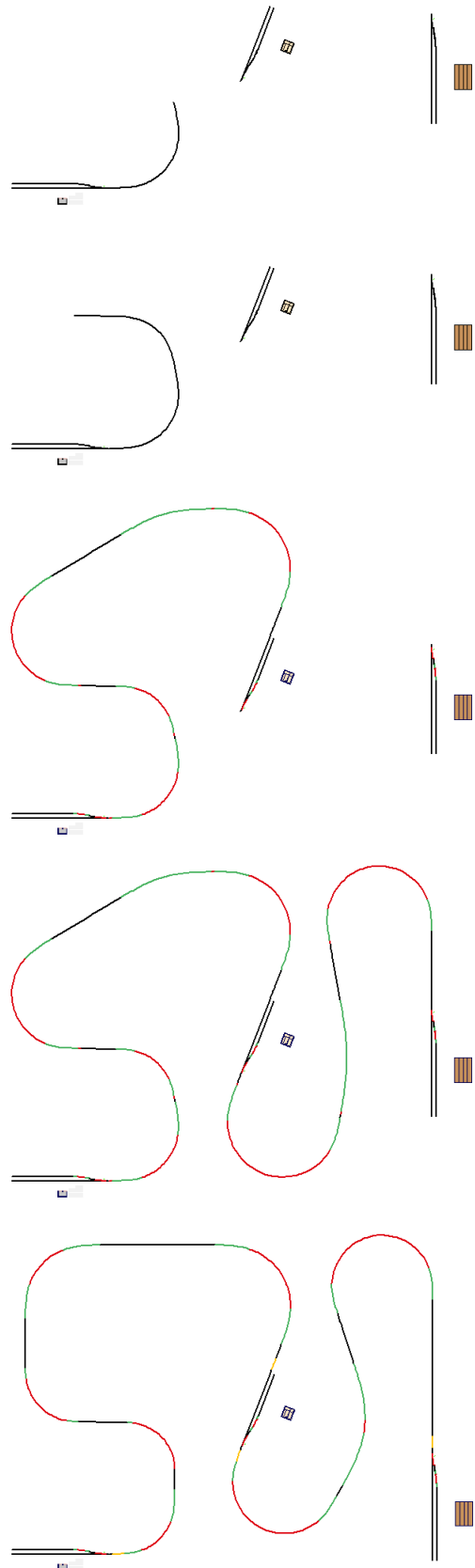
1.2.2   Point-to-Point Layout with SoftTrak

Let's return to the first example, where we began with a few sidings and industries. Choose the tool **Draw / Splines / SoftTrak With Easements** and point to the right end of the lower-left turnout. Hold down the **Alt** key, and the cursor will change to an arrow from a crosshair. This indicates the Snap to End mode, and it will cause the turnout to highlight when you point to it. Still holding the **Alt** key, press and release the Left Mouse Button, then draw it away from the turnout to the right and north, as you see in the example. Click the left mouse button to begin the next segment of the spline.

In the example, the cursor was dragged to the northwest after starting the second segment. Notice how the program treats each vertex of the spline as a definite location for straight track, then provides curves that are in conformance with AREA, European and other railroad and traffic design standards.

The route was completed by clicking (a) along the upper-left side near the center of the tangent, (b) at the top, between two easements, and (c) at the end. The final vertex was inserted by holding the Alt key (Snap to End), then clicking the left mouse button. This automatically completes the route, leaving the draw cursor available to create another route.

The second route was constructed in the same manner. It began from the lower end of the center turnout, using the **Alt** key to establish the alignment. Two vertices guide the track northward between the turnouts, then a final vertex was aligned to the top of the rightmost turnout. The loop from north to south was generated only from the two tangent tracks before and after it. You could easily move the yard to a new location, then drag the open tip to the turnout, completing the track changes in a matter of seconds.

