TQIs – Part I, Statistical

The use of information obtained from track geometry measurement vehicles, such as Track Geometry Cars, has become a normal part of a railroad's track inspection and evaluation procedures. The specific applications of this type of data include: the evaluation of the condition of the track structure, the pin-pointing of specific maintenance locations, and the planning of shorter-term and longer-term maintenance activities. Different uses of track geometry data have been the subject of earlier *Tracking R&D* columns (see RT&S April, 1986; May 1986).

A special area of application for Track Geometry Car information has been the development and use of Track Quality Indices, or *TQIs,* for evaluating the condition of track. The TQI is a numerical representation of track geometry values summarizing the conditions of the track structure over a defined segment of track. It provides a more general assessment of the condition of the track than the simpler 'exception' type of report.

For comparisons

In addition to yielding information about longer stretches of track, TQIs also furnish a broader quantification of track condition than the stark approach of pass or fail by exception. As such, the TQI can be used to determine how close the track in question is to the exception standards, or for that matter, how far past the standards the track condition is. Also, the TQI can permit quality comparisons between various track segments.

In essence, then, TQIs are means of compressing a large volume of track geometry data into a usable parameter, or set of parameters, which represents track condition. And since Statistics is the branch of mathematics dealing with the collection, analysis, interpretation and presentation of masses of numerical data, statistical techniques have been used in developing TQIs. A few of the more commonly used statistical functions applied to track geometry data[1] are the:

a) *Mean,* which is a representation of the average of

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Failure Mode	Cause	Track Geometry Parameter	Track Quality Index (TQI)	TQI No.
Component Wear Wheel Climb	Line Roughness	Alignment	Standard Deviation	1
Lading Damage	Lateral Acceleration	Alignment	Standard Deviation of Short Mid-chord Offset (two feet)	2
Component Wear	Surface Roughness	Profile	Standard Deviation	3
Lading Damage	Vertical Acceleration	Profile	Standard Deviation of Short Mid-chord Offset (two feet)	4
Component Wear	Low Joints	Profile	Standard Deviation of Intermediate Length Mid-chord Offset (16 feet)	5
Component Wear	Surface Roughness	Crosslevel	Standard Deviation	6
Cant Deficiency	Inadequate Elevation	Crosslevel	Standard Deviation from Balanced Superelevation	7
Component Wear	Surface Elevation	Warp (20 Feet)	Standard Deviation	8
Rock and Roll	Low Joints	Warp (20 Feet)	99 Percentile	9
Lack of Support	Wide Gage	Gage	Mean	10
Lack of Support	Wide Gage	Gage	Standard Deviation	11
Lack of Support	Wide Gage	Gage	99 Percentile	12
Lack of Support	Wide Gage	Gage	Third Moment of Probability Function (Skewness)	13
Lack of Support	Wide Gage	Gage	Fourth Moment of Probability Function (Kurtosis)	14

the data values, and can thus represent an 'average' condition of track;

b) *Standard Deviation,* which is a measure of the variation of the parameter around the mean; it can indicate the variability or roughness of the specific track geometry parameter to which it is applied;

c) *99th Percentile Value,* the value below which reside 99 percent of individual data samples, can represent the worst geometry condition in a track segment.

The statistical factors above measure the distribution of the data. The data, then, can be converted to statistical parameters in order to present meaningful information about the track geometry. The attached table illustrates a 'matching' of track geometry characteristics with 'failure' modes and associated causes, giving too, statistical parameters associated with the failure modes.[1] It can be seen from the first row in the table that the standard deviation of the alignment is a measure of the roughness of the alignment of the track. It is directly associated with vehicle lateral acceleration and force. The table presents associations for other TQIs also.

Actually, several different statistical parameters could be attributed to any one track characteristic. Therefore, it is often necessary to select the 'best' statistical parameter to represent a particular track condition. But among those most commonly used in the railway industry are the standard deviation and the 99th percentile.[2,3]

Next month's *Tracking R&D* will discuss non-statistical types of TQI's used in evaluating track conditions.

References:

1. Hamid A. et al, "A Prototype Maintenance of Way Planning System," Federal Railroad Admin. Report FRA/ORD-80/47.1, Nov.-1980.
2. Bing, A. J., "Development of a Track Degradation Modeling Technique," Federal Railroad Admin. Report DOT/FRA/ORD-83/12, April 1983.
3. Bing, A. J., "Track Geometry Data for Maintenance Prediction," ASCE, Spring Convention, Las Vegas, Nevada, April 1982.