GUIDE TO USING THE CURVED TURNOUT & CROSSOVER TEMPLATE DESIGNER

by David Honner © 2016

WHAT THIS GUIDE IS ABOUT

The program

The Curved Turnout & Crossover Template Designer (ct&ctd) is a program that will take the data for a straight turnout and curve it according to specific requirements. It can also construct a straight or a curved single crossover.

The data for straight turnouts comes from the manufacturer. Only a few manufacturers produce turnouts that are designed to be curved. More will be added to the program later if other manufacturers produce curvable turnouts and consent to the use of their data.

![Figure 1: A curved #8 turnout. The dashed green lines show a constant radius curve of 30″ throughout the main route, and 24.8″ through the diverging route. The solid red line is the track centreline. The frog rails are straight.](image)

The prototype

Turnouts are curved in accordance with North American railroad practices. This means that the rails through the frog are straight, not curved.

Switch rails are usually straight in the prototype, but due to the model constraints of tighter curvature and longer switch rails the turnout can look quite ugly and misshapen if straight switch rails are used. Consequently, there are options for the user to choose either straight, slightly curved or fully curved switch rails.
This guide

This guide acts as a detailed reference source, as well as providing an overview of the program’s features prior to purchase. It is not intended to provide detailed advice on actual construction techniques; these are more thoroughly covered in other documentation and videos.

Template designer features

Fitting curved turnouts & crossovers into a layout

A curved turnout or crossover designed using the template will fit into an existing constant radius curve. This means that the start and end of the turnout or crossover lies exactly on the radius of curvature, and is aligned with the direction of track at that point.

For crossovers, the exact middle of the crossover also lies exactly on the radius of curvature and is aligned with the direction of track at that point. This means that crossovers can be built as just two curved turnouts facing each other with no parallel track, or the parallel track can continue past each opposing turnout. The difference between the two options lies in consideration of side clearances.

To assist fitting into a layout, the template prints a dashed green line along both the main route and the diverging route. The dashed green line is at a constant radius throughout, and the actual radius used is printed on the legend. The dashed green line is aligned exactly the same as the track alignment at the ends of the turnout.

Side clearances

To accommodate the straight rails at the frog and (if applicable) the switch rails, the curvature within a turnout varies from side to side throughout the length of the turnout. The algorithm determines the best use of internal curvature to reduce the changes in overall radius automatically. However, all turnouts will have their centreline varying from a perfect curve, and this is expressed as a +/- value on each template.

Figure 2: The circled red area shows an example of how the actual track centreline varies from a perfect curve.
A positive value indicates that the centreline extends beyond the overall radius of curvature, and will reduce clearances to the outside of the curve. A negative number indicates that the centreline extends inside the overall radius of curvature, and will reduce clearances to the inside of the curve.

Usually the change in side clearances are small. However, if clearances are critical then this should be taken into consideration when designing layouts.

For crossovers, the change in side clearances can affect the clearance to the parallel track. For this reason the template will calculate and draw the entire length of parallel track and will ensure that the minimum spacing is always kept, even though the turnout will vary from side to side throughout its length. When building your own crossover, you can decide whether you want to follow the suggested line or, if the clearances are sufficient, just follow the constant radius curve line.

The exact clearance between tracks of a crossover can be infringed in certain circumstances by as much as 1/64” (0.4 mm), often much less. This only occurs in the frog area where the track is straight, or nearly so. This is considered an acceptable minor incursion for the sake of a better looking crossover design, and within the tolerances of a hand built crossover. However, if it is important to you to maintain strict minimum clearances then add a small extra amount to the track spacing before generating the crossover.
Head block ties on curved turnouts and crossovers

The head block ties are the two extended ties at the toe end of the switch points.

Normally all the ties are perpendicular to the track centreline at every point along the turnout. This means that they fan out to follow the curvature. However, the head block ties need to remain parallel to each other because they contain the mechanism to move the switch points. So the two head block ties are always parallel to each other, and their combined centreline is perpendicular to the track centreline at that point.

It is difficult to see, even with an exaggerated curvature. Figure 4 is an attempt to show the difference of the parallel head block ties. If you look closely, you can see that they do not fan out in the same way as the ties around them.

