NATIONAL COOPERATIVE RAIL RESEARCH PROGRAM

NCRRP

Web-Only Document 1:

User Guide for the Multi-Modal Passenger Simulation Model for Comparing Passenger Rail Energy Consumption with Competing Modes

TranSys Research, Ltd.
Glenburnie, ON

RailTEC
University of Illinois at Urbana-Champaign
Urbana, IL

Lawson Economics Research, Inc.
Ottawa, ON

CPCS Transcom
Toronto, ON

Research and Traffic Group
Kars, ON

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Appendix A

MMPASSIM
Spreadsheet Model
User Guide

Table of Contents

Appendix A MMPASSIM Spreadsheet Model User Guide

Appendix B Terms, Abbreviations and Equation Variables

List of Tables

List of Figures

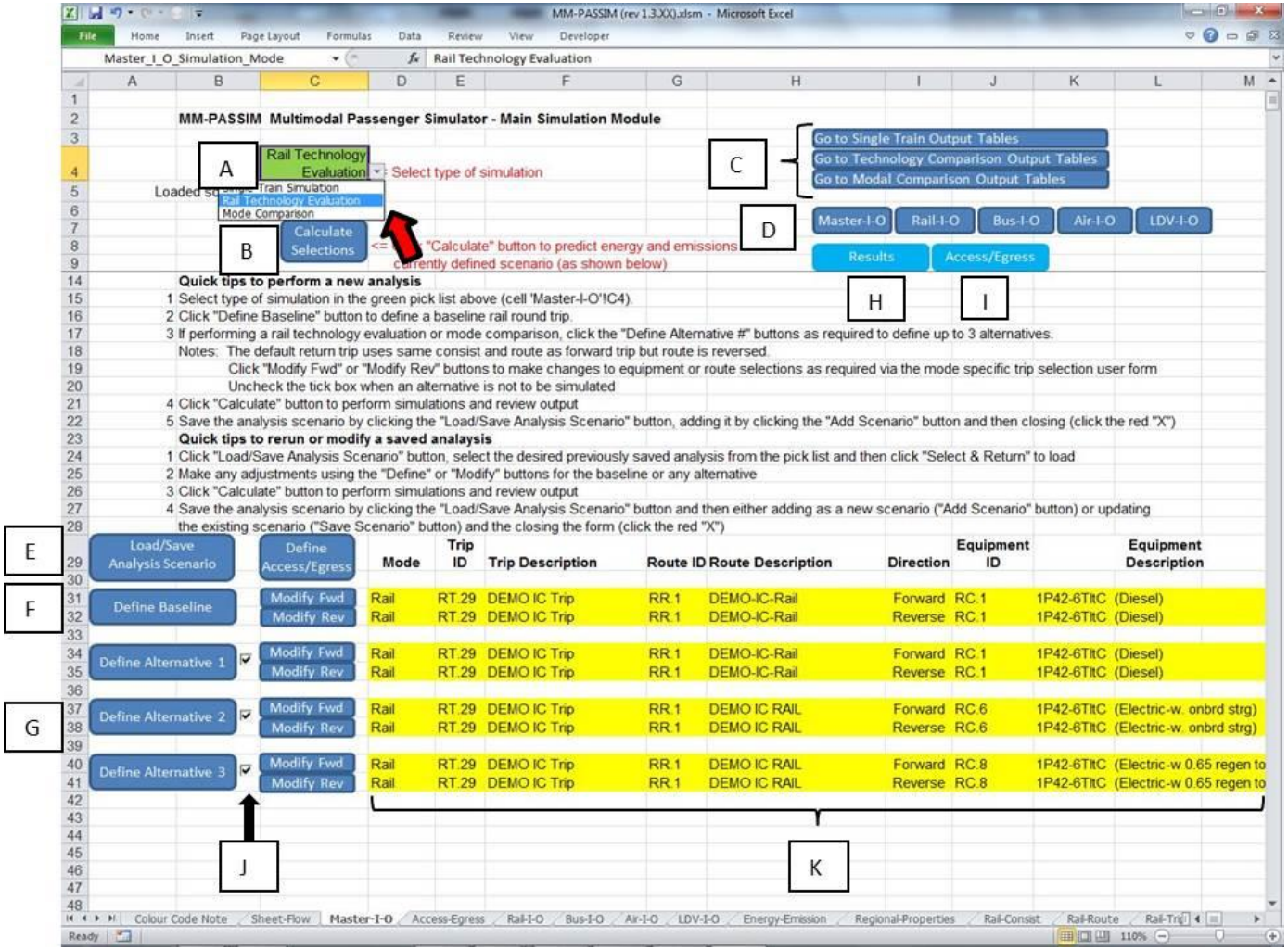
SUMMARY AND QUICK-REFERENCE GUIDE

Overview to Using the MMPASSIM Model

The main user interface of the MMPASSIM model is the '*Master-I-O'* worksheet and is as depicted in the figure on the following page. A simulation scenario may be easily configured from the 'Master-I-O' worksheet using default (or previously stored) data by following these steps:

1. Select the desired simulation mode from the green drop-down list (at cell 'Master-I-O'!$C$4, highlight A in the figure).
2. Define the baseline rail round trip (applicable in all three simulation modes) by clicking the blue "Define Baseline" button (at cell 'Master-I-O'!$A$31, highlight F in the figure).
3. Define each alternative round trip by clicking the blue "Define Alternative 1/2/3 button(s) located below the "Define Baseline" button. A maximum of 3 alternatives can be selected for rail technology comparisons or transportation mode comparisons.
4. Click the blue "Calculate Selections" button (at cell 'Master-I-O'!$B$7, highlight B in the figure) to initiate the simulation of the baseline rail round trip followed by each defined alternative in a rail technology evaluation or mode comparison analysis.
5. Review the simulation results table which is automatically brought into view at the conclusion of all simulations as defined for the selected analysis type.

Pop-up user forms are provided to assist users with managing and configuring the data required for an analysis. The VBA macros will coordinate accessing data from the various worksheets required for the type of analysis being defined. In some cases, an experienced user may also find it more expedient to directly modify vehicle and route data or define new trips. The fuel and emissions intensity data for all transportation modes are provided in the 'Energy-Emission' worksheet and include default values (in yellow highlighted cells) and "used" values (in green highlighted cells). The default values should not normally be modified. The green "used" values are those which the simulation modules use when performing calculations and can be safely modified by a knowledgeable user to adjust for better known values to be used in their simulated scenarios.



MMPASSIM Main User Interface is on `Master-I-O` Worksheet.

Notes:

- A Simulation type selection
- B Calculate selections button
- C Go to the indicated mode specific output table
- D Go to modal IO worksheet
- E Load an existing trip configuration or save current trip configuration
- F Define the baseline trip
- G Define up to 3 alternate trips(s)
- H Display results table for the current analysis type
- I View the access/egress leg results
- J Check the tick box to activate an alternative trip calculation
- K Summarizes the currently configured trips

For the ground transportation modes (rail, LDV and bus), a trip is defined in terms of its route and the vehicle which operates over that route. Vehicle and route data for the ground transportation modes are specified in separate mode-specific vehicle and route worksheets, all of which have green coloured tabs. The route data specifies characteristics such as trip distance, grade profile, speed limits, location and duration of intermediate stops, and other operational factors. The vehicle data specifies the physical properties used by the model to characterize the vehicle's passenger capacity, weight, inherent resistance to motion, and its engine characteristics.

Three "builder" worksheets are also included to provide casual users of MMPASSIM with a quick and easy method to construct simple trips from only very basic trip information. These include the 'Build-Simple-Rail-Trip', 'Build-Simple-Bus-Trip' and 'Build-Simple-LDV-Trip' worksheets (all with green tabs). The basic information required to specify a simple trip using these worksheets include the trip length, average trip speed (or speed limit), number of intermediate stops, scheduled trip time (for rail and bus modes), season, geographical region, origin and destination urban area sizes (for highway modes) and the approximate time of day of departure and arrival. Modal simulations based on trips created using these "builder" worksheets assume various mode-specific default values and do not consider the influence of grades and curves along a route.

Air mode trips are specified differently and do not use data stored on vehicle and route worksheets. Rather, air trips are specified in terms of the sequence of IATA airport codes visited from the origin to destination and the distribution of aircraft types used to travel over each leg of that trip. The model uses default aircraft data provided in the 'Air-Default-Data' worksheet (with a yellow coloured tab). A list of IATA airport codes and their longitude and latitude is also maintained on the 'Air-Default-Data' worksheet and users may update that list by adding new IATA airport codes and locations.

MMPASSIM Analysis Quick Reference Guide

The following pages present a series of lists which summarize the basic steps involved in performing analyses using the MMPASSIM model. In most cases, the sections in the User`s Guide which provide more details on the steps required for an analysis task are noted.

To Perform a Single Train Simulation

A Single Train Simulation is configured and run from the 'Master-I-O' worksheet. Section A.3.1 of this document provides a brief overview of the process while Section A.5.1 discusses the analysis process in greater detail.

The basic steps required to perform a Single Train Simulation are as follows:

1. Click the green 'Master-I-O' worksheet tab along the bottom of the Excel window to bring the 'Master-I-O' worksheet into view.

2. Select "Single Train Simulation" from the green drop-down list at 'Master-I-O'!C4

3. Open the "Rail Trip Selection" menu by clicking on the blue "Define Baseline" button on the 'Master-I-O' worksheet.

4. Choose a pre-existing rail trip from the green drop-down list just below the yellow "Trip ID" box at the top.

5. Modify trip as needed by
   - selecting a different route from the "Route ID" drop-down list
   - selecting a different consist from the "Consist ID" drop-down list
   - adjusting trip departure & arrival times, season, region, etc. as required
   - adjusting access & egress legs by clicking on the gray "Access & Egress"

6. Save or add as a new trip as desired.
   - to save as a new trip, click gray "Add Rail Trip" and then "Save Rail Trip"
   - to save modifications with old name, click gray "Save Rail Trip"
   - you may use modifications temporarily without saving to 'Rail-Trip-List' worksheet

7. Click gray "Select & Return" button to load the displayed trip on the 'Master-I-O' worksheet for analysis.

8. Click blue "Calculate Selections" button to start the simulation

9. Review the results displayed in the Single Train Simulation output tables on the 'Master-I-O' worksheet (automatically brought into view), or by clicking the blue "Go to Single Train Output Tables" button.

To Perform a Rail Technology Evaluation from Existing Characterization Data

A Rail Technology Evaluation is configured and run from the 'Master-I-O' worksheet. A Rail Technology Evaluation compares the energy and emissions performance of up to four rail round trips. Section A.3.2 of this document provides a brief overview of the process while Section A.5.1 discusses the details of setting up a new rail trip simulation.

The basic steps required to perform a Rail Technology Evaluation are as follows:

1. Click the green 'Master-I-O' worksheet tab along the bottom of the Excel window to bring the 'Master-I-O' worksheet into view.

2. Select "Rail Technology Evaluation" from the green drop-down list at 'Master-I-O'!C4

3. Define baseline rail trip by clicking the blue "Define Baseline" button and using the "Rail Trip Selection" menu

4. Tick the check box for each required alternative. Define the alternative rail trip by clicking the blue "Define Alternative 1/2/3" button and using the "Rail Trip Selection" menu. Note – click on any ticked check box to clear it if an alternative is not to be included in this simulation.

5. Review the access and egress defined for the baseline and each alternative. Click on the blue "Define Access/Egress" button on the 'Master-I-O' worksheet to display the "Trip Access and Egress Leg Selection" menu and scroll through the definitions. Adjustments can be made and then saved by clicking the gray "Save" button, but note that they are only saved to the 'Master-I-O' definition (not to the underlying rail trip stored on the 'Rail-Trip-List' worksheet).

6. Click the blue "Calculate Selections" button to start the rail technology evaluation.

7. Review the results displayed in the Rail Technology Evaluation output tables on the 'Master-I-O' worksheet (automatically brought into view), or by clicking the blue "Go to Technology Comparison Output Tables" button.

To Perform a Modal Comparison from Existing Characterization Data

A Modal Comparison is configured and run from the 'Master-I-O' worksheet and Section A.3.3 of this document provides a brief overview of the process. Performing a Modal Comparison requires setting up a baseline rail trip (see Section A.5.1) and up to three trips for competing modes which may include an air trip (see Section A.5.2), a bus trip (see Section A.5.3) and a light duty vehicle trip (see Section A.5.4).

The basic steps required to perform a Modal Comparison are as follows:

1. Click the green 'Master-I-O' worksheet tab along the bottom of the Excel window to bring the 'Master-I-O' worksheet into view.

2. Select "Mode Comparison" from the green drop-down list at 'Master-I-O'!C4

3. Define baseline rail trip by clicking the blue "Define Baseline" button and using the "Rail Trip Selection" menu.
   a. Select a pre-existing trip,
   or
   b. Select a rail route from drop-down list
   c. Select a rail consist from the drop-down list
   d. Make any further modifications to green fields
   and
   e. Click the gray "Select & Return" button to write the updated trip parameters to the 'Master-I-O' worksheet

4. Tick the check box for each required alternative. Define the alternative modal trip by clicking the blue "Define Alternative 1/2/3" button and using the mode-specific "Trip Selection" menu – click on any ticked check box to clear it if an alternative is not to be used in this simulation. Note that for alternative trips, you must select the desired mode from the green drop-down list presented and then click the gray "Select & Edit" button to access the mode-specific trip selection menu.
   – rail trips use the "Rail Trip Selection" menu
   – air trips use the "Air Trip Selection" menu
   – bus trips use the "Bus Trip Selection" menu
   – auto/LDV trips use the "Auto/LDV Trip Selection" menu
   Click the gray "Select & Return" button when finished with a "Trip Selection" menu

5. Review the access and egress defined for the baseline and each alternative. Click on the blue "Define Access/Egress" button on the 'Master-I-O' worksheet to display the "Trip Access and Egress Leg Selection" menu and then scroll through the definitions. Note: adjustments can be made and saved by clicking the gray "Save" button, but are only saved to the 'Master-I-O' definition (not to the underlying rail trip stored on the 'Rail-Trip-List' worksheet).

6. Click the blue "Calculate Selections" button to start the mode comparison.

7. Review the results in the Mode Comparison output tables on the 'Master-I-O' worksheet (automatically brought into view), or by clicking the blue "Go to Modal Comparison Output Tables" button.

To Create a New 'Simple' Rail Trip

The 'Build-Simple-Rail-Trip' worksheet provides a straight forward method of creating a rail trip when little specific information is known about the train makeup and route. The process is as follows (refer to Section A.4.1 for more detail):

1. Click the green 'Build-Simple-Rail-Trip' worksheet tab along the bottom of the Excel window to bring the 'Build-Simple-Rail-Trip' worksheet into view.

2. Select either "U.S." or "metric" from the green drop-down list.

3. Define the rail
    a. Select a locomotive type from the green locomotive drop-down list and indicate the number of locomotives to include
    b. Select up to three types of coaches from the three green coach drop-down lists and indicate the number of each coach type to include
    c. Select the locomotive fuel type from the green "Fuel Type" drop-down list
    d. Adjust the assumed passenger load factor in the green input field
    e. Click the blue "Save to 'Rail-Consist'" button to access the "Simple Rail Consist Selection" menu
    f. Enter a consist description into the green "Description" input box and click the gray "Add Rail Consist" button.
    g. Click the gray "Select & Return" button to return to the 'Build-Simple-Rail-Trip' worksheet.

4. Define the rail route
    a. Set the trip length, average track speed and number of stops in the correspondingly labeled green data input fields.
    b. Click the blue "Save to 'Rail-Route'" button to access the "Simple Rail Route Selection" menu
    c. Enter a route description into the green "Description" input box and click the gray "Add Rail Route" button.
    d. Click the gray "Select & Return" button to return to the 'Build-Simple-Rail-Trip' worksheet.

5. Define the rail trip
    a. Select the region, season, departure and arrival time-of-day and the day-of-week from the correspondingly named green drop-down lists.
    b. Set the number of travelers, schedule trip time and station stop time allowance in the correspondingly named green input data fields.
    c. Select the target 'Rail-I-O' trip from the green drop-down list (this controls if the simple rail trip is loaded as a baseline or alternative trip).
    d. Click the blue "Create Rail Trip" button to access the "Rail Trip Selection" menu
    e. Click the gray "Add Rail Trip" to create a new rail trip.
    f. Enter a trip description into the green "Description" input box and click the gray "Save Rail Trip" button to save to the 'Rail-Trip-List' worksheet.
    g. Click the gray "Select & Return" button to load the new trip parameters onto the 'Rail-I-O' worksheet (and also on the 'Master-I-O' worksheet).

To Create a New ‘Simple’ Bus Trip

The ‘Build-Simple-Bus-Trip’ worksheet provides a simple means to create a basic bus trip. Details may be found in Section A.4.2 of this document. The process is a follows:

1. Click the green ‘Build-Simple-Bus-Trip’ worksheet tab along the bottom of the Excel window to bring the ‘Build-Simple-Bus-Trip’ worksheet into view.

2. Select either “U.S.” or “metric” from the green drop-down list.

3. Choose a type of bus from the green drop-down list.

4. Set rural freeway distance in the green input field and select speed limit from green drop-down list.

5. Select urban area sizes from the green drop-down lists, and set distances traveled on urban freeway and arterial roads in the green input fields.

6. Set number of intermediate stops while leaving origin urban area, along intercity leg and entering destination urban area in the green input fields.

7. Set scheduled trip time.

8. Select region and season from the respective green drop-down lists.

9. Select departure & arrival times and day of week from the green drop-down lists.

10. Enter a description for the route to be created in the green input field and then click the blue "Save to 'Bus-Route'" button.

11. Click the blue "Create Bus Trip" button to open the “Bus Trip Selection” menu

12. Click the gray "Add Bus Trip" button and enter a trip description into the green “Description” field.

13. Click the gray "Save Bus Trip" button to save the trip to the ‘Bus-Trip-List’ worksheet.

14. Click the gray “Select & Return” button to load the new trip parameters onto the ‘Bus-I-O’ worksheet (and ‘Master-I-O’ worksheet when a bus trip is selected for analysis).

To Create a New ‘Simple’ Light Duty Vehicle Trip

The ‘Build-Simple-LDV-Trip’ worksheet provides a simple means to create a basic light duty vehicle trips. Details may be found in Section A.4.3 of this document and the process is summarized as follows:

1. Click the green ‘Build-Simple-LDV-Trip’ worksheet tab along the bottom of the Excel window to bring the ‘Build-Simple-LDV-Trip’ worksheet into view.

2. Select either “U.S.” or “metric” from the green drop-down list.

3. Choose a type of light duty vehicle from the green drop-down list.

4. Set rural freeway distance in the green input field and select speed limit from green drop-down list.

5. Select urban area sizes from the green drop-down lists, and set distances traveled on urban freeway and arterial roads in the green input fields.

6. Set the number of intermediate wayside stops and the cumulative duration of those stops in the green input fields.

7. Select region and season from the respective green drop-down lists.

8. Select departure & arrival times and day of week from the green drop-down lists.

9. Set the number of travelers in the green input field.

10. Enter a description for the route to be created in the green input field and then click the blue "Save to 'LDV-Route'" button.

11. Click the blue "Create LDV Trip" button to open the “Auto/LDV Trip Selection” menu.

12. Click the gray "Add LDV Trip" button and enter a trip description into the green “Description” field.

13. Click the gray "Save LDV Trip" button to save the trip to the ‘LDV-Trip-List’ worksheet.

14. Click the gray “Select & Return” button to load the new trip parameters onto the ‘LDV-I-O’ worksheet (and ‘Master-I-O’ worksheet when an LDV trip is selected for analysis).

To Create a New Rail Route

The columns of the 'Rail-Route' worksheet hold all data used by MMPASSIM to represent the physical characteristics of a rail route. Section A.6.6 of this document discusses details of how to create a new rail route. The basic process is as follows:

1. Click the green 'Rail-Route' worksheet tab along the bottom of the Excel window to bring the 'Rail-Route' worksheet into view.

2. Choose an existing route on the worksheet to use as a template to customize with new route data.

3. Copy the 13 columns of route data to be used as a template into the open columns to the right of last route defined in the worksheet by:
    a. Click on the column label directly above the "Rail Route Index" of the source data.
    b. Hold the shift key and click on the column label of the 13th column to the right.
    c. Release the shift key.
    d. Place mouse pointer anywhere in the highlighted area and click right mouse button.
    e. Select copy from the pop-up menu.
    f. Find the 14th cell to the right of the last "Rail Route Index" defined in the worksheet, right click on it and select paste from the pop-up menu.
    g. Verify the copy is pasted in the correct position by ensuring the new "Rail Route Index" is an integer number 1 greater than the previous route
        – if it is an integer number then the data is pasted in the correct position
        – if it is less, click the undo paste icon (top left corner) and paste to a cell one further to the right
        – if it is more, click the undo paste icon (top left corner) and paste to a cell one further to the left

4. Modify the yellow "Rail Route ID" and green "Description" fields
    – The "Rail Route ID" must be a unique alpha-numeric string

5. Modify data values for the new route as required
    a. The route gradient table is located in rows 5 through 34
        – Can re-use an existing gradient profile by adjusting the milepost and elevation to suit or create a new profile from track chart data using the MMPASSIM track preprocessor and pasting data into this location
    b. The locations of stops are entered in rows 50 through 85 as follows
        – Location of forward direct stops in 1st column (green) in miles
        – Wayside receptivity of forward stops in 3rd column (green)
        – Location of reverse direct stops in 8th column (green) in miles
        – Wayside receptivity of reverse stops in 9th column (green)
        – Clear any unused cells in green columns only
    c. The locations of speed limit changes are input in rows 141 through 561
        – Location in 1st column (green) in miles
        – Conventional speed limit in 3rd column (green) in mph
        – Tilt-body speed limit in 4th column (green) in mph
        – Clear any unused cells in green columns only

To Create a New Rail Consist

The columns of the 'Rail-Consist' worksheet hold all data used by MMPASSIM to represent the physical characteristics of a rail consist. Section A.6.2 of this document describes how to build a new train from an existing base train, Section A.6.3 discusses how to build a new train with a new locomotive and Section A.6.4 details how to build a new train with new coaches. The basic process is as follows:

1. Click the green 'Rail-Consist' worksheet tab along the bottom of the Excel window to bring the 'Rail-Consist' worksheet into view.

2. Choose an existing rail consist on the worksheet to use as a template to customize with new vehicle data.

3. Copy the 7 columns of vehicle data to be used as a template into the empty columns to the right of the last vehicle route defined in the worksheet by:
    a. Click on the column label directly above the "Rail Consist Index" of the source data.
    b. Hold the shift key and click on the column label of the 7th column to the right.
    c. Release the shift key.
    d. Place mouse pointer anywhere in highlighted area and click right mouse button.
    e. Select copy from the pop-up menu.
    f. Find the 8th cell to the right of the last "Rail Consist Index" defined in the worksheet, right click on it and select paste from the pop-up menu.
    g. Verify the copy is pasted in the correct position by ensuring the new "Rail Consist Index" is an integer number 1 greater than the previous route
        – if it is an integer number then the data is pasted in the correct position
        – if it is less, click the undo paste icon (top left corner) and paste to a cell one further to the right
        – if it is more, click the undo paste icon (top left corner) and paste to a cell one further to the left

4. Modify the yellow "Rail Consist ID" and green "Description" fields
    – The "Rail Consist ID" must be a unique alpha-numeric string

5. Modify data values for the new vehicle as required
    a. Number of locomotives & cars, masses, lengths in rows 5 through 20
    b. Resistance coefficients in rows 26 through 28
    c. Tractive effort in rows 42 through 48
    d. Traction engine characteristics in rows 49 through 61

To Create a New Rail Trip

Before creating a new rail trip you should first create any new rail routes or rail consists that will be required (refer to the steps outlined previously). The following outlines the process for selecting a rail route and a rail consist to be used for a rail trip.

1. Click the green 'Master-I-O' worksheet tab along the bottom of the Excel window to bring the 'Master-I-O' worksheet into view.

2. Open the "Rail Trip Selection" menu by clicking on any of the blue "Define Baseline", "Define Alternative 1", "Define Alternative 2" or "Define Alternative 3" buttons on the 'Master-I-O' worksheet.

   Note: if the analysis type is set to "Mode Comparison" then you will need to select "Rail" from the green drop-down list presented on the "Transportation Mode Selection" menu and click the gray "Select & Edit" button to open the "Rail Trip Selection" menu.

3. Choose a rail trip to serve as a template by selecting it from the green drop-down list just below the yellow "Trip ID" box at the top.

4. Click the gray "Add Rail Trip" button at the bottom to create a new "Trip ID".

5. Enter a description in the green "description" field at the top.

6. Select a "Route ID" from the green "Route ID" drop-down list to assign it to this new rail trip.

7. Select a "Consist ID" from the green "Consist ID" drop-down list to assign it to this new rail trip.

8. Make any desired changes to the green user definable/selectable fields.

9. Assign/modify access and egress by clicking the gray "Access & Egress" button and making selections on the "Trip Access and Egress Leg Selection" menu – click the gray "Select & Return" button to return to the "Rail Trip Selection" menu.

10. Click the gray "Save Rail Trip" button to save the newly configured rail trip data to the 'Rail-Trip-List' worksheet.