SoftTrak let you explore possibilities that you might never consider. You get immediate feedback on the radii of your curves as you draw, letting you find a very efficient way to get from point A to point B. You can fine tune the route by double-clicking it, then adjusting the location and direction of vertices. The example plan was changed quite a bit between the last two images, yet the editing took only a minute or two to complete. In the end, when it comes to building your layout, you still have the traditional track elements used anywhere else: curves, easements and tangent track.
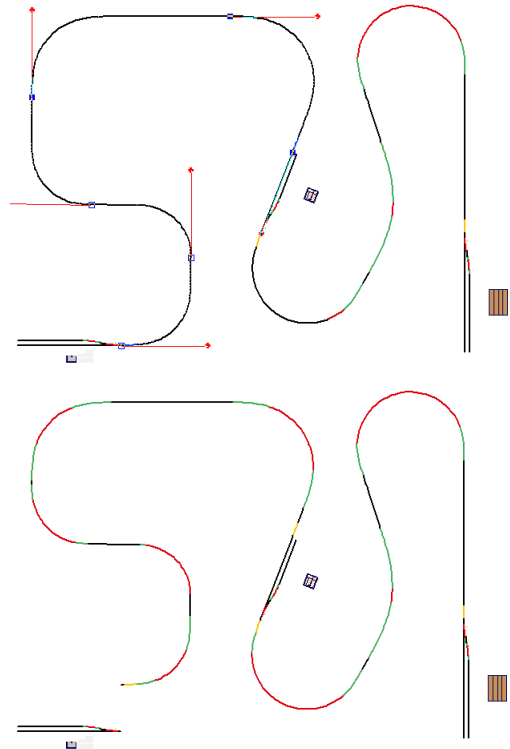
1.2.3   Moving Multiple Vertices while Editing

There are times when a section of track is designed just the way you want, but you'd like to move it intact while keeping it attached to its neighbors. You can easily accomplish this by selecting more than one vertex while editing SoftTrak.
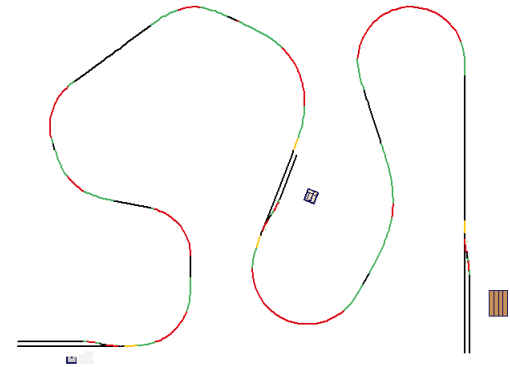
Starting with the example from the preceding section, we double-click the left route to bring up its editing vertices. To select more than one vertex, first, click on one vertex you want selected. It will change from solid blue to a blue box. Then, hold down the Shift key and select any other vertices you want to move. You can also use the rubber-band selection method to surround the vertices you want to move – only blue vertices are captured by rubber-band selection.

To move the whole selection, point to any of the selected vertices, press and hold the left mouse button, then move the mouse to move the vertices – and rebuild the route. In the example, holding the Shift key while moving the vertices forced them to move exactly north. You can see how all the features of the bottom part of the spline remain the same relative to each other, but they have all moved relative to the rest of the spline. It is truly that easy to change your mind about the location of the track, or of the industries and towns that determine its route.

1.2.4   Spline-Like Editing of SoftTrak

If you are looking for some creative ideas for your main line, you might like to use the spline-like qualities of SoftTrak to your advantage. Thus far, the vertices of the route have been locked into a given direction until you choose to change its direction. You can also let 3rd PlanIt generate some unexpected shapes by holding the **Ctrl** key while moving a vertex. This frees the direction of the vertex to follow a path of minimum-acceleration between the previous and next vertex. As you move the vertex around, the angle of the track through the vertex will change. You can extend this minimum-acceleration route generation further by holding both the **Shift** and **Ctrl** keys while moving a vertex. This frees the direction of the moving vertex, as well as its two neighbor vertices.

1.2.5   A Layer for Saved SoftTrak

There are times when you'll transform SoftTrak to curves or objects for detailed work. If you want to be able to come back to the route for further changes in the future, here's an easy technique. Create a layer to hold the routes you want to save, named "Saved SoftTrak" for example. Before you transform the route, select it, use **Ctrl**+**C** to copy it, **Ctrl**+**Shift**+**V** to paste it in place, then change its layer in the Object Data Window to "Saved SoftTrak". It's usually best if the layer is not visible until you want to find a saved route.

