Volume 1

INSTRUCTION MANUAL

AN INTRODUCTION

TO THE

INSTRUCTION MANUALS

FOR APPLYING THE

TOM

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Preface

This document is part of a series of instruction manuals, which can be used as guidelines for applying the Train Operations Model (TOM) to rail systems throughout the world. In this connotation, rail system definition includes main line railroads, heavy and light rail, trolleybuses, high-speed rail and MAGLEV and people movers.

There are several manuals in the series:

**Volume 1 – An Introduction to the Instruction Manual for Applying the TOM**
Volume 2 – Instruction Manual for Applying the TOM to Transit Systems DC Electric – English Units
Volume 3 – Instruction Manual for Applying the TOM to Transit Systems DC Electric – Metric Units
Volume 4 – Instruction Manual for Applying the TOM to Transit Systems AC Electric – English Units
Volume 5 – Instruction Manual for Applying the TOM to Transit Systems AC Electric – Metric Units
Volume 6 – Instruction Manual for Applying the TOM to Railroads Fueled – English Units
Volume 7 – Instruction Manual for Applying the TOM to Railroads Fueled – Metric Units
Volume 8 – Instruction Manual for Applying the TOM to Rail Systems; Technology Aspects
Volume 9 – Instruction Manual for Procedures and Shortcuts in the TOM
Volume 10 – Instruction Manual for Including the Return Circuit in Electric Rail Systems
Volume 11 - Instruction Manual Exercising the AC Drive Model
Volume 12 – Instruction Manual DC Electric Power System Methodology
Volume 13 – Instruction Manual AC Electric Power System Methodology
Volume 14 – Instruction Manual Exercising the Rail Voltage Model for DC Traction Systems

Volumes 2-7 cover nearly all transit systems and railroads in the world.

This instruction manual is Volume 1.

These volumes are unprotected. Thus the user is free to make notes or rewrite sections according to his preferences.

The primary purpose for using the TOM is evaluation. The evaluation generally takes the form of a study, with certain objectives, which may or may not be well defined. As the study is conducted, new objectives may result, because of unanticipated results. Within the framework of evaluation, designs may be modified and further evaluated, so that in this sense, the TOM may be considered a design tool.

The TOM is used together with other standard software, such as Microsoft Office (in particular, WORD, EXCEL and POWERPOINT). This combined package is most effective in assembling client data as well as presenting results. In some instances, the TOM interacts directly with these office programs, while in other cases; the user handles the office packages directly.
1 INTRODUCTION

The purpose of an Instruction Manual, as opposed to a Program Manual, is the showing by example, the procedures to complete certain tasks advertised by the computer model. A Program Manual, on the other hand, is primarily for reference.

The TOM Instruction Manual is scheduled for 14 volumes, 11 of which have been written, and 3 of which are due to be written in the future.

These volumes are titled as follows:

Volume 1 – An Introduction to the Instruction Manual for Applying the TOM
Volume 2 – Instruction Manual for Applying the TOM to Transit Systems DC Electric – English Units
Volume 3 – Instruction Manual for Applying the TOM to Transit Systems DC Electric – Metric Units
Volume 4 – Instruction Manual for Applying the TOM to Transit Systems AC Electric – English Units
Volume 5 – Instruction Manual for Applying the TOM to Transit Systems AC Electric – Metric Units
Volume 6 – Instruction Manual for Applying the TOM to Railroads Fueled – English Units
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Volume 14 – Instruction Manual Exercising the Rail Voltage Model for DC Traction Systems

The volumes in orange do not exist as yet.

In this Introductory volume, a brief description is given of the existing volumes is presented in Section 6.

Licensees of the TOM received all of the files associated with the Instruction Manual, so that they may educate themselves on the “how to” aspects of the model. The Instruction Manual, corresponding EXCEL spreadsheets and archived files used in the manual constitute 1 GB of computer space.

The TOM is extremely user friendly. Help is provided through four main Avenues.

- Extensive built in help to all of the screens of the TOM is included. This help comprises a description of every control and for what it is used and complete instructions on how to enter raw rail system data.
- A complete on-line program manual contains descriptions and pictures of every screen and control, methodology used for all of the processes and sub models and definition of terminology.
- Eleven Instruction Manuals are included to familiarize the user with typical applications of the TOM on real rail system application. Step by step procedures are shown to conduct actual studies and evaluations.
- There is an intensive training course available of five days duration. It may be presented at a licensee facility or on-line using the Web. The course objectives are to understand the:
  - Operation of the TOM
  - Methodology Used in the TOM.
  - Terminology Used in the TOM.
  - Applications and Limitations of the TOM

Section 2 of this volume presents an overview of the TOM and its features. This description is also given in the Program Manual.
The user interface in TOM is written in Visual Basic (VB). All of the features in the TOM are described in Section 3. This section has been written in order that the user can understand all of the terminology associated with the operation of the TOM and reading of both the Instruction and Program Manual.

Section 4 provides a description of the file naming convention used in the TOM. All files are text files, so that they are accessible using any text editor for reading or otherwise manipulating. It is not recommended that they be modified outside of TOM.

A brief history of the development of TOM and the Instruction Manual is presented in Section 5.

Finally, as mentioned, a description of the existing companion volumes of this volume is presented in Section 6.

2 OVERVIEW OF THE TOM

The TOM contains all of the computer tools to simulate the operation of a rail system on a computer. It is transportable among rail systems and anticipates new technical developments in railway operation within the foreseeable future. As used here, a rail system is any form of guided ground transportation.

Simulation of operations means that given the inputs particular to a specific railway, outputs are produced which characterize train motion and energy consumption as both time functions and in summary form.

Application of the TOM to a rail network involves input, output and processes (or tools). The inputs to a TOM are grouped into five general areas.

1. Simulation Control. Data necessary to control and direct the simulation.

2. Rail Network Control. Data necessary to control and direct the operation of trains on the rail network.

3. Train Information. This information includes data, which include the physical parameters necessary to characterize the makeup of trains, its cars, and the propulsion, braking and auxiliary power characteristics of each car.

4. Right of Way Information. The information includes data, which contain the description of tracks or guideways along which the trains are running. These include grades, curves, speed limits, locations of stations and stops and routes.

5. Power System Information. Included here are data, which describe the electrical feed system which powers the trains in the rail network. This information is not required for a rail system, which runs on fossil fuel.

The outputs of the TOM are grouped into three areas.

Train Motion. This includes information about the position, speed, and acceleration of each train operating on the system.

State of Control System. Information on the signals, switches and routings at any given time is given here.
Energy Consumption. This includes information about the energy or fuel used by each train on the system as well as the end use (i.e. auxiliary power, propulsion losses, train resistance losses, etc.). It also includes all of the voltages, currents and powers at all salient points for electrified systems.

The processes or tools required for a TOM are grouped into six general categories.

Construction Tools. These tools are computer programs, which can convert raw rail network or manufacturer’s data into input suitable for the Simulator Tools are included here.