11. Click the gray "Select & Return" button to load the displayed rail trip onto the 'Master-I-O' worksheet.

A.1 Multi-Modal Passenger Simulator Model Introduction

The **M**ulti **M**odal **Pas**senger **Sim**ulator (MMPASSIM) supports three types of analyses: *Single Train Simulations*, *Rail Technology Evaluations* and *Transportation Mode Comparisons*. In each type of analysis, mode-specific trips are defined as a combination of a vehicle travelling along a route. The analyses comprising the *Single Train Simulation* mode considers a two-way trip involving a single train operating over a single route and essentially underlies those of the other two analysis modes whereby a *Rail Technology Evaluation* may combine results obtained from up to four (4) single train analyses (a baseline plus three alternatives) while a *Transportation Mode Comparison* will use the results of a single train simulation in combination with results from simulations of up to three (3) competing transportation modes. The transportation modes which may be considered in a mode comparison analysis include rail, air and highway – where the highway mode encompasses travel by both bus and light duty vehicles.

The method by which passengers access the departure station as well as egress from the arrival station of a transportation mode are also considered, although with less detail than used for the primary transportation legs. Each access trip in a simulation may be comprised of up to five (5) modes encompassing walking, the use of private automobiles and taxis and various forms of public transportation such as buses, light rail and subway systems. Egress trips are similarly, but independently, configured to the access trips.

Within the MMPASSIM workbook, a number of worksheets support four (4) sub-modules which estimate travel times, energy consumption and GHG emissions for round-trips made via rail, air, bus and light duty vehicles. The primary user interface for all simulations is provided in the 'Master-I-O' worksheet (blue tab) from where a user configures all required simulations for an analysis. However each transportation mode is configured and operated as a semi-independent sub-model which may be configured and controlled independently by a user if desired. The sub-model user interfaces are provided in the 'Rail-I-O', 'Air-I-O', 'Bus-I-O' and 'LDV-I-O' worksheets (all with blue tabs). A system of pop-up user forms (menus) and Visual Basic for Applications (VBA) macros coordinates the configuration of all desired simulations as well as the transfer of data to and from the sub-model worksheets. The results are displayed to the user in formatted output tables on the 'Master-I-O' worksheet which are automatically brought into view while the simulation proceeds.

Three "builder" worksheets are also included to provide casual users of MMPASSIM with a quick and easy method to construct simple trips from only very basic trip information. These include the 'Build-Simple-Rail-Trip', 'Build-Simple-Bus-Trip' and 'Build-Simple-LDV-Trip' worksheets (all with green tabs). The basic information required to specify a simple trip using these worksheets include the trip length, average trip speed (or speed limit), number of intermediate stops, scheduled trip time (for rail and bus modes), season, geographical region, origin and destination urban area sizes (for highway modes) and the approximate time of day of departure and arrival. Modal simulations based on trips created using these "builder" worksheets assume various mode-specific default values and do not consider the influence of grades and curves along a route.

A.1.1 System Requirements and Trouble Shooting

MMPASSIM is implemented as a macro enabled Microsoft Excel workbook (with an ".xlsm" file extension). The workbook requires Microsoft Excel 2007 or later to function properly since its worksheet structure uses more than 256 columns (which was the column limit in versions prior

to Excel 2007). In addition to macros, the MMPASSIM workbook uses ActiveX controls in its worksheets and user forms.

Note: *Macros must be enabled since the MMPASSIM workbook makes extensive use of macros to perform its analyses. Users must select "Enable Macros" in response to Microsoft Excel's security notice when opening the workbook.*

There is no installation process required to use the MMPASSIM model other than having a working copy of Microsoft Excel 2007 or later installed. However, it is necessary that Excel be configured to permit macros and ActiveX controls to be executed. The necessary security settings may be set in Excel's "Trust Centre" following these steps:

1. In Excel 2010, click the File tab (or click the Office button in Excel 2007).
2. Click Options.
3. Click Trust Center, and then click Trust Center Settings.
4. Click ActiveX Settings.
5. Select either

   "Prompt me before enabling all controls with minimum restrictions" (recommended)

   or

   "Enable all controls without restrictions…" (not recommended)
6. Click Macro Settings.
7. Select either

   "Disable all macros with notification" (recommended)

   or

   "Enable all macros…" (not recommended)
8. Click OK.

In December of 2014 Microsoft issued a security update which interfered with Excel's ability to use ActiveX controls in worksheets. When this happened, an "Error 438" condition occurred shortly after clicking the "Calculate Selections" button on the 'Master-I-O' worksheet. If you encounter this problem you may be able to resolve the error by following these instructions:

1. Close all open Microsoft Office applications.
2. Using Windows Explorer, search for any "*.exd" files and delete any you find. Make sure to include hidden and system files and folders in the search. This should locate one or more files named "MSForms.exd".
3. Reboot the computer (not always necessary)
4. Restart Microsoft Excel and test.

In March of 2015 Microsoft released new security fixes for Excel 2007, Excel 2010 and Office 2013 which should have resolved this issue.

A.2 MMPASSIM Workbook Structure

MMPASSIM is implemented as a Microsoft Excel (2010) macro enabled workbook and may have a structure less familiar to some. This section contains information that will help a user become familiar with the organization and visual cues used throughout the MMPASSIM workbook. This information appears as the first two worksheets, "Color Code Note" and "Sheet-Flow" and so can be quickly referred to when using MMPASSIM.

The first worksheet, "Color Code Note" (see Figure A-1), explains MMPASSIM's use of color to indicate the general function of its' active cells. Green and yellow cells allow a user to input simulation information, while function "buttons" open detailed simulation input forms, initiate a simulation, or help the user quickly navigate the workbook. Buttons also provide direct access to the current simulation outputs. Cells of other colours, or no color (white), are not to be modified by a user.

The second worksheet, "Sheet-Flow", gives a road map that depicts both the logic flow and the physical layout of information on the main I-O (input-output) worksheets. It also uses color cueing to help indicate what occurs in each functional area.

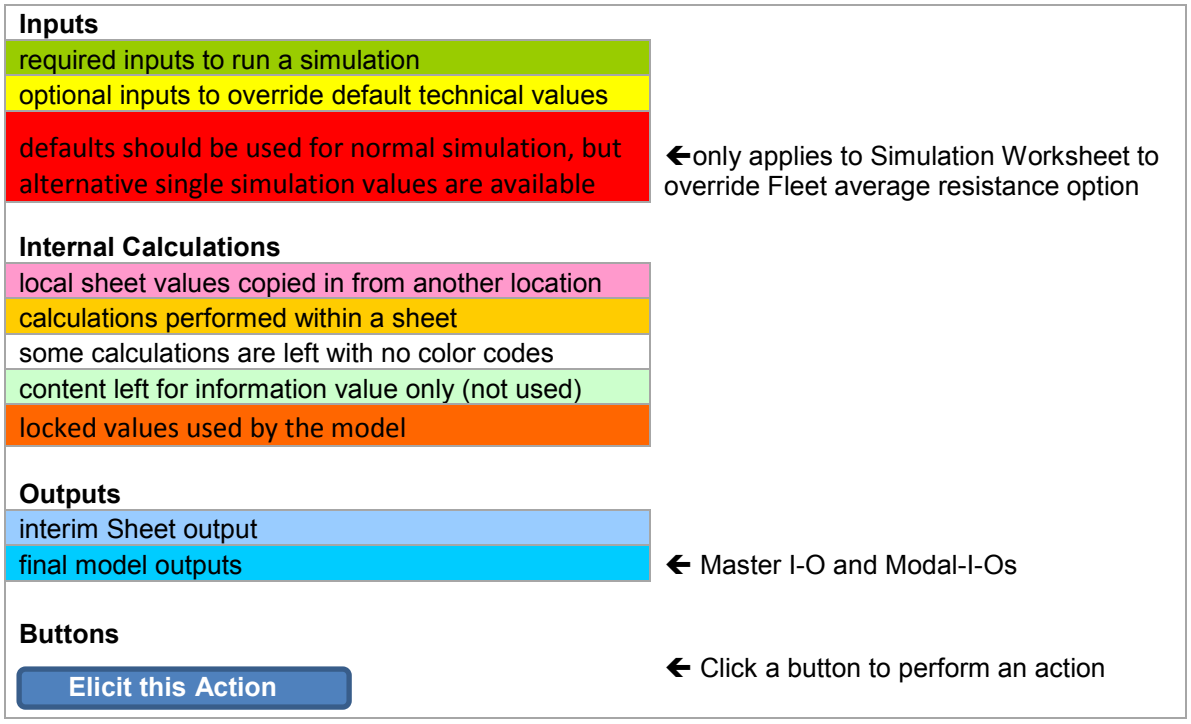


Figure A-1 MMPASSIM Worksheet 'Color Code Guide'

Cell colours indicate how the contents are used within the MM-PASIM analysis program.

A.3 The Basics of Configuring and Running a Simulation Scenario

Begin an MMPASSIM modal simulation by opening an MMPASSIM macro enabled workbook and selecting "Enable Marcos" in response to the Microsoft Excel Security Notice if displayed. It is recommended that you work with a copy of the MMPASSIM workbook so that you will always have a clean copy of the original workbook on hand in case, for example, cell formulas become lost due to inadvertent copying and pasting. The workbook will open and automatically display the 'Master-I-O' worksheet which functions as the main user interface.

Figure A-2 on page A-5 provides a flowchart overview of the simulation process for the three categories of analyses which MMPASSIM may be configured to perform. Dashed lines delineate the three analyses categories that can be configured. Note the consistent process structure across analysis types. A user selects the type of analysis, configures the trips to be analyzed and then clicks the "Calculate Selections" button to initiate the simulation.

Figure A-3 illustrates the layout of the 'Master-I-O' worksheet while Table A-1 provides a summary of its' top level functions. The 'Master-I-O' worksheet allows selection of the simulation category (*Single Train*, *Rail Technology Evaluation* or *Transportation Mode Comparison*) and assists a user in constructing the individual trips of a simulation scenario. This is done by: selecting from lists of available vehicle configurations and routes; choosing the time and season when trips take place; and selecting from other mode-specific configuration options – all accomplished on pop-up mode-specific trip selection forms. The list of available vehicles and routes can be expanded by adding vehicle and route data sets that are stored in mode-specific worksheets. For example the 'Rail-Consist' worksheet stores train consist definitions while the 'Rail-Route' worksheet stores the track characterization. Many pre-defined vehicle configurations and routes are provided from which a user may build representative trips. These can also be used as templates to build customized vehicles and routes. More detail on each of these steps is provided in the following sections.

A simulation scenario may be easily configured from default (or previously stored) data by following these steps:

1. Select the desired simulation mode from the green drop-down list (at cell 'Master-I-O'!$C$4, see Figure A-3, highlight "A").

2. Define the baseline rail round trip (applicable in all three simulation modes) by clicking the blue "Define Baseline" button (at cell 'Master-I-O'!$A$31 see Figure A-3, highlight "F").

3. Define each alternative round trip by clicking the blue "Define Alternative 1/2/3 button(s) located below the "Define Baseline" button (see Figure A-3, highlight "G"). A maximum of 3 alternatives can be selected for rail technology comparisons or transportation mode comparisons.

4. Click the blue "Calculate Selections" button (at cell 'Master-I-O'!$B$7 see Figure A-3, highlight "B") to initiate the simulation of the baseline rail round trip followed by each defined alternative in a rail technology evaluation or mode comparison analysis.

5. Review the simulation results table which is automatically brought into view at the conclusion of all simulations as defined for the selected analysis type.

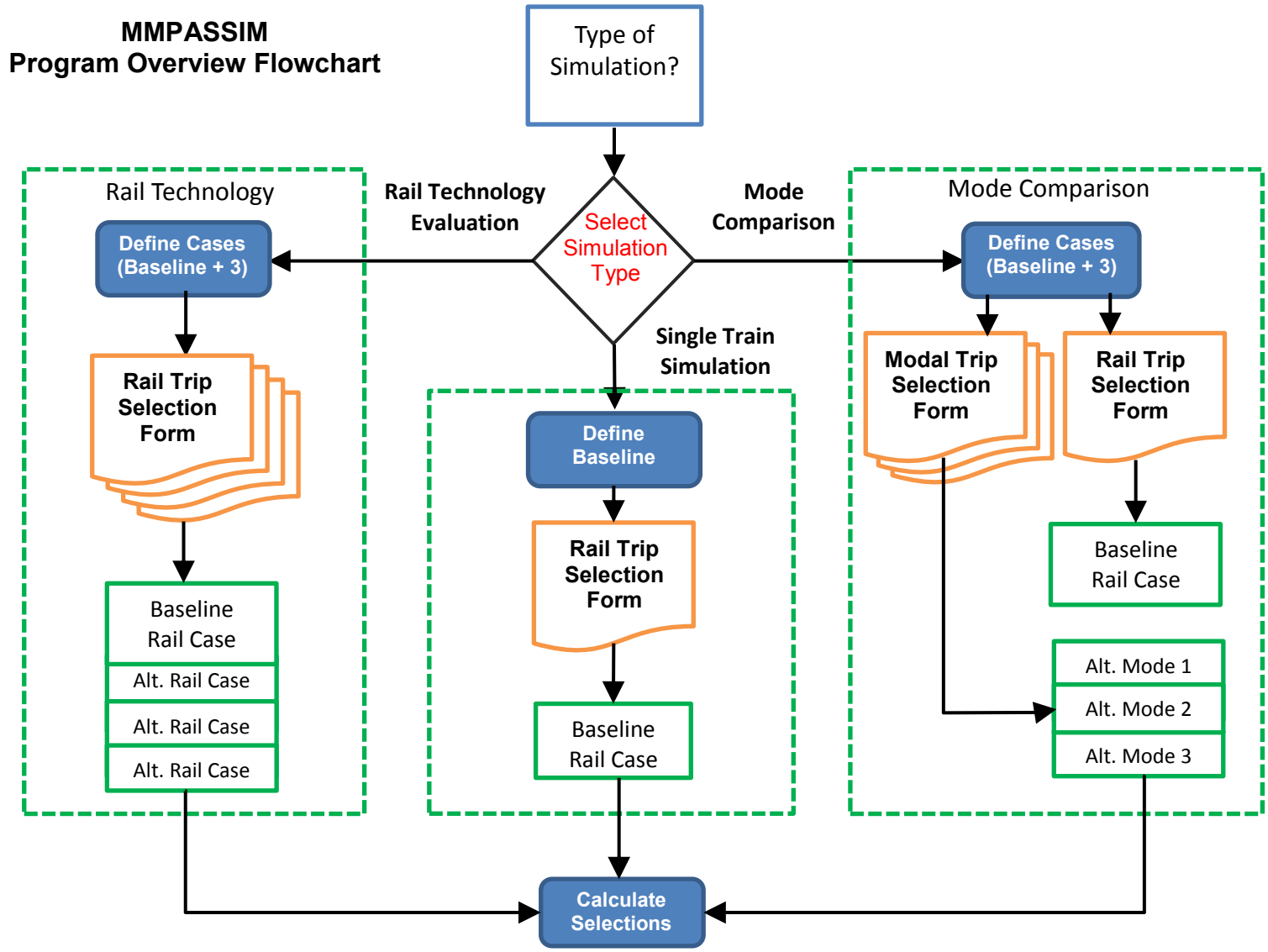
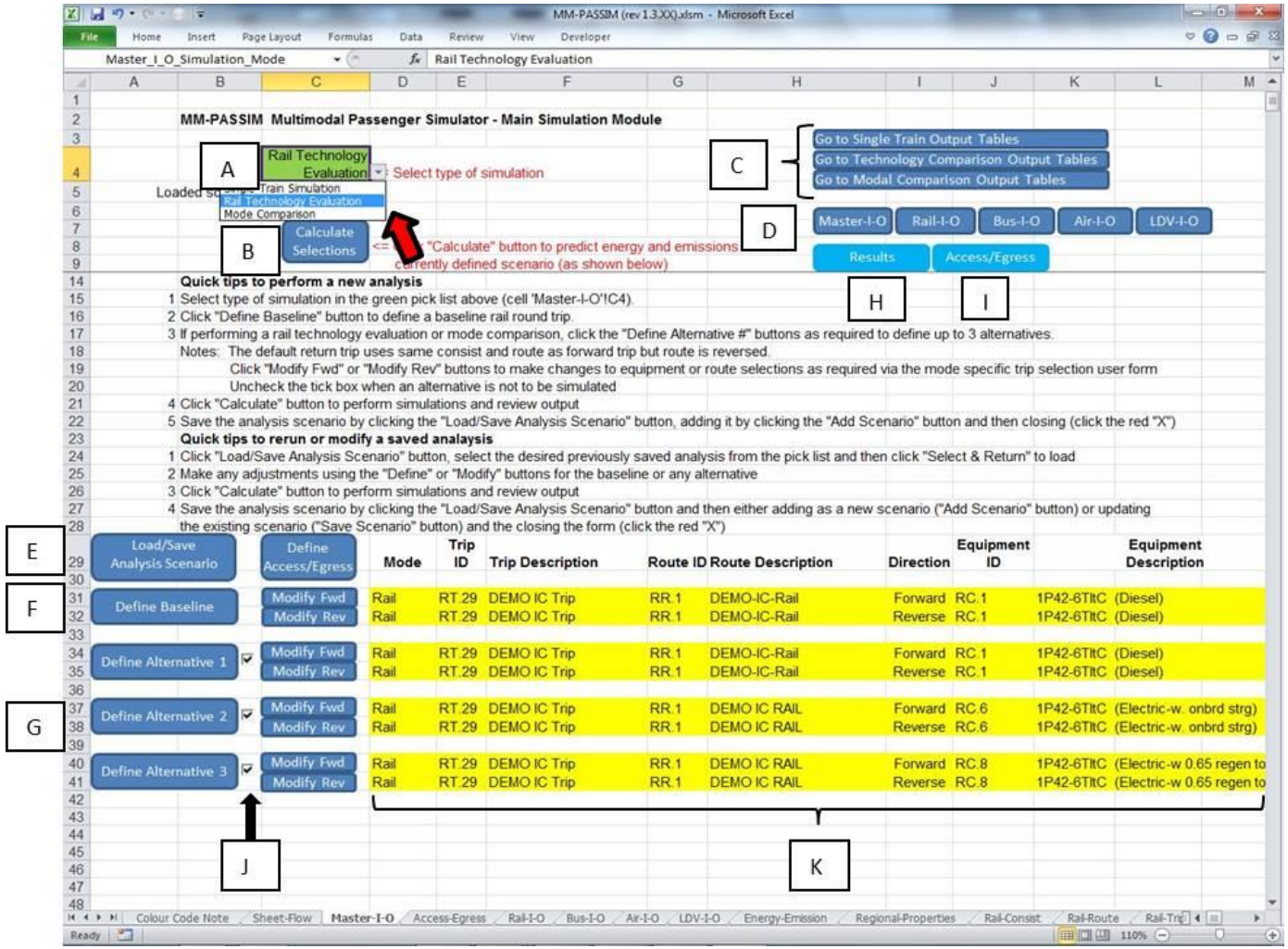


Figure A-2 MMPASSIM Program Overview Flowchart

Pop-up user forms are provided to assist the simulation program user in managing and configuring the data required for an analysis. The VBA macros will coordinate accessing data from the various worksheets required for the type of analysis being defined. In some cases, an experienced user may also find it more expedient to directly modify vehicle and route data or define new trips. The fuel and emissions intensity data for all transportation modes are provided in the 'Energy-Emission' worksheet and include default values (in yellow highlighted cells) and "used" values (in green highlighted cells). The default values should not normally be modified. The green "used" values are those which the simulation modules use when performing calculations and can be safely modified by a knowledgeable user to adjust for better known values to be used in their simulated scenarios.

The check boxes located immediately to the right of each "Define Alternative #" button (Figure A-3, highlight "J") are used to enable simulation of that alternative. This allows rail technology and mode comparison analyses involving fewer than the maximum number of alternatives to be performed. Unchecking a box will cause the configuration data for an alternative to be hidden and the associated simulation will not be performed when calculations are initiated. However, the configuration data is preserved and checking the box again will reveal the data and the corresponding simulation will be performed when calculations are next initiated (by clicking on the blue "Calculate Selections" button).



Notes:

A Simulation type selection

B Calculate selections button

C Go to the indicated mode specific output table

D Go to modal IO worksheet

E Load an existing trip configuration or save current trip configuration

F Define the baseline trip

G Define up to 3 alternate trips(s)

H Display results table for the current analysis type

I View the access/egress leg results

J Check the tick box to activate an alternative trip calculation

K Summarizes the currently configured trips

Figure A-3 'Master-I-O' Worksheet Simulation Configuration Screen Layout

Table A-1 Active components of the "Master-I-O" worksheet identified in Figure A-3

Top Level Functions – Visible and Active from all Worksheets and Output Screens		
ID	Name of Button(s)	Action When Selected
A	Simulation Type Selection Single Train Simulation	Displays drop-down list of analyses choices: 1. Single Train Simulation 2. Rail Technology Evaluation 3. Mode Comparison
B	Calculate Calculate	Initiates analysis for the defined scenarios. Outputs: Energy and Emissions
C	Go To Output Buttons Single Train Output tables Rail Technology Output Mode Comparison Output	Takes user directly to analysis output summary tables. Provides quick navigation between the configuration screen and the analysis output screens. Note: Depending on screen zoom level, some output tables may be below the visible screen window. Simply scroll downwards.
D	I-O Buttons Master-I-O Rail-I-O Bus-I-O Air-I-O LDV-I-O	Takes user directly to the I-O worksheet selected. Provides quick navigation between configuration and analysis output screens.
E	Load/Save Analysis Scenario	Allows user to load an existing (previously saved) analysis setup. And Allows user to save the current trip analysis setup.
F	Define Baseline	Opens the Rail Trip Selection Form to define the baseline rail trip. 1. Consist 2. Route 3. Time of Day and Season
G	Define Alternative #	Opens an Alternative Mode Selection window and then a mode specific Trip Selection Form to define the Alternative Mode trip. 1. Vehicle type 2. Route 3. Time of Day and Season
H	Results	Takes user to the Output Results Table for the current Analysis
I	Access/Egress	Takes user to the Access/Egress Leg Results
J	☑	Activates (i.e. includes in the analysis) the trip shown.
K	Rail RT 29 Demo …..	Summary information for the trips as currently defined. **Note**: These yellow cells contain formulas used to display the trip information and should not be modified by the user.

A.3.1 Overview of Steps Required for a Single Train Simulation

A Single Train Simulation, as outlined in Figure A-4 on page A-10, requires only the baseline case be defined via the 'Rail Trip Selection' form.

The process of defining a baseline rail trip begins by clicking the blue "Define Baseline" button located at 'Master-I-O'!A29:B30 (see Figure A-2) to open the 'Rail Trip Selection Form'. An existing rail trip may be selected by picking it from the green drop-down list found immediately below the yellow "Trip ID" information field. A different route may be chosen by selecting it from the green drop-down list positioned immediately below the light yellow "Route ID" information field. A different train consist may be chosen by selecting it from the list of all those currently defined in the green drop-down list positioned below the light yellow "Consist ID" information field.

Further adjustments may be made to any of the green input fields on the form. Some require numerical input while others are selected from the values presented on the drop-down list. If changes have been made, the currently displayed trip may be saved under a new name by clicking on the "Add Rail Trip" button which automatically increments its "Trip ID", then edit the green "Description" field as required and finally click on the "Save Rail Trip" button to store the new trip – please note that an added trip is not saved until the "Save Rail Trip" button has been clicked. Clicking the "Select & Return" button passes the current baseline rail trip configuration to the baseline trip definition area on the 'Rail-I-O' worksheet and returns focus to the 'Master-I-O' worksheet. Clicking the blue "Calculate Selections" button executes the Single Train Simulation and displays the Single Train output tables. A more detailed description of setting up and running rail mode simulations may be found in Section A.5.1 beginning on page A-33.

A.3.2 Overview of Steps Required for a Rail Technology Evaluation

A Rail Technology Evaluation, as outlined in Figure A-5 on page A-11, requires definition of a baseline rail trip and up to three additional rail trips, all of which are defined using the 'Rail Trip Selection' form. The baseline rail trip is defined by clicking the blue "Define Baseline" button located at 'Master-I-O'!A29:B30 (see Figure A-2) and then following the same procedure as outlined for defining the baseline rail trip for a Single Train Simulation (see Figure A-4 and Table A-4).

Definition of each alternative rail trip is initiated by clicking on the corresponding "Define Alternative #" button on the 'Master-I-O' worksheet and again following the same process through the 'Rail Trip Selection' form to define the trip and then upon clicking the "Select & Return" button the trip definition is passed back to be stored on the 'Rail-I-O' worksheet. If all three alternatives are not required in an analysis then uncheck the tick box adjacent to any alternative not required and a macro will hide the selections. Once all trips are defined, clicking on the blue "Calculate Selections" button which overlays 'Master-I-O'!C7:C8 instructs a macro to start the Rail Technology Evaluation which will sequentially set up and execute each rail trip simulation and finish by displaying the Rail Technology Evaluation output tables for review. A more detailed description of setting up and running rail mode simulations may be found in Section A.5.1 beginning on page A-33.

