Planning Through Track Geometry – Part II

Last month's *Tracking R&D* covered various uses of track geometry data in maintenance planning. One of the applications of the data is for forecasting changes in the track geometry condition with time. As such, the geometry data is used to guide longterm maintenance planning, and to evaluate the effectiveness of ongoing maintenance activities. This represents an extension of the current uses of the data, as in exception reporting or assessing of present track condition. For long-term planning, the data requires an additional level of processing, as illustrated in Figure 1.[1]

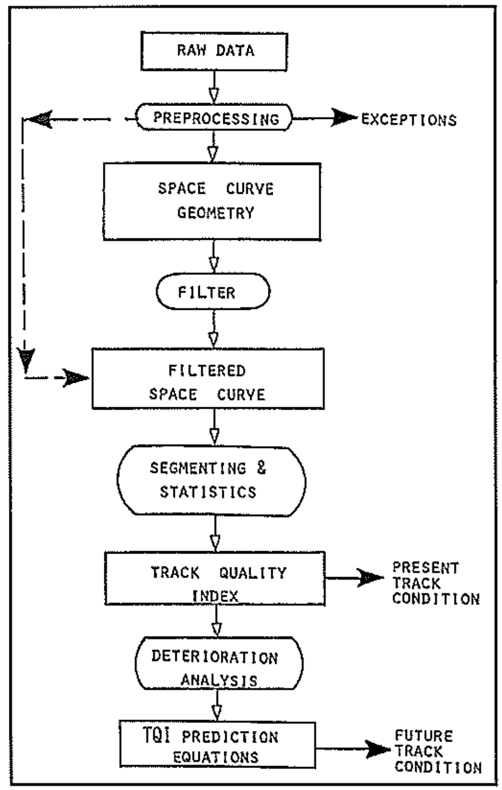

Figure 1 — Track Geometry Data Analysis

Two variations

There are two basic variations to employing the data for forecasting track geometry degradation. The first variation requires only the track geometry information itself. It relies on the accumulation of track geometry data over a period of time, but obtaining several distinct time points. Given a sufficient period of time and then developing relationships for the key track geometry parameters, or corresponding indices based on the geometry such as the Track Quality Indices (as discussed in last month's Tracking R&D), track geometry deterioration can then be forecast. The approach is similar to that presented for rail fatigue defects in earlier Tracking R&Ds (RT&S April 1985 and July 1985).

To date, however, only limited applications of this method have been carried out. One such is currently being developed and implemented by a major eastern railroad.[2] In this, track geometry data is first converted into appropriate track quality indices (TQI) which are representative of the "state" of the track. This data is then reduced into a group of several parameters, which are a mathematical series representative of the TQI over the track segment under analysis. This produces an "equation of state"[2] for the track segment at a given instant in time.

After obtaining several such equations of state at different points in time, a mathematical series or relationship can be obtained for these TQI, in reference to time as well as in space. These degradation relationships are used for forecasting track geometry deterioration. While mathematically complex in concept, the actual execution of this approach can be relatively simple when compared to the manipulation of vast quantities of track geometry data.

Combining the data

The second variation in the use of track geometry data for forecasting track geometry degradation involves the combination of the data itself (at least one set of data at one point in time) with the basic traffic and track parameters that affect track deterioration. This approach involves the development of an empirical model for track geometry degradation based on both the last measured data and those parameters that can be related to track deterioration. Figure 2 presents a list of the traffic, track and maintenance parameters that have been examined for use in such a combined degradation model.[3,4]

Several predictive relationships[3,4] have been developed using this approach. In all cases, however, rather than attempt to forecast the track geometry directly, the attempt is made to identify and predict "critical" track quality indices. These are related directly to geometry car measurements. Actual degradation relationships evolved from statistical regression analysis for a given set of data[3,4]. Though the two approaches noted selected different TQI as being the most sensitive to degradation, both employed TQI to represent the measured track geometry and traffic, as well as track and maintenance parameters (see Figure 2).

Category	Causal Parameters	Units	Analysis Used in Phases I, II	Phase III
Traffic	Cumulative tonnage	MGT	0	0
	Heavy axle loads	Percent	0	0
	Posted speed	mph	0	
	Modified posted speed	mph		0
Track Structure	Curvature	Degres	0	0
	Rail weight	lb/yard	0	0
	Rail type	Welded/jointed	0	0
	Rail age	Years		0
	Ballast type	Aggregate index		0
	Ballast condition	Clean/dirty Pumping/fouled	0	0
	Drainage condition	Good/bad	0	0
	Rail profile	Percent bent	0	
	Time since surfacing	Months		0
Maintenance	Basic maintenance	Levels:0 10, 20, 30%	0	
		Fraction surfaced		0
	Production maintenance	Surface, tie and Surface, rail Renewal	0	0

Figure 2 — Track Deterioration causal parameters

In general, not all of the parameters defined in Figure 2 or used in the degradation equations were significant for forecasting the future TQI. The only major exception to this is the last TQI value which is always of statistical significance.

For the other variables, the statistical significance varied considerably. However, in both cases, it was found that statistically valid prediction equations for track geometry could be developed for key track quality indices by using the last measured track geometry data and appropriately derived track and traffic parameters.

Most significant in all of these studies was the conclusion that predictive relationships for track condition can be developed. Based on measured track geometry data, they are useful for forecasting the deterioration of the track geometry with time and traffic. And this forms the basis for long-term maintenance planning for railroad systems.

References:

1. Bing, A.J., "Track Geometry Data for Maintenance Prediction, "Paper presented at the ASCE Spring Convention, Las Vegas Nevada, April 1982.
2. Doby, R., "Conrail's Track Quality Index, The Equation of State of Railroad Track," Paper presented to AREA Committee 2, March 1985.
3. Hamid A. et. al., "A Prototype Maintenance-of-Way Planning System, Volume I," Federal Railroad Administration Report FRA/ORD-80/47.1, November 1980.
4. Bing, A.J.,"Development of a Track Degradation Modeling Technique," Federal Railroad Administration Report DOT/FRA/ORD-83/12, April 1983.