Figure 4: For curved turnouts the ties on either side of the switch stand ties will fan in/outwards but the two switch stand ties are always parallel to each other. They will not be perpendicular to the rails but at a small angle. Note that the radius in this figure has been greatly exaggerated.
Tie spacings and the reference rail used for curvature

Tie spacings are preserved throughout the turnout along the reference rail used for curvature. Along the other rails the ties fan out or fan in, as applicable, to make the curve. The difference in looks between using a different reference rail for curvature is almost undetectable.

The reference rail used for curvature is:

- Turnouts from Central Valley Model Works (www.cvmw.com) have a webbing joining the ties together. This may be cut underneath one rail or the other to allow curvature of the tie base. The rail used for curvature is the main route rail that passes through the frog.

- Turnouts from the “Ultimate” range from the Proto:87 stores (www.proto87.com) are curved under the main route rail that passes through the frog. The ties included with the turnout have a small gap underneath that can fit a flexible piece that joins the ties together. The construction technique is to use the straight turnout jig to correctly space the ties and fit all the tie plates first before curving. Once the ties are curved over a template they may be fixed to a base card just like a straight turnout.

- Turnouts from the “Fast & Easy” range from the Proto:87 stores (www.proto87.com) have the same track base as cvmw turnouts and are curved in the same way. The rail used for curvature is the main route rail that passes through the frog.

- Parallel track in curved crossovers curve along the inside rail.

Overall radius of diverging route

The overall radius of the diverging route (shown as a green dashed line) is a curve of constant radius calculated by:

- aligning one end of the overall radius with the end of the actual diverging route;
- keeping the other end within the bounds of the switch area; and
- using a least squares method to determine the closest overall curve.

In practical terms the overall radius can be used to determine the “average” radius...
as seen by long wheelbases as they move through the turnout; it does not correspond to any actual or specific internal curvature used within the turnout.

**User Inputs**

Type A and type B curved turnouts

Curved turnouts are either type A or type B. These two types are opposite in three principle areas—

- **Type A curved turnouts (figure 5):**
  - are curved towards the diverging route;
  - have their ties aligned along the outside of the curve, and their ties stepped along the inside of the curve; and
  - are used when the diverging route is to the inside of the curve.

  ![Figure 5: A left hand type A curved turnout. A type A curved turnout has the ties aligned on the outside of the curve and stepped on the inside, and the diverging route is to the inside of the curve. The stepped ties are indicated by the green arrow. The turnout is left handed because the diverging route goes off to the left.](image)

- **Type B curved turnouts (figure 6):**
  - are curved away from the diverging route;
  - have their ties aligned along the inside of the curve, and their ties stepped along the outside of the curve; and
  - are used when the diverging route is to the outside of the curve.

The type of curved turnout has nothing to do with the handedness of the turnout; each type A or B can be either left-handed or right-handed. Superficially, a left-handed type A curved turnout can look like similar to a right-handed type B curved...
turnout. However, the alignment of the ties is different for each type (i.e., stepped on one side and aligned on the other), and this shows clearly which type is which. Similarly, a right-handed type A curved turnout can look superficially similar to a left-handed type B curved turnout.

![Figure 6: A left hand type B curved turnout. A type B curved turnout has the ties aligned on the inside of the curve and stepped on the outside, and the diverging route is to the outside of the curve. The stepped ties are indicated by the green arrow. The turnout is left handed because the diverging route goes off to the left. This is the same turnout as in figure 5, the only setting that has been changed is the type from A to B.](image)

A curved crossover always has one type A curved turnout and one type B curved turnout. This can be deduced because one turnout always has the diverging route to the inside of the curve, and the other turnout always has the diverging route to the outside of the curve. When selecting the crossover option the program automatically sets the correct turnout type, so there is no need for the user to do this.

**Switch rail curvature & optical illusions**

Switch rails may be straight, slightly curved, or curved. The switch rails lie between the two dashed red lines near the beginning of the turnout.

![Figure 7: A #6 curved turnout at an overall radius of 24”. The switch rails are fully curved. Notice the tiny deviation of the track centreline (red line) from the overall radius curve (dashed green line).](image)

Curved switch rails (figure 7) are fully curved at the same radius of curvature as the main route. They usually result in turnouts with the least deviation from the overall radius of curvature.
Slightly curved turnouts (figure 8) are a compromise, to allow a straighter looking switch rail without distorting the overall look of the curved turnout. The radius of curvature of the slightly curved switch rails is double the specified overall radius of curvature of the main route. For example, if the main route has a radius of 24” then the slightly curved switch rails will have a radius of 48”.