Simulator Tools. The simulators are computer programs, which use the refined input data to simulate the rail system operation and produce time function and summary output. Three simulators comprise the TOM. These include a Train Performance Simulator (TPS), which simulates the performance of a single train on the rail network; a Train Movement Simulator (TMS) which simulates the performance of the multi-train network under a train control system; and an Electric Network Simulator (ENS) which simulates power flows on the system.

Manipulation Tools. These tools are computer programs, which manipulate the input to and output of the Simulation Tools for appropriate tasks. The output from the Manipulation Tools can be used as final output and as input to the Simulation Tools.

Control Tools. Control tools are computer programs, which control the use of and interaction among the Construction, Simulation and Manipulation Tools and the Input and Output.

Visual Displays and Viewers. These are output screens, which allow the user to observe the motion of the railway, graphs of parameters of interest, and the input and output files.

Supplementary Programs. These are programs which use the data generated by the TOM, as well as other information to compute various aspects of simulated train operation.

A block diagram of the TOM is shown in Error! Reference source not found.
The block diagram shows the overall flow process of the model. The File Construction Module (FCM) is used to convert the raw rail transportation system data into files, which are readable by the simulators or by other programs within other modules. Most of these files are stored in a Rail System Database (RSDB), which can be accessed by the user and read by the simulators, modules, utilities and other programs.

The three simulators read the files in the RSDB and produce output, which is deposited in the RSDB and used by the other simulators, modules, utilities and other programs.

The TPS simulates a single train on the rail network and produces output, which is read as input by the ENS, the TMS and the File Manipulation Module (FMM). The output from the TPS resides in the RSDB.

The ENS simulates a system of trains, the prescribed running of which is determined beforehand, and calculates the power consumption as seen at the metering points as well as the voltages and currents at all salient points in the electrical network under which the trains are fed power. The output from the ENS is used by the FMM, the Energy Cost Module (ECM), and the Rail Voltage Model (RVM) and resides in the RSDB.

The TMS simulates a system of trains, which is controlled by a train control system, either manual, automatic fixed block or automatic moving block. While the system of trains is being simulated, the power consumption can also be calculated at the metering points as well as the voltage and currents of all salient points in the electric network under which the trains run. The output from the TMS is used by the FMM and the ECM and resides in the RSDB.

The FMM is a group of computer programs, which manipulates the output of the simulators and produces files, which reside in the RSDB. These manipulations are used for special purposes to be described in detail in Section Error! Reference source not found.

The ECM is a group of computer programs, which summarize outputs from the ENS and TMS to determine the main components of energy cost, namely, demand and energy use. The output from these programs is located in the RSDB.

The RSDB holds all of the files, which are input and output of the simulators and modules. There is a naming convention for these files, which is described in some detail in Section 4. A utility program (DB) allows the user to interact directly with this database.

A supplementary program, the Rail Voltage Model (RVM), estimates the rail to ground voltage on DC electrified systems.

The TOM is the package of the category of tools just described. It is designed for persons experienced with computers and railway operations, although on line help can aid less experienced people.

At this writing, there are over 75 licensees of the model, worldwide. These licensees include rail transit authorities and railroads, their suppliers and their consultants worldwide. The TOM is extremely useful for the study of energy consumption and performance in rail transit and mainline railroad operation. It has also been used to evaluate power distribution and train control system performance. It has been verified for accuracy on over fifteen rail systems.

All of the programs of the TOM are written exclusively in FORTRAN 90. These source codes were compiled as dynamic link libraries (DLL) with the Microsoft Developer Studio (FORTRAN Power Station 4.0). The screens of the TOM access these DLL's, which were developed under Microsoft Visual Basic 6.0. The TOM runs under Microsoft Windows Operating Systems.

The requirements for operation of the TOM are a personal computer with a color monitor with 64 MB of RAM and 1 GB of hard disk space free. Microsoft Windows must be installed on the computer. Microsoft WORD 2000 or higher version must be installed in order to access the on-line version of the manual.
The package also contains input and output files for test purposes, so those users may check the software operation before beginning serious work. All of the programs have been subject to extensive testing to verify proper operation.

3 VB PROGRAMMING BASICS AND TERMINOLOGY

Throughout these Instruction Manual Volumes, in the Program Manual and throughout the help screens of the TOM itself, certain terminology is used which refer to the object programming of Visual Basic. Such expressions as “click a command button” or “select an item from a combo box” are used throughout. The purpose of this Section is to present the objects used in the TOM and define the terminology used to refer to them.

3.1 Objects Used in the TOM
An object is a combination of code and data that can be treated as a unit.

A Form object is a window or dialog box that makes up part of an application's user interface.

The following screen shows examples of the objects used in the TOM.
Example of a Form, with all TOM Objects

A **Screen** is a particular view of a form. Several screens may be produced at run time from a single form. An example of a screen which is a different view of the above form is shown next. **Run time** refers to the time that the program is actually executing, while **design time** refers to the time the programmer is building or modifying the code.
The following additional objects are used in the TOM, examples of which are shown on the form.

A **Check Box** control displays an X when selected; the X disappears when the **Check Box** is cleared. This control is used to give a True/False or Yes/No option. An action of a mouse or keyboard can actually initiate a procedure as well.

A **Label** control is a graphical control used to display text that a user can't change directly. In the TOM, many labels are used to name other objects.

A **Command Button** control is used to begin, interrupt, or end a process or procedure. An action of a mouse or keyboard can actually initiate a procedure as well.

A **Text Box** control, sometimes called an edit field or edit control, displays information entered at design time, entered by the user, or assigned to the control in code at run time. An action of a mouse or keyboard can actually initiate a procedure as well.
A List Box control displays a list of items from which the user can select one or more. If the number of items exceeds the number that can be displayed, a scroll bar is automatically added to the control. An action of a mouse or keyboard can actually initiate a procedure as well.

A Combo Box control combines the features of a Text Box control and a List Box control—Information can be entered in the text box portion or an item may be selected from the list box portion of the control. An action of a mouse or keyboard can actually initiate a procedure as well.

A File List Box control locates and lists files in the directory specified by the Path property at run time. Use this control to display a list of files selected by file type. An action of a mouse or keyboard can actually initiate a procedure as well.

A Grid control allows the displaying of information in cells, which have a row number and column number. An action of a mouse or keyboard can actually initiate a procedure as well.

A Picture Box control can display a graphic from a bitmap, icon, or metafile, as well as enhanced metafile, JPEG or GIF files. An action of a mouse or keyboard can actually initiate a procedure as well.

A Frame control provides an identifiable grouping for controls. A Frame control can be used to subdivide a form functionally

3.2 Properties of Objects

Objects have properties, are able to recognize events and are able to react to methods.

