

Chapter 4

TRAKVU

TRAKVU is a program developed to work with the dynamic modeling program NUCARS. TRAKVU serves as a track preprocessor for creating track input files for NUCARS. This chapter provides some background on the origin of TRAKVU, as well as a discussion on the layout of some of its features. Finally, a description on how track irregularities are included in TRAKVU is given.

4.1 Background

An important aspect to a good NUCARS model is the track. By supporting and guiding the vehicle along its path, the track supplies essential inputs to the dynamic system, as discussed in previous sections. Before TRAKVU, NUCARS users were limited to the few track files that were provided with NUCARS. Users could also use NUCARS to create track geometry using analytic shapes, but without the irregularities inherent in actual track and essential to the validity of the model.

This deficiency established the need for a practical track preprocessor that would not only allow users to create their own NUCARS track files, but would also better represent track irregularities in analytically created track. TRAKVU was developed for this purpose. TRAKVU gives NUCARS users the ability to use their own measured track geometry data as the input to a model. It also enables users to create analytic track data with the essential track irregularities. TRAKVU can be used to view the measured or created track data, and can generate the files necessary for use as NUCARS input files.

4.2 TRAKVU Layout

The main purpose of TRAKVU is to process track data so that it may be used with NUCARS. In addition, TRAKVU has many other features and capabilities that make it

unique and useful. These include various input formats, plotting and data utilities, and output formats compatible with NUCARS. This section will step through these basic features and capabilities of TRAKVU. For more information on the structure of TRAKVU, one can refer to the menu structure included in Appendix B.

4.2.1 Input Formats

As previously discussed, TRAKVU allows the user to view and create track files for NUCARS using track geometry input data that can be supplied by either reading in measured track geometry data or allowing TRAKVU to analytically create the track data. In the case of using measured track geometry data, the data are supplied to TRAKVU in the form of an external, user-supplied ASCII data file. TRAKVU has the capability to read measured track geometry data in various formats, selected by the user, to suit the data file. Figure 4.1 shows the TRAKVU menu for selecting the order, units, and signs of the variables in the track data file. In this menu, the nominal gauge, in inches, can also be entered.

TRAKVU internally uses the NUCARS standard English units and sign conventions shown in Fig. 2.2, although it allows the user to change the units and sign conventions of the input data. For instance, if the track data were measured in metric units or with signs opposite to the sign conventions used by NUCARS, the user could specify the unit and sign for each variable. TRAKVU will also ask the user if the track data are measured or analytically created. If the data were analytically created, the user can select to add-in irregularities. If the data already contain irregularities, the user can choose to continue with or without adding additional irregularities. The types of irregularities are discussed in more detail in Section 4.3. Once the program has been setup to read the data, the track data are loaded, converted to NUCARS standard English units and sign conventions, and the necessary track geometry variables are calculated.