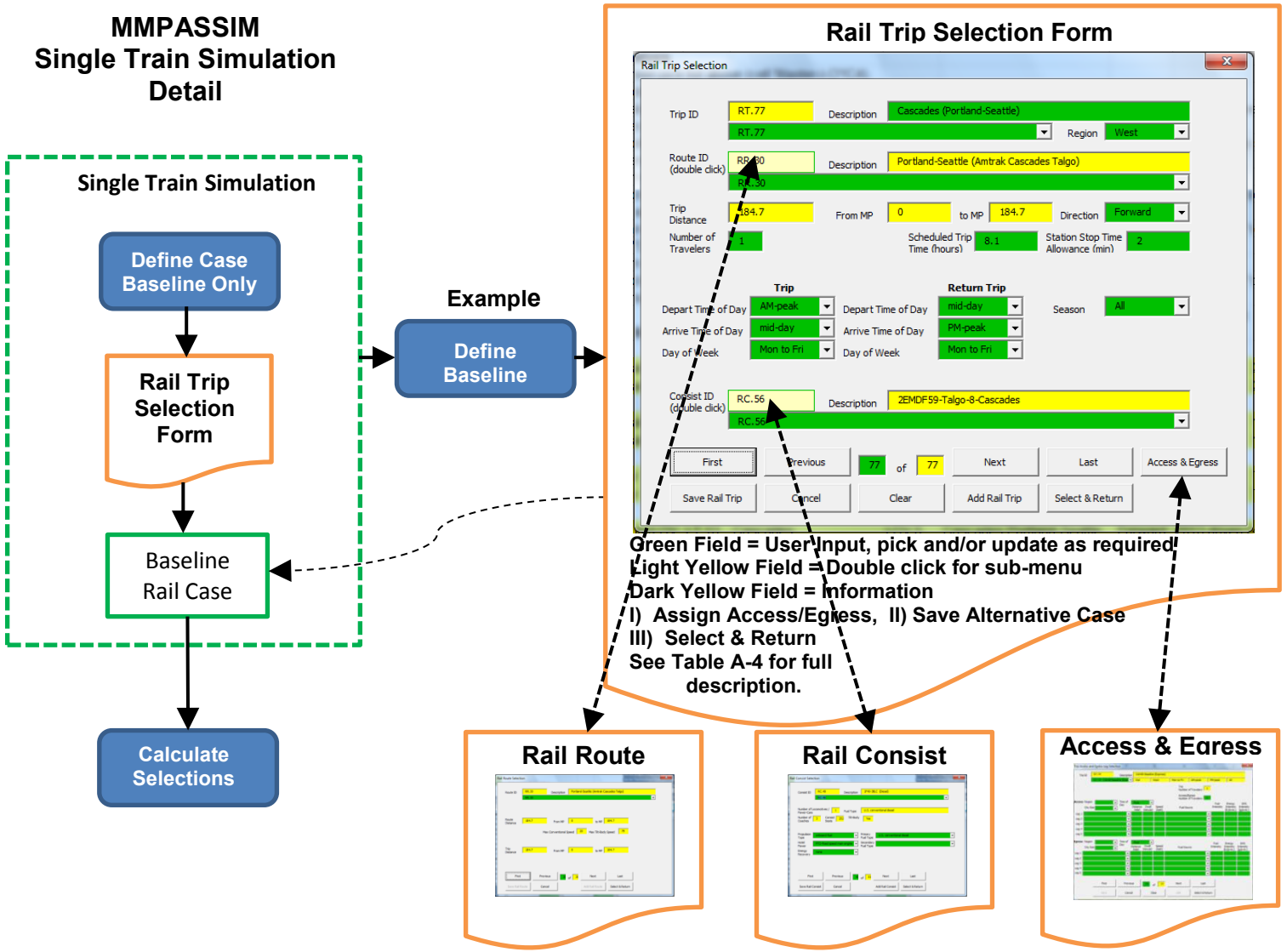


Figure A-4 MMPASSIM Single Train Simulation Configuration

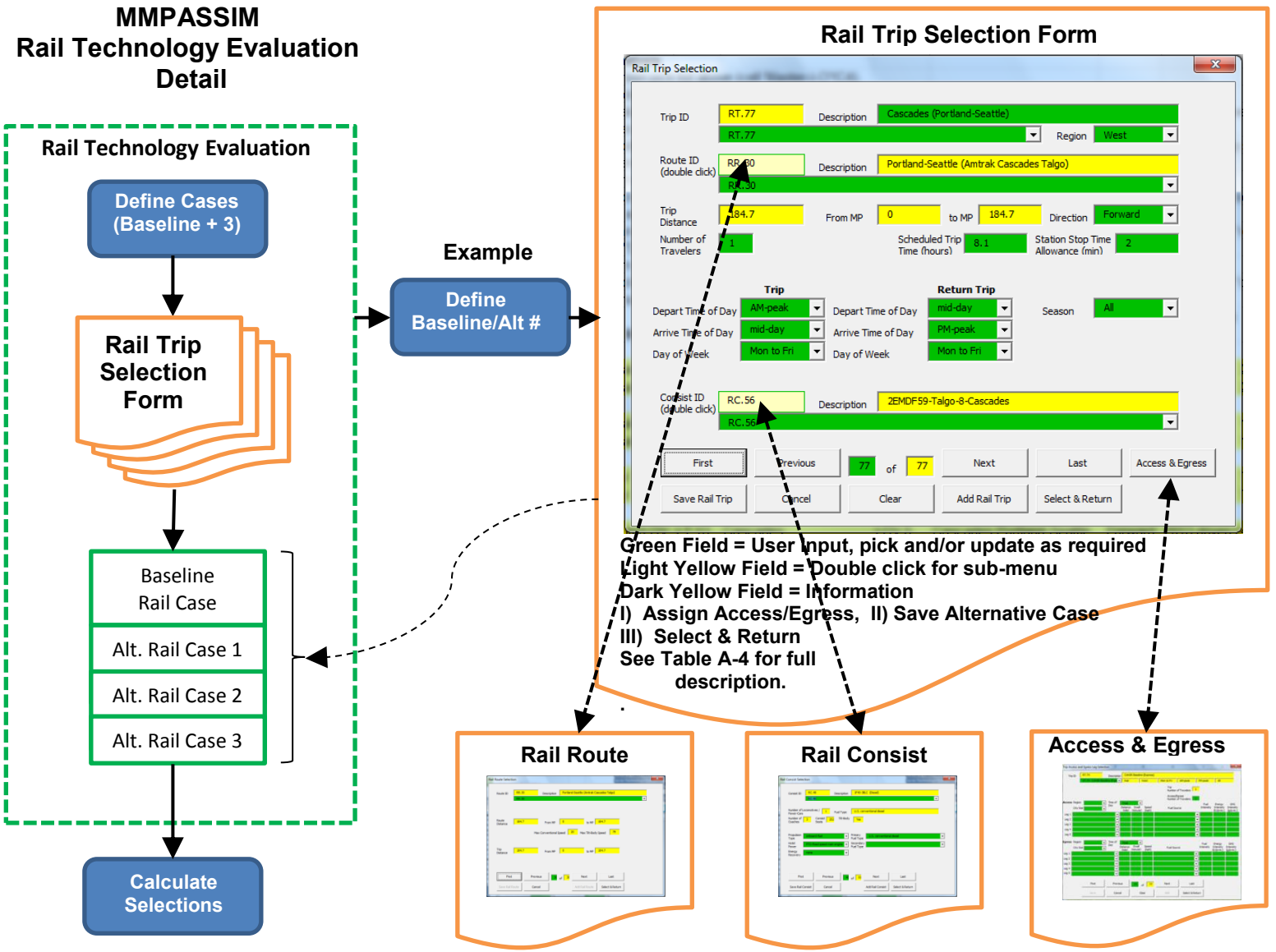


Figure A-5 MMPASSIM Rail Technology Evaluation Simulation

A.3.3 Overview of Steps Required for a Mode Comparison

A Mode Comparison requires definition of a baseline rail trip and up to three additional two-way trips for comparison which may include a single return bus trip, a single return LDV trip, a single return air trip and alternate return rail trips as required (where the term return trip refers to a complete two-way trip comprised of an outbound trip from the origin to destination and then an inbound trip from the outbound trip's destination back to its origin). Please note that only one two-way trip for each non-rail transportation mode may be selected for analysis in a mode comparison but several two-way alternative rail trips can be specified if desired. Begin by selecting "Mode Comparison" from the drop-down list at 'Master-I-O'!C4 and then defining the baseline rail trip case by clicking the blue "Define Baseline" button and then selecting a rail trip, rail routes and rail consists as required from the 'Rail Trip Selection' user form. The procedure for selecting the baseline trip for a Mode Comparison is outlined in Figure A-6 on page A-13 and is the same as that discussed previously for configuring a Single Train Simulation.

Definition of each alternative trip is initiated by clicking on the corresponding "Define Alternative #" button on the 'Master-I-O' worksheet and a macro will prompt the user to select the desired transportation mode from the green drop-down list presented in a small pop-up menu. The drop-down list will by default indicate the mode which was last configured for that alternative but you are free to make another selection by clicking on the gray arrow and selecting from the "Rail", "Bus", "Air" and "Auto/LDV" choices as desired. Then clicking on the "Select & Edit" button will open the transportation-mode-specific trip selection menu from which the alternative trip is configured. Figure A-7 (page A-14) outlines selecting and configuring an alternative rail trip, Figure A-8 (page A-15) a bus trip, Figure A-9 (page A-16) an air trip and finally Figure A-10 (page A-17) outlines selecting and configuring an alternative auto/LDV trip. Clicking the "Select & Return" button on any of the transportation-mode-specific trip selection menus causes a macro to pass the trip definition back to be stored on the mode-specific '<mode>-I-O' worksheet (where <mode> is either "Rail", "Bus", "Air" or "LDV"). If all three alternatives are not required for an analysis then uncheck the tick box adjacent to the definition button on the 'Master-I-O' worksheet of any alternative not required and a macro will hide the selections. Once all trips are defined, clicking on the blue "Calculate Selections" button which overlays 'Master-I-O'!C7:C8 instructs a macro to start the Mode Comparison which will sequentially set up and execute each modal trip simulation and finish by displaying the Mode Comparison output tables for review.

The upper right hand area of the 'Master-I-O' display (see Figure A-3) contains several navigation buttons which may be used to access the results summary tables (upper medium blue buttons), the detailed results for the main trip leg and access/egress legs (lower light blue buttons) or to jump to the user interface of one of the simulation sub-models (middle medium blue buttons). The yellow highlighted area provides a summary of the baseline trip and any alternative trips defined in a scenario. Please note that these yellow highlighted cells contain formulas used to display mode-specific trip information and should not be modified by the user.

More detailed discussions on using the mode-specific trip and vehicle selection menus required to configure trips for a mode comparison are discussed in later sections. Section A.5.1 outlines rail trip configuration, Section A.5.2 outlines air trip configuration, Section A.5.3 outlines bus trip configuration and Section A.5.4 outlines configuration of light duty vehicle trips.