A property is an object’s setting or attribute.
EXAMPLES: SIZE, COLOR

A partial listing of the Command Button Properties is shown next.
3.3 Events Recognized By Objects

An event is an action recognized by an object.
Example: Click of a Mouse button

A partial listing of the Command Button Events is shown next.
3.4 Methods Which Operate on Objects

A method is a procedure which can operate on an object.
Example: dialing a telephone

A partial listing of the Command Button Methods is shown next.
4 FILE NAMING CONVENTIONS

4.1 RAIL SYSTEM FILE NAMING CONVENTION

The file naming convention for the TOM has been carefully selected to present the user with the bookkeeping features of the model together with the power of its tools. The data files for all of the rail systems are expected to reside in the directory ..\tomdat which is further subdivided into directories \ext, which hold the actual input and output files. A list of the conventions used for the TOM is shown below.
### File Naming Convention for the TOM By Transit Authority

<table>
<thead>
<tr>
<th>Rail System</th>
<th>Acronym</th>
<th>Mnemonic</th>
<th>City</th>
<th>State</th>
<th>ext</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bi-State Development Agency</td>
<td>BIDA</td>
<td>BIDA</td>
<td>St. Louis</td>
<td>MO</td>
<td>bid</td>
</tr>
<tr>
<td>British Columbia Rapid Trans. Co.</td>
<td>BCRAIL</td>
<td>BCRN</td>
<td>Vancouver</td>
<td>BC</td>
<td>vnc</td>
</tr>
<tr>
<td>Calgary Transit</td>
<td>CT</td>
<td>CT</td>
<td>Calgary</td>
<td>AL</td>
<td>cts</td>
</tr>
<tr>
<td>Chicago Transit Authority</td>
<td>CTA</td>
<td>CTA</td>
<td>Chicago</td>
<td>IL</td>
<td>cta</td>
</tr>
<tr>
<td>City of Detroit Dept. of Transp.</td>
<td>DDOT</td>
<td>DDOT</td>
<td>Detroit</td>
<td>MI</td>
<td>det</td>
</tr>
<tr>
<td>Dallas Area Rapid Transit</td>
<td>DART</td>
<td>DART</td>
<td>Dallas</td>
<td>TX</td>
<td>dar</td>
</tr>
<tr>
<td>Edmonton Transit</td>
<td>ET</td>
<td>ET</td>
<td>Edmonton</td>
<td>AB</td>
<td>edm</td>
</tr>
<tr>
<td>Government of Ontario Transit</td>
<td>GO RAIL</td>
<td>GOTRN</td>
<td>Toronto</td>
<td>ON</td>
<td>gor</td>
</tr>
<tr>
<td>Gr. Cleveland Reg. Trans. Auth.</td>
<td>GCRTA</td>
<td>GCRTA</td>
<td>Cleveland</td>
<td>OH</td>
<td>rta</td>
</tr>
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<td>Houston Metro</td>
<td>MTAHC</td>
<td>HOUS</td>
<td>Houston</td>
<td>TX</td>
<td>hou</td>
</tr>
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<td>LIRR</td>
<td>LIRR</td>
<td>New York</td>
<td>NY</td>
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<td>Los Angeles Co. Metro. Transp.</td>
<td>LACMTA</td>
<td>LACMT</td>
<td>Los Angeles</td>
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<td>lac</td>
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<td>MA Bay Transportation Auth.</td>
<td>MBTA</td>
<td>MBTA</td>
<td>Boston</td>
<td>MA</td>
<td>mbt</td>
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<td>MTAMD</td>
<td>MTAMD</td>
<td>Baltimore</td>
<td>MD</td>
<td>mdt</td>
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<td>Metro-Dade Transit Agency</td>
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<td>MDTA</td>
<td>Miami</td>
<td>FL</td>
<td>mia</td>
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<tr>
<td>Metro-North Commuter Railroad</td>
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<td>MNCR</td>
<td>New York</td>
<td>NY</td>
<td>mnc</td>
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<td>Metro. Atlanta Rapid Trans. Auth.</td>
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<td>MARTA</td>
<td>Atlanta</td>
<td>GA</td>
<td>mar</td>
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<td>Metro. Trans. Auth. Of Harris Co.</td>
<td>MTAH</td>
<td>MTAH</td>
<td>Houston</td>
<td>TX</td>
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<td>Metropolitan Transit</td>
<td>METRA</td>
<td>METRA</td>
<td>Chicago</td>
<td>IL</td>
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<td>MVRTA</td>
<td>Dayton</td>
<td>OH</td>
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<td>Montreal</td>
<td>PO</td>
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<td>Municipality of Metro. Seattle</td>
<td>MMS</td>
<td>MMS</td>
<td>Seattle</td>
<td>WA</td>
<td>mms</td>
</tr>
<tr>
<td>N. IN Commuter Transp. District</td>
<td>NICTD</td>
<td>NICTD</td>
<td>Chicago</td>
<td>IN</td>
<td>ssh</td>
</tr>
<tr>
<td>New Jersey Transit Corporation</td>
<td>NJT</td>
<td>NJT</td>
<td>Newark</td>
<td>NJ</td>
<td>njt</td>
</tr>
<tr>
<td>New York City Trans. Authority</td>
<td>NYCTA</td>
<td>NYCTA</td>
<td>New York</td>
<td>NY</td>
<td>nyc</td>
</tr>
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<td>Niagara Frontier Transp. Auth.</td>
<td>NFTA</td>
<td>NFTA</td>
<td>Buffalo</td>
<td>NY</td>
<td>nft</td>
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<td>Port Auth. Trans-Hudson Corp.</td>
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<td>New York</td>
<td>NY</td>
<td>pth</td>
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<td>Port Authority of Allegheny Co.</td>
<td>PAT</td>
<td>PAT</td>
<td>Pittsburgh</td>
<td>PA</td>
<td>pat</td>
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<tr>
<td>Port Authority Transit Corp.</td>
<td>PATCO</td>
<td>PATCO</td>
<td>Lindenwold</td>
<td>NJ</td>
<td>ptc</td>
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<tr>
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<td>NORTA</td>
<td>New Orleans</td>
<td>LA</td>
<td>nor</td>
</tr>
<tr>
<td>Regional Transportation District</td>
<td>DRTD</td>
<td>DRTD</td>
<td>Denver</td>
<td>CO</td>
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<td>Philadelphia</td>
<td>PA</td>
<td>sep</td>
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<td>Sacramento Reg. Transit District</td>
<td>SRTD</td>
<td>SRTD</td>
<td>Sacramento</td>
<td>CA</td>
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<tr>
<td>San Diego Trolley, Inc.</td>
<td>SDTI</td>
<td>SDTI</td>
<td>San Diego</td>
<td>CA</td>
<td>sdt</td>
</tr>
<tr>
<td>San Francisco Municipal Railway</td>
<td>MUNI</td>
<td>MUNI</td>
<td>San Francisco</td>
<td>CA</td>
<td>mun</td>
</tr>
<tr>
<td>San Francisco Bay Area Railway</td>
<td>BART</td>
<td>BART</td>
<td>San Francisco</td>
<td>CA</td>
<td>bar</td>
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<td>Santa Clara Co. Transp. Agency</td>
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<td>San Jose</td>
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<td>TTC</td>
<td>Toronto</td>
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<td>WMATA</td>
<td>Washington</td>
<td>DC</td>
<td>wma</td>
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</tbody>
</table>

The sub directory `ext` used for each rail authority is the same as the TOM file extension (.ext) used in the last column of the above table.