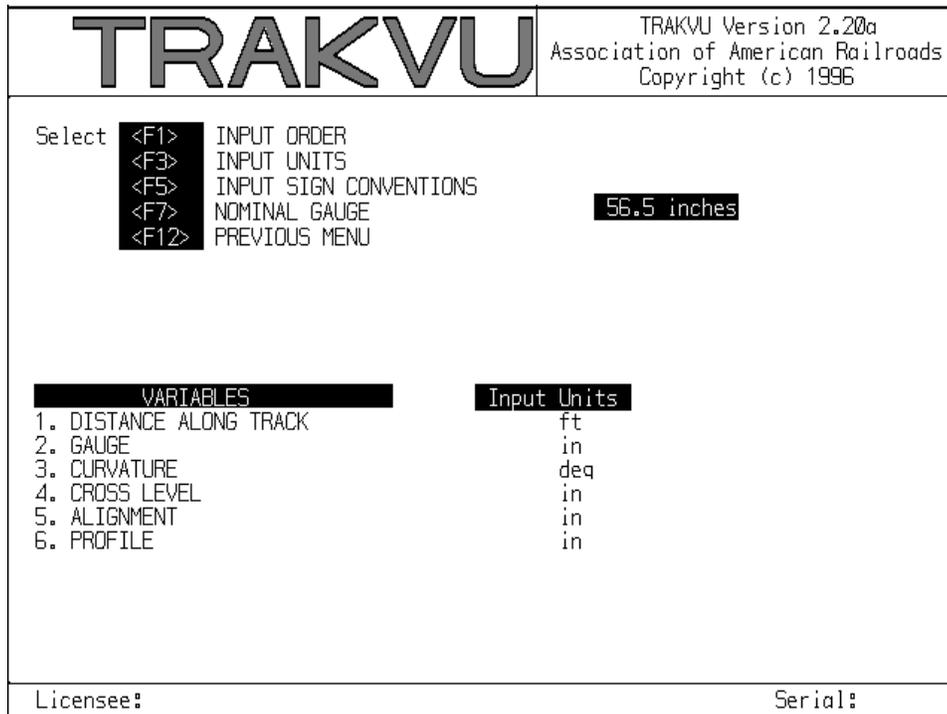


Figure 4.1 TRAKVU Menu for Setting Up to Read Data

If the user does not have measured track geometry data, TRAKVU can be used to generate it analytically. Figure 4.2 shows the steps involved in creating track data with TRAKVU. Several variables are needed for creating analytical track data, including: the start and end distances, the distance between data points, the distance between rail centers, the nominal gauge, and the number of segments that each track input is to be divided into. The left lateral, left vertical, right lateral, and right vertical track inputs are used to generate the track geometry. Next, the track is divided into as many sections, or segments, as necessary, each described by a mathematical shape such as a cusp, bend, sine, or a null [8].

Track irregularities can now be added to the individual segments. The user can choose between random irregularities, various wave shapes, or track class irregularities. The track irregularities will be discussed in more detail in Section 4.3. Finally, the curvature and superelevation are divided up into segments as well. The user then specifies the values of the curvature and superelevation for each segment. At this point, all the necessary information has been entered into TRAKVU, and it will then generate the track geometry data.

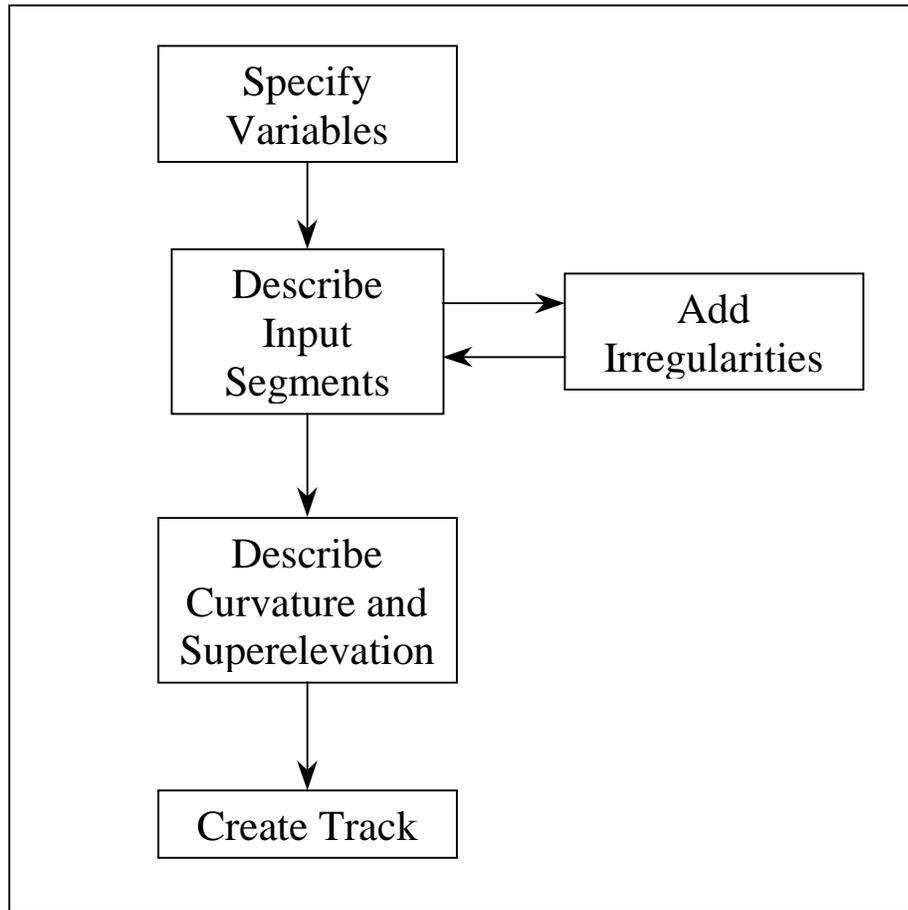


Figure 4.2 Flow Chart of Track Creation in TRAKVU

4.2.2 Features

Upon loading or generating the track geometry data, the user can use other features of TRAKVU to plot the data, save the data, or perform various other operations on the data. Except for the saving options, these features will be outlined next. For more detailed instructions on these features, see the TRAKVU User's Manual [14].