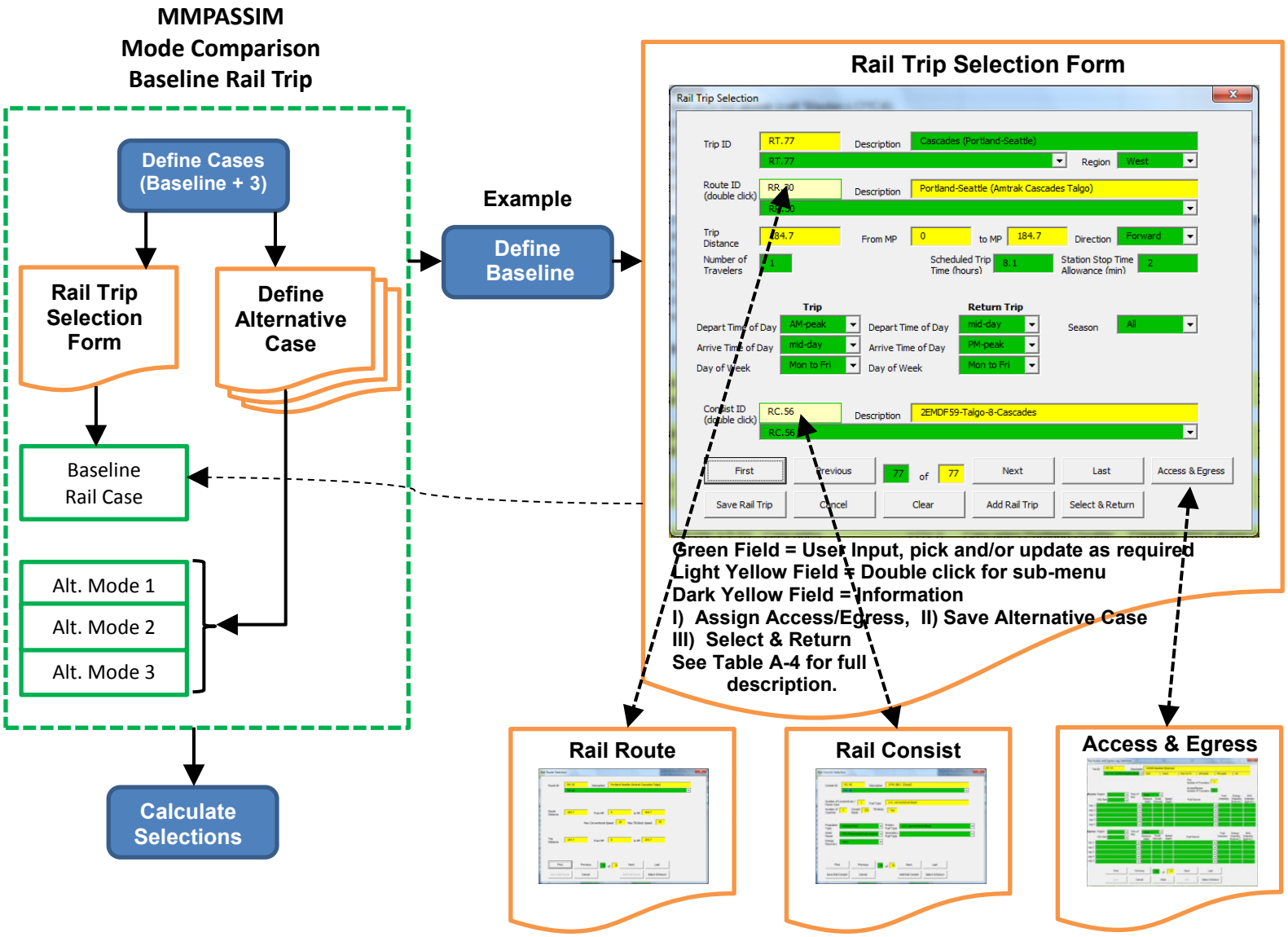


Figure A-6 MMPASSIM Mode Comparison Baseline Rail Trip Configuration

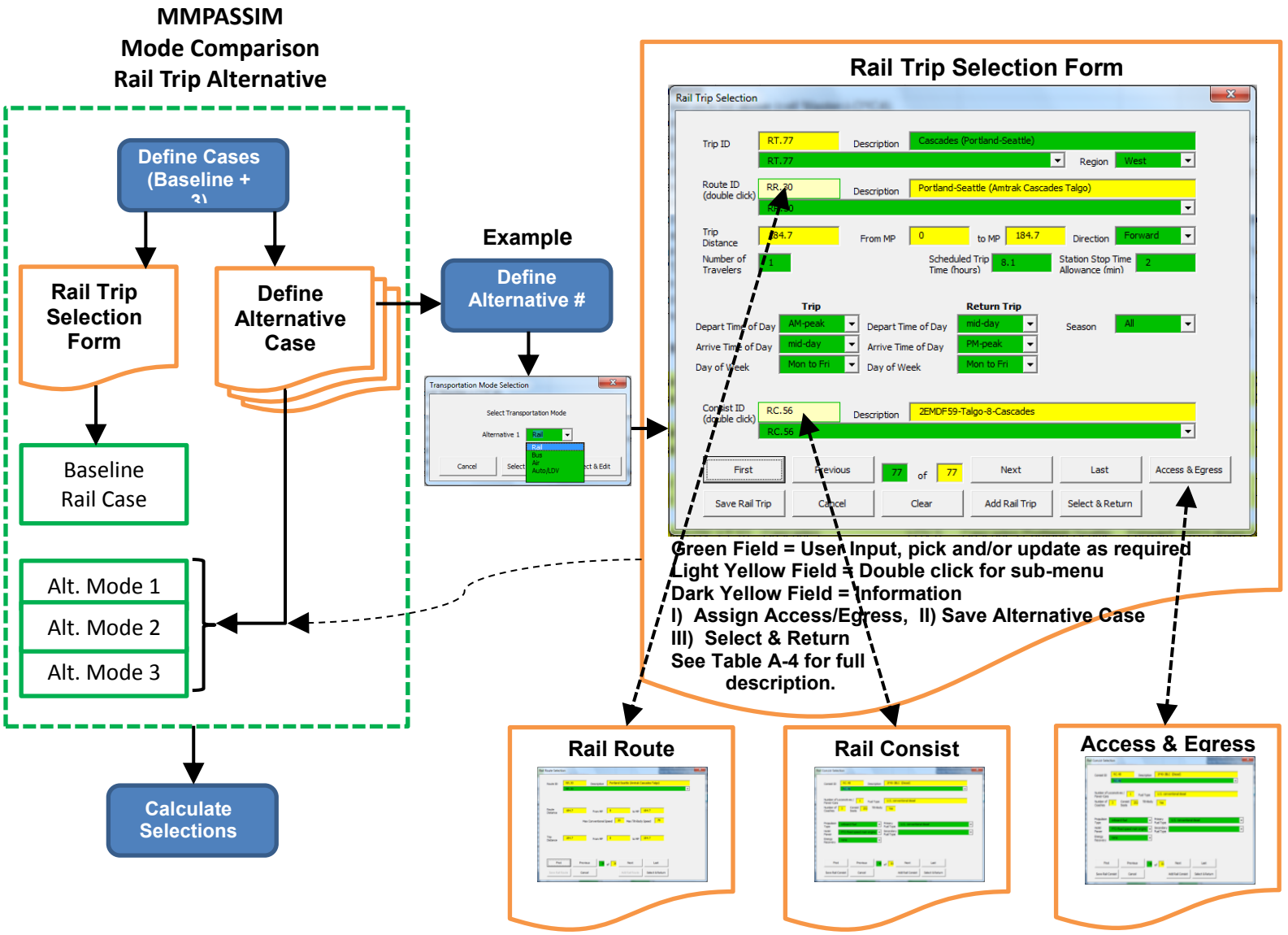


Figure A-7 MMPASSIM Mode Comparison Alternative Rail Trip Configuration

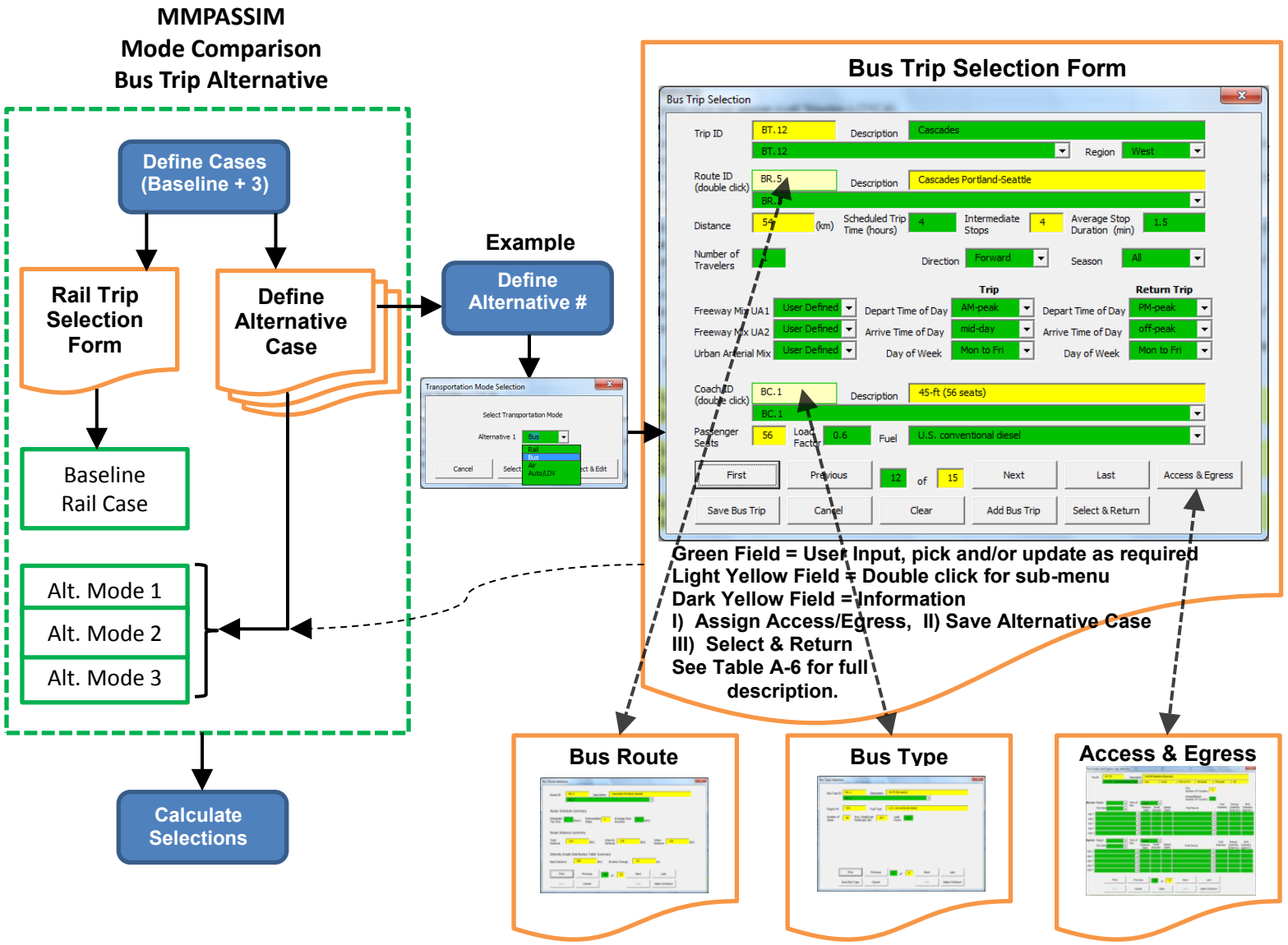


Figure A-8 MMPASSIM Mode Comparison Alternative Bus Trip Configuration

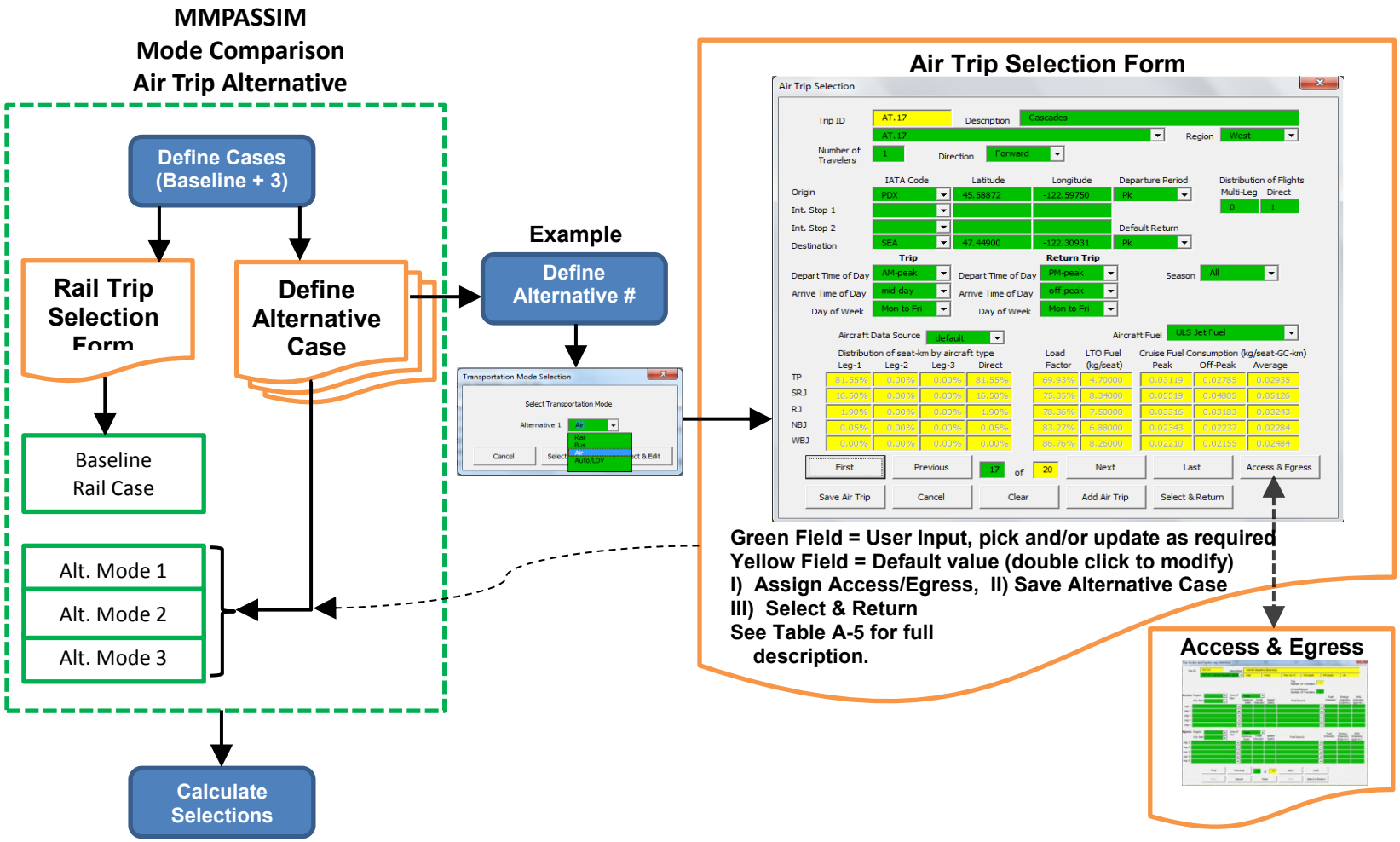


Figure A-9 MMPASSIM Mode Comparison Alternative Air Trip Configuration

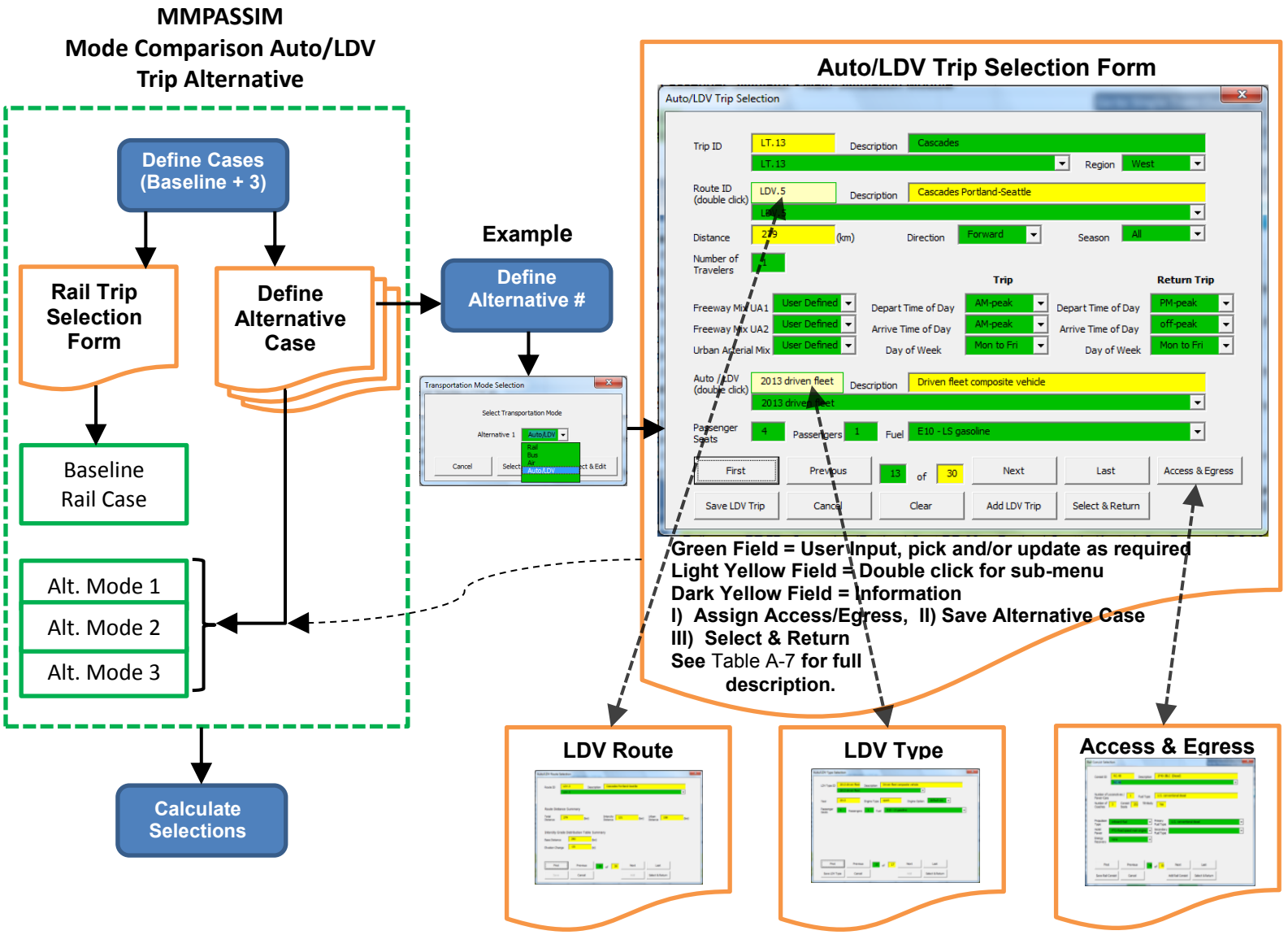


Figure A-10 MMPASSIM Mode Comparison Alternative Auto/Light Duty Vehicle Trip Configuration

A.4 Building Simple Trips from Limited Information

This section provides guidance on building simple rail, bus and light duty vehicle trips with the minimum amount of input data. For rail trips, a simple train consist may be built by selecting from basic locomotive and car types. For rail and highway modes, simple routes can be created by specifying a trip distance and average speed and MMPASSIM will then create a properly formatted mode-specific route using default values.

A.4.1 Building a Simple Rail Trip

The 'Build-Simple-Rail-Trip' worksheet provides a straight forward method of creating a rail trip when little specific information is known about the train makeup and route. Figure A-11 depicts the layout of the worksheet. The light green box on the right hand side provides a brief list of instructions to follow. The process involves:

1) Selecting the vehicles in a rail consist and then creating a simple rail consist by clicking on the blue "Save to 'Rail-Consist'" button.

2) Specifying the trip distance, speed limit and number of stops to be made during the trip and then creating a simple rail route by clicking on the blue "Save to 'Rail-Route'" button.

3) Specifying other trip parameters such as region, season, departure and arrival times and the scheduled trip time and then creating the trip by clicking on the blue "Create Rail Trip" button.

Defining the Simple Rail Consist

To build a simple rail consist, begin by selecting a system of units from the green pulldown list located at 'Build-Simple-Rail-Trip'!E4. Then, select a locomotive type from the green pulldown list at 'Build-Simple-Rail-Trip'!D10. Please note that there can only be one type of locomotive included in a simple rail consist, but you may select multiple units in the green quantity field at 'Build-Simple-Rail-Trip'!E10. For most locomotive types the number of passenger seats indicated in the yellow information field at 'Build-Simple-Rail-Trip'!F10 will be zero. However, self-propelled vehicles, such as rail diesel cars (RDC) and diesel multiple units (DMU), are treated as locomotives with passenger seats. Select the desired locomotive fuel type from the green pulldown list at 'Build-Simple-Rail-Trip'!H10.

You can continue to build up a simple rail consist by selecting up to three types of rail coaches from the pulldown lists at 'Build-Simple-Rail-Trip'!D11:D13 and specifying the quantity of each of those coaches in the adjacent green fields located in cells 'Build-Simple-Rail-Trip'!E11:E13. The number of passenger seats in each of the selected rail coach types is indicated in the yellow information cells at 'Build-Simple-Rail-Trip'!F11:F13 while the total number of passenger seats in the train consist is indicated in the yellow cell at 'Build-Simple-Rail-Trip'!F14.

The final inputs required to specify a simple rail consist are the passenger load factor, input in the green cell at 'Build-Simple-Rail-Trip'!I10, and the passenger weight (including all luggage), indicated in the yellow cell at 'Build-Simple-Rail-Trip'!J10. Please be aware that a default passenger weight of 85 kg is used to calculate the passenger weight which is displayed in the selected system of units. You may adjust the calculated value by editing the formula but do not simply overwrite the contents of the cell with a value.

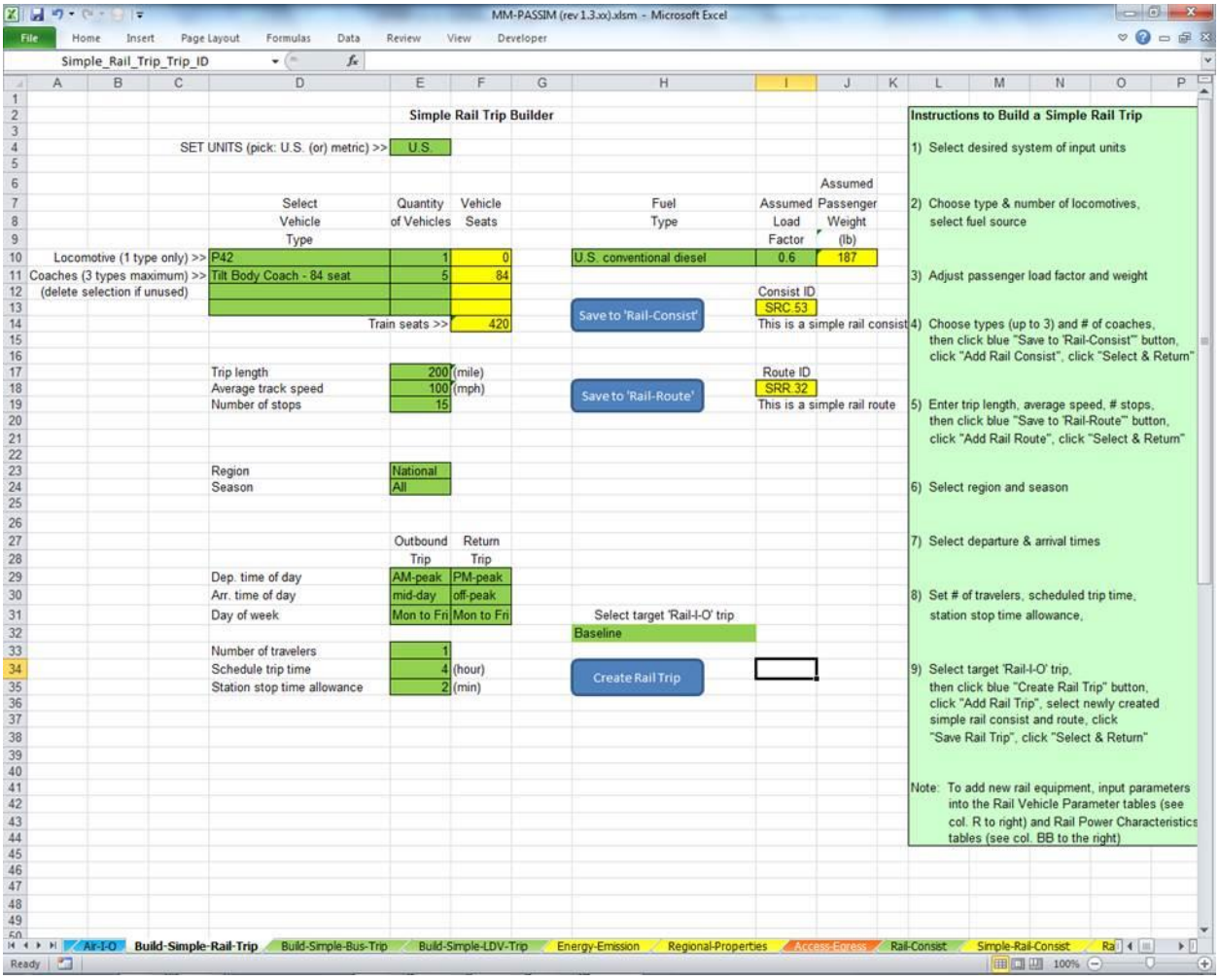


Figure A-11 'Build-Simple-Rail-Trip' Worksheet

Clicking the blue “Save to ‘Rail-Consist’” button displays a ‘Simple Rail Consist Specification’ menu. You may interactively adjust the vehicle selections and quantities and the passenger load factor in the appropriately labeled green fields. You may also adjust the fuel type to be used onboard the locomotive and the method by which hotel power is generated. However, you may not change the propulsion type from “onboard-fuel”. Once all desired adjustments have been made you should input a description of the train consist in the green “Description” field at the top of the menu and then click on the gray “Add Rail Consist” button to instruct a VBA macro to add the displayed simple rail consist into the list of consists defined in the ‘Rail-Consist’ worksheet. Clicking the gray “Select & Return” button will close the menu and record the automatically assigned “Consist ID” and description to cells ‘Build-Simple-Rail-Trip’!I13 and ‘Build-Simple-Rail-Trip’!I14, respectively.

While in the ‘Simple Rail Consist Specification’ menu, you may create as many simple rail consists as you wish by changing the selections as desired, entering a new consist description in the green field at the top and then clicking on the gray “Add Rail Consist” button. The yellow “Consist ID” information field will be automatically incremented to a new unique value and written to the “Consist ID” at the top (in row 3) of the newly added rail consist in the ‘Rail-

Consist' worksheet (refer to Section A.7.3 for more details on the content of the 'Rail-Consist' worksheet). However, it is not possible to automatically alter the composition of a simple rail consist once it has been added into the 'Rail-Consist' worksheet. This is a consequence of how the simple rail consist is built in the 'Simple-Rail-Consist' worksheet and the fact that cells which calculate the combined properties of an entire consist are copied by value into destination cells in the 'Rail-Consist' worksheet.

The 'Simple-Rail-Consist' worksheet provides a template of the rail consist data which is copied into the 'Rail-Consist' worksheet. Many of the data fields in the 'Simple-Rail-Consist' are calculated by formulas which combine the properties of the individual rail vehicle types as selected on the 'Build-Simple-Rail-Trip' pulldown lists. The parameters defining the characteristics of individual rail vehicles are specified in two "Rail Vehicle Parameter" tables located on the 'Build-Simple-Rail-Trip' worksheet at 'Build-Simple-Rail-Trip'!R6:AI25 for metric units and at 'Build-Simple-Rail-Trip'!R28:AI47 for U.S. units (see Figure A-12).

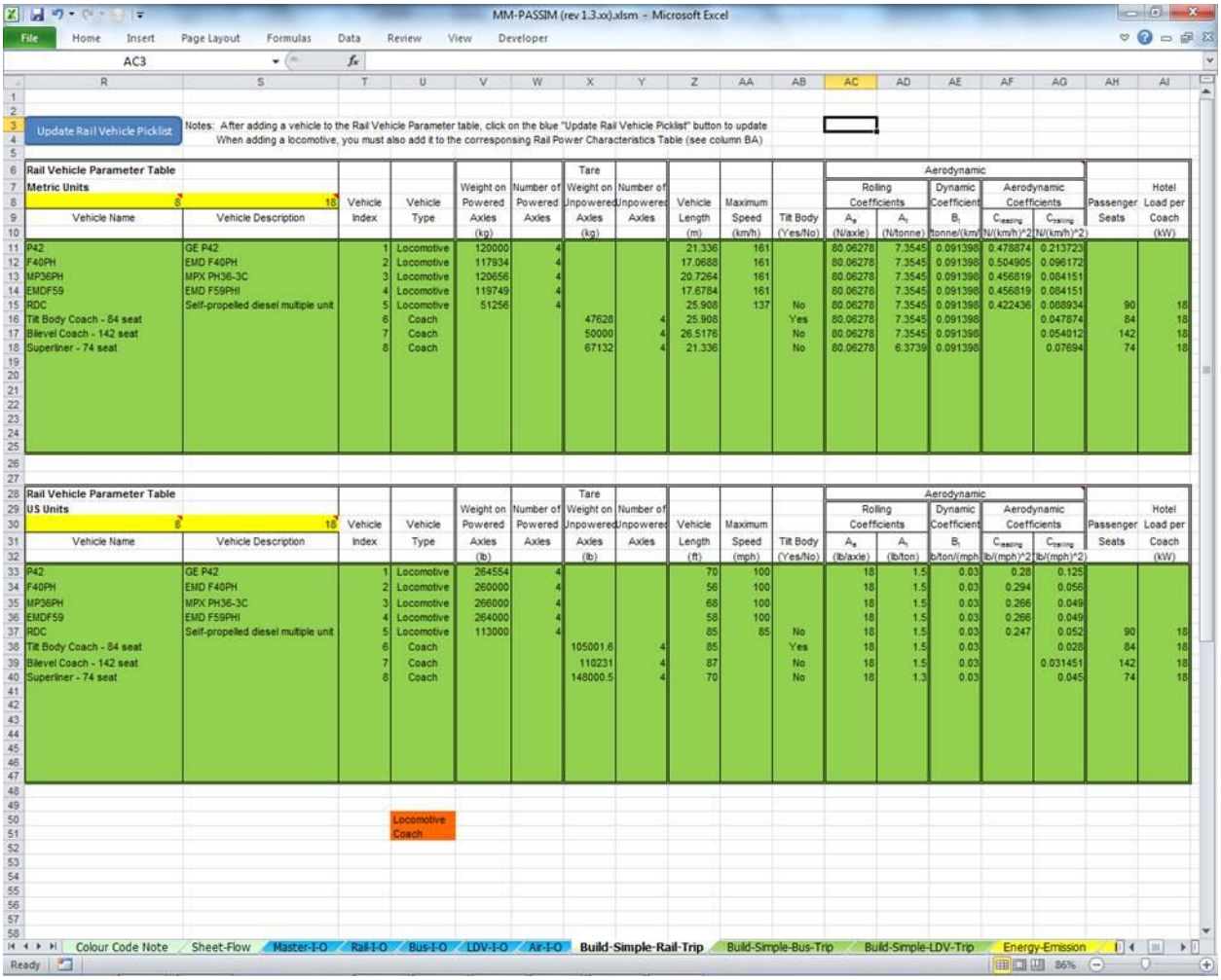


Figure A-12 The Simple Rail Vehicle Parameter Tables

The list of rail vehicles available for use in building simple rail consist may be easily expanded by adding data into these data tables. When adding new vehicle parameters, you must be sure to select the vehicle type (column U) to be either “Locomotive” or “Coach” and then click on the blue “Update Rail Vehicle List” button which instructs a VBA macro to update the sorted lists of locomotive and coaches available in both metric and U.S. units. Guidance in developing suitable resistance coefficients is provided in the light green shaded area at ‘Build-Simple-Rail-Trip’!AL6:AY68. The power characteristics of each vehicle identified as a “Locomotive” in a “Rail Vehicle Parameter” table must also be defined in the corresponding “Rail Power Characteristics” table located at ‘Build-Simple-Rail-Trip’!BB6:BJ20’ in metric units and ‘Build-Simple-Rail-Trip’!BB28:BB42 in U.S. units (see Figure A-13). The name specified for each locomotive in column R of a “Rail Vehicle Parameter” table must also be defined in column BB of the companion “Rail Power Characteristics” table.

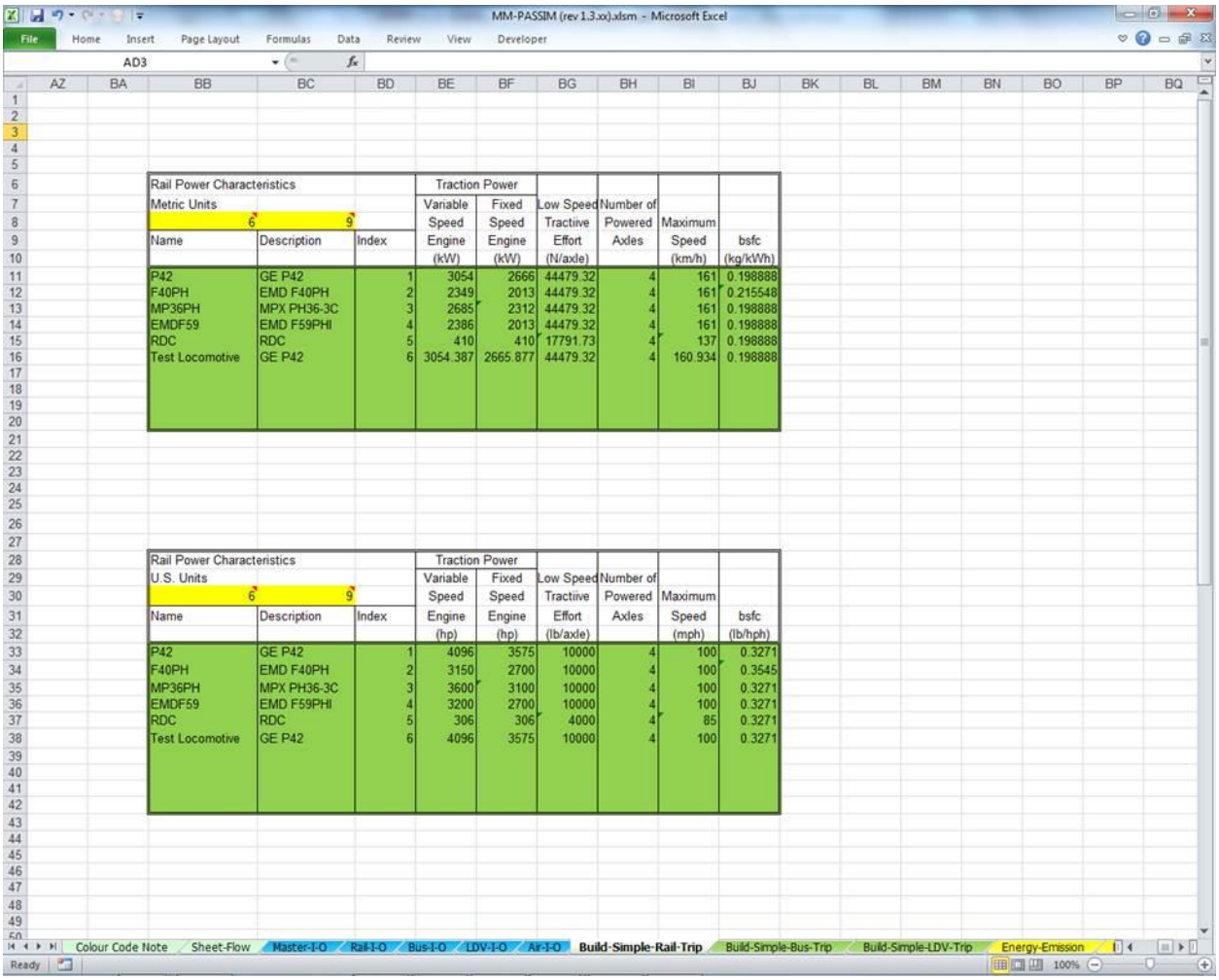


Figure A-13 The Simple Rail Power Characteristics Table

Defining the Simple Rail Route

To build a simple rail route, a user must specify the trip's length in the green cell 'Build-Simple-Rail-Trip'!E17, the average track speed (interpreted as the track speed limit) in the green cell 'Build-Simple-Rail-Trip'!E18 and the total number of stops to be made in the green cell 'Build-Simple-Rail-Trip'!19. These user inputs are used in the 'Simple-Rail-Route' worksheet to define the default stop table and speed limit table. The default speed limit table in the 'Simple-Rail-Route' worksheet is constructed assuming an initial half mile segment with a 15 mph speed limit, a final half mile segment with a 15 mph speed limit and the middle segment between these end segments set to the user indicated average track speed. The initial location is always set to 0 miles and the final location in set to the user assigned trip length in miles (as converted when specified in kilometers). The default stop table is constructed by assuming that each stop is evenly spaced along the trip's length. It is assumed that the track in a simple rail route is both level and straight, so the grade table is populated with zeros and the total degrees of central angle is also zero.

Clicking the blue "Save to 'Rail-Route'" button displays the 'Simple Rail Route Specification' menu. The trip length, average track speed and number of stops to be used in building the simple rail route are displayed in the correspondingly labeled green input fields, each of which can be modified interactively by the user. A simple rail route is built by entering a description in the green "Description" field at the top of the menu and clicking the gray "Add Rail Route" button which instructs a VBA macro to create a unique "Route ID" and copy the simple rail route template from 'Simple-Rail-Route' to the next available location in the 'Rail-Route' worksheet. The yellow "Route ID" field and the green "Description" field are copied to the top of the newly created route in the 'Rail-Route' worksheet. While in the 'Simple Rail Route Specification' menu a user may create and add as many simple rail routes as they wish by adjusting the length, speed and number of stops and clicking the gray "Add Rail Route" button. Clicking the gray "Select & Return" button will close the menu and record the automatically assigned "Route ID" and user assigned "Description" to cells 'Build-Simple-Rail-Trip'!I18 and 'Build-Simple-Rail-Trip'!I19, respectively.

Creating the Simple Rail Trip

With both a simple rail consist and a simple rail route built and added, the user must provide additional details of the desired trip to complete its' specification. The geographical region is set by selecting it from the green pulldown list at 'Build-Simple-Rail-Trip'!E23. The season is selected from the green pulldown list at 'Build-Simple-Rail-Trip'!E24. Selecting "All" for the season will result in the rail simulation calculating a combined result for individual trips made in each season and weighted for the seasonal traffic distributions specified in the 'Regional-Properties' worksheet. The departure time-of-day, arrival time-of-day and day-of-week of the outbound trip are selected from the green pulldown lists at 'Build-Simple-Rail-Trip'!E29:E31 while those same inputs for the return trip are selected from 'Build-Simple-Rail-Trip'!F29:F31. The number of people assumed to be traveling together in a party is input in the green input cell at 'Build-Simple-Rail-Trip'!E33. Finally, the scheduled trip time is input in the green cell at 'Build-Simple-Rail-Trip'!E34 while the station stop time allowance is input at 'Build-Simple-Rail-Trip'!E35.