A tabulation of the input and output files connected with the simulators and modules are shown below. The file format and purpose are summarized in the table.
## Filename Convention for the TOM File Types

<table>
<thead>
<tr>
<th>Filename Format</th>
<th>File Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADMSPC*.ext</td>
<td>FCM Admittance Matrix (Primary Circuit)</td>
</tr>
<tr>
<td>ADMSRC*.ext</td>
<td>FCM Admittance Matrix (Return Circuit)</td>
</tr>
<tr>
<td>AM*.ext</td>
<td>ENS &amp; TMS Current Measurement Input</td>
</tr>
<tr>
<td>AO*.ext</td>
<td>ENS &amp; TMS Current Measurement Output</td>
</tr>
<tr>
<td>CAO$PC*.ext or CAO$RC*.ext</td>
<td>FMM Circuit Current Analyzer Output (Primary or Return)</td>
</tr>
<tr>
<td>FCCSPC*.ext</td>
<td>FCM Check Circuit File (Primary Circuit)</td>
</tr>
<tr>
<td>CCTSRC*.ext</td>
<td>FCM Check Circuit File (Return Circuit)</td>
</tr>
<tr>
<td>CL*.ext</td>
<td>TPS Control Input</td>
</tr>
<tr>
<td>CU*.ext</td>
<td>TPS Curve Input</td>
</tr>
<tr>
<td>DC*.ext</td>
<td>TPS Max Deceleration Modification Input (Bombardier Proprietary)</td>
</tr>
<tr>
<td>DefCalPar.ext</td>
<td>Rail System Default Calculational Parameters for Circuit Current Analysis</td>
</tr>
<tr>
<td>DR*.ext</td>
<td>TPS Aero Drag Modification Input (Bombardier Proprietary)</td>
</tr>
<tr>
<td>EDC*.ext</td>
<td>EDC Energy-Demand Summary</td>
</tr>
<tr>
<td>EL*.ext</td>
<td>Elevation</td>
</tr>
<tr>
<td>END*.ext</td>
<td>ENS &amp; TMS Detailed Output</td>
</tr>
<tr>
<td>ENS*.ext</td>
<td>ENS File of Filenames Input</td>
</tr>
<tr>
<td>GR*.ext</td>
<td>TPS Grade Input</td>
</tr>
<tr>
<td>ImpedancesDefault*.ext</td>
<td>Rail System Impedance Default</td>
</tr>
<tr>
<td>L*.ext</td>
<td>ENS &amp; TMS Load Curve Output</td>
</tr>
<tr>
<td>M*.ext</td>
<td>EDC Meter Reading Output</td>
</tr>
<tr>
<td>MC*.ext</td>
<td>Meter Consolidation Input</td>
</tr>
<tr>
<td>N*.ext</td>
<td>ENS &amp; TMS Network Input</td>
</tr>
<tr>
<td>NN*.ext</td>
<td>RVM Negative Network Input</td>
</tr>
<tr>
<td>OC*.ext</td>
<td>Occupancy</td>
</tr>
<tr>
<td>OP*.ext</td>
<td>ENS &amp; TMS Operating Time Input</td>
</tr>
<tr>
<td>P*.ext</td>
<td>Power Profile</td>
</tr>
<tr>
<td>PCA*.ext</td>
<td>ENS &amp; TMS Primary Circuit Input</td>
</tr>
<tr>
<td>PCA*.ext</td>
<td>Primary Circuit Current Analysis Output</td>
</tr>
<tr>
<td>RC*.ext</td>
<td>ENS &amp; TMS Return Circuit Input</td>
</tr>
<tr>
<td>RCA*.ext</td>
<td>Return Circuit Current Analysis Output</td>
</tr>
<tr>
<td>RU*.ext</td>
<td>TPS Route Input</td>
</tr>
<tr>
<td>RVD*.ext</td>
<td>RVM Detailed Output</td>
</tr>
<tr>
<td>RVM*.ext</td>
<td>RVM File of Filenames Input</td>
</tr>
<tr>
<td>RVS*.ext</td>
<td>RVM Summary Output</td>
</tr>
<tr>
<td>RVT*.ext</td>
<td>RVM Rail Voltage Table</td>
</tr>
<tr>
<td>RX*.ext</td>
<td>Return Circuit Rail Voltage</td>
</tr>
<tr>
<td>SC*.ext</td>
<td>TPS Speed Command Input</td>
</tr>
<tr>
<td>SD*.ext</td>
<td>TMS Station Description Input</td>
</tr>
<tr>
<td>SP*.ext</td>
<td>TPS Speed Restriction Input</td>
</tr>
<tr>
<td>ST*.ext</td>
<td>TPS Station Input</td>
</tr>
<tr>
<td>SUMSENS*.ext</td>
<td>ENS Summary Output</td>
</tr>
<tr>
<td>SUMSTMS*.ext</td>
<td>TMS Summary Output</td>
</tr>
<tr>
<td>SUMC$AO*.ext</td>
<td>Converter Current Analysis Summary</td>
</tr>
<tr>
<td>SUMM$AO*.ext</td>
<td>Current Measurement Analysis Summary</td>
</tr>
<tr>
<td>T*.ext</td>
<td>TPS Train Input</td>
</tr>
<tr>
<td>TG*.ext</td>
<td>Propulsion Model Detailed Output</td>
</tr>
<tr>
<td>TL*.ext</td>
<td>ENS &amp; TMS Train Location Input</td>
</tr>
<tr>
<td>TMA*.ext</td>
<td>TMS Alarm Output</td>
</tr>
<tr>
<td>TMS*.ext</td>
<td>TMS File of Filenames Input</td>
</tr>
<tr>
<td>TPS*.ext</td>
<td>TPS File of Filenames Input</td>
</tr>
<tr>
<td>TRAN*.ext</td>
<td>Circuit Line Name Translator</td>
</tr>
<tr>
<td>TS*.ext</td>
<td>Stop Distance</td>
</tr>
<tr>
<td>TSD*.ext</td>
<td>TPS Detailed Output</td>
</tr>
<tr>
<td>TSS*.ext</td>
<td>TPS Summary Output</td>
</tr>
<tr>
<td>TW*.ext</td>
<td>TMS Track Layout</td>
</tr>
<tr>
<td>ZR*.ext</td>
<td>Return Circuit Impedance</td>
</tr>
</tbody>
</table>
4.2 SUB MODEL FILE NAMING CONVENTION

The naming convention for the Sub Model Database is shown in the next table.

