How to Provide Track Profiles for Open Rails Dynamic Track

This “How to” guide describes track profiles for dynamic track implemented in Open Rails as of V716. Externally defined track profiles for dynamic track were supported in Open Rails beginning with V402. The purpose of this document is to describe the capabilities in enough detail to design and implement track profiles for dynamic track.

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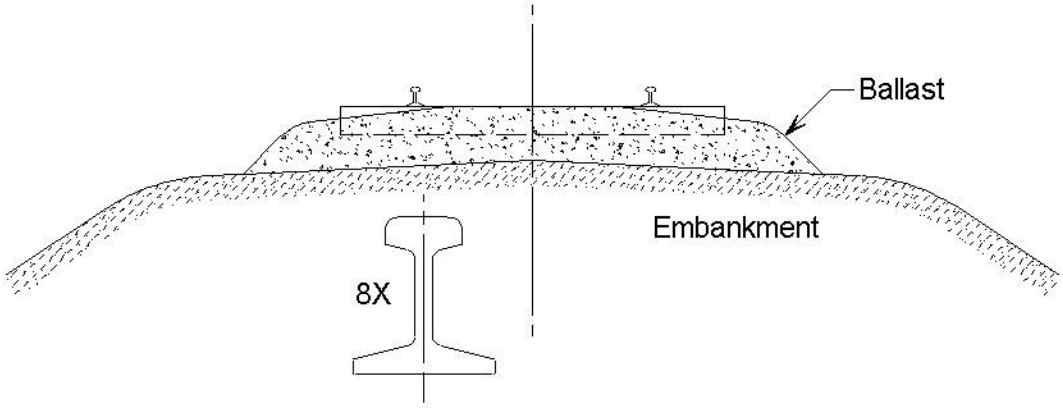
Track Profiles

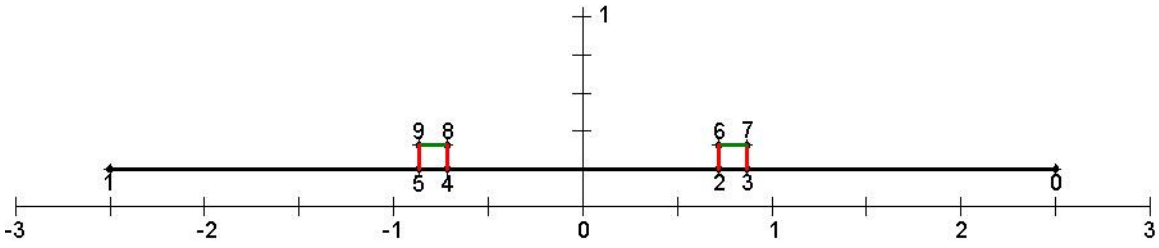
Track profiles are cross sections of track – rails, ties, ballast, etc. – used to specify the geometry of construction. Track profiles are used to generate a mesh of triangles that can be rendered to provide a visual representation of “track.” The generation process involves *sweeping* (or *extruding*) the cross section along the railroad’s path, whether straight or curved. The method is termed *generative* or *procedural*.



Scale 1:48 drawing of Northern Pacific track profile for single track, rock ballast roadbed. Rail section shown is 80 pound ARA-B. *Redrawn from references provided courtesy of Dave Nelson.*

A representative prototype cross section is shown above. It consists of rail, ties, ballast, and embankment. We can model whatever we want in as much detail as we want. However, we can't handle the circular arcs used for rounds and fillets; we have to break them down into line segments. And, we must trade off (experimentally) the performance impact of detail with the quality of the rendering.

The default profile that Open Rails uses for dynamic track is extremely simple:



Default profile for Open Rails dynamic track. The scale is in meters.

The long horizontal line segment (black) models the ballast surface and ties. Details like rounding and tie detail are suggested by painting those effects on the texture (image) that is wrapped on the mesh generated. The two short horizontal line segments (green) model the rail tops. The four short vertical line segments (red) model the rail sides (left and right, inner and outer).