One of the most useful features of TRAKVU is its ability to plot the track data. TRAKVU is capable of plotting, in either English or metric units, up to four y-axis variables against one x-axis variable. Any of the original variables or any of the variables created by other TRAKVU features may be plotted. The minimum and maximum values of each

variable may be changed to scale the plots. A scale factor may also be applied to any of the variables so that, variables with different orders of magnitudes may be viewed together. Figure 4.3 shows the menu for setting up the variables to plot in TRAKVU. Figure 4.4 shows a plot of two variables, left vertical and right vertical vs. distance traveled.

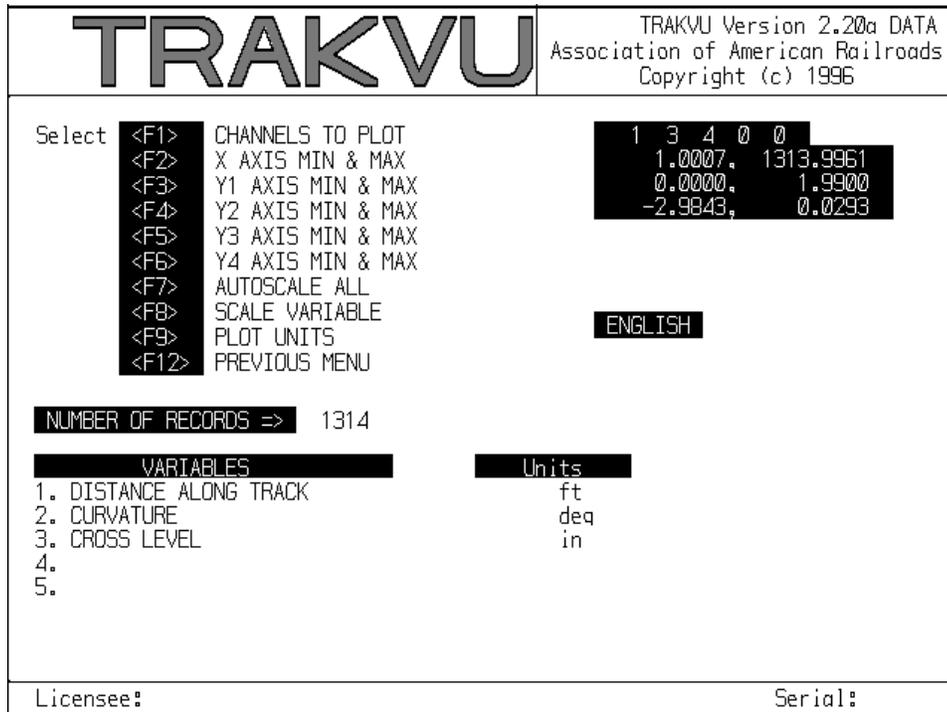


Figure 4.3 TRAKVU Plot Menu

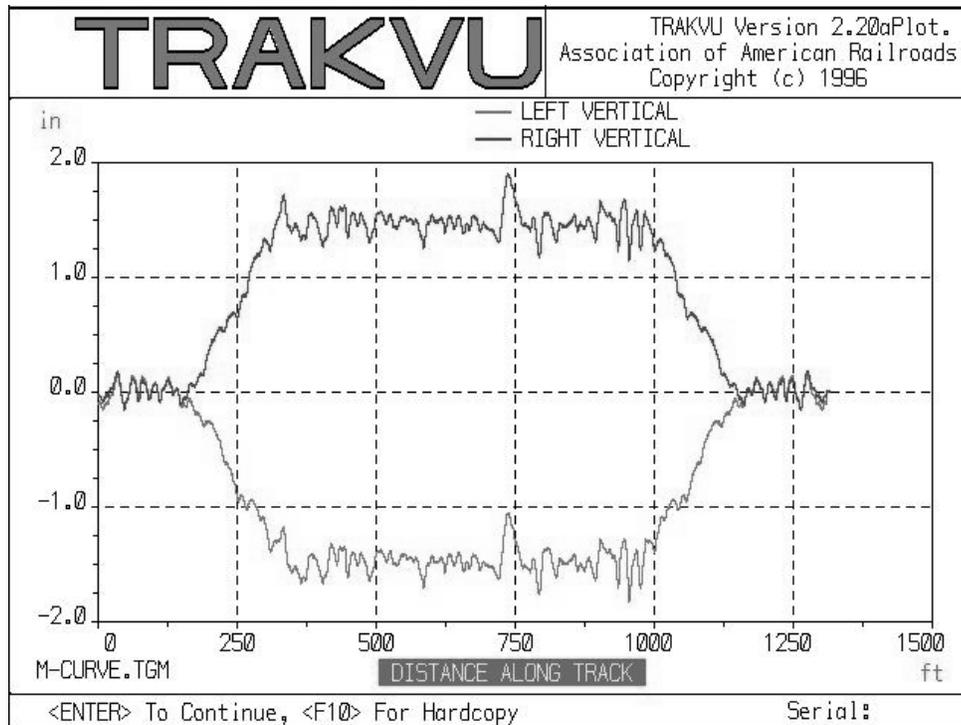


Figure 4.4 TRAKVU Plot of Two Variables

The next option is the creation of the PTB/PWL. This option enables the user to create a piece wise linear (PWL) representation of the curvature and superelevation. To create a PWL representation of a variable, the data