<table>
<thead>
<tr>
<th>Filename Format</th>
<th>File Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>*.txt</td>
<td>TOM Reference Text</td>
</tr>
<tr>
<td>SI*.txt</td>
<td>Screen Instruction Text</td>
</tr>
<tr>
<td>ImpDefPerm.txt</td>
<td>Impedance Default</td>
</tr>
<tr>
<td>DefCalParPerm.txt</td>
<td>Default Calculational Parameters for Circuit Current Analysis</td>
</tr>
<tr>
<td>*.lib</td>
<td>Car Library</td>
</tr>
<tr>
<td>*.mot</td>
<td>Motor Model</td>
</tr>
<tr>
<td>*.con</td>
<td>Motor Control Model</td>
</tr>
<tr>
<td>*.gum</td>
<td>Gear Unit Model</td>
</tr>
</tbody>
</table>

5 HISTORY OF TOM AND INSTRUCTION MANUAL DEVELOPMENT

The history of TOM development is long. It began its commercial venture as the Energy Management Model (EMM) and the first version was released on July 1, 1984.

It was licensed under the EMM until May 1, 1996, when Version 1.0 of the TOM was released. TOM Version 1.0 contained all of the features of the EMM plus additions.

TOM Version 2.0 was released on February 2, 1998 and was a major upgrade. It was with this release that the Block Diagram and components of the TOM outlined in Section 2 became reality.

At each level of upgrade, improvements of user friendliness and bug fixes were included. As well as incorporating requests from clients.

Other major improvements were dated as follows.

TOM Version 3.0 was released on July 30, 2004. It was a major upgrade over 2.0.

TOM Version 3.2 was released on January 31, 2009, which had emphasis on mainline non-electric passenger and freight railroads. Building trains and locomotive dispatch was an extended feature.

TOM Version 3.3 was released September 1, 2009. All graphs could now be scaled by the user.

TOM Version 3.4 was released March 12, 2013. This was a major improvement, which included a return circuit and an all graphic method of producing circuits both primary (positive) and return (negative).

TOM Version 3.5 was released March 1, 2014. This release included a generalized Rail Voltage Model plus a Four Quadrant Control – AC Induction Motor Drive for mainline AC railroad electrification.

Training courses and other educational material has always been a high priority item developed along with the EMM and later the TOM. The Training Course grows in substance and duration as the TOM adds more features. It began at a level of two days with the EMM in 1984 and has now grown to five days with TOM Version 3.5 in 2014.

The Instruction Manual has also grown in size by adding volumes as the TOM has grown in features.
Four volumes were produced in 2008, which included:

- Volume 2 – Instruction Manual for Applying the TOM to Transit Systems DC Electric – English Units
- Volume 3 – Instruction Manual for Applying the TOM to Transit Systems DC Electric – Metric Units
- Volume 4 – Instruction Manual for Applying the TOM to Transit Systems AC Electric – English Units
- Volume 5 – Instruction Manual for Applying the TOM to Transit Systems AC Electric – Metric Units

As the TOM improved, other volumes were added, corresponding to the improvements.

Volume 1 – An Introduction to the Instruction Manual for Applying the TOM – 3/1/2014
Volume 6 – Instruction Manual for Applying the TOM to Railroads Fueled – English Units – 9/1/2009
Volume 11 - Instruction Manual Exercising the AC Drive Model – 10/15/2012

Modifications have been made on earlier volumes from time to time, but no major revisions. Thus many of the screens, which are present in the older volumes have been updated to reflect improvements.

The development of new volumes of the Instruction Manual is expected to continue.

6 DESCRIPTIONS OF INSTRUCTION MANUAL VOLUMES
A brief description of each of the developed volumes is presented in the next several sections.

6.1 Volume 2 – Instruction Manual for Applying the TOM to Transit Systems DC Electric – English Units

This Volume was prepared using TOM Version 3.1, so that the screens are those of that version. There is a companion Excel Book and Archived TOM files.

The DCEE Rail Transit System is a fabricated rail transit system, which has been designed to contain most of the features of a real transit system. The purpose of this document is to guide the user to apply the Train Operations Model (TOM)© to this transit system in order to familiarize the user with the techniques of this application. Having gone through this exercise, the user can then apply the TOM to similar real systems.

The Mnemonic DCEE represents DC Electric – English units, which means that the rail transit system uses DC electricity, which is converted from AC in substations and distributed via a third rail, overhead trolley or overhead catenary to the trains running on the system, the return path of the current being the running rails and the earth or a separate return, such as is the case with a trolley bus. English units are used to describe the system, rather than metric units, which are in favor in most of the world, except the United States. This situation is valid for most of the Rail Transit Authorities in the United States, including heavy and light rail systems.
This document can be used as a guideline for applying the TOM to most of the Transit Authorities in the United States.

The evaluation process begins with the client’s requirements statement. The second step is to describe the rail system in a format appropriate for input for the TOM. The third step is to cast the requirements statement into a format for application of the TOM to the rail transit system. The remaining steps consist of using the TOM to satisfy the requirements of the client.

This volume has four parts. Each of the parts corresponds to the steps in the evaluation process.

The first part (Chapter 2) presents the requirements of the client. These requirements are generally presented as his desired objectives. In the case of this instruction manual, these objectives were selected to use most of the features of the TOM, so that the user may have guidelines for further applications for his clients.

The second part (Chapter 3) contains a description of the rail transit system in technical terms, which are closely compatible with the kind of inputs required by the TOM. The inputs have already been through one condensation in the sense that a lot of work gathering and assembling raw data has already been done by the user. These data have already been assembled into tables, which can be used as references for input into the TOM. When working on a real rail transit system, the user should produce a document in the format of Chapter 3, which can then be similarly used as guidance for input to the TOM.

The third part (Chapter 4) contains the Exercises, which can be viewed as the expanded steps leading to the specification of what the client wants in terms of the application of the TOM. The process begins with the specification of what is to be accomplished. The chapter then continues listing the steps needed using the TOM to accomplish the goals of the client.

Finally the fourth part, consisting of the remaining chapters, shows how the TOM is applied using the data of the transit system to satisfying the clients request as specified in the exercises. In contrast to the Exercises chapter, which provides a listing of the work to be done, these chapters actually provide a step-by-step accomplishment of the work.

### 6.2 Volume 3 – Instruction Manual for Applying the TOM to Transit Systems DC Electric – Metric Units

This Volume was prepared using TOM Version 3.1, so that the screens are those of that version. There is a companion EXCEL Book and Archived TOM files.

The DCEM Rail Transit System is a fabricated rail transit system, which has been designed to contain most of the features of a real transit system. The purpose of this document is to guide the user to apply the Train Operations Model (TOM)© to this transit system in order to familiarize the user with the techniques of this application. Having gone through this exercise, the user can then apply the TOM to similar real systems.