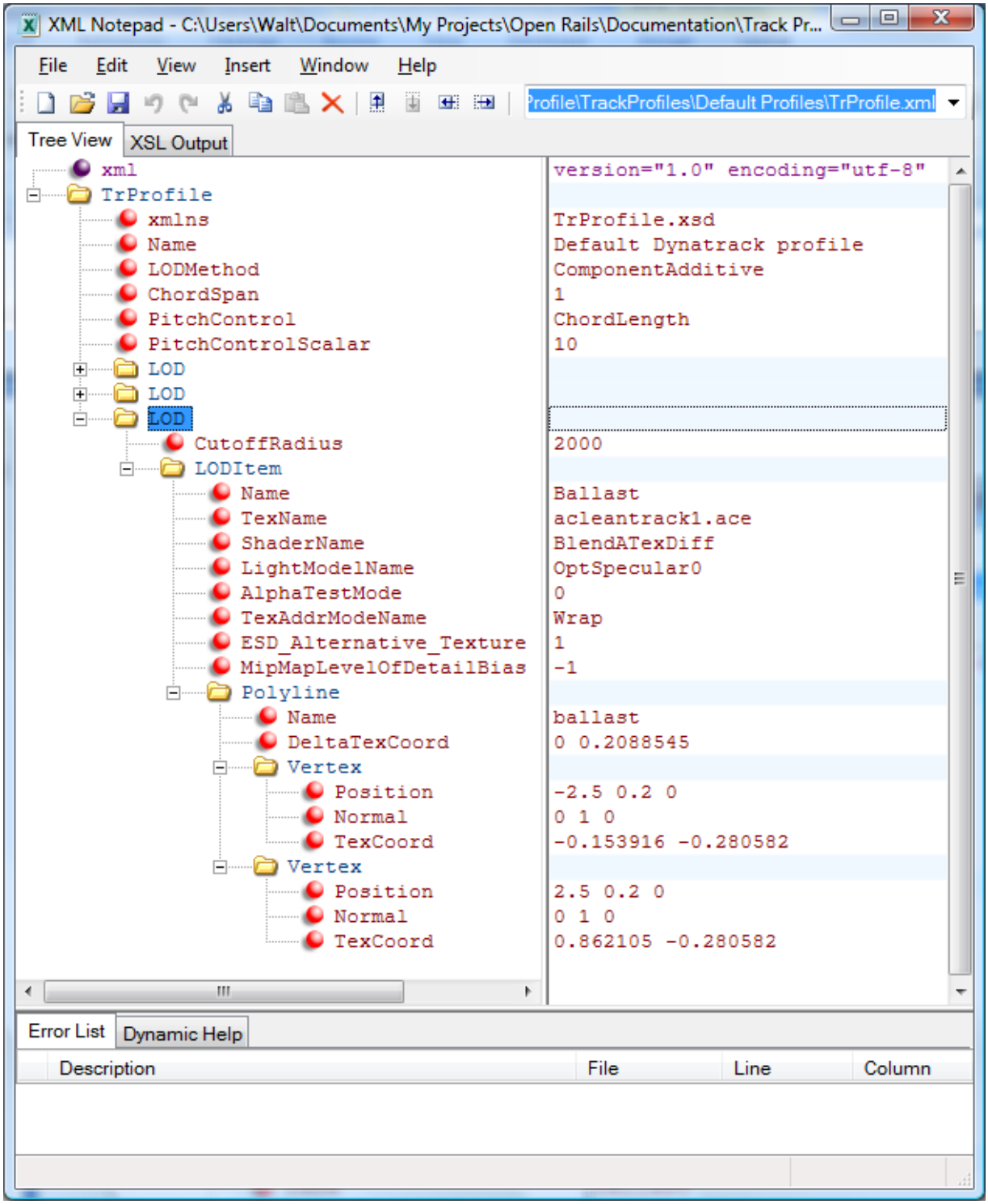
The three categories are used as levels-of-detail (LODs). Suppose that you have a camera positioned for an external view of the track, low enough so you can see rail sides and high enough so you can see rail tops. Imagine that you pull back the camera. When you get far enough back, the rail sides will disappear. (You probably won't notice.) You'll still notice the shine off the rail tops. If you continue moving back, the rail tops will disappear. And, if you continue back farther, eventually the ballast LOD will disappear. Then, if you reverse direction and move toward the track sections, the LODs will pop back in (in the reverse order). All this is designed to relieve the load on the processors for complex scenes.

The method of LOD control described above is called *Component Additive*: *Component* because each LOD is a model of a component, some number of which represent the complete track model. *Additive* because, as the camera moves in toward the model, component items are *added*. There is another method available to designers called *Complete Replacement*. There, each LOD item is a *complete* model, more or less detailed than the previous LOD item, and, as an LOD item is added, it *replaces* the previous one. This topic will be covered in more detail later.

Track Profile Hierarchy

Track profiles consist of a hierarchy in which an element named *TrProfile* is at the very top of the hierarchy. The screenshot on the next page is *XML Notepad 2007's* view of one of the file formats that can be used to define a track profile for Open Rails. Note the hierarchy in the tree view in the left-hand pane that progresses from TrProfile to LOD to LODItem to Polyline to Vertex as you descend in the tree. Those elements will be discussed in sequence in the subsections below.

Note that there are three LODs. Only the third (Ballast) is expanded to display the full hierarchy. The first two LODs are collapsed to save space.



XML Notepad's view of the hierarchy of the default track profile.