Figure 8: The same #6 curved turnout as in figure 7 with the switch rails slightly curved. Notice the optical illusion that causes the switch rails to look straight when they are in fact curved at double the overall radius (48” in this case). The track centreline is slightly more displaced from the overall curve than the same turnout in figure 7.

Straight switch rails (figure 9) are prototypical. Due to the much sharper radius that are typical for model layouts, and also due to the over-long switch rails for HO turnouts, the straight option can result in ugly looking curved turnouts if the overall radius of the main route is less than approximately 40” (1,000 mm). However it is available at any radius for those modellers who strive for prototype accuracy, or who wish to try different settings to see how they look.

Figure 9: The same #6 curved turnout as in figure 7 with straight switch rails. Notice the optical illusion that causes the switch rails to look slightly curved in the opposite direction when they are in fact totally straight. The track centreline is displaced even more from the overall curve than the same turnout in figure 7. The curvature required in the closure rails to get the turnout to fit into a 24” overall radius is extreme, and results in an ugly looking turnout. It is for this reason that straight switch rails are recommended only at large radii.

For sharply curved turnouts, such as those used on typical model layouts, there is an optical illusion with the switch rails. Slightly curved switch rails actually look as
if they are straight; straight switch rails look as if they are slightly curved in the opposite direction. It is for this reason, as well as because they produce better looking curved turnouts, that the slightly curved switch rail option is recommended instead of the straight switch rail option.

Crossover considerations

The effect of track spacing on the alignment of middle ties

When a crossover is designed, the program will automatically add or subtract ties in the middle to suit the desired track spacing. This occurs for both straight and curved crossovers.

The number and length of middle ties is printed on each template output. The length of the middle ties is in prototype feet and the lengths are set to the availability of specific tie lengths from the turnout manufacturer. The lengths available are in multiples of prototype 6”.

When building crossovers using turnouts from the "Ultimate" range from the Proto:87 stores, each half is built initially separately using turnout jigs to align ties and tie plates. Each jig aligns the ties along the edge of the main route for its half of the crossover. Consequently, at the centre of the crossover the ties may be

![Diagram of a crossover with a green oval showing the worst case of tie offset at the centre of a crossover using two “Ultimate” range turnouts, where the ties are offset by a prototype 3” (approximately 0.035” in HO, or less than 1 mm). This can be avoided by choosing a track spacing in prototype feet that is a multiple of 6”.

Figure 10: The green oval shows the worst case of tie offset at the centre of a crossover using two “Ultimate” range turnouts, where the ties are offset by a prototype 3” (approximately 0.035” in HO, or less than 1 mm). This can be avoided by choosing a track spacing in prototype feet that is a multiple of 6”.
offset by up to a prototype 3″ (approximately 0.035″ in HO, or less than 1 mm), i.e. half of the multiple of the available tie lengths. A worst case example showing the maximum offset is in figure 10.

The same issue can occur when building crossovers from two **CVMW** turnouts, or two turnouts from the “**Fast & Easy**” range, as shown in figure 11.

It should be emphasised that for most track spacings the offset of the ties in the centre of the crossover is usually small enough that it cannot be noticed by the casual observer. For example, if the track spacing in HO is 2″ this is almost exactly a prototype spacing of 14’ 6″. The ties in the middle will be offset by a tiny 0.002″ or 0.05 mm; the natural variation in tie length easily exceeds this amount.

If the track spacing is chosen in prototype feet and is an exact multiple of 6″ (e.g., a track spacing of 13’ 6″, 14’, 14’ 6″, etc.) then there will be zero offset, as the tie lengths are in multiples of 6″. All the ties edges will then be perfectly aligned.

If offsets seem too large then the tie ends can be disguised by ballasting after the turnout is laid. Another option is to trim the tie ends before laying the crossover. Alternatively if the offset is small enough you can simply ignore the issue and use the natural variation in tie lengths to portray an accurate, realistic look.