Clicking on the blue "Create Rail Trip" button brings the 'Rail-I-O' worksheet into view and displays the 'Rail Trip Selection' menu preloaded with the simple rail route, simple rail consist and simple rail trip specifications transferred from the 'Build-Simple-Rail-Trip' worksheet. From that menu, the new trip is created by clicking the gray "Add Rail Trip" button which creates and

displays a unique rail trip ID in the yellow “Trip ID” field in the top left of the menu. Enter a description for this new simple rail trip in the green “Description” field at the top of the menu and then click the gray “Save Rail Trip” to write it onto the bottom of the list or rail trips stored in the ‘Rail-Trip-List’ worksheet.

Note: *The new trip will not be automatically saved if the “Save Rail Trip” button is not clicked. Clicking on the gray “Select & Return” button will populate the rail trip fields on the ‘Rail-I-O’ worksheet. The particular rail trip to be saved to (either Baseline, Alternative-1, Alternative-2 or Alternative-3) is controlled by the target ‘Rail-I-O’ trip as selected from the green pulldown list at ‘Simple-Rail-Trip-Builder’!H32.*

A.4.2 Building a Simple Bus Trip

The ‘Build-Simple-Bus-Trip’ worksheet provides a simple means to create a basic bus trip. Figure A-14 depicts the worksheet layout. The light green box on the right hand side (‘Build-Simple-Bus-Trip’!K5:O43) provides a brief list of instructions to follow. The process involves:

1) Selecting the bus.
2) Specifying the distances traveled, speed limit, number of intermediate stops, duration of stops, origin and destination urban area sizes, trip departure and arrival periods, scheduled trip time and then creating a simple bus route by clicking on the blue “Save to ‘Bus-Route’” button.
3) Specifying other trip parameters such as region, season, number of persons travelling together in a party and then creating the trip by clicking on the blue “Create Bus Trip” button.

Selecting a Bus Type

To build a simple bus trip, begin by selecting a system of units from the green pulldown list located at ‘Build-Simple-Bus-Trip’!E4. Then, select a bus type from the green pulldown list at cell ‘Build-Simple-Bus-Trip’!D10. Default parameters appropriate for the selected bus type will be used for the simple bus trip. These parameters may be reviewed in the yellow information cells at ‘Build-Simple-Bus-Trip’!Q10:X10 (page to the right).

The list of bus types available in the green pulldown list at ‘Build-Simple-Bus-Trip’!D10 and their corresponding default parameters are defined in two Excel VLOOKUP tables; ‘Build-Simple-Bus-Trip’!Q15:X24 when U.S. units are selected and ‘Build-Simple-Bus-Trip’!Q31:X40 when metric units are selected (see Figure A-15). These two tables are populated by cell references to source data contained in the ‘Bus-Type’ worksheet. MMPASSIM provides U.S. and metric parameters for four (4) representative buses which include:

- a 45 foot bus with 56 seats
- a 41 foot bus with 48 seats
- a double deck bus with 81 seats
- a hybrid commuter bus with 57 seats

Users may expand the list of buses available for selection in the 'Build-Simple-Bus-Trip' by adding data into the 'Bus-Type' worksheet (see Section A.7.8 on page A-146 for an explanation of layout and content) and then adding lines of cell references into these VLOOKUP tables. The VLOOKUP statements used in cell formulas are constructed using offsets which automatically adjust when new lines of bus type data are added.

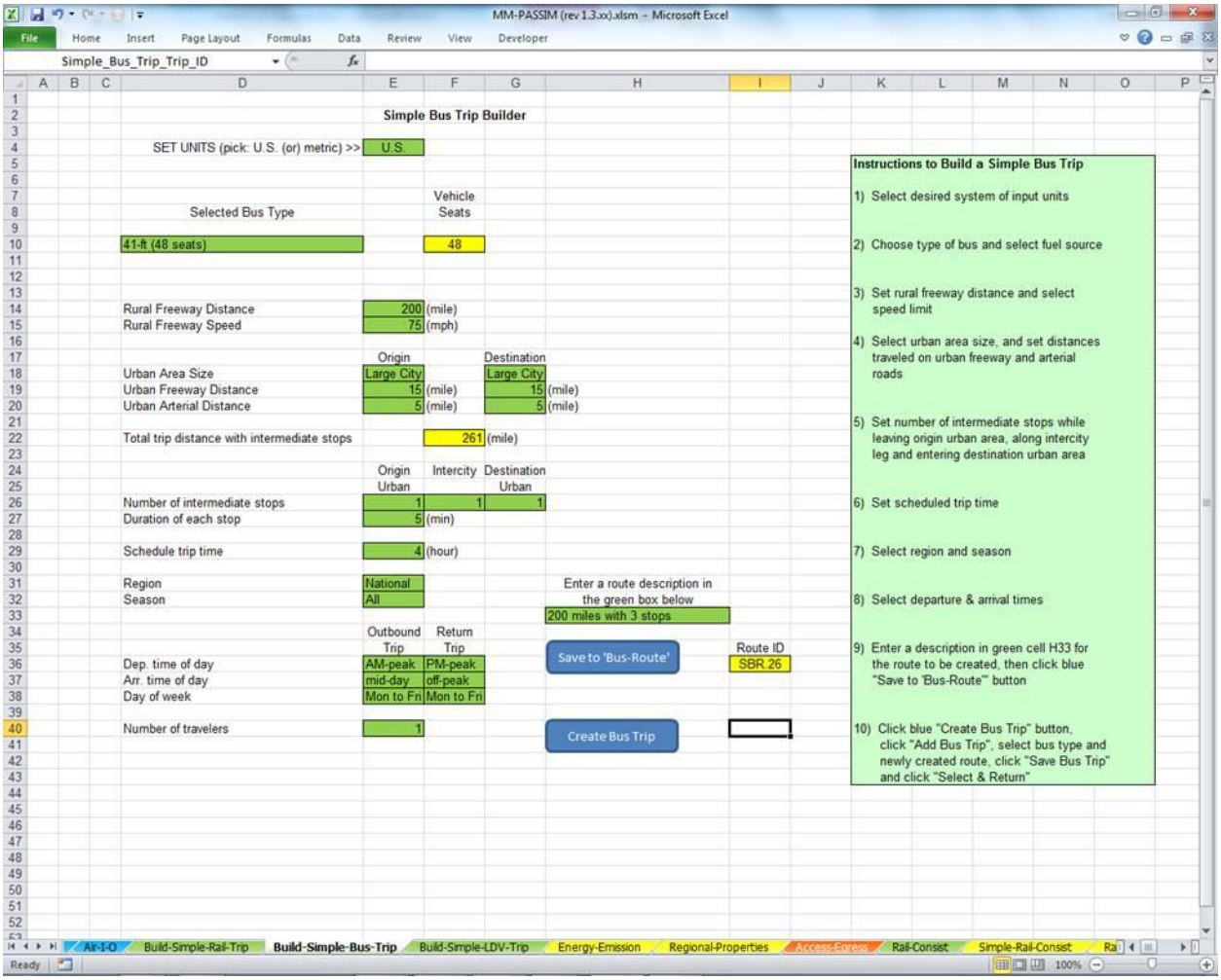
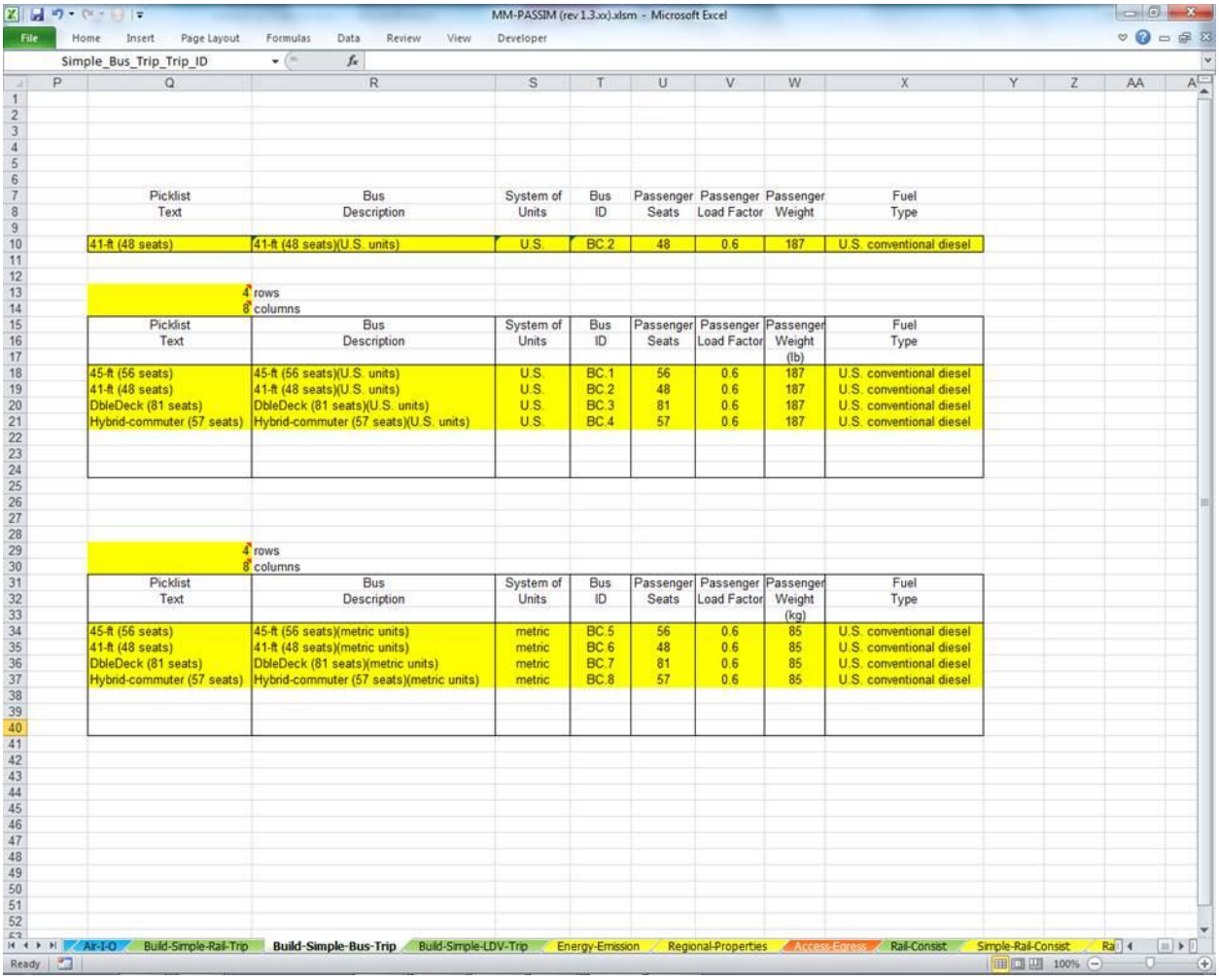


Figure A-14 The 'Build-Simple-Bus-Trip' Worksheet



Picklist Text	Bus Description	System of Units	Bus ID	Passenger Seats	Passenger Load Factor	Passenger Weight	Fuel Type
41-ft (48 seats)	41-ft (48 seats)(U.S. units)	U.S.	BC.2	48	0.6	187	U.S. conventional diesel

4 rows
8 columns

Picklist Text	Bus Description	System of Units	Bus ID	Passenger Seats	Passenger Load Factor	Passenger Weight (lb)	Fuel Type
45-ft (56 seats)	45-ft (56 seats)(U.S. units)	U.S.	BC.1	56	0.6	187	U.S. conventional diesel
41-ft (48 seats)	41-ft (48 seats)(U.S. units)	U.S.	BC.2	48	0.6	187	U.S. conventional diesel
DbleDeck (81 seats)	DbleDeck (81 seats)(U.S. units)	U.S.	BC.3	81	0.6	187	U.S. conventional diesel
Hybrid-commuter (57 seats)	Hybrid-commuter (57 seats)(U.S. units)	U.S.	BC.4	57	0.6	187	U.S. conventional diesel

4 rows
8 columns

Picklist Text	Bus Description	System of Units	Bus ID	Passenger Seats	Passenger Load Factor	Passenger Weight (kg)	Fuel Type
45-ft (56 seats)	45-ft (56 seats)(metric units)	metric	BC.5	56	0.6	85	U.S. conventional diesel
41-ft (48 seats)	41-ft (48 seats)(metric units)	metric	BC.6	48	0.6	85	U.S. conventional diesel
DbleDeck (81 seats)	DbleDeck (81 seats)(metric units)	metric	BC.7	81	0.6	85	U.S. conventional diesel
Hybrid-commuter (57 seats)	Hybrid-commuter (57 seats)(metric units)	metric	BC.8	57	0.6	85	U.S. conventional diesel

Figure A-15 The Simple Bus Type VLOOKUP Tables

Creating a Simple Bus Route

To specify a simple bus route, you must first determine the overall trip distance and then divide that distance into 5 individual distances traveled on the following road types:

- Origin urban area freeways
- Origin urban area arterial roads
- Rural freeways (outside of the origin and destination urban areas)
- Destination urban area freeways
- Destination urban area arterial roads

Enter the distance traveled along rural freeways (between the origin and destination urban areas) into the green cell at 'Build-Simple-Bus-Trip'!E14 and select the most appropriate speed limit from the green pulldown list at 'Build-Simple-Bus-Trip'!E15. Note that the rural freeway speed limits are provided in 5 mph increments between 60 and 75 mph, or when using metric units those values are converted to km/h. Choose the value closest to the anticipated speed of travel.

Select the size of the origin urban area ("Small City" or "Large City") from the green pulldown list at cell 'Build-Simple-Bus-Trip'!E18 and enter the distances traveled along freeways and arterial roads in the origin urban area in the green cells at 'Build-Simple-Bus-Trip'!E19:E20. Then select the urban area size and input the distances traveled on freeways and arterial roads in the destination urban area at cells 'Build-Simple-Bus-Trip'!G18:G20. The origin and destination urban area size will affect the mix of drive schedules used to simulate bus travel in the urban areas. The total distance traveled is indicated in the yellow information cell at 'Build-Simple-Bus-Trip'!F22. Note that the total trip distance reported may include additional distances automatically added if intermediate stops are to be included in the trip (a default of 7 miles per intermediate stop is used).

The total number of intermediate stops made along a bus trip are split into individual numbers made in the origin urban area, along the rural freeway and in the destination urban area. These are input in the green cells at 'Build-Simple-Bus-Trip'!E26:G26. All stops are assumed to have the same duration (a delay in trip minimum run time) which is input in the green cell at 'Build-Simple-Bus-Trip'!E27. The scheduled trip time is input in the green cell at 'Build-Simple-Bus-Trip'!E29.

The departure time-of-day, arrival time-of-day and day-of-week for the outbound trip are all selected from green pulldown lists at 'Build-Simple-Bus-Trip'!E36:E38 and for the return trip from cells 'Build-Simple-Bus-Trip'!F36:F38. These selections are used by the bus simulation in determining the mix of drive schedules used when simulating movement in urban areas.

A simple bus route may now be created by entering a description in the green cell at 'Build-Simple-Bus-Route'!H33 and then clicking on the blue "Save to 'Bus-Route'" button. This invokes a VBA macro which automatically assigns a unique bus route ID and then copies the new bus route from the template in the 'Simple-Bus-Route' worksheet to the next available position in the 'Bus-Route' worksheet. The unique identifier assigned to the newly added bus route is indicated in the yellow "Route ID" cell at 'Build-Simple-Rail-Trip'!I36.

The simple bus route is created from the data specified on the 'Build-Simple-Bus-Trip' worksheet using the 'Simple-Bus-Route' worksheet as a template. Some cells of this bus route template are built using formulas which reference data cells on the 'Build-Simple-Bus-Trip' worksheet while others provide default values. It is assumed that there are no grades on a simple bus route.

The automated process of copying the 'Simple-Bus-Route' template into the 'Bus-Route' worksheet replaces the contents of cells having formulas which reference cells on the 'Build-Simple-Bus-Trip' worksheet with their values. Users may modify the data once added for a simple bus route by editing the cells in the 'Bus-Route' worksheet using the information provided in Section A.7.9 on page A-148 as a guide.

Note: *Do not manually copy the 'Simple-Bus-Route' template and paste into the 'Bus-Route' worksheet as errors will result.*

Creating the Simple Bus Trip

The final inputs which must be provided before a simple bus trip can be created include the geographical region selected from the green pulldown list at 'Build-Simple-Bus-Trip'!E31, the season for the trip selected from the green pulldown list at 'Build-Simple-Bus-Trip'!E32 and the number of people assumed to be traveling together in a party which is input in the green input cell at 'Build-Simple-Bus-Trip'!E40.

Clicking on the blue "Create Bus Trip" button brings the 'Bus-I-O' worksheet into view and displays the 'Bus Trip Selection' menu preloaded with the simple bus route, the bus type selection and the balance of the simple bus trip specifications transferred from the 'Build-Simple-Bus-Trip' worksheet. From that menu, the new trip is created by clicking the gray "Add Bus Trip" button which creates and displays a unique bus trip ID in the yellow "Trip ID" field in the top left of the menu. Enter a description for this new simple bus trip in the green "Description" field at the top of the menu and then click the gray "Save Bus Trip" to write it onto the bottom of the list of bus trips stored in the 'Bus-Trip-List' worksheet. Please note that the new trip will not be automatically saved if the "Save Bus Trip" button is not clicked. Clicking on the gray "Select & Return" button will populate the bus trip fields on the 'Bus-I-O' worksheet.

A.4.3 Building a Simple Light Duty Vehicle (LDV) Trip

The 'Build-Simple-LDV-Trip' worksheet provides a simple means to create a basic light duty vehicle trip. Figure A-16 depicts the worksheet layout. The light green box on the right hand side ('Build-Simple-LDV-Trip'!K5:O40) provides a brief list of instructions to follow. The process involves:

1) Selecting the light duty vehicle type.
2) Specifying the distances traveled, speed limit, number of wayside stops, duration of stops, origin and destination urban area sizes, trip departure and arrival periods and then creating a simple LDV route by clicking on the blue "Save to 'LDV-Route'" button.
3) Specifying other trip parameters such as region, season, number of people traveling together in party and then creating the trip by clicking on the blue "Create LDV Trip" button.

Selecting a Light Duty Vehicle Type

To build a simple light duty vehicle trip, begin by selecting a system of units from the green pulldown list located at 'Build-Simple-LDV-Trip'!E4. Then, select a light duty vehicle type from the green pulldown list at cell 'Build-Simple-LDV-Trip'!D10. The number of passenger seats provided in the selected vehicle type is indicated in the yellow cell at 'Build-Simple-LDV-Trip'!F10. Other default parameters associated with the selected light duty vehicle type which will be used for the simple LDV trip may be reviewed in the yellow information cells located at 'Build-Simple-Bus-Trip'!R10:W10 (page to the right).

The list of vehicle types available in the green pulldown list at 'Build-Simple-LDV-Trip'!D10 and their corresponding default parameters are defined in an Excel VLOOKUP table located at 'Build-Simple-LDV-Trip'!R14:W36 (see Figure A-17). This table is populated by cell references to the source data contained in the 'LDV-Type' worksheet. MMPASSIM provides parameters for the following light duty vehicles:

- Small automobile
- Midsize automobile or station wagon
- Minivan or small Sport Utility Vehicle
- Large auto or medium SUV or small pickup
- Pickup truck
- Large Sport Utility Vehicle
- Composite local vehicle
- Composite intercity vehicle
- Composite taxi
- 2011 sales weighted
- 2011 driven fleet
- 2012 sales weighted
- 2012 driven fleet
- 2013 sales weighted
- 2013 driven fleet

Note: *If new light duty vehicles are added into the 'LDV-Type' worksheet, for example by updating with sales weighted and driven fleets for a new year, then new lines containing the appropriate cell references must be added into this VLOOKUP table in order for them to be selected from the 'Build-Simple-LDV-Trip' pulldown list. The VLOOKUP statements used in cell formulas are constructed using offsets which automatically adjust when new lines of LDV type data are added.*

Creating a Simple Light Duty Vehicle Route

To specify a simple LDV route, you must first determine the overall trip distance and then divide that distance into 5 individual distances traveled on the following road types:

- Origin urban area freeways
- Origin urban area arterial roads
- Rural freeways (outside of the origin and destination urban areas)
- Destination urban area freeways
- Destination urban area arterial roads

Enter the distance traveled along rural freeways (between the origin and destination urban areas) into the green cell at 'Build-Simple-LDV-Trip'!E14 and select the most appropriate speed limit from the green pulldown list at 'Build-Simple-LDV-Trip'!E15. Note that the rural freeway speed limits are provided in 5 mph increments between 60 and 75 mph, or when using metric units those values are converted to km/h. Choose the value closest to the anticipated speed of travel.

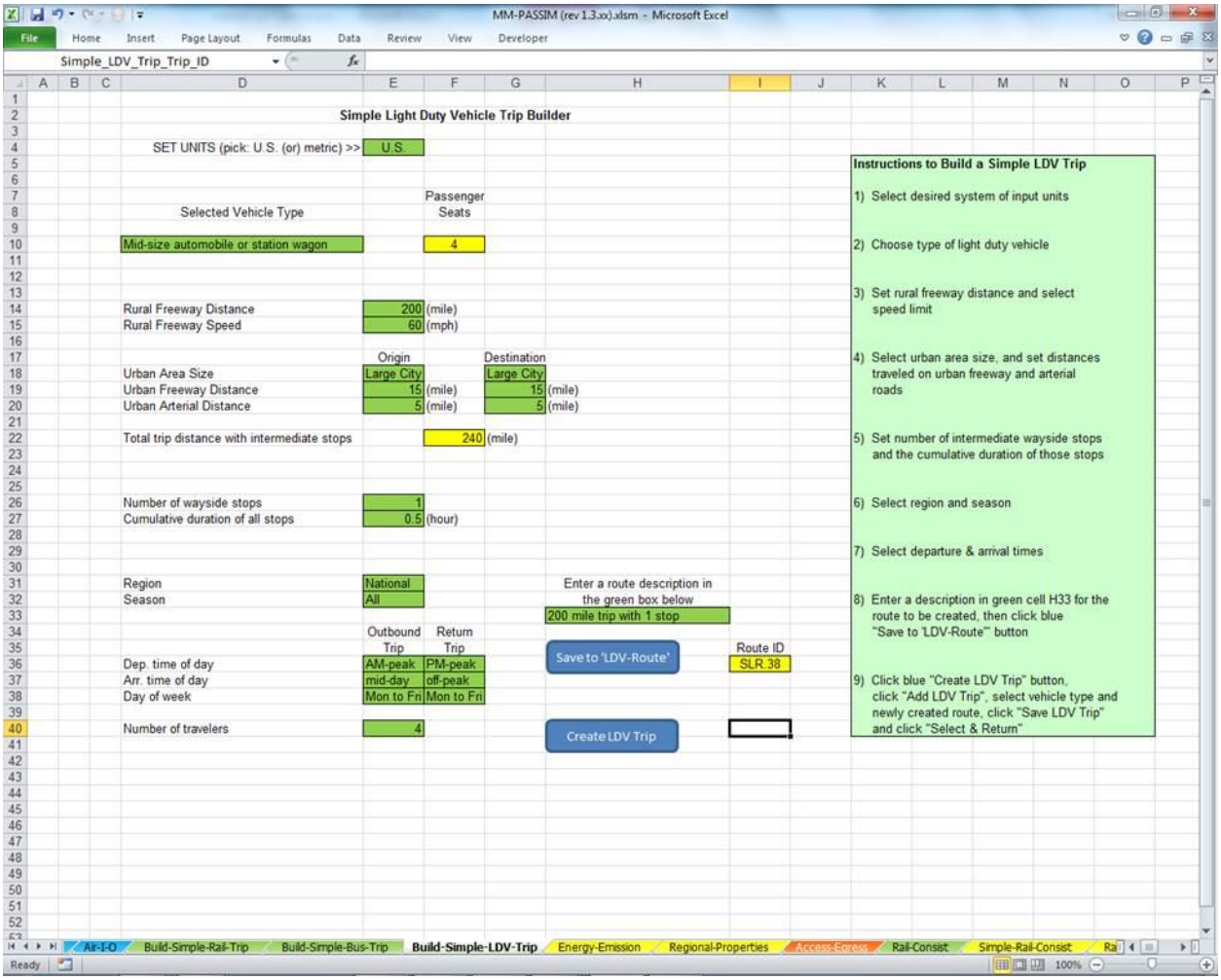


Figure A-16 The 'Build-Simple-LDV-Trip' Worksheet

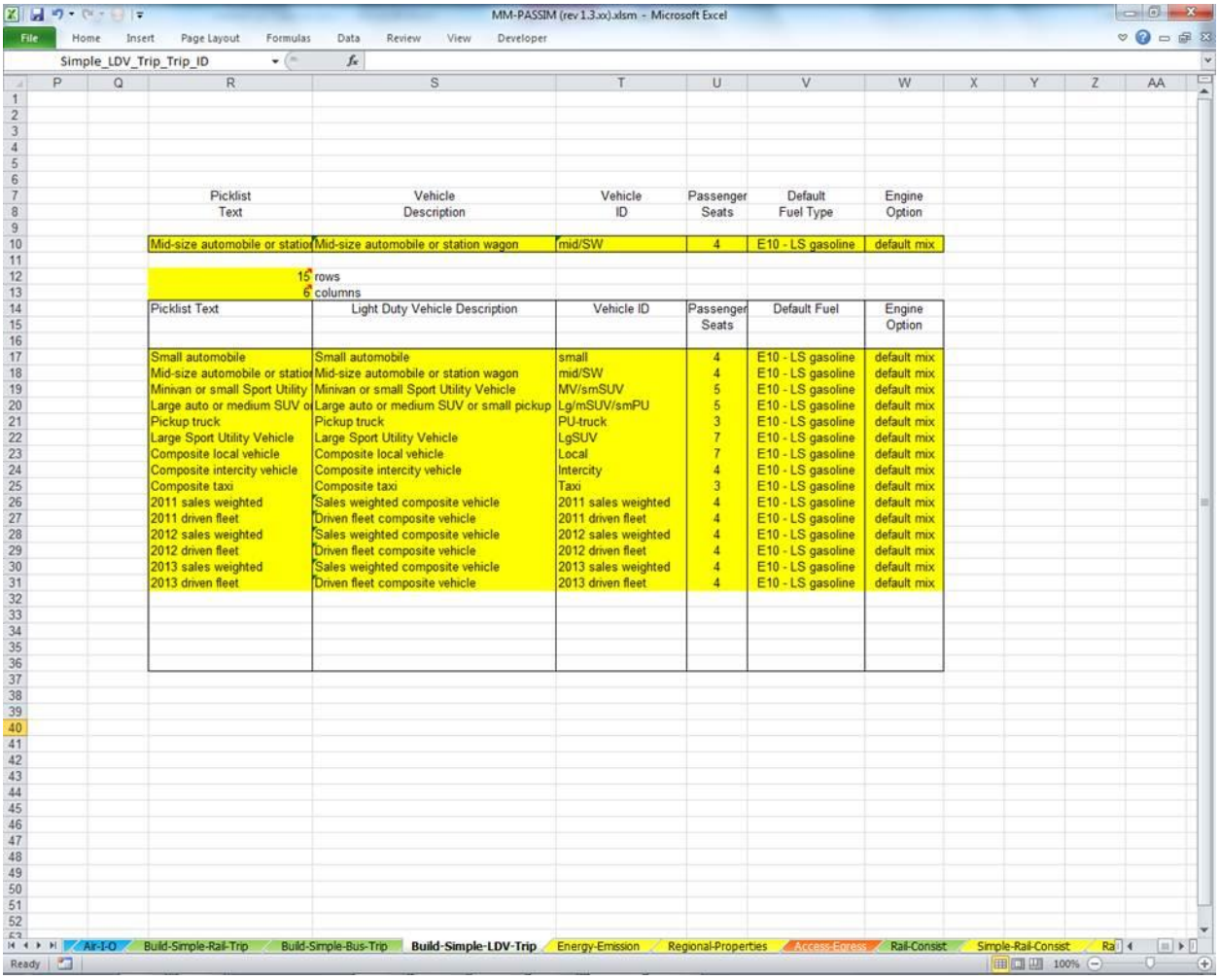


Figure A-17 Simple LDV Type VLOOKUP Tables

Select the size of the origin urban area ("Small City" or "Large City") from the green pulldown list at cell 'Build-Simple-LDV-Trip'!E18 and enter the distances traveled along freeways and arterial roads in the origin urban area in the green cells at 'Build-Simple-LDV-Trip'!E19:E20. Then select the urban area size and input the distances traveled on freeways and arterial roads in the destination urban area at cells 'Build-Simple-LDV-Trip'!G18:G20. The origin and destination urban area size will affect the mix of drive schedules used to simulate light duty vehicle travel in the urban areas. The total distance traveled is indicated in the yellow information cell at 'Build-Simple-LDV-Trip'!F22.