TrProfile

The *TrProfile* element is at the head (or root) of the hierarchy. A set of attributes and a collection of *LODItems* comprise a TrProfile as children. The attributes are:

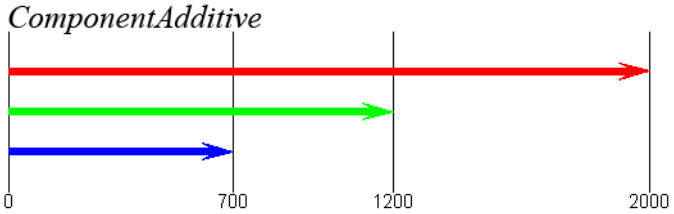
xmlns	Standard for all track profiles that use XML for their definition. The MSTS Structured Text File (STF) format may alternatively be used.
Name	A descriptive name for the track profile.

ChordSpan	Specifies the angle (degrees) desired for the pitch with which the profile should be replicated for curves. The profile plus all its replications form a set of cross sections for the track shape.
LODMethod	Identifies the method of LOD control desired – *ComponentAdditive* or *CompleteReplacement*. See LOD Control below for a detailed explanation.
PitchControl	Specifies the method of pitch refinement for curves.. It may be: ***None*** — No refinement desired. ***ChordLength*** — If the angle specified by *ChordSpan* results in a chord length greater than *PitchControlScalar*, the chord length will be refined to *PitchControlScalar*. ***ChordDisplacement*** — If the angle specified by *Chordspan* results in a chord displacement (distance between the curve and chord at the point of maximum deviation) greater than *PitchControlScalar*, the chord displacement will be refined to *PitchControlScalar*. See Pitch Control below for a detailed explanation.
PitchControlScalar	Holds the value for ChordLength or ChordDisplacement.

LOD Control

The purpose of LOD control is to handle the way LODs are switched in and out of the rendering queue as a function of the distance between the camera and the object. Two control schemes are implemented: ComponentAdditive and CompleteReplacement.

ComponentAdditive – To see how this scheme works, consider the illustration below.

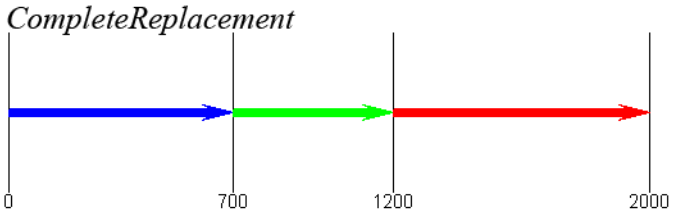


In this example, the blue LOD has a cutoff radius of 700 meters; the green and blue LODs, 1200 and 2000, respectively. That is, when those distances are exceeded, the respective LOD is not added to the rendering queue (i.e., is not seen). Each LOD models a *Component* of the object, and the effect of an observer moving in closer to the camera (from the right end of the distance scale here) is *Additive*. That is, as the observer moves closer, each time he hits a cutoff radius boundary, another component is *added*.

A good example of this scheme is the default track profile where the red, green, and blue arrows correspond to ballast and ties (red), rail tops (green), and rail sides (blue). Starting with the camera close to the object, all three components are seen. As the camera moves away from the object and the 700-meter range is crossed, the rail sides are no longer rendered. Then, as the camera crosses the 1200-meter range, the rail tops leave the render list. Finally, after the camera crosses the 2000-meter

range, no component of this object is rendered. Reversing the camera and moving it closer to the object, the components pop into the scene in reverse order, that is, ballast (red) at 2000 meters, rail tops (green) at 1200 meters, and rail sides (blue) at 700 meters.

CompleteReplacement – For the alternative scheme, take a look at the following diagram:



Here, 700, 1200, and 2000 again divide the camera range space into four regions: 0-700 (blue), 700-1200 (green), 1200-2000 (red), and beyond 2000 (nothing). Here, the rules are different: Only one LOD is displayed for a given camera position. And that is the LOD that has a *CutoffRadius* corresponding to the range that the camera is in, that is, 700 (blue), 1200 (green), and 2000 (red). Each LOD must constitute an appropriate *Complete* model for that range (hence the *Complete* in *CompleteReplacement*).

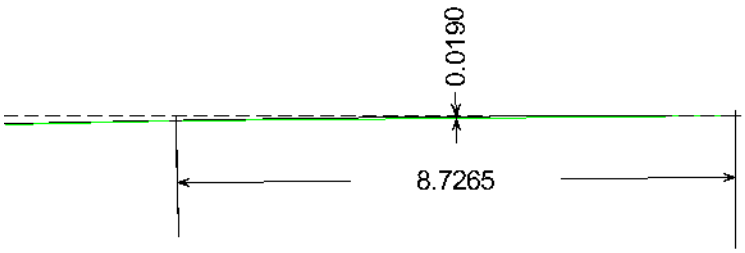
Note that, as the camera crosses a region boundary while moving away from the object, an LOD leaves the scene and is *replaced* by another (except for the last – beyond-2000). This accounts for the *Replacement* in *CompleteReplacement*.

Which of these methods should be used is strictly a designer preference. Note that, with either of these two schemes, it is required that the LOD items be arranged in ***ascending*** order of *CutoffRadius*.