The Mnemonic DCEM represents DC Electric – Metric units, which means that the rail transit system uses DC electricity, which is converted from AC in substations and distributed via a third rail, overhead trolley or overhead catenary to the trains running on the system, the return path of the current being the running rails and the earth or a separate return, such as is the case with a trolley bus. Metric units are used to describe the system, rather than English units, which are in favor in United States. This situation is valid for most of the Rail Transit Authorities in the World, except for the United States, including heavy and light rail systems.

This document can be used as a guideline for applying the TOM to most of the Transit Authorities of the World, except for the United States.
The evaluation process begins with the client’s requirements statement. The second step is to describe the rail system in a format appropriate for input for the TOM. The third step is to cast the requirements statement into a format for application of the TOM to the rail transit system. The remaining steps consist of using the TOM to satisfy the requirements of the client.

This volume has four parts. Each of the parts corresponds to the steps in the evaluation process.

The first part (Chapter 2) presents the requirements of the client. These requirements are generally presented as his desired objectives. In the case of this instruction manual, these objectives were selected to use most of the features of the TOM, so that the user may have guidelines for further applications for his clients.

The second part (Chapter 2) contains a description of the rail transit system in technical terms, which are closely compatible with the kind of inputs required by the TOM. The inputs have already been through one condensation in the sense that a lot of work gathering and assembling raw data has already been done by the user. These data have already been assembled into tables, which can be used as references for input into the TOM. When working on a real rail transit system, the user should produce a document in the format of Chapter 3, which can then be similarly used as guidance for input to the TOM.

The third part (Chapter 4) contains the Exercises, which can be viewed as the expanded steps leading to the specification of what the client wants in terms of the application of the TOM. The process begins with the specification of what is to be accomplished. The chapter then continues listing the steps needed using the TOM to accomplish the goals of the client.

Finally the fourth part, consisting of the remaining chapters, shows how the TOM is applied using the data of the transit system to satisfying the clients request as specified in the exercises. In contrast to the Exercises chapter, which provides a listing of the work to be done, these chapters actually provide a step-by-step accomplishment of the work.

6.3 Volume 4 – Instruction Manual for Applying the TOM to Transit Systems AC Electric – English Units

This Volume was prepared using TOM Version 3.1, so that the screens are those of that version. There is a companion EXCEL Book and Archived TOM files.

The ACEE Rail System is a fictitious rail system, which has been designed to contain most of the features of a real system. The purpose of this document is to guide the user to apply the Train Operations Model (TOM)© to this rail system in order to familiarize the user with the techniques of this application. Having gone through this exercise, the user can then apply the TOM to similar real systems.

The Mnemonic ACEE represents AC Electric – English units, which means that the rail system uses AC electricity, which is transformed from high voltage AC in substations to lower voltage AC and distributed via an overhead catenary to the trains running on the system, the return path of the current being the running rails and the earth. English units are used to describe the system, rather than metric units, which are in favor in most of the world, except the United States. This situation is valid for most of the AC electrified railroads in the United States.

This document can be used as a guideline for applying the TOM to most of the electric railroads in the United States.

This volume has three parts. The first part contains a description of the rail system in technical terms, which are closely compatible with the kind of inputs required by the TOM. The second part contains the
exercises, which can be viewed as what the client wants, in the application of the TOM. Finally the third part shows how the TOM is applied using the data of the rail system to satisfying the clients request as specified in the exercises.

6.4 Volume 5 – Instruction Manual for Applying the TOM to Transit Systems AC Electric – Metric Units

This Volume was prepared using TOM Version 3.1, so that the screens are those of that version. There is a companion EXCEL Book and Archived TOM files.

The ACEM Rail System is a fictitious rail system, which has been designed to contain most of the features of a real system. The purpose of this document is to guide the user to apply the Train Operations Model (TOM)© to this rail system in order to familiarize the user with the techniques of this application. Having gone through this exercise, the user can then apply the TOM to similar real systems.

The Mnemonic ACEM represents AC Electric – Metric units, which means that the rail system uses AC electricity, which is transformed from high voltage AC in substations to lower voltage AC and distributed via an overhead catenary to the trains running on the system, the return path of the current being the running rails and the earth. Metric units, which are in favor in most of the world, except the United States, which uses English units, are used to describe the system.

This document can be used as a guideline for applying the TOM to most of the electric railroads in the world.

This volume has three parts. The first part contains a description of the rail system in technical terms, which are closely compatible with the kind of inputs required by the TOM. The second part contains the exercises, which can be viewed as what the client wants, in the application of the TOM. Finally the third part shows how the TOM is applied using the data of the rail system to satisfying the clients request as specified in the exercises.

6.5 Volume 6 – Instruction Manual for Applying the TOM to Railroads Fueled – English Units

This Volume was prepared using TOM Version 3.2, so that the screens are those of that version. There is a companion EXCEL Book and Archived TOM files.

The FE Railroad (FERR) is a fabricated freight railroad, which has been designed to contain most of the features of a real freight railroad. The purpose of this document is to guide the user to apply the Train Operations Model (TOM)© to this railroad in order to familiarize the user with the techniques of this application. Having gone through this exercise, the user can then apply the TOM to similar real systems.

The Mnemonic FE represents Fueled – English units, which means that the railroad uses fuel driven prime movers (principally diesel locomotives). English units are used to describe the railroad, rather than metric units, which are in favor in most of the world, except the United States. This situation is valid for most of the railroads in the United States.

This document can be used as a guideline for applying the TOM to most of the railroads in the United States.

The evaluation process begins with the client’s requirements statement. The second step is to describe the railroad in a format appropriate for input for the TOM. The third step is to cast the requirements statement
into a format for application of the TOM to the railroad. The remaining steps consist of using the TOM to satisfy the requirements of the client.

This volume has four parts. Each of the parts corresponds to the steps in the evaluation process.

The first part (Chapter 2) presents the requirements of the client. These requirements are generally presented as his desired objectives. In the case of this instruction manual, these objectives were selected to use most of the features of the TOM, which are appropriate to mainline railroads, so that the user may have guidelines for further applications for his clients.

The second part (Chapter 3) contains a description of the railroad in technical terms, which are closely compatible with the kind of inputs required by the TOM. The inputs have already been through one condensation in the sense that a lot of work gathering and assembling raw data has already been done by the user. These data have already been assembled into tables, which can be used as references for input into the TOM. When working with a real railroad, the user should produce a document in the format of Chapter 3, which can then be similarly used as guidance for input to the TOM.

The third part (Chapter 4) contains the Exercises, which can be viewed as the expanded steps leading to the specification of what the client wants in terms of the application of the TOM. The process begins with the specification of what is to be accomplished. The chapter then continues listing the steps needed using the TOM to accomplish the goals of the client.

Finally the fourth part, consisting of the remaining chapters, shows how the TOM is applied using the data of the transit system to satisfying the clients request as specified in the exercises. In contrast to the Exercises chapter, which provides a listing of the work to be done, these chapters actually provide a step-by-step accomplishment of the work.

6.6 Volume 9 – Instruction Manual for Procedures and Shortcuts in the TOM

This Volume was prepared using TOM Version 3.2, so that the screens are those of that version. There is a companion EXCEL Book and Archived TOM files.