1.3   Quintic Easements

3rd PlanIt offers a design capability previously available only to full scale high-speed railroads. Quintic Easements have their roots in CAD software, based on mathematics not available until recently: quintic splines. Unlike cubic splines available in many drawing programs, splines based on a quintic equation allow the curvature at each endpoint to be specified. Quintic Easements can also be referred to as quintic transition curves.

1.3.1   Background

To better understand the role of the quintic in railroading, we can look into the role of the transition curve in general. If you'd like to simply use them, feel free to skip to the next section.

Before CAD design systems were available, both regular curves and transition curves (easements) were determined by "stationing". Surveying points, or stations, are located every 100ft along the track (in the United States). If one was laying out a curve of constant radius, at each station the surveyor would set out an angle of a few degrees, using the same angle at each station.

To transition that curve to a tangent (straight) track, the surveyor would subtract a small value from the angle at each station, until the angle between stations reached zero. This natural measuring process resulted in a curve that is represented by a cubic spiral. "Cubic" means that the distance from the tangent increases as the cube of the distance along the curve.

Quintic transition curves find their power in CAD systems by exploiting the mathematics of equations using the distance along the curve raised to the fifth power, rather than the third. What is special to us is that a quintic equation can calculate a curve with specified curvatures at each end. Traditional cubic splines must approach zero curvature at each end – which renders them ineffective for connecting curved track to tangent track or to another curve.

What new design capabilities are available with Quintic Easements? There are three major benefits. The first is the shape of the curve. It is very close to the same curve as a cubic easement, but it is optimized to provide a better transfer of lateral acceleration when entering or leaving a curve. This difference is critical to the operation of high-speed trains, as momentum is proportional to velocity squared. The second benefit is that the quintic curve operates in three dimensions, not just two. It can just as easily transition vertical grades as horizontal grades. One or both ends may have curvature, as well. Finally, it allows connection between two curves in situations that are difficult or impossible to accomplish with traditional easements, such as curves whose center of radius is concentric or closely spaced.

1.3.2   Vertical easements

If a track at one grade meets track at another grade, the simplistic solution appears at the right. The difference in grade between the flat segment on the left and the 10% grade to the right is made more noticeable here by the use of terrain underneath the track. One never sees track like this in the real world, as there would be a huge bump changing from one grade to another. The track designer must provide transition track to smoothly change grades.

3rd PlanIt offers a connect tool to quickly add vertical easements to your design. Select the "Connect Quintic Easement" tool, shown at the right. This tool operates in much the same manner as Connect With Easements, and other Connect tools. The transition track is made by clicking first on the left track segment (press and release the left mouse button).

Next, point your cursor to the center of the right track segment. Press and hold the left mouse button, then move the mouse to adjust the length of the vertical easement. When you think the transition track looks reasonable, release the left mouse button to complete the connection.

Your track should look like the image on the right when you view it in 3D. You can see that the track now smoothly curves from the 10% grade on the right into the flat track on the left. The abrupt change in grade is still visible in the terrain below the track.

The image on the right was made after conforming the terrain to the new vertical easement and placing a short train on it. The train looks natural despite the huge change in grade, with each car's angle a bit more than the one in front of it. This not only looks better, but makes reliable operation possible.

Building vertical easements is easy. They are created naturally by gradual flexing of the track and roadbed, be it wood or foam. 3rd PlanIt gives you valuable reference points at each end of the curve, which can be transferred to your layout as you build it.

1.3.3 Vertical easements with a fixed radius

The Connect Tool also lets you create a vertical easement with a fixed radius. This provides regularity in your design and building. Select the tool "Connect vertical easement, fixed radius" as shown at the right.
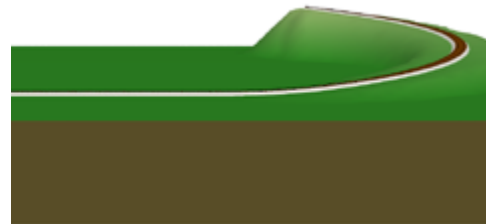
Using the tool is much the same as using the adjustable radius version discussed above. There is no need to adjust the curve using the left mouse button, though. The length of the transition curve is set to achieve the fixed radius. You can set the value of the fixed radius by pressing the button with the lock and blue check mark.