Pitch Control

ChordSpan (described above) is the first level of control of the *pitch* with which profiles are generated to define a mesh for a model of a curved section of dynamic track. *Pitch* refers to the angle subtended by two adjacent profiles, which is a constant for any particular circular-arc section.

ChordSpan pitch control leaves something to be desired for large-radius curves. Hence, two alternative methods have been introduced for refinement of *ChordSpan* control – *ChordLength* and *ChordDisplacement*. The following illustrations define these quantities:



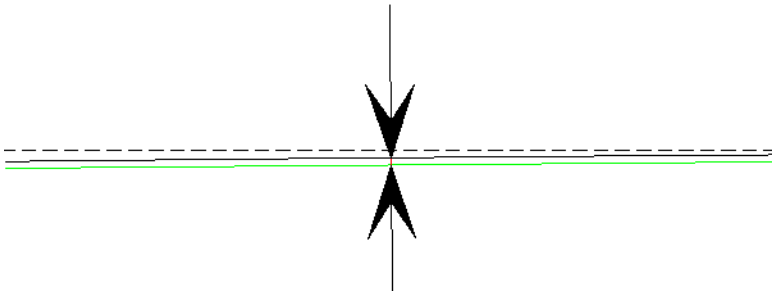
The diagram above is an "eye test." It depicts a curve, which is supposed to be a solid black arc, but it is broken up by interference from the green straight line segments which approximate the circular arc. The dashed black line is tangent to the arc at its point of origin (right). A tiny cross marks the origin of the arc (right). The curve is of 500-meter radius. The diagram depicts one pitch unit of one degree. There is a second tiny cross at the top of the left-hand extension line for the 8.7265 dimension. The second cross marks the point where the curve has deflected one degree (one pitch unit). In fact, the left-hand extension line has a severe case of the "jaggies" because, superimposed with it is a one-degree radial line to the center of the arc.

The green line segments (two of them) are chords spanning one-degree segments. The 8.7265 (meters) dimension is the length of the chord. It is this length that is tested for *ChordLength* control.

ChordLength Control – Under *ChordLength* control, when *ChordSpan* control (one degree in this example) yields a chord length that is greater than *PitchControlScalar* , then the pitch will be refined such that the chord length is exactly *PitchControlScalar*.

One suggested "rule of thumb" is that target chord lengths should be held to a maximum in the 10.0-12.5 meter range.

ChordDisplacement Control – Referring again to the diagram above, the other dimension illustrated (the 0.0190-meter dimension) refers to the miniscule distance between the arc and chord at its point of maximum excursion, which is at the center of the chord. Just to be sure that this is clear, here is a "blow-up" of the dimension. Note that there is, in fact, a miniscule red line segment that identifies the maximum excursion.



Under *ChordDisplacement* control, when *ChordSpan* control fails to produce a chord displacement less than *PitchControlScalar*, then the pitch will be refined such that the chord displacement is exactly *PitchControlScalar*.

One suggested guideline for profile designers is to consider a target chord displacement as a fraction of railhead width. For example, the 19 mm chord displacement in this one-degree pitch example is 28 percent of a 68 mm railhead width.

For more on pitch control, see the Appendix.

Returning to the description of the structure of a track profile, after the root item, *TrProfile*, next in the hierarchy is a list of the one or more LODs that comprise the track profile, arranged in order of increasing *CutoffRadius* (see below).

LOD

The only purpose for an LOD is to define the *component* model for a *ComponentAdditive* model or the *complete* model for a *CompleteReplacement* model. Each LOD has an associated *CutoffRadius* that defines the range of camera positions where the LOD is seen. An LOD has only one attribute:

CutoffRadius	The end-of-range distance between the center of this track section and the camera. This LOD will not be rendered when this distance is exceeded. (The start-of-range will be the next previous LOD with a *CutoffRadius* less than this one.)

LODs give control over model complexity as a function of distance of the object from the camera. As the distance increases, the model can become less complex, which economizes hardware/software performance.

Each LOD consists of one or more *LODItems*.

LODItem

Each *LODItem* that follows as a child of an LOD serves a single purpose: It serves as a (geometry, material) unit. All material properties (including texture) are introduced at this level.

