

Chapter 1

Introduction

This chapter provides an introduction to the research that was conducted throughout the course of this study. An introduction is given on rail vehicle dynamic modeling and the importance of track inputs. A summary of the research objectives and approach is covered next. Finally, an outline of the remaining chapters is provided.

1.1 Rail Vehicle Modeling

With the advent of personal computers and fast processors, the use of analytical modeling programs has become less complicated and far more practical for more users. This is true in the area of rail vehicle modeling. The low cost of computer modeling compared with actual testing is a significant benefit to railcar modeling. Modeling allows a customer to test a new car design without having to build a prototype and tie up the track for testing, therefore increasing productivity through saving valuable time and manpower. This cost saving advantage of railcar modeling only magnifies the importance of its various uses and applications.

One such use is “what if” analysis. Computer modeling allows the user to test out various situations without spending the time, money, and equipment to test them on a track. Further, modeling can provide the means for such tests as derailment to enable the prediction of when a given car may derail or jump the tracks. Modeling can predict at what speeds derailment will occur or under what conditions it may be prevented. Directly related to derailment studies is stability analysis. One can model different suspensions and loading options and examine the dynamic responses.

Another important aspect of rail dynamics is ride comfort analysis, or predicting what travelers and cargo may experience under various conditions. Modeling software can predict forces and accelerations at various positions throughout the railcar to predict the ride characteristics or to evaluate ideas for improving ride.

The modeling programs that have received wide acceptance in recent years include:

- NUCARS
- MEDYNA
- AGEM
- AutoDYN
- SIDIVE
- VAMPIRE
- VOCO

Although the above programs have different attributes, they were all developed specifically for rail dynamic modeling. Each program includes a different solution methodology, wheel-rail model, analysis method, and user interface. In the U.S., NUCARS, developed by the Association of American Railroads (AAR), has been widely adopted and has become an industry standard. NUCARS provides a variety of output options that can be used for derailment and dynamic stability analysis. As such, it has been used primarily for rail vehicle dynamic analysis [1].

1.2 Importance of Track Input

Due to the unique dynamics that exist between the rail and wheel, rail vehicle dynamics are often difficult to model accurately. These non-linear and velocity-dependent dynamics justify the importance of the track input to railcar modeling [1]. In the physical system, the input comes from the actual track. In a model, a user-defined input is used to predict the actual track characteristics. The user-defined input can be created analytically or can be based on actual measurements. Measured track data are obtained by running a specialized railcar down the track while it makes various measurements of the track geometry. Track geometry will be explained further in Section 2.2. Analytic track data are created using mathematical shapes, such as cusps, bends, or sines, to represent the track geometry.

Although it is relatively easy to analytically model the general shape and geometry of a track, the model does not include the small perturbations and irregularities that are inherent in an actual track. These irregularities are important to the reality of the model. The reality of the dynamic response of the model is dependent on the reality of the track input. The

dynamic responses of modeled railcars on measured track have compared well with actual railcar responses. Engineers at the Transportation Technology Center, Inc. (TTCI), a subsidiary of the Association of American Railroads have observed, however, that the modeling results in the absence of track irregularities can have more error, as compared with actual test results, and reduce the predictive benefits of the model. This is the fundamental purpose of this study: to analytically create tracks with the irregularities necessary to reproduce the input provided by actual track.

1.3 Research Objectives

The primary objective of this study is to characterize and model railroad track irregularities, with the goal to create software that will allow the user to analytically create track, as well as user-defined track irregularities, with varying parameters. The created track can then be used as the input to a vehicle modeled in NUCARS such that it will generate dynamic responses comparable to that of an actual rail vehicle.

1.4 Research Approach

The approach includes first analyzing track data from the Transportation Technology Center, Inc. (TTCI), specifically the alignment and profile data, to identify any similarities among the characteristics across the various track classes. The characteristics will be applied to TRAKVU to emulate the irregularities that are inherent in actual track. TRAKVU is a program that was written to enable NUCARS users to create and view track data for use with NUCARS. Finally, to validate the procedure, a direct comparison of track characteristics will be performed. A cross comparison of the actual vehicle response with modeled vehicle response for the analytically created track data and measured track data will also be performed.

1.5 Outline

The result of a literature search on related studies is presented Chapter 2. A background on track geometry and NUCARS modeling is also discussed in Chapter 2. The analysis of the track data is discussed in Chapter 3, along with the results of the statistical and frequency analysis of a series of data collected by TTCL. Chapter 3 also includes a discussion on how the results of the track data analysis can be applied to model the track irregularities and perturbations. An overview of TRAKVU is provided in Chapter 4, including discussions on how it works, how track irregularities are included, and how it interacts with NUCARS. Chapter 5 presents the validation comparisons between an actual vehicle response and NUCARS-predicted response with analytical track data, and NUCARS-predicted response with measured track data and analytical track data. Finally, Chapter 6 summarizes the results of the study and provides recommendations for future research.