are divided into linear sections that describe the general trend of the data. These linear sections are then described by their start and end points. Figure 4.5 shows an example of a PWL representation of the curvature. The squares indicate the start and end points for each linear section. In TRAKVU, the PWL representation is created by selecting the start and end points of the linear sections using the mouse, or other pointing devices while viewing the plots of the curvature and superelevation.

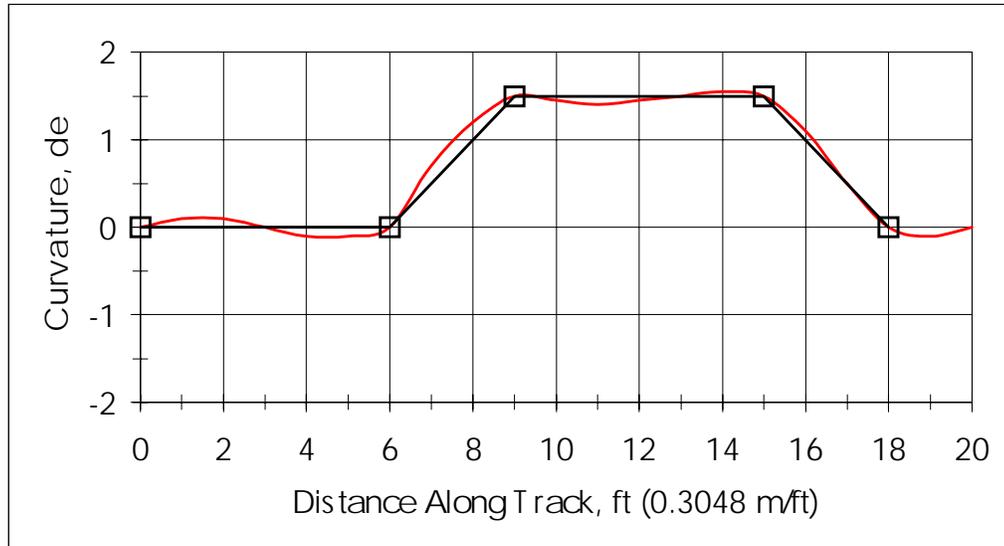


Figure 4.5 Example of Piece Wise Linear (PWL) Representation

Another option is the spline fit calculation. This selection performs several operations on the track geometry data. This option first applies a low-pass and a high-pass filter, with user-selected cut-off frequencies, to the data to smooth it. It then fits the alignment and profile data with a cubic spline fit. The alignment and profile data can then be represented by a series of spline coefficients that can be saved to a file, as will be described in Section 4.2.3.