The total number of wayside stops along the rural freeway portion of a light duty vehicle trip is input in the green cell at 'Build-Simple-LDV-Trip'!E26. The total cumulative duration of all wayside stops is specified in hours and input in the green cell at 'Build-Simple-LDV-Trip'!E27.

The departure time-of-day, arrival time-of-day and day-of-week for the outbound trip are all selected from green pulldown lists at 'Build-Simple-LDV-Trip'!E36:E38 and for the return trip from cells 'Build-Simple-LDV-Trip'!F36:F38. These selections are used by the light duty vehicle simulation in determining the mix of drive schedules used when simulating movement in urban areas.

A simple light duty vehicle route may now be created by entering a description in the green cell at 'Build-Simple-LDV-Route'!H33 and then clicking on the blue "Save to 'LDV-Route'" button. This runs a VBA macro which automatically assigns a unique light duty vehicle route ID and then copies the new light duty vehicle route from the template in the 'Simple-LDV-Route' worksheet to the next available position in the 'LDV-Route' worksheet. The unique identifier assigned to the newly added light duty vehicle route is indicated in the yellow "Route ID" cell at 'Build-Simple-LDV-Trip'!I36.

The simple light duty vehicle route is created from the data specified on the 'Build-Simple-LDV-Trip' worksheet using the 'Simple-LDV-Route' worksheet as a template. Some cells of this light duty vehicle route template are built using formulas which reference data cells on the 'Build-Simple-LDV-Trip' worksheet while others provide default values. It is assumed that there are no grades on a simple light duty vehicle route.

The process of copying this template into the 'LDV-Route' worksheet replaces the contents of cells having formulas which reference the 'Build-Simple-LDV-Trip' worksheet with their values. Users may modify the data added for a simple light duty vehicle route by editing the cells in the 'LDV-Route' worksheet using the information provided in Section A.7.13 on page A-159 as a guide.

Note: *Do not manually copy the 'Simple-LDV-Route' template and paste into the 'LDV-Route' worksheet as errors will result.*

Creating the Simple LDV Trip

The final inputs required before a simple light duty vehicle trip can be created include the geographical region selected from the green pulldown list at 'Build-Simple-LDV-Trip'!E31, the season for the trip selected from the green pulldown list at 'Build-Simple-LDV-Trip'!E32 and the number of people assumed to be traveling together in a party which is input in the green input cell at 'Build-Simple-LDV-Trip'!E40.

Clicking on the blue "Create LDV Trip" button brings the 'LDV-I-O' worksheet into view and displays the 'Auto/LDV Trip Selection' menu preloaded with the simple light duty vehicle route, the selected light duty vehicle type and the balance of the simple light duty vehicle trip specifications transferred from the 'Build-Simple-LDV-Trip' worksheet. From that menu, the new trip is created by clicking the gray "Add LDV Trip" button which creates and displays a unique light duty vehicle trip ID in the yellow "Trip ID" field in the top left of the menu. Enter a description for this new simple light duty vehicle trip in the green "Description" field at the top of the menu and then click the gray "Save LDV Trip" to write it onto the bottom of the list of light duty vehicle trips stored in the 'LDV-Trip-List' worksheet.

Note: *A newly created trip will not be automatically saved if the "Save LDV Trip" button is not clicked.*

Clicking on the gray "Select & Return" button will populate the light duty vehicle trip fields on the 'LDV-I-O' worksheet and close the 'Auto/LDV Trip Selection' menu.

A.5 Details of Configuring and Running Modal Simulations

This section provides details of how the MMPASSIM menu system is used to configure simulations of rail, air, bus and light duty vehicle trips. Only rail trips are simulated in *Single Train Simulations* and *Rail Technology Evaluations*. Rail, air, bus and light duty vehicle trips can be simulated in *Mode Comparisons*. Table A-2 and Table A-3 identify the major configuration steps for each of these analysis types.

Table A-2 Major Configuration Steps Required for a MMPASSIM Analysis

Type of Analysis	Major Configuration Steps Required
Single Train Simulation	• Pick "Single Train Simulation" at 'Master-I-O'!C4 • Define Baseline Rail Case – click on "Define Baseline" and refer to 'Define Rail Case' (Table A-4) • Click "Calculate Selections" button
Rail Technology Evaluation	• Pick "Rail Technology Evaluation" at 'Master-I-O'!C4 • Define Baseline Rail Case – click on "Define Baseline" and refer to 'Define Rail Case' (Table A-4) • Define Alternative Rail Case 1 (optional, check box to activate) – click on "Define Alternative 1" and refer 'Define Rail Case' (Table A-4) • Define Alternative Rail Case 2 (optional, check box to activate) – click on "Define Alternative 2" and refer 'Define Rail Case' (Table A-4) • Define Alternative Rail Case 3 (optional, check box to activate) – click on "Define Alternative 3" and refer to 'Define Rail Case' (Table A-4) • Click "Calculate Selections" button
Mode Comparison	• Pick "Mode Comparison" at 'Master-I-O'!C4 • Define Baseline Rail Case – click on "Define Baseline" and refer to 'Define Rail Case' • Define Alternative 1 (optional, check box to activate) – click on "Define Alternative 1", refer to 'Define Alternative Case' (Table A-3) • Define Alternative 2 (optional, check box to activate) – click on "Define Alternative 2", refer to 'Define Alternative Case' (Table A-3) • Define Alternative 3 (optional, check box to activate) – click on "Define Alternative 3", refer to 'Define Alternative Case' (Table A-3) • Click "Calculate Selections" button

Table A-3 Selecting an Alternative Mode Trip

Define Alternative Case	Configuration Steps Required
Define Alternative Case	• Click "Define Alternative #" button (where # is 1, 2 or 3) • Pick desired transportation mode from drop-down list • Either select the current trip defined on a '<modal>-I-O' worksheet by clicking "Select & Return" button or • Select an existing modal trip as a template and edit by clicking "Select & Edit" – see appropriate mode specific trip selection form steps

A.5.1 Configuring and Running a Rail Simulation

The Rail-Simulation module serves as the backbone of the MMPASSIM simulator. It is implemented using five (5) primary user accessible worksheets which, in addition to the 'Master-I-O' worksheet, together provide for complete simulation configuration, user input and results output. These user accessible worksheets include the 'Rail-I-O', 'Energy-Emission', 'Regional-Properties', 'Rail-Consist' and 'Rail-Route' worksheets. An additional 'Rail-Trip-List' worksheet, used to maintain the list of all configured rail trips, is accessible to the user but is typically maintained by the application. The 'Energy-Emission' worksheet specifies the energy and emissions characteristics of all fuel/energy sources used for all transportation modes and is therefore shared by all transportation mode sub-models. The 'Regional-Properties' worksheet defines factors which often vary with geographical location, such as seasonal temperatures, traffic distributions, heating/cooling loads, urban congestion and energy and emission intensities for local urban area access and egress modes. The rail simulation calculations are performed on another worksheet named 'Rail-Simulation' which should not normally be modified by a user. That worksheet predicts the energy use, GHG emissions produced and travel time associated with a single rail leg of a rail trip. Simulation of a return rail trip requires two successive simulation sequences involving transfer of configuration data to the worksheet, recalculation of the worksheet and then transfer of results from the worksheet.

Defining the baseline rail round trip (applicable in all simulation modes) is initiated by clicking the blue "Define Baseline" button (at cell 'Master-I-O'!$A$31, see highlight 1 on Figure A-18). This displays the pop up "Rail Trip Selection" user form from which a trip can either be selected from the list of all currently defined rail trips or a new trip may be added and configured. Table A-4 summarizes the steps involved in configuring a rail trip.

For a rail simulation, a trip definition involves specifying a route and a rail consist. The trip being displayed is identified by its unique 'Trip ID' (upper left yellow field) and a user modifiable 'Description' (upper right green field). The 'Route ID' associated with a trip is displayed in the green-bordered light yellow field located immediately below the 'Trip ID' field (see highlight 2 in Figure A-19). The 'Route ID' is not directly modifiable by a user, but is changed using the 'Rail Route Selection' pop up user form which is accessed by double clicking within the boundaries of the 'Route ID' field (see highlight 3 in Figure A-19). Navigation through that user form follows the same procedures described above and once the desired route is displayed, clicking on the 'Select & Return' will return the selected 'Route ID' back to the previous 'Rail Trip Selection' form. A rail route may also be conveniently selected directly from the Rail Trip Selection user form by picking it from a list of route descriptions available on the green drop-down list located immediately below the yellow Route ID and Description information fields.

Most parameters of a route specification are defined in the 'Rail-Route' worksheet and are not modifiable from either the Rail Trip Selection or the Rail Route Selection user forms. The yellow 'Route ID', 'Description', 'Route Distance', 'From MP' and 'to MP' and speed limit fields on the Rail Route Selection user form are filled in by the VBA macro to offer sufficient information to the user to identify and confirm the route selection. The lower 'Trip Distance', 'From MP' and 'to MP' values differ from the upper 'Route' values because a rail trip can be configured to use only a portion of a longer rail route as specified in the 'Rail-Route' worksheet.

Table A-4 Configuration Steps for a Rail Trip

Define Rail Case	Configuration Steps Required
Rail Trip Selection Form	• Either select an existing rail trip from the 'Trip ID' drop-down list and click "Select & Return" or • Create a new trip by clicking "Add Rail Trip" button • Pick a rail route from the "Route ID" drop-down list • Pick direction of travel • Set number of travelers • Set scheduled trip time in hours (if desired) • Set station stop time allowance in minutes (if desired) • Pick time of day for departure of outbound trip • Pick time of day for arrival of outbound trip • Pick day of week for outbound trip • Pick time of day for departure of return trip • Pick time of day for arrival of return trip • Pick day of week for return trip • Pick season of both outbound and return trips • Pick a rail consist from the "Consist ID" drop-down list • Assign access and egress legs by clicking the "Access & Egress" button • Save the new rail trip by clicking "Save Rail Trip" button • Select the newly added rail trip by clicking "Select & Return" button

The yellow 'Trip Distance', 'From MP' and 'to MP' fields associated with the currently selected rail route are displayed on the Rail Trip Selection user form for information purposes. There are eleven additional user modifiable green fields available to configure the operational parameters of a rail trip. These fields are identified as 'Direction', 'Number of travelers', 'Scheduled Trip Time (hours)', 'Station Stop Time Allowance (min)', 'Season', 'Departure Time of Day', 'Arrival Time of Day', and 'Day of Week' for the forward trip along with 'Departure Time of Day', 'Arrival Time of Day' and 'Day of Week' for the return trip. All of these values are stored with the rail trip record when saved to the rail trip list by clicking on the gray 'Save' button located in the lower left hand corner of the user form.

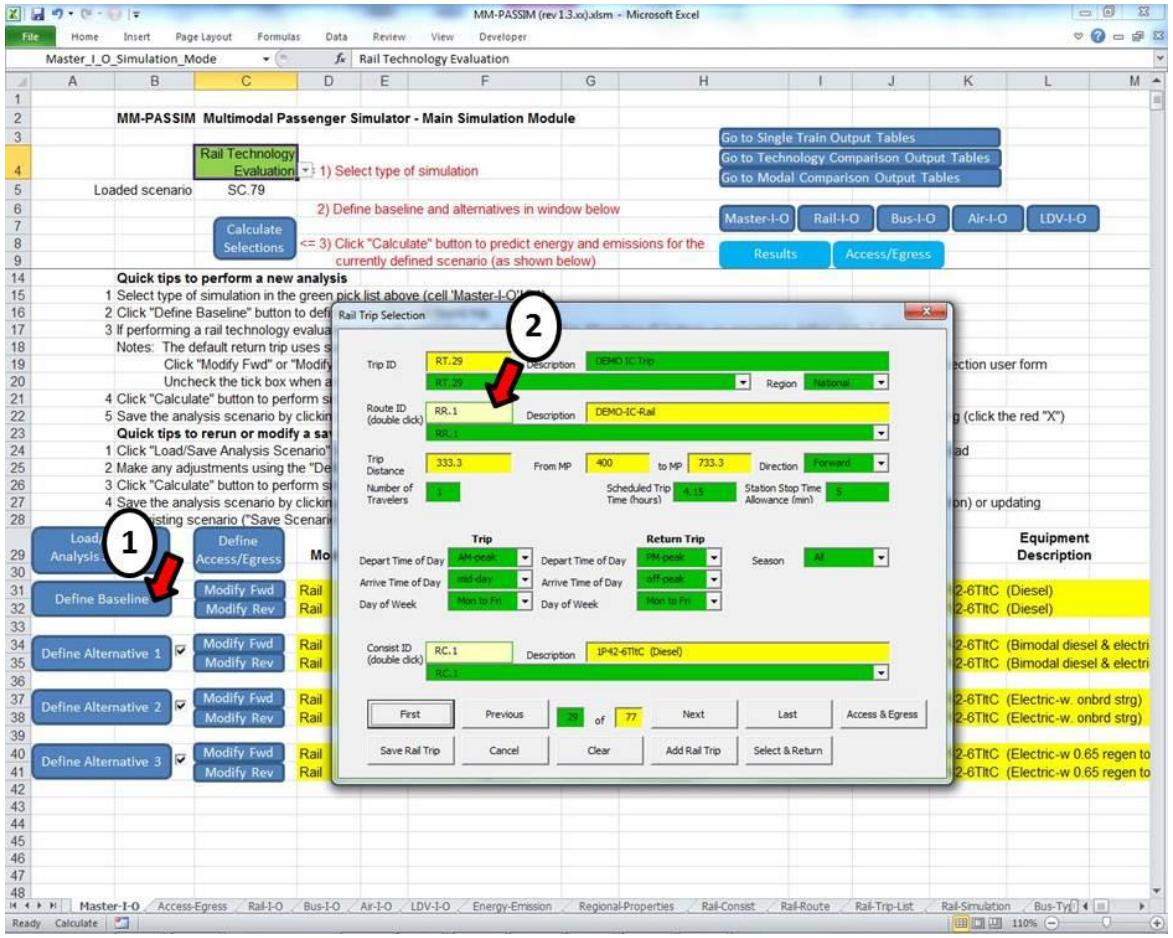


Figure A-18 Defining the Baseline Round Trip

Usage Notes:

On the "Master-I-O" worksheet:

a) Click blue "Define Baseline" button on left hand side of worksheet (see highlight 1) to open the "Rail Trip Selection" form.

On the "Rail Trip Selection" form:

b) Pick a rail trip from the green "Trip ID" drop-down list at the top.
or
Use the gray navigation buttons at the bottom to display a desired trip

c) Click gray "Add Rail Trip" button if you wish to create a new trip by modifying the currently displayed trip.

d) Double click on light yellow "Route ID" box (see highlight 2) to open "Rail Route Selection" form and make a route selection.
or
Select a route from the green "Route ID" drop-down list.

e) Double click on light yellow "Consist ID" box to open "Rail Consist Selection" form and make a consist selection
or
Select a consist from the green "Consist ID" drop-down list.

f) Make any changes to green fields (trip rimes, day of week, season, number of travelers, etc.).

g) Click on the gray "Save Rail Trip" button to save the modifications.

h) Click on the gray "Select & Return" button to return trip information back to "Master-I-O".

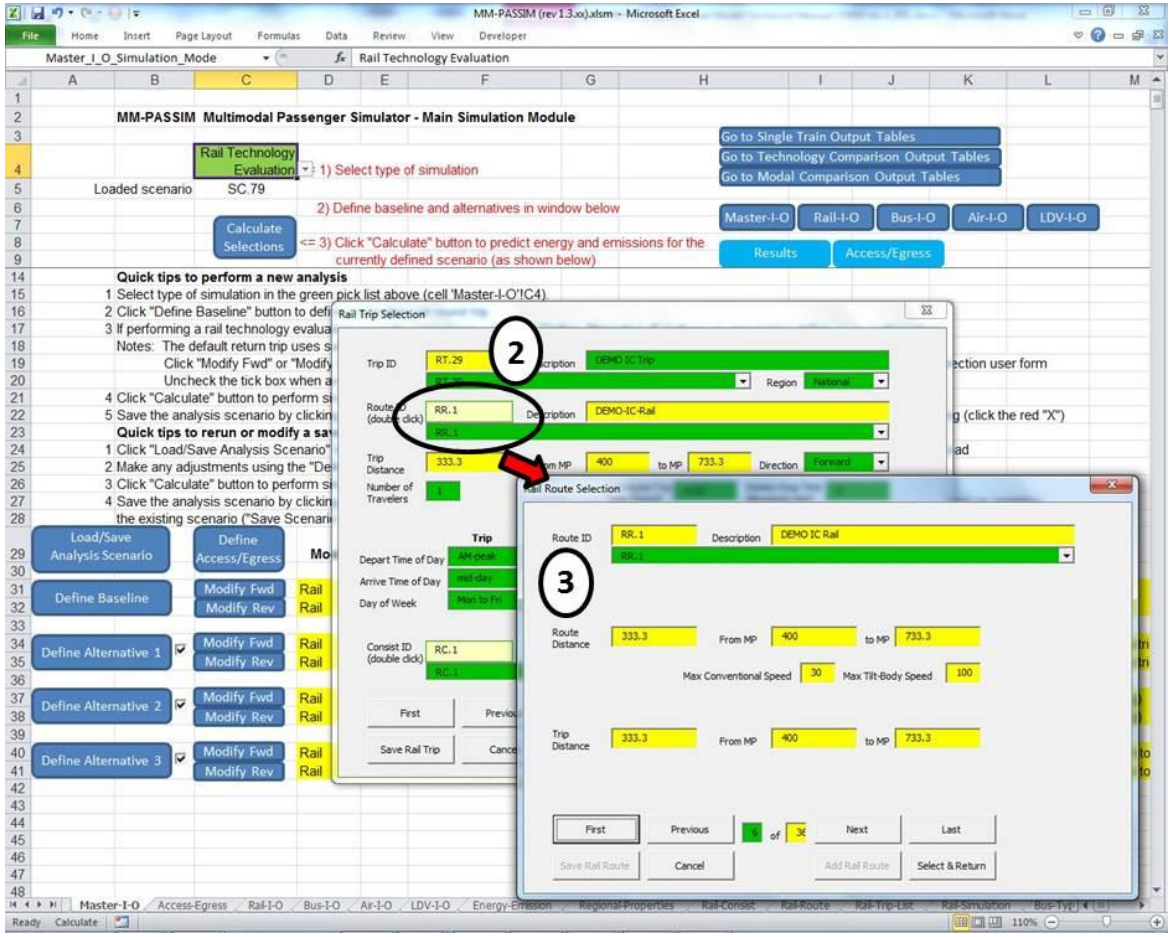


Figure A-19 Selecting a Rail Route

Usage Notes:

On "Rail Trip Selection" form:

a) Pick a rail route from the green "Route ID" drop-down list.

or

Double click on the light yellow "Route ID" box (see highlight 2) to open the "Rail Route Selection" form and make a route selection.

On the "Rail Route Selection" form:

b) Pick a rail route from the green "Route ID" drop-down list (see highlight 3).

or

Use gray navigation buttons to display desired rail route

c) Click gray "Select & Return" button to return to the "Rail Trip Selection" form.

The ‘Consist ID’ associated with a trip is displayed in the green-bordered light yellow field located just above the ‘First’ and ‘Previous’ navigation buttons of the ‘Rail Trip Selection’ form. A consist is selected by either using the ‘Rail Consist Selection’ pop up form which is activated by double clicking on the ‘Consist ID’ field (see Figure A-20) or selecting from the green drop-down list immediately below the yellow ‘Consist ID’ and ‘Description’ fields. If a user wishes to view or modify the rail consist data then they must double click on the ‘Consist ID’ field, otherwise choosing from the drop-down list simply selects the desired consist with the configuration as saved in the ‘Rail-Consist’ worksheet.

Double clicking on the ‘Consist ID’ field from the ‘Rail Trip Selection’ user form will display the ‘Rail Consist Selection’ pop up form. At the top of this form are yellow ‘Consist ID’ and ‘Description’ fields and a green consist drop-down list. The user accesses the desired ‘Consist ID’ by navigating through the available list of rail consists currently defined in the ‘Rail-Consist’ worksheet using the gray navigation buttons at the bottom of the form or alternatively selecting from the consist descriptions offered in the green drop-down list. The five yellow information fields displayed below the green consist drop-down list are not modifiable on the form. The five green drop-down lists positioned below the yellow information fields allow a user to configure the propulsion type and fuel(s), the method of hotel power generation and the method of energy recovery, if any, which may be assumed for the propulsion equipment. Propulsion type may be “onboard-fuel” (primarily diesel), “electric” or “dual-fuel” (both onboard-fuel and electric). The types of fuel presented in the primary and secondary fuel type drop-down lists are dependent on the propulsion type which has been selected. The method of hotel power provision is via engine power takeoff (PTO), a dedicated diesel generator or from grid power in the case of an electric power car. Energy recovery options include onboard storage, wayside storage, supplying electricity back to the electrical grid and adopting an optimal coasting driving strategy.

A user can add a new rail consist based upon an existing consist by first navigating through the list of existing rail consists until the one desired is displayed and then clicking on the gray ‘Add’ button. There are very few user modifiable consist parameters displayed on the ‘Rail Consist Selection’ form and the user will therefore need to adjust consist parameters directly in the appropriate area of the ‘Rail-Consist’ worksheet which is accessible to the user.

Note: *Changes made to a displayed rail consist are not automatically saved and will be lost unless the gray ‘Save’ button is clicked prior to navigating away to another consist or clicking on the ‘Select & Return’ button to pass that selection back to the ‘Rail Trip Selection’ form.*

Caution: *The relative position of consist parameters within the ‘Rail-Consist’ worksheet must not be altered except to manually insert or create a new consist which should be positioned relative to the last consist definition using a fixed 7 column offset. For example, the first consist definition begins in column I of the ‘Rail-Consist’ worksheet while the next begins in column P.*

A new rail trip may be added by clicking the ‘Add’ button on the ‘Select Rail Trip’ menu. This creates a new ‘Trip ID’ while preserving the values in the other data fields. A user can clear all data fields by clicking on the ‘Clear’ button if they so desire, however this should not normally be required as the process of selecting a ‘Route ID’ and ‘Consist ID’ will result in the replacement of most of the data fields.