**Figure 11:** The green oval shows the worst case of tie offset at the centre of a crossover using two **CVMW** turnouts, or two turnouts from the “**Fast & Easy**” range, where the ties are offset by a prototype 3″ (approximately 0.035″ in HO, or less than 1 mm). This can be avoided by choosing a track spacing in prototype feet that is a multiple of 6″.
Hand laying rails

The manufacturer of each turnout provides tie plates to accurately position rails. These tie plates are separately added in the case of “Ultimate” turnouts, or are part of the plastic tie base in the case of turnouts from the “Fast & Easy” range or CVMW turnouts.

When building a crossover, there are some parts outside the turnouts that require rails to be hand laid. Typically these areas are the track joining the two turnouts, and the parallel track. In these areas there are no tie plate positions provided by the manufacturer, so the rails must be laid by referring to the template.

The black rail lines on the template indicate the position of the inside gauge line at the top of the rail. It is not easy to position rail using this line because the base of the rail is wider than the head, and is also offset by half the rail head width. To aid accurate rail positioning, dashed lines are printed on the template in these areas to indicate the exact rail base, as shown in figure 12.

The width of the base of the rail and its offset from the inside gauge line is defined by the type of rail used. The CT&CTD program has a large range of rail types included as a drop down list. Once selected by the user the template will accurately indicate the rail base lines.

Read the legend

The legend on each template contains much useful information. Information is only
displayed if it is required by that particular template. Consequently there can be in-
stances where the legend changes for some outputs and as the difference is small
you may not notice the changes unless you specifically check for them.

As an example, on crossovers using either “Fast & Easy” or cvmw turnouts there
can be an extra note added to the legend when the track spacing is close; below ap-
proximately 2”.

Another example is on crossovers using “Ultimate” turnouts there can be an extra
note added to the legend when the track spacing is wide; above approximately 2 ¼”.

**Additional considerations for “Ultimate”
crossover templates**

Information about straight and curved crossover templates using “Ultimate”
turnouts has been moved to a separate document.

**Program outputs**

**Template paper size considerations**

The output from the program is constrained to being no higher than a US Letter or
A4 page width. The program will shift the text around automatically to keep the re-
quired width. On the screen the margins to the edges may appear small but when
printed extra margin space will automatically be added.

The reason for doing all of this this is to support banner or continuous roll paper to
be used, if available. Many home printers may be capable of using this sort of paper,
even if only used in their manual feed. This has the advantage of not requiring the
stitching together of multiple pages.

If banner or continuous roll paper is not available, the program minimises the
wasted white space and the number of pages required for a multiple page output.

**Printing the template**

Templates are output as conventional pdf files, and may be viewed on any pdf
reader the user chooses. Examples in this guide use Adobe Acrobat Reader but this
software is not a requirement.
When the print option is selected in Adobe Acrobat Reader, a typical print dialogue screen comes up as shown in figure 13. The important user selections are highlighted by red ovals.

The user should select “Multiple” to allow for a multiple page printout; the tile scale should be “100%” and the orientation should be “Landscape”. A picture on the right size will show the shape of the output and dotted lines will indicate the join(s) between the pages.

If banner or continuous roll paper is not available, the user will have to stitch the multiple pages together using tape, glue or any other suitable means. Adobe Acrobat has two selections to assist alignment in this case. The “Overlap” box allows the user to select a suitable overlap between pages, and “Cut marks” will automatically add cut and alignment marks to each output page.

On larger outputs, “Cut marks” sometimes will reorientate the output so that it becomes “Portrait” instead of “Landscape”, and this may increase the number of pages used when printed. The picture on the right side will show when this happens. The user will be unable to change this. If this is undesirable the only way to get back to “Landscape” is to deselect the “Cut marks” option.

**Track planning software 3rd PlanIt**

Data is calculated to build a virtual turnout for the track planning program 3rd PlanIt. Instructions for entering the data into 3rd PlanIt are available on a separate page of the program.
Enter the units used in 3rd PlanIt into the blue box (options available are inches, centimetres or millimetres). The correct data for 3rd PlanIt may then be copied from each cell in the CT&CTD program and pasted into the appropriate place in 3rd PlanIt. Use all of the decimal places; even if 3rd PlanIt does not display the extra decimal places it will still store them internally.

**Purchasing the program**

**Demonstration program**

There is a free version of the program available as a demonstration. This program restricts the choice of radius and track spacing to a few examples, but every other feature may be changed to demonstrate the capabilities of the software.