TRAKVU also has the ability to reverse the direction of the track and normalize the distance. Often the user wishes to model a car traveling over the track in the direction opposite to the direction in which the data were recorded. This requires changing the curvature and superelevation signs to reflect the direction of travel of the vehicle in the model. For instance, a rail vehicle traveling in a three-degree right-hand curve with five inches of superelevation experiences a three-degree left-hand curve with negative five inches of superelevation if it is traveling in the opposite direction. TRAKVU can easily reverse the direction of the track and all of the appropriate signs so that the model can then be run in the desired direction. TRAKVU also has the ability to normalize the travel distance. Occasionally, the variable that describes the distance along the track does not start at zero. This occurs if the data is taken from the middle or end of a larger data file. TRAKVU can be used to normalize the distance or to reset the distance variable so that it starts at zero.

4.2.3 Output Formats

Once the user is satisfied with the track data, it can be saved in various formats. The first format is a basic ASCII file format and is used for the raw track geometry data. Up to six of the available variables may be saved in either English or metric units for either the whole track or just a section of the track. This option is useful if the user only wants to model a section of the original track, or to view the data in a spreadsheet or other program.

The remaining two output formats, the PTB file and the TRK file, are specifically for use with NUCARS, and can also be saved in either English or metric units. The PTB file uses the data generated by the PTB/PWL feature. Two separate files are generated with this option. The first file is a .PTB file, which contains the perturbed track data. This can either be the left and right alignment and profile histories; or the gauge, alignment, cross level, and profile histories. The filename of the .PTB file is indicated in the NUCARS INP file. The other file generated by this option is a .PWL file. This ASCII file, shown in Fig. 4.6, can then be “cut and pasted” into the INP file. It contains the keyword and all of the information necessary for specifying the track curve data.

```
\TRACK CURVE DATA
! Number of Data Segments, Track Base Width, Curve Flag
7      56.5      .T.
! DISTANCE   CURVATURE   CROSS LEVEL   KINK
      0.00      0.03      0.01      0.00
      19.09     0.66      0.02      0.00
      39.09     1.18      0.99      0.00
      53.64     1.55     -0.60      0.00
      403.64    0.00     -0.61      0.00
      429.09    0.02     -0.02      0.00
      498.18    0.00      0.01      0.00
```

Figure 4.6 Example of .PWL File for Use in NUCARS INP File

The other output option is the TRK file, which uses the data generated by the spline fit calculation. When choosing this option, the file is saved in a binary format with the .TRK

extension. The file is indicated in the NUCARS INP file and contains the spline fit coefficients that describe the gauge, cross level, curvature, alignment, and profile history. When running a NUCARS model, only one of these methods may be used. As described in Section 2.3, although track data can also be generated mathematically by NUCARS, the data does not contain the necessary track irregularities that are included in the .PTB and .TRK files if they are generated by TRAKVU.

4.3 Using TRAKVU to Model Track Irregularities

We have already discussed the importance of track irregularities to the accuracy of the dynamic model. Although present in measured track data, track irregularities are often absent from analytically created track data, unless explicitly modeled by a program such as TRAKVU. TRAKVU has several methods for including irregularities in analytically created track. These methods are random irregularities, basic shapes, and track class irregularities. Random irregularities, shown in Fig. 4.7, add normally distributed random data to the track with a user-selected mean and standard deviation.

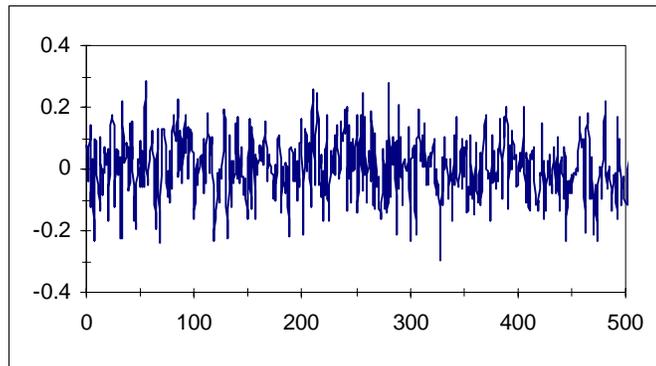
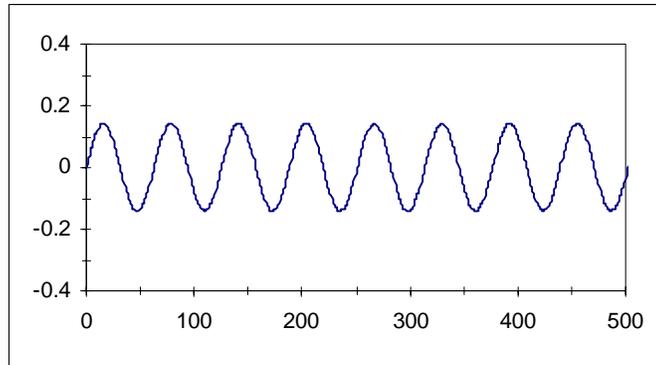