Again, attributes and a collection comprise a LODItem. The attributes are:

Name	A descriptive name for the LOD.
TexName	The filename (with file extension) for the texture to be used for this LOD.
ShaderName	A material property that controls how light reflects off the surface of the LOD item: ***Diffuse*** Diffuse light reflected. ***TexDiff*** Diffuse light reflected. ***BlendATexDiff*** Diffuse light reflected with alpha-testing and blending. ***AddATexDiff*** Diffuse light reflected with alpha-testing and blending. ***Tex*** Diffuse light not reflected. ***BlendATex*** Diffuse light not reflected with alpha-testing and blending. ***AddATex*** Diffuse light not reflected with alpha-testing and blending.
LightModelName	A material property modeling how an LOD item is lit. ***DarkShade*** Darkly shaded. ***OptHalfBright*** Half lit. ***OptFullBright*** Fully lit. ***Cruciform*** Simulates lighting on vegetation. ***CruciformLong*** Simulates lighting on vegetation. ***OptSpecular0*** Dull finish. ***OptSpecular25*** Shiny. ***OptSpecular750*** Very shiny.
AlphaTestMode	A material property that controls whether or not alpha-testing is done. ***0*** No alpha-testing. ***1*** Alpha-testing is performed, and, if the texture's alpha channel is less than *ReferenceAlpha*, the texture is opaque at a pixel; otherwise it is transparent. *ReferenceAlpha* is 10 for all of the shaders with "ATex" in their names and 200 otherwise.
TexAddrModeName	A material property that determines how the texture gets

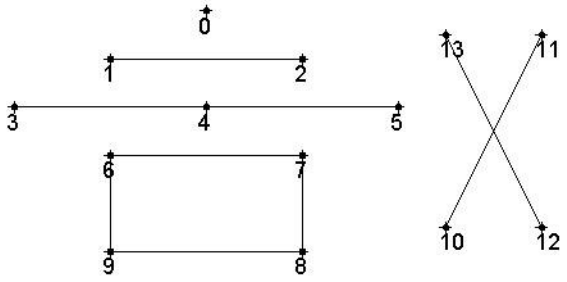
	applied to the surface of the LOD item. ***Wrap*** — Tile the texture at every integer value of a texture coordinate (u, v). For example, for u values between 0 and 3, the texture is repeated three times. ***Mirror*** — Similar to *Wrap*, except that the texture is flipped at every integer value of (u, v). ***Clamp*** — Texture coordinates less than 0 are set to the texture color at 0, and texture coordinates greater than 1 are set to the texture color at 1. ***Border*** — Texture coordinates outside the range 0-1 are set to the border color.
ESD_Alternative_Texture	Equivalent to the MSTS parameter of the same name. This integer indicates where OpenRails should look to find alternative textures, depending on weather and time-of-day: 0: The LODItem has no alternative texture. The base texture is used all of the time. 1: The LODItem has two textures, the base texture and one in the Snow subdirectory. 252: The LODItem has alternative textures to cover seasonal variations with and without snow. These should go in Summer, SummerSnow, Autumn, AutumnSnow, Winter, and WinterSnow subdirectories. 256: The LODItem has one alternative texture, in the Night subdirectory.
MipMapLevelOfDetailBias	A number that can be "tweaked" to sharpen or blur textures. Negative changes sharpen; positive changes blur. (0 means no bias.)

The collection that follows the attributes of an LODItem is a collection of Polylines.

The last two LODItems are not expanded in the XML Notepad screenshot to save space. In XML Notepad, the LODItems can be expanded to show their Polyline children simply by clicking the '+' sign.

Polyline

A *Polyline* element is a contiguous* set of straight line segments that connect a set of points. For example, consider the illustration to the right. The part labeled "0" is not a polyline; it's a point. "1–2" is a polyline, a single-segment polyline. "3 – 4 – 5" is a two-segment polyline. "6 – 7 – 8 – 9 – 6" is a four-segment closed



* Contiguous – arranged head-to-tail.

polyline, rightfully called a *polygon*. "10 – 11 12 – 13" is not a polyline; it is two polylines.

Each Polyline element is defined in the track profile file by a set of attributes and a collection of child elements. The attributes follow:

Name	A descriptive name for the polyline.
DeltaTexCoord	The change in texture coordinates (Δu, Δv) per meter along the path of the track centerline.

It is obvious from the examples above that a polyline is defined by a collection of points, in addition to its attributes. We term these vertices because they describe more than just the location. The collection that constitutes the child elements of a polyline is a collection of vertices.

Vertex

A *Vertex*, by definition, is at the bottom of the hierarchy tree because it has no children. It has only attributes, which are as follows:

Position	The position vector (x, y, z) at the point relative to the local origin (root) of the track section.
Normal	A unit normal vector (n_x, n_y, n_z) at the point, which is used for lighting calculations.
TexCoord	A texture coordinate (u, v) at the point, which is used for texture wrapping.

Track Profile Hierarchy Summary

Before leaving the topic of the track profile hierarchy, it is important to emphasize quantities:

- There is one and only one *TrProfile*, which serves as the root of the hierarchy tree.
- There may be one or more *LODs*; there must be at least one. The *LODs* must be sorted in *TrProfile* in order of increasing *CutoffRadius*. Multiple *LODs* with the same *CutoffRadius* are not allowed.
- There may be one or more *LODItems* for each *LOD*; there must be at least one.
- There may be one or more *Polylines* for each *LODItem*; there must be at least one.
- There may be two or more *Vertices* for each *Polyline*; there must be at least two.