This document can be used to discover most of the user-friendliness and shortcuts within the TOM.

This volume has four parts. Each of the parts corresponds to user-friendliness or shortcut features of the TOM.

The first part (Chapter 2) describes the help availability to users of the model. These user-friendly features are of several varieties, including the program manual, several instruction manuals, screen instructions for each screen related to an input file and a question mark (?) help access for every object on every screen.

The second part (Chapter 3) describes the text transfer features, which several screens have, allowing a smooth connection for data flows between EXCEL and the TOM. Supplemental calculations may be performed in EXCEL and then transferred to the TOM.

The third part (Chapter 4) contains the Procedures. Some of these procedures are short, while others are lengthier; this section highlights many of these procedures.

The fourth part (Chapter 5) is Working With The Database. The Database Utility (DB) is a series of computer programs, which interact with the user to access all of the files, which are readable by the modules and the simulators of the TOM. This chapter provides examples of using the DB to operate the TOM.
6.7 Volume 10 – Instruction Manual for Including the Return Circuit in Electric Rail Systems

This Volume was prepared using TOM Version 3.4, so that the screens are those of that version. There is a companion EXCEL Book and Archived TOM files.

Previously, the Train Operations Model (TOM©) had used the loop method of load flow for calculating powers, voltages and currents in the power distribution of electrified rail systems. This means that the primary circuit is considered in the load flow and the return circuit is handled by lumping its impedance in series with the primary circuit impedance. So, for example when a catenary or third rail impedance is specified, the impedance of the running rail is added to that of the catenary or third rail and then the load flow is performed.

In many cases of rail systems, the return circuit impedance does not simply add in series to the primary circuit impedance. There is one case in which the answers would be very close; namely, the case where track bonds are very close together compared to the length of the trains, which are running on the system and there are no tie stations (breaker houses) between substations. These tie stations improve the conductivity of the primary circuit as well as provide isolation capability. In this case the bonded rails are considered in parallel. Where this condition is not met, it is not clear how or in what direction the circuit powers, voltages and currents vary from the case, for which the return circuit is taken into account.

In order to clarify this question, it has been necessary to include the return circuit for all cases in the TOM. However, this inclusion also gives the TOM the full capability of doing both the primary and return circuits. In adding this capability to the TOM, a graphical method is used to construct both the primary and return circuits, giving the TOM an improved way of building the network, representing these circuits. This improvement makes network construction much simpler, whether or not a return circuit or loop method is used.

The purpose of this instruction manual is to state and carry out a procedure for including the return circuit.

In order to understand the dynamics of including the return circuit, very simple rail systems are used for these exercises. Both AC and DC Rail Systems are illustrated as well as no regeneration and regeneration. Both methods, Loop and Return Circuit Inclusion, are applied to these Rail Systems, and the results are compared.

Chapter 2 outlines the procedure for both Loop and Inclusion of Return Circuit Methods of ENS. It also provides a means of comparing the results of both methods.

Chapter 3 describes the application of the procedure to a simple DC Rail System for both no regeneration and regeneration cases.

Chapter 4 provides a description of the application of the procedure to a simple AC Rail System for both no regeneration and regeneration cases.

Finally, Chapter 5 shows the application to a more complicated DC system, which is an extension of the DCEE Instruction Manual.

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1 Primary circuit in this context refers to the substations and the catenary or third rail. In DC systems, the positive circuit is the primary circuit and the negative circuit is the return circuit.
6.8 Volume 11 - Instruction Manual Exercising the AC Drive Model

This Volume was prepared using TOM Version 3.4.2 and parts TOM Version 3.5, so that the screens are those of that version. There is a companion EXCEL Book and Archived TOM files.

The AC Drive is a type of adjustable-speed drive used in electro-mechanical drive systems to control AC motor speed and torque by varying motor input frequency and voltage. Modern rail systems are becoming more and more dependent on the AC Drive as the propulsion system of choice because of its lower initial and operating cost.

AC Drives for modern traction consist of a variable frequency and variable voltage solid state control of three phase ac induction motors. Most of the modern traction systems which are now produced for rail cars, even on older rail systems, are AC Drives.

The Train Operations Model (TOM ©) has built into it an AC Drive SubModel, which can be used to provide the electrical characteristics of the AC Drive propulsion system, which are further used to simulate train and power system operation. The purpose of this study is to apply that SubModel in order to study parameter sensitivity and other electrical characteristics.

In particular, it would be important to know which parameters have the greatest effect on the Traction Effort and Traction Efficiency Curves, in order to determine motor design parameters, which manufacturers are reluctant to give to clients which use the TOM.

A description of the AC Drive model used in the TOM is provided in the TOM Program Manual.

Chapter 2 defines the base case for the AC Drive study. The base case is the AC Drive to which all other AC Drives are compared. A change in one of the parameters of an AC Drive produces a new AC Drive to be compared to the original.

Chapter 3 contains a discussion of the sensitivity of AC Drives to the parameters which define them. This discussion is presented in terms of the parameter change on the Traction Effort and Traction Efficiency. Sensitivity is put into quantitative terms. For variation of one of the parameters of the motor, inverter and gear unit models by a fixed percentage in the positive and negative directions, traction effort curves (tractive effort and electrical braking effort) and traction efficiency curves are presented and compared to the base case.

Chapters 4 and 5 view the AC Drive from the point of view of input line voltage variation. The line voltage varies as a result of the current being drawn by the train as well as the currents being drawn by all of the other trains on the power system feeding the trains. Most models used in power systems studies do not take this into account. It is important to know how much capability the AC Drive has relative to its performance requirements.

Maximum voltage drops and performance are usually obtained by assuming a constant voltage for the train, which can range from open circuit voltage to minimum voltage allowed on the line. If a power system is designed on this basis, it can be either designed conservatively or liberally depending on the selection of this voltage. A conservative design will use a nominal train voltage close to the open circuit voltage, while a liberal design will choose the nominal voltage, which is lower. Choice of this voltage will also determine the schedule performance and energy consumption of the train.

The TOM has the capability of developing traction and efficiency curves where the line voltage varies with the power drawn. Chapter 4 considers development of power dependent curves, while chapter 5 evaluates performance on the basis of these curves. An iteration process for determining both nominal and minimum
voltages is outlined for use with the **TOM**. This is a less conservative approach to power system evaluation.

The **TOM** Training Course, which is offered to any licensee of the **TOM**, provides an exercise to develop and **AC Drive** using the propulsion system SubModel of the **TOM**. These trains are replacing trains which use an old style resistor control propulsion model and there is a requirement that they have the same performance as the older style trains. Chapter 6 illustrates how this process is conducted.