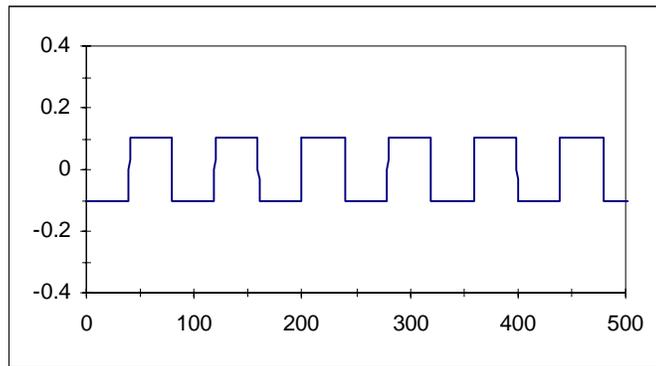
Figure 4.7 Example of Random Track Irregularities

The basic shapes option enables the user to add a sine wave, square wave, or saw tooth wave to the track data. Examples of the basic wave shapes are shown in Fig. 4.8. The mean, amplitude, and wavelength of the waves are specified by the user. These methods are

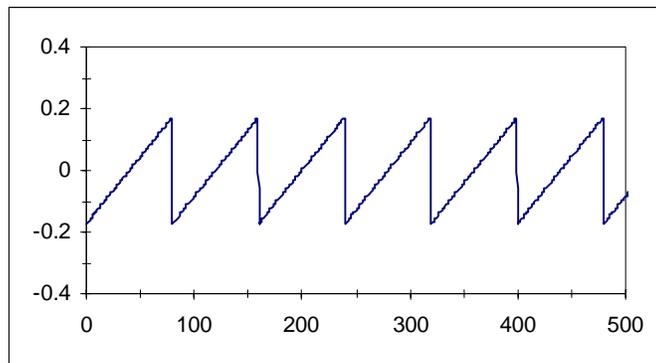
useful for creating a distinct perturbation or disturbance on the track, with a specific shape and frequency.



(a)



(b)



(c)

Figure 4.8 Examples of Basic Shape Irregularities; (a) Sine Wave,
(b) Square Wave, (c) Saw Tooth Wave

The track class type of irregularity is the result of the data analysis discussed in the previous chapter. The user can select either class 4, 5, or 6 track, and the created track will be an analytical model of an actual track of the same class. Figure 4.9 presents an example of class 5 track irregularities, which are significantly different from the random data in Fig. 4.7, even though the standard deviations for the two sets of data are the same. As previously discussed, the irregularities are created by filtering random data using the digital filter described in Section 3.5, applying a standard deviation, and zeroing the mean. This creates irregularities with the same characteristics as a specified track class without the need to spend the time and money to measure the track. This feature is particularly useful for modeling sections of track that may not physically exist.

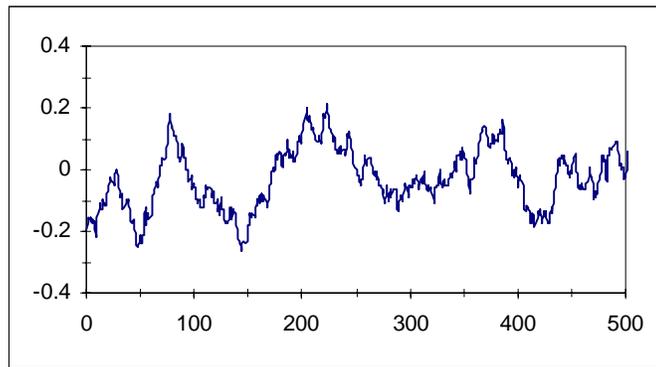


Figure 4.9 Example of Class 5 Track Irregularities