Track Profile Files

Track profiles are defined by external files. Currently, they all have a common file name of "TrProfile."* The file extension changes from style to style. If Open Rails finds no TrProfile.*xxx* in the TrackProfiles folder for a route, where *xxx* is a supported file extension, then it builds a default track profile in memory. The default profile looks identical to the one you're used to for dynamic track.

Currently, two track profile file styles (or formats) are supported – MSTS STF-style and XML-style.† The search order is XML first, STF next; if neither exist, then the default is built.

STF-Style

MSTS veterans probably have experience with the complete parenthesis syntax of ENG, WAG, etc. files. Take a look at what an STF-style track profile file looks like for the default profile (page 12).

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* In the future, we intend to extend this to multiple profiles, probably distinctly named.

† Hopefully, experience will reveal the superior style, and one will be deprecated in the future.

It's relatively clean when formatted this way, and you may be used to it. The down side is that validation is minimal, and you may have problems figuring out where you made an error. (But MSTS veterans don't make errors.*)

The MSTS-style track profile files have a file extension of ".stf".

All STF files must have a SIMIS-style header on Line 1 which is specific to profiles. It must be: "`SIMISA@@@@@@@@@@JINX0p0t_____`" (without the quotation marks).

XML-Style

You've already seen what XML-style track profile files look like when viewed with XML Notepad 2007. To see what an XML track profile really looks like, see page 13.

There's not a lot of difference. The principal difference is that XML uses tags (< … >) to bound elements and *name* = *value* syntax to define attributes. Also, XML bounds all values with quotes. So, there's a little bit more typing required by the XML style. But then you'll probably be using an XML editor (e.g., XML Notepad 2007).

But wait. There is one additional file required by the XML style – TrProfile.xsd. But there is one of these provided for you, and you had better not modify it. Modify it, and the code breaks!

TrProfile.xsd defines (in XML) the syntax of a track profile. It drives the validation code in Open Rails used to check the syntax of your track profile (TrProfile.xml).

All you have to remember is to put your TrProfile.xml and the standard TrProfile.xsd in the TrackProfiles folder in the root folder of the desired route. (If there is sufficient interest in support for XML, TrProfile.xsd will be treated as Open Rails "content," and you won't have to worry about it.)

Installation

Installation is simple:

1. Select a style: STF or XML.
2.
   a. If there is no TrackProfiles folder in the root folder of the desired route, make one.
   b. If STF, copy TrProfile.stf to the route's TrackProfiles folder. If there is a TrProfile.xml in the folder, delete it, rename it, or move it elsewhere. (TrProfile.xml takes precedence over TrProfile.stf if both are in the folder.)
   c. If XML, copy TrProfile.xml and TrProfile.xsd to the route's TrackProfiles folder.
3. Start the game. (When the game loads, you'll notice an additional item logged on the "Loading …" line. It is "TRP," which stands for TRackProfile. "Default," "STF," or "XML" is output in parenthesis following the "TRP."