Note: *Any changes made to the data fields on the 'Select Rail Trip' user form are not automatically saved and the user must explicitly save them by clicking the 'Save' button. Doing so will update the internally stored list of trip definitions (in the 'Rail-Trip' worksheet) but will not modify the trip definitions displayed in the rail trip definition area on the 'Master-I-O' sheet or the 'Rail-I-O' sheet. To do so, the user must click on the 'Select & Return' button which will write the trip definitions onto the 'Rail-I-O' worksheet. It is therefore possible to configure and run one-off simulated trips without modifying the trip list.*

The baseline round trip definition will automatically assign both the forward and return trips using the same consist and route selections, but the direction of the return trip is reversed from that of the forward trip and the return departure, arrival and day of week values are exchanged with the forward trip's departure, arrival and day of week values. In situations where this default return trip definition is not desired, the user can modify either the forward trip or the return trip individually by clicking on the blue "Modify Fwd" or "Modify Rev" buttons as required to access the 'Rail Trip Selection' form (see Figure A-21). A return trip does not have to be run in the reverse direction. For cases where a different route (as defined in the 'Rail-Route' worksheet) is selected for a return trip, the user must select the direction of travel which is consistent for travel from the destination back to the origin. The direction of travel is selected from the green drop-down list (see left pointing arrow highlight in Figure A-21).

Caution: *A user should not directly modify any of the yellow highlighted fields associated with the trip selections listed on the 'Master-I-O' worksheet. This list is used by the VBA macros during the sequencing of the simulation steps and any invalid data or moved items may cause invalid predictions or program failure.*

The passenger's access to the rail mode departure station and their egress from the rail mode arrival station may both be characterized with up to five (5) access/egress legs each. This may be conveniently configured using the pop-up user form accessed by clicking the blue "Define Access/Egress" button on the 'Master-I-O' worksheet to activate the 'Trip Access and Egress Leg Selection' user form (see Figure A-22). Any currently defined access or egress legs for the selected rail trip will be displayed in the 'Trip Access and Egress Leg Selection' user form. All yellow fields on the form present information to the user about the rail trip to which the displayed access and egress legs apply while all green fields may be adjusted to meet the user's requirements in specifying the characteristics of those access and egress legs. For a single train simulation, the access and egress legs are specified separately for the forward and return trips and the user may switch between those trips by clicking the 'Next' and 'Previous' navigation buttons. For a technology comparison analysis, access and egress legs are defined separately for each rail trip involved. Therefore a complete comparison involving the baseline rail case and all three alternative rail round trips will require eight (8) sets of access/egress legs be specified. The green drop-down list located beneath the yellow 'Trip ID' field may be used to quickly select the desired trip from a list of descriptions without cycling through the sequence of applicable trips.

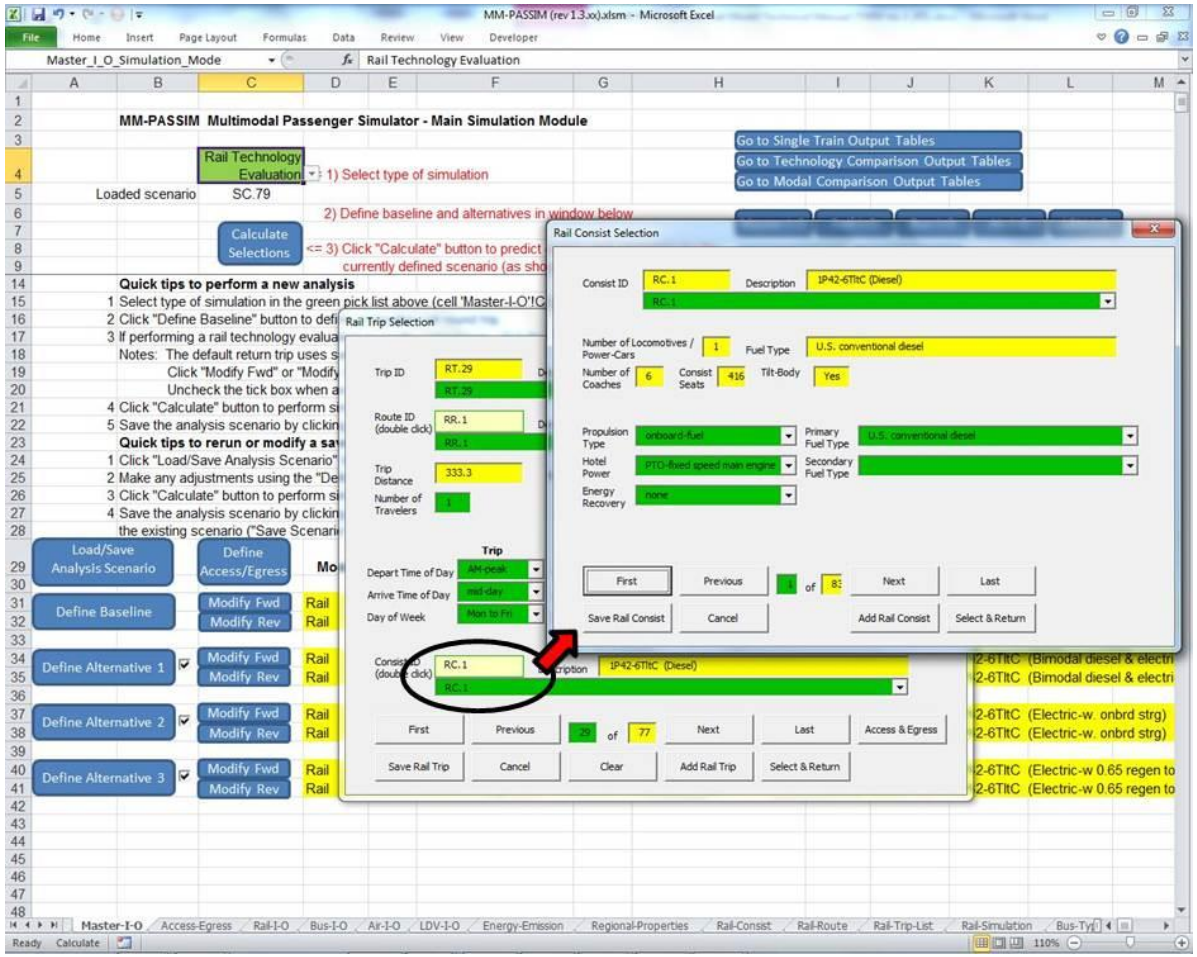


Figure A-20 Selecting a Rail Consist

Usage Notes:

On "Rail Trip Selection" form:

a) Pick a rail consist from the green "Consist ID" drop-down list.

or

Double click on the light yellow "Consist ID" box to open the "Rail Consist Selection" form and make a consist selection.

On the "Rail Consist Selection" form:

b) Pick a rail consist from the green "Consist ID" drop-down list at the top.

or

Use gray navigation buttons to display desired consist

c) Click gray "Add" button if you wish to create a new consist by modifying the displayed consist.

d) Make any changes to propulsion type, fuel, hotel power and energy recovery by selecting from the green drop-down lists (middle of form).

e) Click gray "Save" button to save changes to the displayed consist.

f) Click gray "Select & Return" button to return to the "Rail Trip Selection" form.

A user can also assign the access/egress legs for any rail trip by clicking the “Access & Egress” button on the right hand side of the “Rail Trip Selection” user form as depicted in Figure A-23. The access and egress legs currently defined for the displayed rail trip will be presented and the user may adjust all green fields accordingly. If all five legs are not required then any extra legs should be removed by selecting ‘none’ from the first position of the drop-down list for any leg not required and a macro will remove that data. The user can also scroll through the access and egress legs configured for any existing rail trips using the navigation buttons or by selecting from the green drop-down list immediately below the yellow ‘Trip ID’ field. This allows any existing access/egress configuration to be used as a template for the current trip. Clicking the “Select & Return” button will associate the currently displayed access & egress leg configurations with the rail trip being defined.

The ‘Trip Access and Egress Leg Selection’ user form provides yellow information fields indicating the ‘Trip ID’ and ‘Description’ on the top row and below that the transportation mode, region, day of week, departure time of day, arrival time of day, season of travel and finally the number of people assumed to be travelling together in one group. Please note that the number of travelers is specified in two places, in the yellow information field as just mentioned and also in a user modifiable green field which affects the intensity values used for the Auto/LDV based access and egress legs as specified on the ‘Regional-Properties’ worksheet. The number of travelers specified in the green field is the value used when evaluating access and egress leg intensities and should normally be the same as the yellow value stored with the main trip. However, in some Auto/LDV intercity trips where ride-sharing is involved it may be useful to independently assign the number of travelers in the main trip versus that assumed for access to a pickup point as well as egress from a drop-off point.

Access and egress legs are defined separately in the ‘Trip Access and Egress Leg Selection’ form. The region, city size and time of day may all be selected to best characterize the origin and destination of a trip. Clicking on the green ‘Region’ drop-down list permits selection of any region defined in the ‘Regional-Properties’ worksheet. A table of fuel and emissions intensity values for all access and egress modes is provided for each defined region presented in the drop-down list. The green ‘City Size’ and ‘Time of Day’ selections offer a limited number of choices to further tailor the access or egress modes. The choices of ‘City Size’ may be ‘Small Cities’, ‘Large Cities’, ‘Rural Municipality’ or ‘All Cities’ while the choices for ‘Time of Day’ include ‘Peak’, ‘Off-peak’ and ‘All’. Those values guide the VBA macro when choosing the most appropriate values from the table for a selected access/egress mode. The user is advised that the VBA macro expects every unique access/egress mode to be defined within the top portion of that table which would normally be associated with ‘All Cities’.

Each access and egress leg is selected by picking from the modes presented in the green drop-down lists. When a mode is selected, the user form automatically fills five of the remaining seven green user modifiable data fields with default values selected from the region’s data table. These default data include speed, fuel source, fuel intensity, energy intensity and GHG intensity. Although the inserted default data fields are yellow, the values may be adjusted to meet the user’s requirements. The user must manually provide data for the green fields specifying the distance to be traveled using that access/egress mode (in miles) and a dwell time (in minutes) for that leg. Once these access/egress data have been saved with a trip, they will appear green the next time they are loaded.

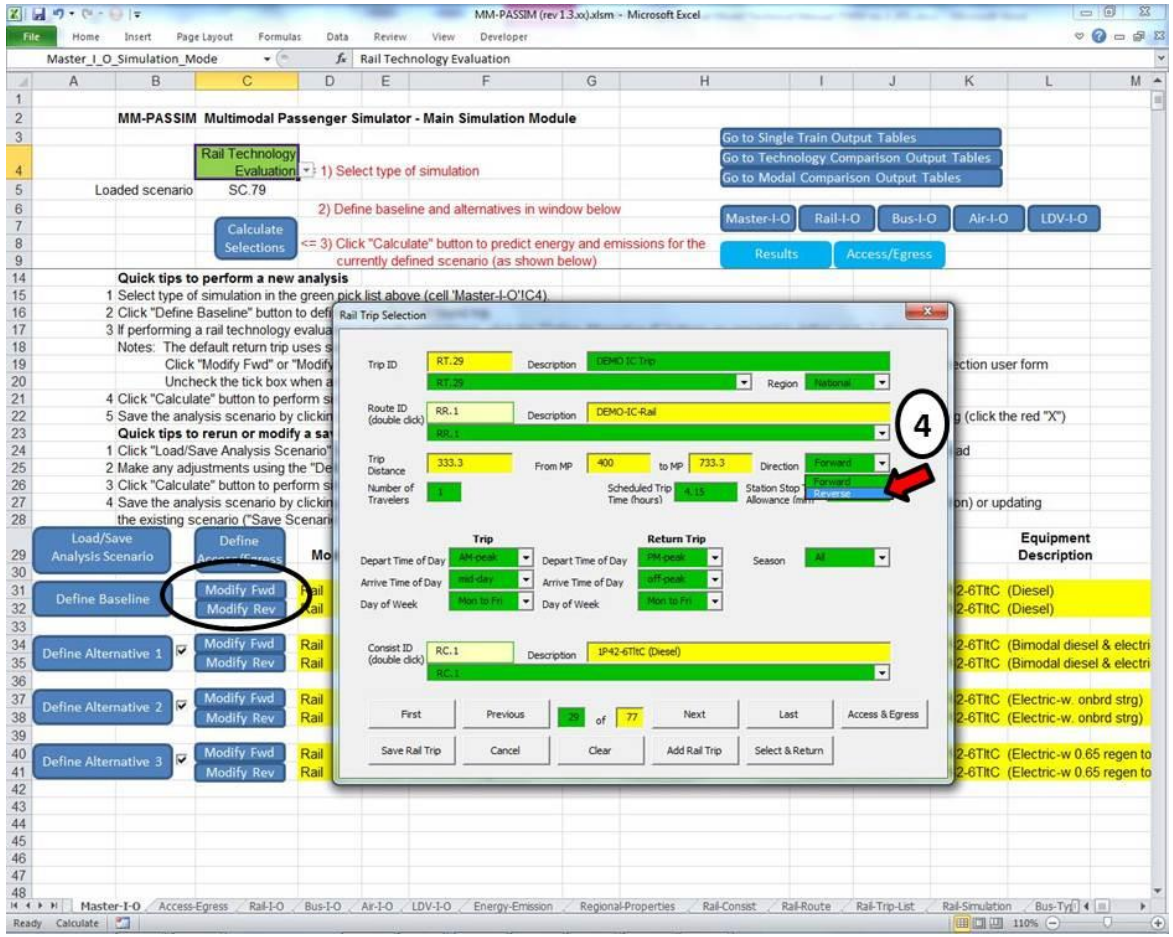


Figure A-21 Modifying a Return Rail Trip

Usage Notes:

On "Master-I-O" worksheet:

a) Click on either a blue "Modify Fwd" or "Modify Rev" button adjacent to a trip you wish to modify to open the "Rail Trip Selection" form – it will display the currently configured trip.

On the "Rail Trip Selection" form:

b) Pick a rail trip from the green "Trip ID" drop-down list at the top.

or

Use gray navigation buttons to display a desired trip.

c) Use the Click gray "Add" button if you wish to create a new trip by modifying the displayed trip.

d) Click on gray arrow to the right side of green "Direction" drop-down list to modify direction of travel (see highlight 4).

e) Make any other required adjustments to the green fields in the middle of the form.

f) Click gray "Save" button to save changes to the displayed trip.

g) Click gray "Select & Return" button to return to the "Master-I-O" worksheet.

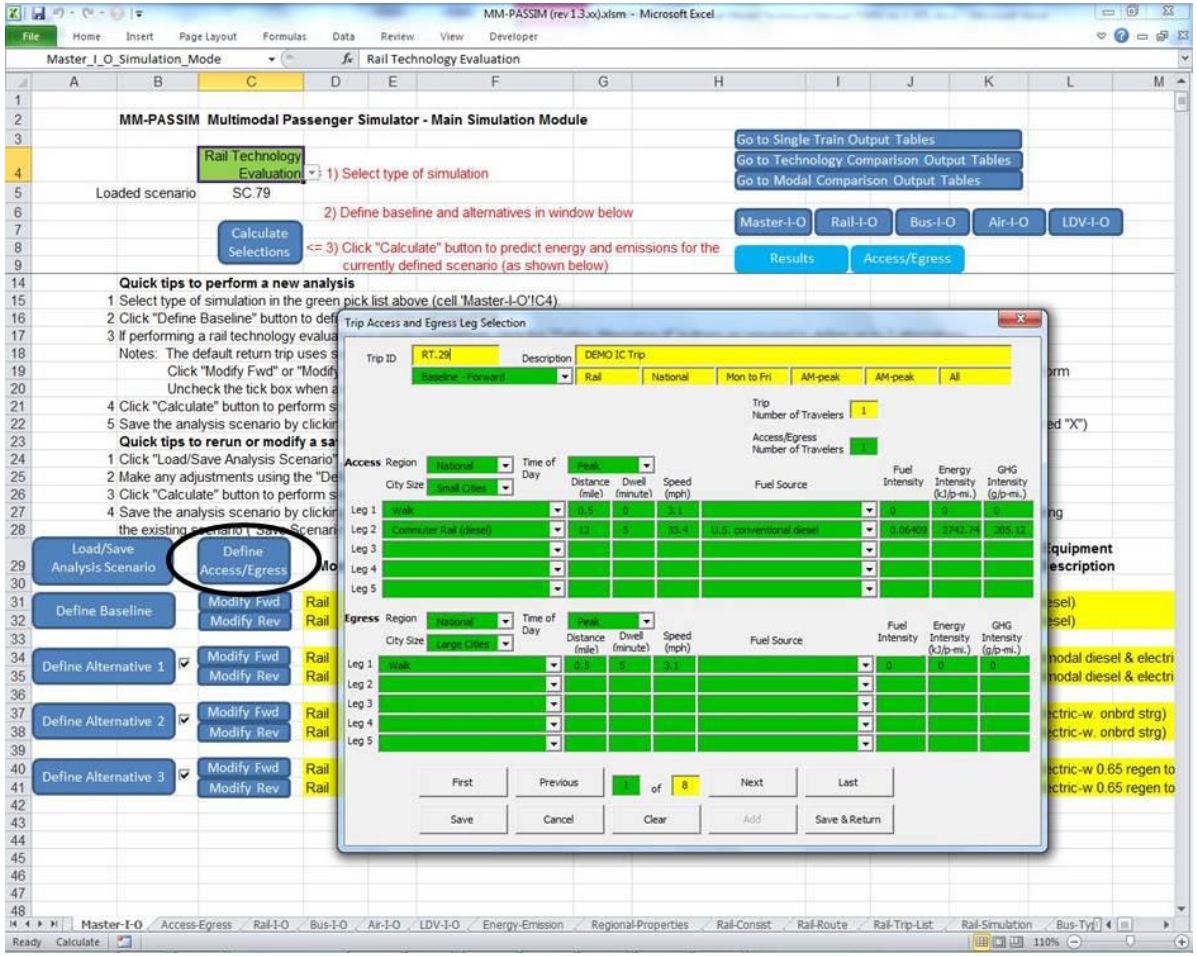


Figure A-22 Assigning Access & Egress Legs from 'Master-I-O' User Interface

To view and modify access/egress legs from the "Master-I-O" worksheet:

On the "Master-I-O" worksheet:

a) Click on the blue "Define Access/Egress" (see oval highlight) to open the "Trip Access and Egress Leg Selection" form.

On "Access and Egress Leg Selection Form:

b) Select a trip from the green "Trip ID" drop-down list showing all trips currently configured on the "Master-I-O" worksheet.

or

Use the gray navigation buttons to display the access/egress legs for a trip.

c) Make any required adjustments in the green fields

d) Click on the gray "Select & Return" button

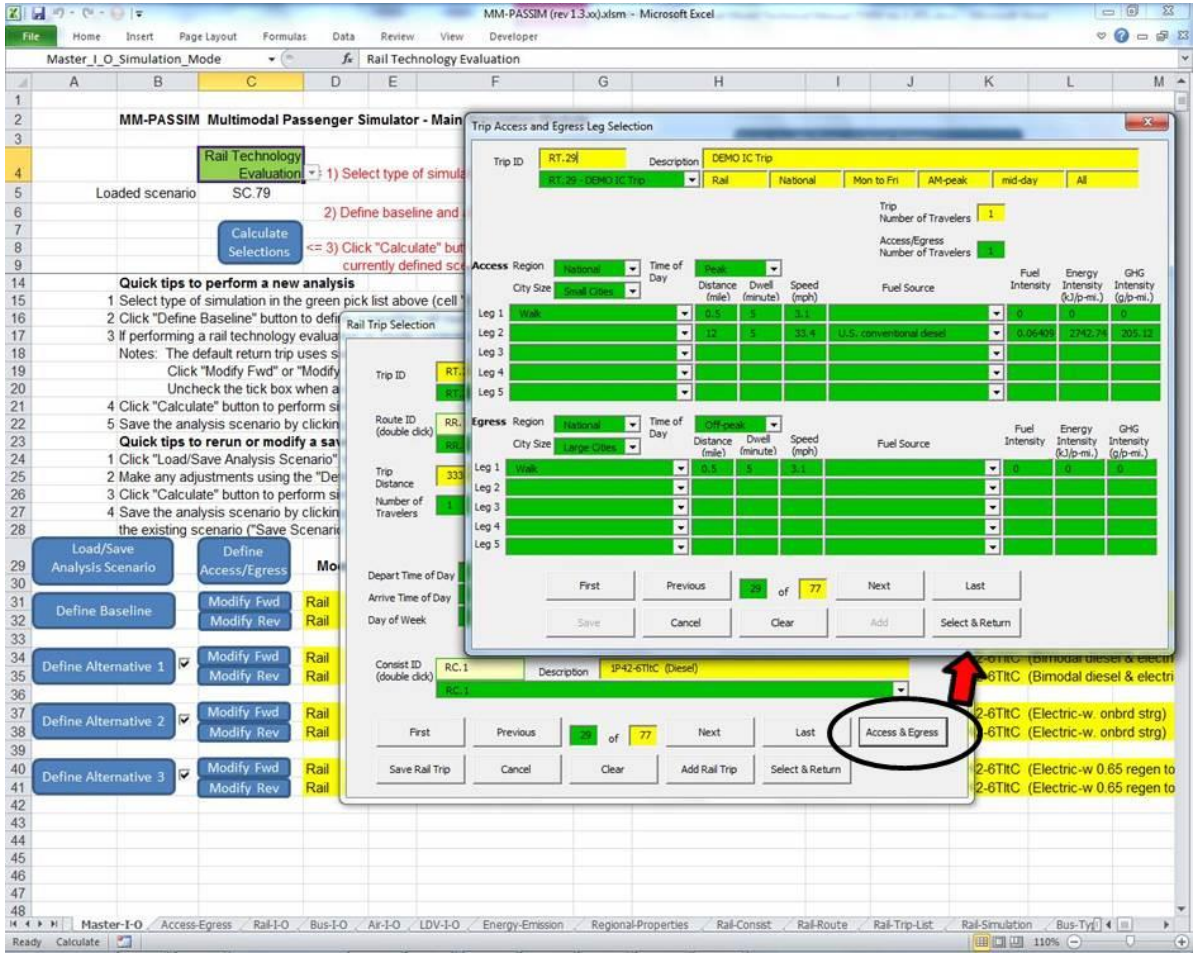


Figure A-23 Assigning Access & Egress Legs from Rail Trip Selection User Form

To view and modify access/egress legs from the "Rail Trip Selection" form:

On the "Rail Trip Selection" user form:

a) Click on the gray "Access & Egress" button (see oval highlight and arrow) to open the "Trip Access and Egress Leg Selection" form – the form will display the access & egress legs configured for the current trip.

On "Access and Egress Leg Selection Form:

b) Select any trip from the green "Trip ID" drop-down list

or

Use the gray navigation buttons to display the access/egress legs for any saved rail trip.

c) Make any required adjustments in the green fields

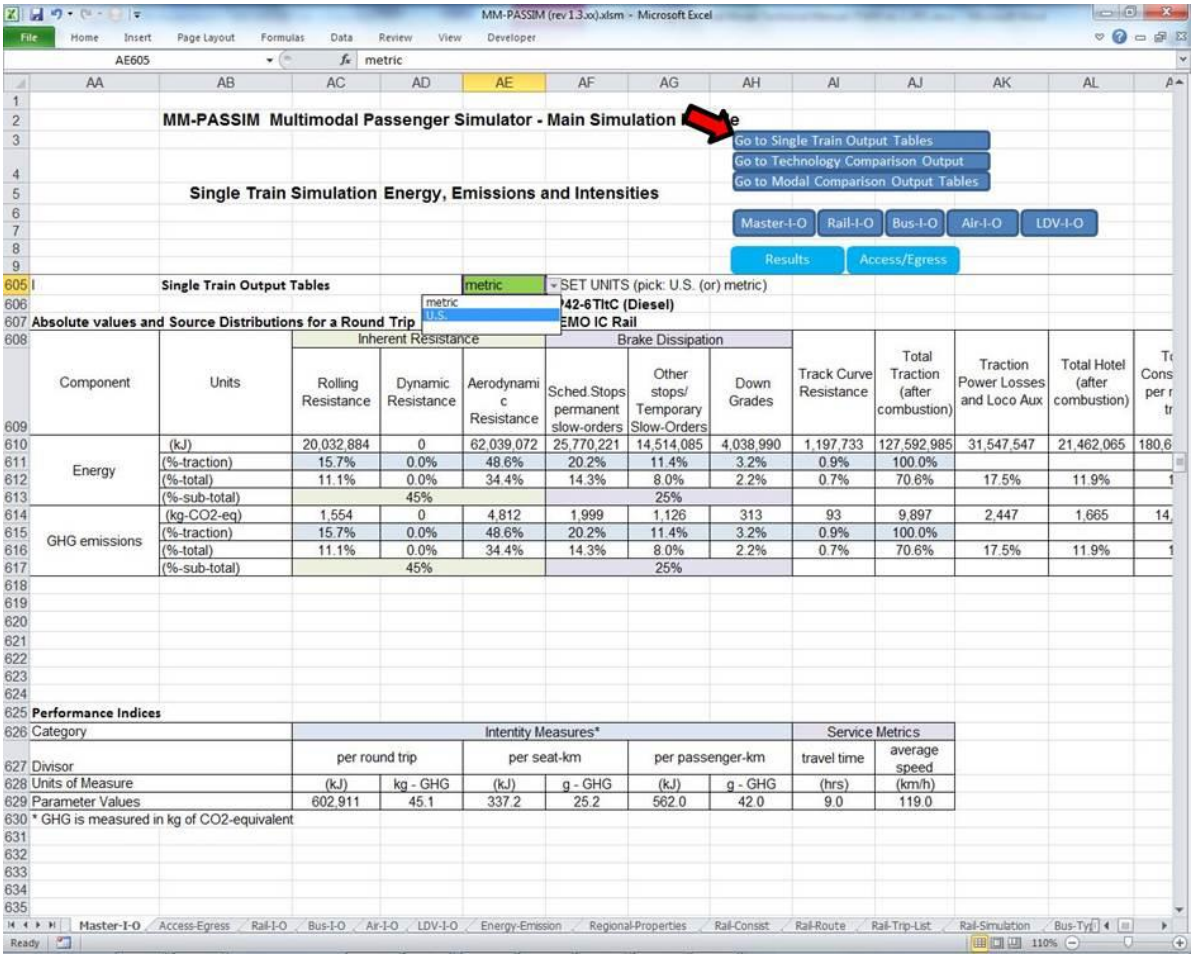
d) Click on the gray "Select & Return" button to pass the currently displayed access & egress leg configuration back and returns to the "Rail Trip Selection" user form.