Finally, Chapter 7 deals with the design of passenger and freight locomotives using the **AC Drive** but operation under a single phase **AC Power Distribution System**. In particular, the **Four Quadrant Control** is added to the propulsion system to provide the DC power input for the **AC Drive**. A **Main Transformer** is also provide to step down the high catenary voltage (12-50 kV). The propulsion system for the locomotives consist of **Main Transformer – Four Quadrant Control – AC Drive**. The locomotives are generally called **Four Quadrant Control (FQC) Locomotives**.

Two types of locomotives are considered using essentially the same **FQC** design. The first is a passenger locomotive, modeled to have the characteristics of the **AMTRAK Sprinter 64**. The freight locomotive is the same locomotive but re-geared for a lower top speed.

The passenger locomotive is tested on the Northeast Corridor between New York and Washington and the freight locomotive is tested on a simulated freight line in mountainous and flat terrain.

### 6.9 Volume 12 – Instruction Manual DC Electric Power System Methodology

This **Volume** was prepared using **TOM Version 3.4.2**, so that the screens are those of that version. There is a companion **EXCEL Book** and **Archived TOM files**.

The purpose of this manual is to provide a guideline for application of the **TOM** to DC Power Distribution in Rail Transit Systems. Generally, heavy and light rail systems fall into this category. Three phase AC power is provided to DC Transformer-Rectifier substations, which in turn distribute this power via a third rail, catenary or trolley to trains, which pick up the power and use it for propulsion and on-board auxiliaries.

**It is important to understand what the TOM “is and is not “ in order to properly apply it.**

The **TOM** is not a design model for any of its applications. As quoted on the web page located at [http://www.railsystemscenter.com/](http://www.railsystemscenter.com/): “The Train Operations Model (TOM) contains all of the computer tools to simulate the operation of a rail transit system or mainline railroad on a computer.”

The **TOM** is a tool for evaluation. Traction Power Engineering consultants use the **TOM** as an evaluation tool. The design of the power system is laid out, evaluated by the **TOM** and things are adjusted based on **TOM** evaluation. This is done until an “adequate” design is achieved.

The **TOM** is neither a liberal nor conservative tool. It is the engineering process that generates inputs to the **TOM** that are either liberal or conservative. The **TOM** can do no more than those inputs. If liberal input then liberal output. If conservative input then conservative output. The decision of “**adequate**” is made by the experienced engineer using the **TOM**.
The terms liberal and conservative are used here to measure the strength of the power distribution system. Liberal applies to a weak power system and conservative applies to a strong power system.

From time to time within this guideline, these terms will be used to describe method of evaluation.

This guideline is based on the IEEE Standard:

**P1653.3 Guide for Rail Transit Traction Power Systems Modeling**

The first question to be answered in terms of this standard is what the **TOM** can and cannot do as an evaluation tool.

The **TOM** can:

- Determine energy consumption
- Estimate train voltages at every position
- Estimate train currents at every position and currents through all lines feeding the train as functions of time.
- Provide information on substation loading.
- Develop Root-Mean-Square (RMS) current in all lines feeding the trains.
- Simulate contingency conditions

The **TOM** cannot:

- Perform fault modeling
- Harmonic analysis of the power circuit
- Estimate rail to ground voltages (except under special circumstances). **TOM Version 3.5** has this capability.

The last “cannot;” namely “Estimate rail to ground voltages” should be qualified. The **TOM** has a **Rail Voltage Model**, which has the capability of estimating, rail-to-ground voltage with a single train running on a two track network. With this configuration, only one train is between substations at any given time. With two trains between substations, the rail-to-ground voltage will be lower because of cancellation effects of the current through the rails between the trains and substations. However, this is no longer true for three trains between substations. So the **Rail Voltage Model** is of limited usefulness and could be used as a starting point for a more sophisticated model.

This guideline uses a base rail transit system in order to provide instruction to the reader. This base system has all of the characteristics of real world transit systems.

The first step is to provide a description of the rail system appropriate for determining input data to the **TOM**. This is actually the first step that anyone uses for any model. More specifically that step is a preliminary step to conversion of “the raw rail system data” into files which are readable by the simulators.

Any user of the **TOM** should take the time to produce such a description before producing input files to the **TOM**. The description then becomes a working document,
which is updated as new information is obtained, which subsequently require changing TOM input.

Chapter Error! Reference source not found. is such a document. This document will use metric units. Since the TOM has both English and Metric unit capability, the document can be converted to English units if desired.

After the system description document is written, the next step is to complete the initial simulations using the TOM. This is usually accomplished by considering the most taxing conditions, but with normal operation. For example, the minimum headway operation with crush loaded trains is such a case. This condition is referred as initial operation.

Chapter Error! Reference source not found. illustrates the use of the TOM in this simulation. It includes setting up the trains and right of way conditions for the TPS (Train Performance Simulator). This is then followed by inputting the parameters and conditions for running the ENS (Electric Network Simulator) and the running it for initial operation.

Chapter Error! Reference source not found. shows the methodology for analyzing the power system design. This methodology uses the output of both the TPS and ENS to effect these analyses. The topics of Energy Consumption, the Ghost Train, Train Voltages, Train Currents, Substation Loading and Distribution System Currents and RMS Currents are discussed in this section.

Chapter Error! Reference source not found. describes power system contingency analysis. Conditions such as substations out of service and restarting stopped trains are considered here.

Chapter Error! Reference source not found., labeled Power System Design Re-Evaluation re-visits the design and develops discussion of other options which should be considered.

Finally, Chapter Error! Reference source not found. summarizes the instruction manual and summarily reiterates the items covered.

6.10 Volume 14 – Instruction Manual Exercising the Rail Voltage Model for DC Traction Systems

This Volume was prepared using TOM Version 3.4.2, so that the screens are those of that version. There is a companion EXCEL Book and Archived TOM files.

The Train Operations Model (TOM)© Version 2.5 in the year 2000, included a Rail Voltage Model at the request of one of the licensees. The method used is now referred as the Old Method. It is explained below.
The Rail Voltage Model (RVM) has been designed to estimate maximum rail to ground voltage in train networks with DC Power Distribution. There are two methods by which this estimate can be made. These methods are termed the Old Method and the New Method. The terms are applied to versions of the model lower than 3.5 (Old Method) and 3.5 and higher (New Method). Both methods can be used with version 3.5 and higher.

**Old Method**
This method can estimate maximum rail to ground voltage in very simple two track networks and with a single train running on the network.

Rail voltage estimates can be made on more complicated networks by separating them into pieces, where each piece is a simple network described above.

**New Method**
This method can estimate maximum rail to ground voltage in any train network with no limits on the number of trains running. It utilizes the return circuit to make the estimate and depends on the line currents moving through the rails.

Chapter 2 outlines the procedure for both the Old and New Method for applying the Rail Voltage Model (RVM).

Chapter 3 describes the application of the new procedure to a simple DC Rail System for both no regeneration and regeneration cases. Several of its features are described and parameter variation on many fronts is studied.

Chapter 4 shows the application to a more complicated DC system, which is an extension of the DC Electric & Electronic Engineering (DCEE) Instruction Manual.