1.3.4 Complex vertical easements

In the Background section of this chapter, it was noted that quintic equations allow us to specify curvature at both ends. This fact brings great flexibility to quintics, allowing track designs not possible otherwise. As an example, a tangent track with no grade is butted against a curve that has a 10% grade.

You can see the abrupt change in grade in the left image. On the right, a transition curve has replaced a few inches of both sections of track. The track transitions not only as a vertical easement, it smoothly connects the curve and the tangent while smoothing the change in grade. This design would be extremely difficult to achieve without quintic transition track.

1.3.5   Editing Quintic Easements

SoftTrak Easements may be simply edited, bringing new speed and flexibility to track design. Starting from the example above, each primary track segment was shortened using the double-click edit feature. A gap appears between the primary tracks and the easement, shown at the right.

Note the yellow tips of the Quintic Easements. These tips indicate a powerful new editing feature – flexible track that maintains smooth curvature from end to end. Before completing the broken trackwork, take time to experiment with the Quintic Easements. Choose the Select Tool and point your cursor to the left end of the easement, at the yellow tip.

As you move the tip, the whole track flexes from end to end. The curvature of the other end is maintained until you adjust it by its tip.
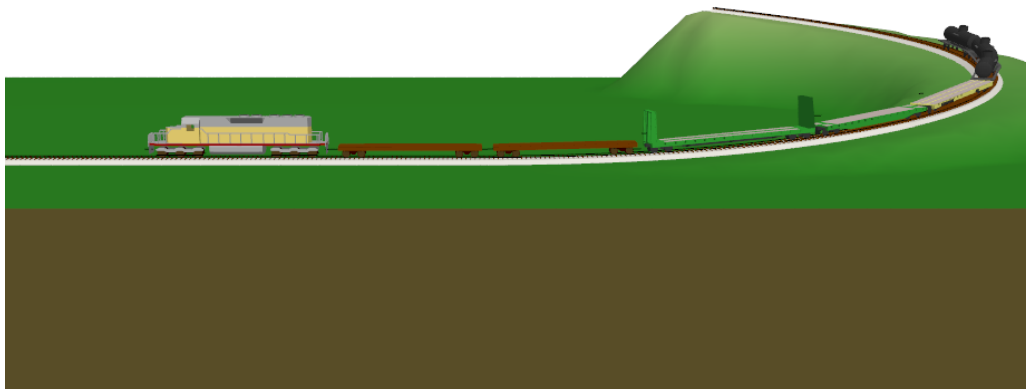

As shown above left, the left tip of the easement was dragged to the tangent track. When the tip hovers over the end of the tangent track, the tangent is highlighted in confirmation. At that point, the left mouse button is released and the easement is aligned to the tangent track.

To move a Quintic Easement, point your cursor near the center of the track segment. When it highlights, press and hold the left mouse button, then drag the easement elsewhere. If you double-click the Quintic Easement, you can move the editing handles without changing the curvature.

Note that there is a bit of an S-curve in the track on the left. An S-curve is not good track design in general. However, given the curvature and location of the easement's right end, the path with the least acceleration is accomplished as shown. You need to be aware of this when designing with Quintic Easements, and avoid unwanted S-curves by using good geometry. When the right tip of the easement is connected to the constant radius curve, the easement is adjusted for its new location and the curvatures in play. This longer easement allows a smooth transition from curve to tangent, absorbing the change in grade along the way.

After adding a train and swapping to 3D by pressing the Tab key, you can see the graceful results.

It's worth considering this connection in detail. The 10% grade of the curved track has been transitioned smoothly to a tangent track with no grade, while at the same time transitioning from curve to tangent. This kind of track planning power lets you design complex track in very little time.

1.3.6 Connecting with Quintic Easements

If you use easements in your designs, using quintic easements is much the same. In fact, the program computes the quintic curves with the same routines used for cubic easements. quintic easements replace cubic easements as the final step.