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* They'll blame it on the programmer.

```
SIMISA@@@@@@@@@@JINX0p0t______
TrProfile ( Name ( "Default Dynatrack Profile" ) LODMethod ( "ComponentAdditive" ) ChordSpan ( 1 )
              PitchControl ( "ChordLength" ) PitchControlScalar ( 10 )
       LOD ( CutoffRadius ( 700 )
              LODItem ( Name ( "Railsides" ) TexName ( "acleantrack2.ace" ) ShaderName ( "TexDiff" )
                     LightModelName ( "OptSpecular0" ) AlphaTestMode ( 0 ) TexAddrModeName ( "Wrap" )
                     ESD_Alternative_Texture ( 0 ) MipMapLevelOfDetailBias ( 0 )
                     Polyline ( Name ( "left_outer" ) DeltaTexCoord ( 0.1673372 0 )
                            Vertex ( Position ( -0.8675 0.200 ) Normal ( -1 0 0 ) TexCoord ( -0.139362  0.101563 ) )
                            Vertex ( Position ( -0.8675 0.325 ) Normal ( -1 0 0 ) TexCoord ( -0.139363  0.003906 ) )
                     )
                     Polyline ( Name ( "left_inner" ) DeltaTexCoord ( 0.1673372 0 )
                            Vertex ( Position ( -0.7175 0.325 ) Normal (  1 0 0 ) TexCoord ( -0.139363  0.003906 ) )
                            Vertex ( Position ( -0.7175 0.200 ) Normal (  1 0 0 ) TexCoord ( -0.139362  0.101563 ) )
                     )
                     Polyline ( Name ( "right_inner" ) DeltaTexCoord ( 0.1673372 0 )
                            Vertex ( Position (  0.7175 0.200 ) Normal ( -1 0 0 ) TexCoord ( -0.139362  0.101563 ) )
                            Vertex ( Position (  0.7175 0.325 ) Normal ( -1 0 0 ) TexCoord ( -0.139363  0.003906 ) )
                     )
                     Polyline ( Name ( "right_outer" ) DeltaTexCoord ( 0.1673372 0 )
                            Vertex ( Position (  0.8675 0.325 ) Normal (  1 0 0 ) TexCoord ( -0.139363  0.003906 ) )
                            Vertex ( Position (  0.8675 0.200 ) Normal (  1 0 0 ) TexCoord ( -0.139362  0.101563 ) )
                     )
              )
       )
       LOD ( CutoffRadius ( 1200 )
              LODItem ( Name ( "Railtops" ) TexName ( "acleantrack2.ace" ) ShaderName ( "TexDiff" )
                     LightModelName ( "OptSpecular25" ) AlphaTestMode ( 0 ) TexAddrModeName ( "Wrap" )
                     ESD_Alternative_Texture ( 0 ) MipMapLevelOfDetailBias ( 0 )
                     Polyline ( Name ( "right" ) DeltaTexCoord ( 0.0744726 0)
                            Vertex ( Position ( -0.8675 0.325 ) Normal ( 0 1 0 ) TexCoord (  0.232067  0.126953 ) )
                            Vertex ( Position ( -0.7175 0.325 ) Normal ( 0 1 0 ) TexCoord (  0.232067  0.224609 ) )
                     )
                     Polyline ( Name ( "left" ) DeltaTexCoord ( 0.0744726 0 )
                            Vertex ( Position (  0.7175 0.325 ) Normal ( 0 1 0 ) TexCoord (  0.232067  0.126953 ) )
                            Vertex ( Position (  0.8675 0.325 ) Normal ( 0 1 0 ) TexCoord (  0.232067  0.224609 ) )
                     )
              )
       )
       LOD ( CutoffRadius ( 2000 )
              LODItem ( Name ( "Ballast" ) TexName ( "acleantrack1.ace" ) ShaderName ( "BlendATexDiff" )
                     LightModelName ( "OptSpecular0" ) AlphaTestMode ( 0 ) TexAddrModeName ( "Wrap" )
                     ESD_Alternative_Texture ( 1 ) MipMapLevelOfDetailBias ( -1 )
                     Polyline  ( Name ( "ballast" ) DeltaTexCoord ( 0 0.2088545 )
                            Vertex ( Position ( -2.5000 0.200 ) Normal ( 0 1 0 ) TexCoord ( -0.153916 -0.280582 ) )
                            Vertex ( Position (  2.5000 0.200 ) Normal ( 0 1 0 ) TexCoord (  0.862105 -0.280582 ) )
                     )
              )
       )
)
```