**Activation key**

The full program may be downloaded at any time but it requires an activation key to allow access. This key ties the program to one specific computer, and requires the name of the computer to be provided to the vendor. Once payment is processed you will be sent an activation key that can be used to access the program.

**Finding your computer name**

With the large number of different operating systems this guide will not provide specific instructions; you can refer to your particular system’s instructions or use a web search.
There is another, possibly easier way to find your computer name: simply run the program. The first screen (figure 15) will ask for the activation key, which you don’t have yet; but it will also display the computer name for you. Copy this name exactly, with the correct case, and send it to the vendor so that they may provide you with your activation key.

Moving computers

If it becomes necessary to move computers then the previous activation key will not work. While the licence is on a per computer basis, if you provide proof of purchase (e.g., your email address and the original computer name) then you’ll be sent a new activation key for your new computer.

When moving computers don’t forget to delete the software on the old computer.

Software updates

Minor software updates will be published as required on the vendor’s website. The same activation key will work for any minor update.

Major version changes incorporating new features might require a new purchase and a new activation key, depending upon the changes. You can choose to keep the old version if it is sufficient for your needs, you will never be forced to upgrade.

Technical notes

Diverging route behaviour at large radii
with type B curved turnouts

Technical note: The following paragraphs describe the effects of large radius on the
shape of type B turnouts. It is unlikely that a model railroad layout would need such large radii but this note is included to explain the mathematical behaviour when curving a turnout. The examples given below are based on an HO scale “Ultimate” range #6 turnout with fully curved switch rails.

With type B turnouts, as the radius of the main route is increased (e.g., user input radius larger than about 80” or 2,000 mm), the diverging route flips direction and will start to curve in the opposite direction from the main route through the closure rails. The diverging route remains straight through the frog and after the frog the diverging route flips direction again so that the diverging route and the main route both exit the turnout curving in the same direction (see figure 16).

Since the eye is drawn to the closure rails it appears to approximate a wye, but note that at the exit both the main and the diverging route curve in the same direction; overall the diverging route becomes a small, gentle S-bend with a straight in the middle at the frog. The overall radius (shown on the template as a dashed green line) is aligned to the exit angle of the diverging route, so it appears to curve in the opposite direction to the closure rails. However, it is the alignment at the end of the turnout that is important when fitting a turnout into a layout; the curvature within the turnout is of no consequence.
With type b turnouts, as the radius of the main route further increases (e.g., user input radius about 160” or 4,000 mm) the radius of the diverging route approximates a straight line, and at some point it will flip so that the exit from the turnout is now in the opposite direction to the exit of the main line. When the direction flips the overall radius of the diverging route becomes extremely large, and it will not be displayed when above 4,000” or 100 metres (i.e., it is effectively a straight line).

As the radius of the main route further increases again (e.g., user input radius about 240” or 6,000 mm), the radius of the diverging route in the opposite direction will start to decrease in radius from the extremely large values previously attained. When the overall radius of the diverging route reduces below 4,000” or 100 m it will once again be calculated and displayed on the template. As it is now curving entirely in the opposite direction, the radius will be shown as a negative number (see figure 17).

**Middle tie spacing**

*Technical note:* When a crossover is designed, the program will automatically add or subtract ties in the middle to suit the desired track spacing. The tie spacing used will be the same tie spacing as used by the last ties of the turnout. To get the exact track spacing sometimes the spacing of a few ties (up to eight) in the middle will have to be slightly adjusted. This occurs automatically and the variation in tie spacing is designed to be so small as to be undetectable.

The settings will allow for up to a 4% variation in tie spacing over several middle ties (up to eight) before adding or subtracting an extra middle tie automatically. Occasionally on the smallest track spacings (less than 2” or 50 mm track centreline to centreline) this 4% variation has to be exceeded because there are insufficient ties.
over which the spacing can be varied. At unrealistically close track spacings (e.g.,
the absolute minimum allowed by the program) you can sometimes notice the vari-
ation in tie spacing; this is unavoidable but unlikely to be required for layouts.

For a typical HO crossover the difference in tie spacing in the middle ties compared
to the tie spacing at the ends of each turnout usually works out to being less than
0.010” (0.25 mm), which is less than 1” on the prototype, within the normal range
of tie spacing variation that the prototype used in any case.

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