This implies that you can replace any cubic easements in an existing design with quintic easements. That's quite true. You'll find two versions of the tool, providing variable and fixed radius connections. The Toolkit shown at the right has the variable radius version checked; the fixed radius version lays to its right.

This example begins with two segments of tangent track at a shallow angle to each other. The "Connect Quintic Easement" tool is used in the same manner as the "Connect with Easements" tool, optionally with a fixed radius curve.

While it is only evident in this illustration by their colored tips, the easements are Quintic. You use the same procedures found elsewhere in the program to design with modern geometry. By printing your design 1:1, you can build your layout to the exact specifications you designed.

1.3.7 Connecting with a Single Quintic Easement

When connecting obtuse angles of 135 degrees or more, you might prefer having the connection made with a single Quintic Easement. This provides a very smooth curve, with lateral acceleration distributed evenly throughout the transition.

Although a quintic transition curve does not follow track design standards prior to the 21st century, this kind of transition is currently used on prototype high-speed rails on shallow curves. You might also find it useful in designs of an earlier era, where it can provide more attractive flow or let you achieve complex yard designs.

This example begins with two segments of tangent track at a shallow angle to each other. If the lines to be connected form an angle less than 135 degrees, a traditional easement-curve-easement will be automatically be produced, not a single easement.

1.3.8 S-curves with Quintic Easements

You might be wondering – if the quintic transition curve can have an S-curve, can it be used to solve an S-curve situation intentionally? The answer is definitely "Yes". A new tool is available to connect existing endpoints with Quintic Easements, as shown on the right.

Shown at the right is an arbitrary misalignment of track to serve as an example.

After selecting the "Connect Quintic Easement, between ends" tool, click on the end of the left track, then the end of the right track. A new piece of track is laid out between the ends, without repositioning the ends.

Even this artificial design situation is resolved smoothly with the quintic transition track. It would not only be difficult and time-consuming to perform a similar design with curves, easements and tangent track. It would not be possible to minimize the transitions as effectively, nor provide reliable operation in a small area. You will be able to make more compact and interesting designs by carefully using this new curve.

1.3.9 Connecting two circles

You will occasionally run into a situation where you wish to connect two curves that form overlapping circles, as in the example at the right. These nearly concentric circles are of 24" (on the left) and 36" radius (on the right). It would be nearly impossible to connect these curves using traditional design tools. However, the Quintic Easement makes it easy and customizable.

Start by slicing each curve at places that appear to provide reasonable transition opportunities, such as shown below on the left.

Use the "Connect Quintic Easement, between ends" tool to produce a very smooth curve that gradually eases one radius into the other. The transition curve that resulted is not a unique solution to the overall problem, though. Let's try the same situation, with a slightly different end for the left curve.

You can decide which curve is preferable to your eye. Both will provide reliable and smooth operation when you build your layout. Use good judgment, though – you can also take things to an extreme.

If you consider the image above left, it does not appear that a smooth connection can result. It can't, but the Quintic Easement will try its best to smooth the complex connection. The new track looks like it is in the mountains, but if the radii are large enough, it will operate reliably. The curvature from the left track is bled off as the S-curve begins, and curvature to the right track is worked in near that end. It is the best available solution to the complex (or inappropriate) starting geometry.
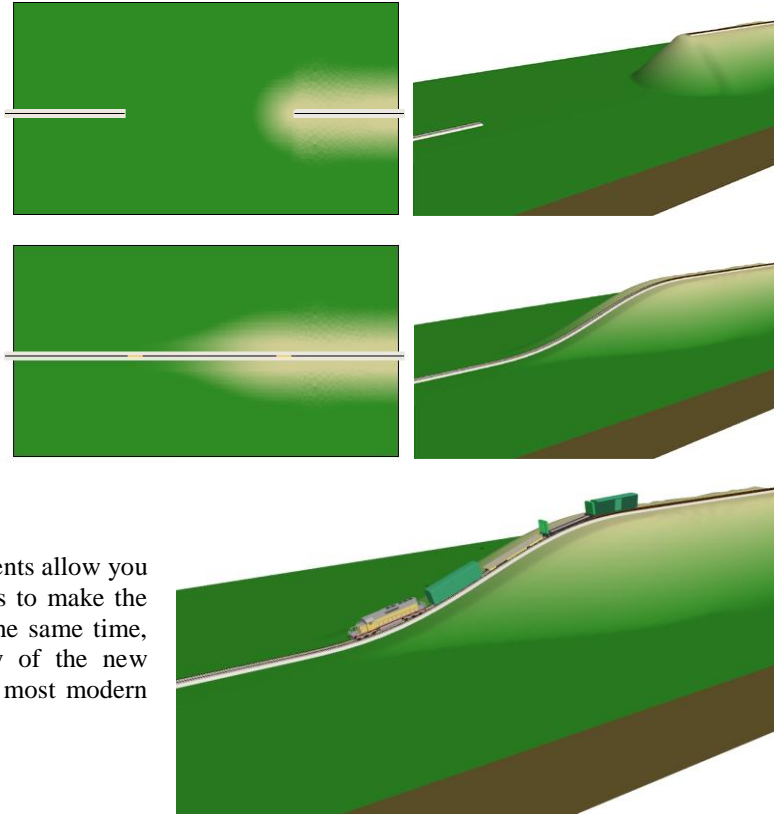
1.3.10   Understanding the vertical component