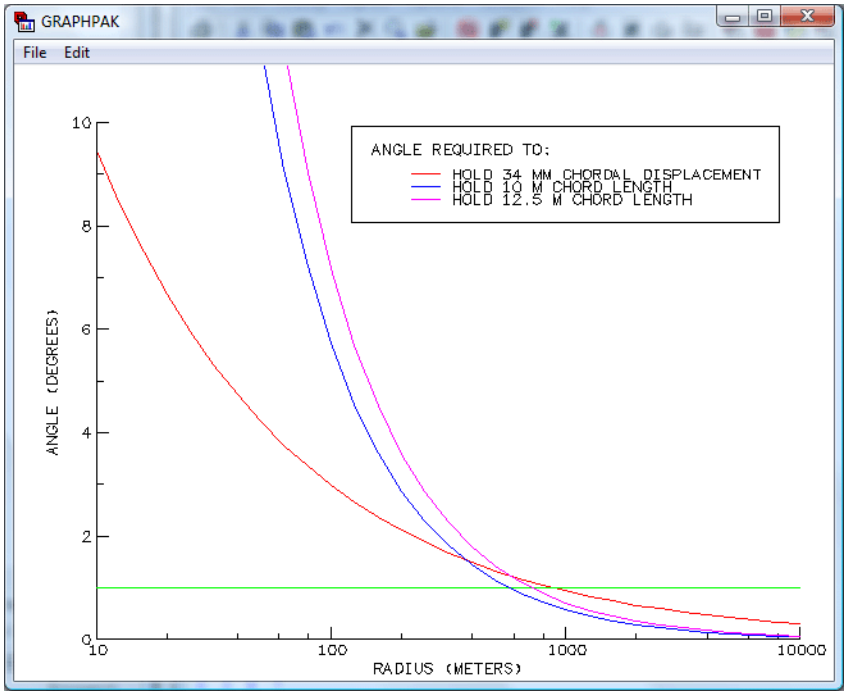
MSTS-Style Track Profile (TrProfile.stf)

```
<?xml version="1.0" encoding="utf-8"?>
<TrProfile xmlns="TrProfile.xsd" Name="Default Dynatrack profile" LODMethod="ComponentAdditive" ChordSpan="1"
       PitchControl="ChordLength" PitchControlScalar="10">
  <LOD CutoffRadius="700">
    <LODItem Name="Railsides" TexName="acleantrack2.ace" ShaderName="TexDiff" LightModelName="OptSpecular0"
             AlphaTestMode="0" TexAddrModeName="Wrap" ESD_Alternative_Texture="0" MipMapLevelOfDetailBias="0">
      <Polyline Name="left_outer" DeltaTexCoord="0.1673372 0">
        <Vertex Position="-0.8675 0.2 0" Normal="-1 0 0" TexCoord="-0.139362 0.101563" />
        <Vertex Position="-0.8675 0.325 0" Normal="-1 0 0" TexCoord="-0.139363 0.003906" />
      </Polyline>
      <Polyline Name="left_inner" DeltaTexCoord="0.1673372 0">
        <Vertex Position="-0.7175 0.325 0" Normal="1 0 0" TexCoord="-0.139363 0.003906" />
        <Vertex Position="-0.7175 0.2 0" Normal="1 0 0" TexCoord="-0.139362 0.101563" />
      </Polyline>
      <Polyline Name="right_inner" DeltaTexCoord="0.1673372 0">
        <Vertex Position="0.7175 0.2 0" Normal="-1 0 0" TexCoord="-0.139362 0.101563" />
        <Vertex Position="0.7175 0.325 0" Normal="-1 0 0" TexCoord="-0.139363 0.003906" />
      </Polyline>
      <Polyline Name="right_outer" DeltaTexCoord="0.1673372 0">
        <Vertex Position="0.8675 0.325 0" Normal="1 0 0" TexCoord="-0.139363 0.003906" />
        <Vertex Position="0.8675 0.2 0" Normal="1 0 0" TexCoord="-0.139362 0.101563" />
      </Polyline>
    </LODItem>
  </LOD>
  <LOD CutoffRadius="1200">
    <LODItem Name="Railtops" TexName="acleantrack2.ace" ShaderName="TexDiff" LightModelName="OptSpecular25"
             AlphaTestMode="0" TexAddrModeName="Wrap" ESD_Alternative_Texture="0" MipMapLevelOfDetailBias="0">
      <Polyline Name="right" DeltaTexCoord="0.0744726 0">
        <Vertex Position="-0.8675 0.325 0" Normal="0 1 0" TexCoord="0.232067 0.126953" />
        <Vertex Position="-0.7175 0.325 0" Normal="0 1 0" TexCoord="0.232067 0.224609" />
      </Polyline>
      <Polyline Name="left" DeltaTexCoord="0.0744726 0">
        <Vertex Position="0.7175 0.325 0" Normal="0 1 0" TexCoord="0.232067 0.126953" />
        <Vertex Position="0.8675 0.325 0" Normal="0 1 0" TexCoord="0.232067 0.224609" />
      </Polyline>
    </LODItem>
  </LOD>
  <LOD CutoffRadius="2000">
    <LODItem Name="Ballast" TexName="acleantrack1.ace" ShaderName="BlendATexDiff" LightModelName="OptSpecular0"
             AlphaTestMode="0" TexAddrModeName="Wrap" ESD_Alternative_Texture="1" MipMapLevelOfDetailBias="-1">
      <Polyline Name="ballast" DeltaTexCoord="0 0.2088545">
        <Vertex Position="-2.5 0.2 0" Normal="0 1 0" TexCoord="-0.153916 -0.280582" />
        <Vertex Position="2.5 0.2 0" Normal="0 1 0" TexCoord="0.862105 -0.280582" />
      </Polyline>
    </LODItem>
  </LOD>
</TrProfile>
```

XML Track Profile (TrProfile.xml)

Appendix – More on Pitch Control

For more insight into pitch control, consider the following plot:



The vertical axis of the plot represents the pitch angle of a series of straight-line segment used as an approximation to a circular-arc curve; the horizontal axis represents the radius of the curve. The green line represents a constant one-degree pitch angle, independent of radius – what you get with a *ChordSpan* control scheme.

Look at the blue curve, which is a plot of the pitch angle required to hold a 10-meter chord length as a function of curve radius. Note that it crosses the one-degree line at about 600 meters radius. (Note that the radius axis has a logarithmic scale.) This tells you that, above 600 meters radius, you will be missing a target of 10-meter chord length with a one-degree chord span. Similarly, you will be missing a target of 12.5-meter chord length (magenta curve) for radii above about 700 meters. If you seek a target of 34 mm chord displacement (half a rail width), you will miss it with a one-degree chord span for radii above about 900 meters.

The *ChordLength* and *ChordDisplacement* scheme are, in fact, algebraically related. If L is the chord length and d is the chord displacement, then:

$$L\left(1-\cos\frac{\theta}{2}\right)=2\,d\sin\frac{\theta}{2}$$

for any given chord span θ. Thus, L and d are linearly related for any given chord span, θ. For example, for a one-degree chord span:

$$d=.00218\,L$$

Thus, for a one-degree chord span, a 10-meter chord length would yield a chord displacement of 21.8 mm.