This example will help you understand the capabilities of the Quintic Easement. We start with a contrived design to make the nature of the curve more visible.

The track at the left has no grade and is at 0"elevation. The right track is at 10" elevation with no grade. The terrain makes this quite evident.

After using the "Connect Quintic Easement, between ends" tool and conforming the mesh to the track, a smooth roller-coaster track appears between the two original tracks.

3rd PlanIt's unique Quintic Easements allow you to create flowing, complex designs to make the best use of your layout area. At the same time, you will enjoy the subtle beauty of the new curve, knowing you are using the most modern design methods available.
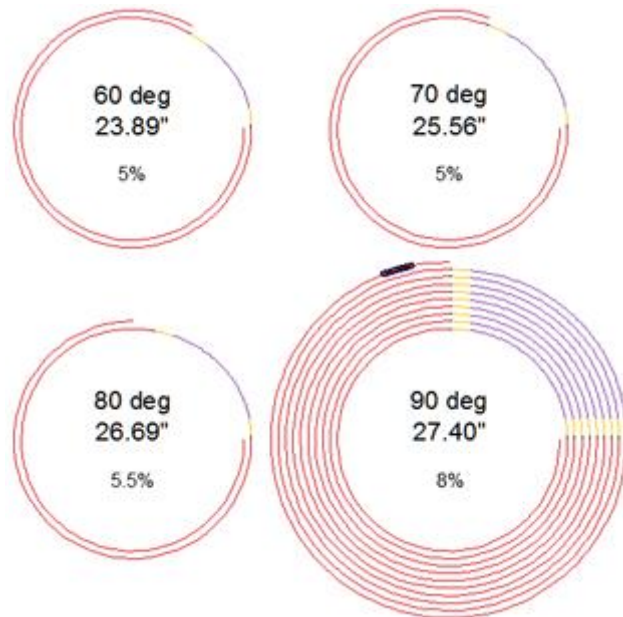
1.3.11   Concentric Circles

Connecting two concentric circles can be a particularly difficult problem. This most commonly arises when one is designing a dual-track helix, crossing from the inner to the outer helix.

At the right are four sets of two concentric circles. The radius of the inner circle is 30", and outer circle has a radius of 32". There are an infinite number of paths by which you can connect the two. It's up to you to choose the curve that will operate reliably with your equipment, and has a smooth flow throughout the curve.

Four examples are shown, with the transition length varying from 60 to 90 degrees of arc. The 60 degree example has a clear bulge at the bottom of the arc; the 70 degree is fairly good, and the 80 and 90 degree curves are both quite usable. The minimum radius in the curve is shown, and comes very near the 30" radius of the inner circle despite the bending required.

These smooth curves were accomplished using the **Straighten** feature of Quintic Easements. In most cases, you will only use Straightening with Minimum Acceleration (MA) splines, not Quintic Easements. However, in some cases such as this, it comes in very handy to adjust the location of the smallest radius.