Caution: *The simulation dynamically calculates Auto/LDV access/egress mode intensities using the number of travelers as displayed in the pink cell in the on line 64 of the 'Regional-Properties' worksheet in the area associated with the currently selected region. That number is set to correspond with the number of travelers indicated in the green field when the 'Trip Access and Egress Leg Selection' user form loads. If the number of travelers is manually changed, then a user must also change the region selection to force the macro to update the number of travelers written to the 'Regional-Properties' worksheet.*

Advanced users may also manually adjust the access and egress leg specifications for a rail trip directly on the 'Rail-I-O' worksheet. Clicking on the blue "Rail-I-O Access/Egress" button in the upper left region of the 'Rail-I-O' worksheet will change the display focus to the appropriate area of the worksheet. The access legs are defined in the green fields of the left hand table while the egress legs are defined in the green fields of the table to the right (the user must scroll the screen to view it). Clicking one of the light blue buttons at the top of the screen will bring the associated access/egress tables into view. Clicking the blue "Rail-I-O" button will return to the main Rail Simulation Module user's interface. The currently configured rail mode simulations may then be executed directly from the 'Rail-I-O' worksheet by clicking the blue "Calculate Rail" button or the user can return to the main user interface on the 'Master-I-O' worksheet by clicking the blue "Master-I-O" button in the upper right area.

Clicking the blue "Calculate Selections" button at the upper left of the 'Master-I-O' display or the blue "Calculate Rail" button at the upper left of the 'Rail-I-O' display will trigger the VBA macros to perform the currently configured simulations. Executing an analysis from the 'Master-I-O' display will cause the display focus to switch to the simulation results summary table appropriate for the type of analysis being performed and the numbers will be updated as the simulation process proceeds. Executing from the 'Rail-I-O' worksheet does not automatically switch display focus and the results summary tables may be accessed by clicking the appropriate blue navigation button in the top right hand quadrant.

Simulation results are reported in the 'Master-I-O' worksheet in a location dedicated to the specific type of analysis being performed. As previously mentioned, the VBA macro automatically changes the focus of the worksheet window to the relevant data output area. Figure A-24 illustrates the tabular format of results provided after a single train simulation analysis. This output table may be configured to display results in either "metric" or "U.S." units according to a selection made from the green pulldown list at cell 'Master-I-O'!AE605. The highlighted arrow in the figure indicates a blue shortcut button located in the upper frozen pane of the 'Master-I-O' worksheet which may be clicked to jump directly to the single train simulation output area when it is not in view. Clicking on the blue 'Master-I-O' button will return window focus to the trip definition area on the 'Master-I-O' worksheet.



Component	Units	Inherent Resistance: Rolling Resistance	Inherent Resistance: Dynamic Resistance	Inherent Resistance: Aerodynamic Resistance	Brake Dissipation: Sched Stops permanent slow-orders	Brake Dissipation: Other stops/ Temporary Slow-Orders	Brake Dissipation: Down Grades	Track Curve Resistance	Total Traction (after combustion)	Traction Power Losses and Loco Aux	Total Hotel (after combustion)	To Cons per r tr
Energy	(kJ)	20,032,884	0	62,039,072	25,770,221	14,514,085	4,038,990	1,197,733	127,592,985	31,547,547	21,462,065	180,6
	(%-traction)	15.7%	0.0%	48.6%	20.2%	11.4%	3.2%	0.9%	100.0%			
	(%-total)	11.1%	0.0%	34.4%	14.3%	8.0%	2.2%	0.7%	70.6%	17.5%	11.9%	1
	(%-sub-total)		45%			25%						
GHG emissions	(kg-CO2-eq)	1,554	0	4,812	1,999	1,126	313	93	9,897	2,447	1,665	14,
	(%-traction)	15.7%	0.0%	48.6%	20.2%	11.4%	3.2%	0.9%	100.0%			
	(%-total)	11.1%	0.0%	34.4%	14.3%	8.0%	2.2%	0.7%	70.6%	17.5%	11.9%	1
	(%-sub-total)		45%			25%						

Category	Intentity Measures*						Service Metrics	
Divisor	per round trip		per seat-km		per passenger-km		travel time	average speed
Units of Measure	(kJ)	kg - GHG	(kJ)	g - GHG	(kJ)	g - GHG	(hrs)	(km/h)
Parameter Values	602,911	45.1	337.2	25.2	562.0	42.0	9.0	119.0

* GHG is measured in kg of CO2-equivalent

Figure A-24 Single Train Simulation Output Tables Area

Figure A-25 depicts the output tables provided for a technology comparison analysis. These tables may be configured to display results in either “metric” or “U.S.” units according to a selection made from the green pulldown list at cell ‘Master-I-O’!AE705. In these tables, the results of the technology alternatives are compared with those for the baseline rail trip. In cases where less than a full set of 3 alternatives are evaluated, the user should uncheck the check box located just to the right of the ‘Define Alternative #’ button on the trip definition area of the ‘Master-I-O’ worksheet (see Figure A-3 on page A-7) so that the unneeded analyses will not be performed.

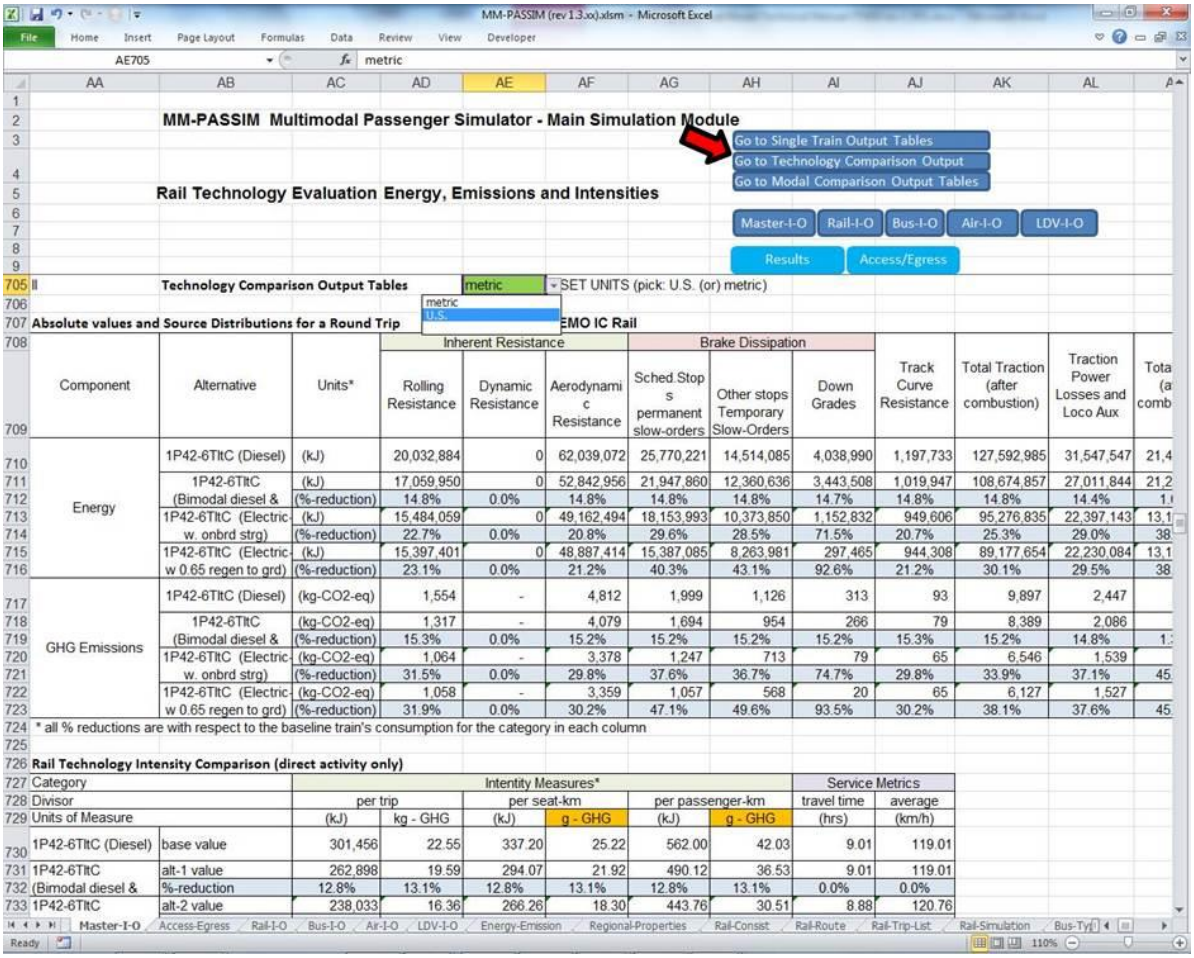
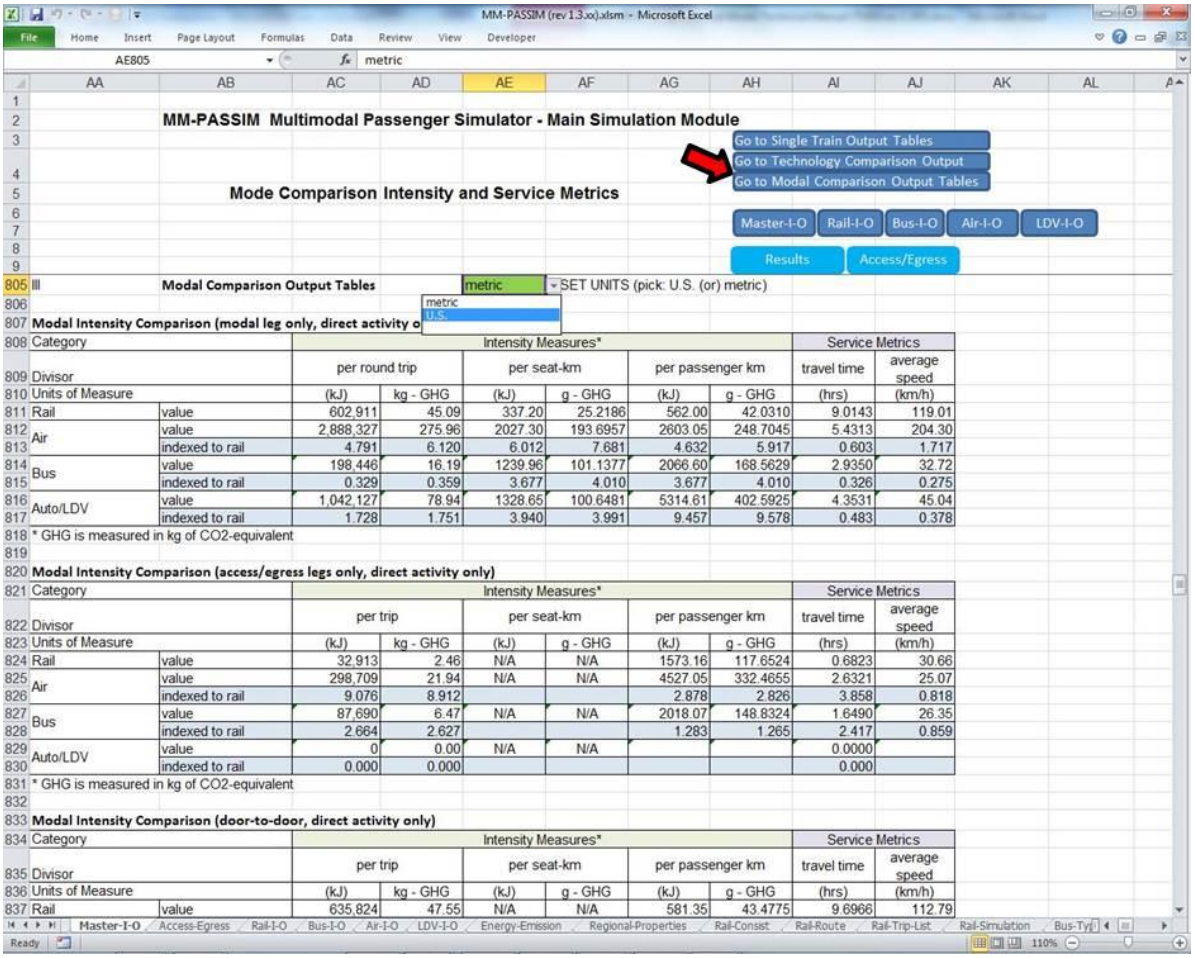


Figure A-25 Rail Technology Comparison Output Tables Area

Figure A-26 illustrates the output tables provided for a modal comparison analysis. You may select the unit system output by selecting from the green pulldown list at 'Master-I-O'!AE805. The rail related numbers on the top line always correspond with those calculated for the rail mode baseline trip. The modal comparison analysis organizes results into four tables. The first table presents a modal intensity comparison for the direct activity on the main modal leg of each mode simulated and includes energy and GHG emission intensities for a passenger round trip, per seat-distance and also per passenger-distance. Travel time and average speed for a round trip on the main modal leg are also shown. The intensity measures and service metrics for each non-rail mode are also indexed to the baseline rail mode case. The second output table presents a modal intensity comparison for the direct activity of the access/egress legs involved in the round trip for each selected transportation mode. We note that per seat-distance intensities are not calculated in this table, as indicated by "N/A" in the column, because the number of seats is not defined for all modes in in the access/egress source data. The third table calculates the intensities and service metrics for the door-to-door direct activity of the main trip's transportation mode and the access/egress legs. Finally, the fourth table presents the overall door-to-door intensities and service metrics including both direct activity as well as indirect well-to-pump consumption,



Category		Intensity Measures*						Service Metrics	
Divisor		per round trip		per seat-km		per passenger km		travel time	average speed
Units of Measure		(kJ)	kg - GHG	(kJ)	g - GHG	(kJ)	g - GHG	(hrs)	(km/h)
Rail	value	602.911	45.09	337.20	25.2186	562.00	42.0310	9.0143	119.01
Air	value	2,888.327	275.96	2027.30	193.6957	2603.05	248.7045	5.4313	204.30
	indexed to rail	4.791	6.120	6.012	7.681	4.632	5.917	0.603	1.717
Bus	value	198.446	16.19	1239.96	101.1377	2066.60	168.5629	2.9350	32.72
	indexed to rail	0.329	0.359	3.677	4.010	3.677	4.010	0.326	0.275
Auto/LDV	value	1,042.127	78.94	1328.65	100.6481	5314.61	402.5925	4.3531	45.04
	indexed to rail	1.728	1.751	3.940	3.991	9.457	9.578	0.483	0.378

* GHG is measured in kg of CO2-equivalent

Category		Intensity Measures*						Service Metrics	
Divisor		per trip		per seat-km		per passenger km		travel time	average speed
Units of Measure		(kJ)	kg - GHG	(kJ)	g - GHG	(kJ)	g - GHG	(hrs)	(km/h)
Rail	value	32.913	2.46	N/A	N/A	1573.16	117.6524	0.6823	30.66
Air	value	298.709	21.94	N/A	N/A	4527.05	332.4655	2.6321	25.07
	indexed to rail	9.076	8.912			2.878	2.826	3.858	0.818
Bus	value	87.690	6.47	N/A	N/A	2018.07	148.8324	1.6490	26.35
	indexed to rail	2.664	2.627			1.283	1.265	2.417	0.859
Auto/LDV	value	0	0.00	N/A	N/A			0.0000	
	indexed to rail	0.000	0.000					0.000	

* GHG is measured in kg of CO2-equivalent

Category		Intensity Measures*						Service Metrics	
Divisor		per trip		per seat-km		per passenger km		travel time	average speed
Units of Measure		(kJ)	kg - GHG	(kJ)	g - GHG	(kJ)	g - GHG	(hrs)	(km/h)
Rail	value	635.824	47.55	N/A	N/A	581.35	43.4775	9.6966	112.79

Figure A-26 'Master-I-O' Modal Comparison Output Tables Area

A.5.2 Configuring and Running an Air Mode Comparison

The Air-Simulation module is implemented using five (5) user accessible worksheets which together with the 'Master-I-O' worksheet provide for simulation configuration, user input and results output of air mode comparison analyses. These user accessible worksheets include the 'Air-I-O', 'Energy-Emission', 'Regional-Properties', 'Air-Trip-List' and 'Air-Default-Data' worksheets. While the 'Air-Trip-List' worksheet, which maintains the list of all configured air mode trips, is accessible to the user, it is typically maintained by the VBA macro code via the system of coordinated user forms. The 'Energy-Emission' worksheet specifies the energy and emissions characteristics of all fuel/energy sources used for all transportation modes and is therefore shared by all transportation mode sub-models. The Regional-Properties' worksheet is also used by all transportation modes. The 'Air-Default-Data' worksheet contains the default data referenced and used by the other air mode related worksheets. These data can be adjusted with care by a knowledgeable user.

The air mode simulation calculations are performed on the 'Air-Simulation' worksheet which should not normally be modified by a user. That worksheet predicts the energy use, GHG emissions produced and travel time associated with a forward direction air mode trip and a default return trip (assumed to be the mirror image of the forward trip). However, it is possible, and often desirable, to configure a two-way air mode trip as two successive one-way forward trips to achieve considerably more flexibility than if confined to a return trip defined as a simple mirror-image of the forward trip. That being the case, simulations of a two-way air trip may require two successive simulation sequences involving transfer of configuration data to the worksheet, recalculation of the worksheet and then transfer of results from the worksheet. That scenario is automatically set up and handled by the pop-up user forms and the VBA macros.

Defining an air mode simulation can be accomplished using the VBA macros and system of pop-up user forms available from the 'Master-I-O' worksheet when "Mode Comparison" has been selected in the green drop-down list at the top of the display or alternatively it may be configured directly from the 'Air-I-O' worksheet. Clicking any of the blue "Define Alternative #" buttons available on the left hand side of the 'Master-I-O' worksheet while the "'Mode Comparison" has been selected will prompt the user to choose a transportation mode for comparison. Selecting "Air" from the green drop-down list, as depicted in Figure A-27, and then clicking on the "Select & Edit" button will open the "Air Trip Selection" user form as shown in Figure A-28. Clicking on the "Select & Return" button will change the 'Master-I-O' trips to those defined on the 'Air-I-O' worksheet without displaying the "Air Trip Selection" user form. Table A-5 summarizes the steps required to configure an air trip.

Table A-5 Configuration Steps Required for an Air Trip

Define Air Case	Configuration Steps Required
Air Trip Selection Form	• Either select an existing Air trip from the 'Trip ID' drop-down list and click "Select and Return" or • Create a new Air trip by clicking "Add Air Trip" button • Enter a description of the Air trip • Pick the region • Set the number of travelers • Pick direction of travel • Pick the IATA code of the origin airport • Pick the departure airport activity period • Pick the IATA code of first intermediate airport stop (optional) • Pick the IATA code of second intermediate airport stop (optional) • Pick the IATA code of the destination airport • Pick the airport activity period for the default return trip • Set the fraction of multi-leg flights (multi + direct must equal 1) • Set the fraction of direct flights (multi + direct must equal 1) • Pick time of day for departure of outbound trip • Pick time of day for arrival of outbound trip • Pick day of week for outbound trip • Pick time of day for departure of return trip • Pick time of day for arrival of return trip • Pick day of week for return trip • Pick season of both outbound and return trips • Pick the aircraft data source (either default or user) • Pick the aircraft fuel type and only when user aircraft data is selected • Set/adjust the seat-km for each aircraft type over each leg of travel (note that each leg column must sum to 100%) • Set/adjust the load factor for each aircraft type (double click a green field to select the value from default data) • Set/adjust the landing and takeoff fuel for each aircraft type (double click a green field to select the value from default data) • Set/adjust the cruise fuel consumption for each aircraft type during peak activity period (double click a green field to select the value from default data) • Set/adjust the cruise fuel consumption for each aircraft type during off-peak activity period (double click a green field to select the value from default data) • Set/adjust the average cruise fuel consumption for each aircraft type (double click a green field to select the value from default data) • Assign access and egress legs by clicking the "Access & Egress" button • Save the new Air trip by clicking "Save Air Trip" button • Select the newly added Air trip by clicking "Select & Return" button

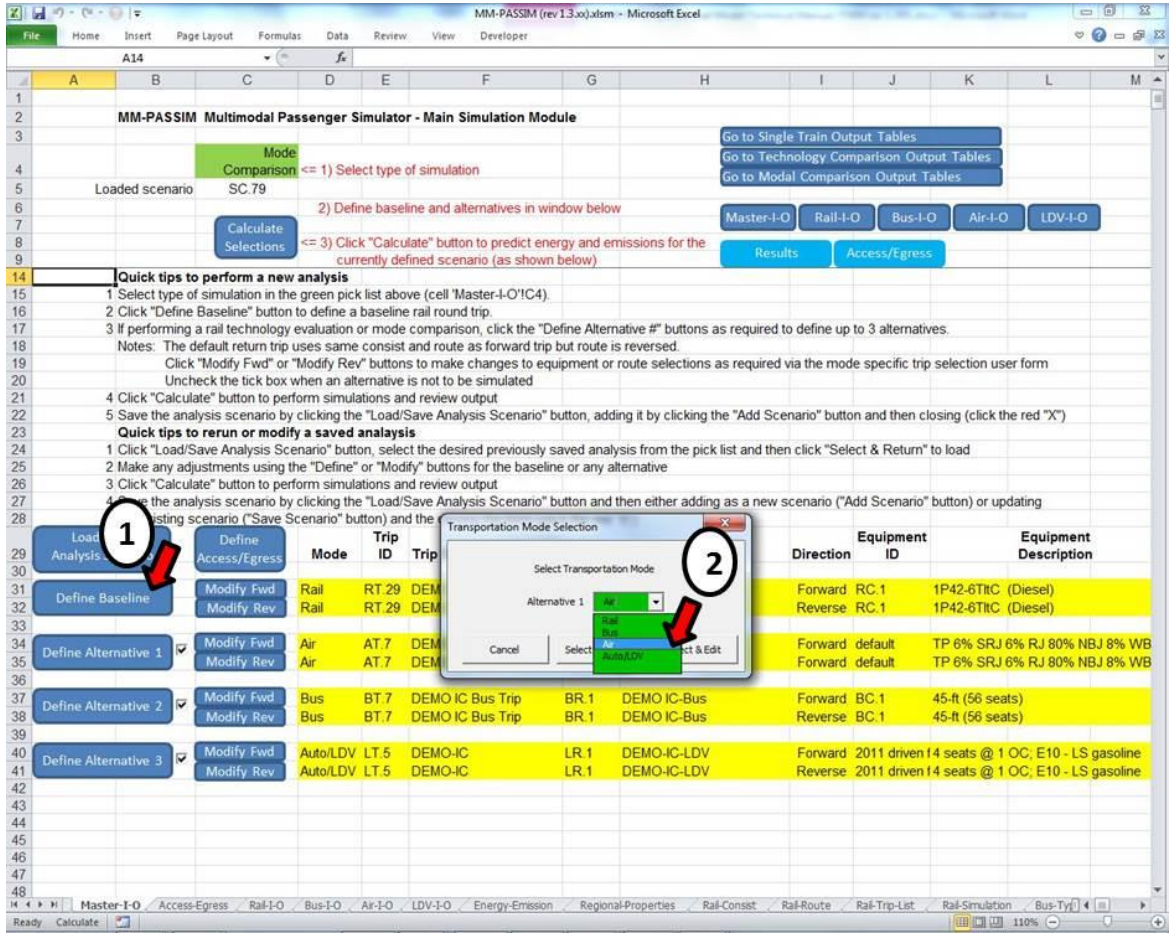


Figure A-27 Selecting an Air Mode Round Trip

Selecting an Air Mode Trip

On the "Master-I-O" worksheet:

a) Click blue "Define Alternative #' button on left hand side of worksheet (see highlight 1).

On "Transportation Mode Selection" form:

b) Click on gray arrow on right hand side of the green transportation mode drop-down list and then select the "Air" mode from the list (see highlight 2)

c) Click gray "Select & Edit" button at right to open the "Air Trip Selection" form.

or

Click gray "Select & Return" button in centre to use trip currently defined on the "Air-I-O" worksheet

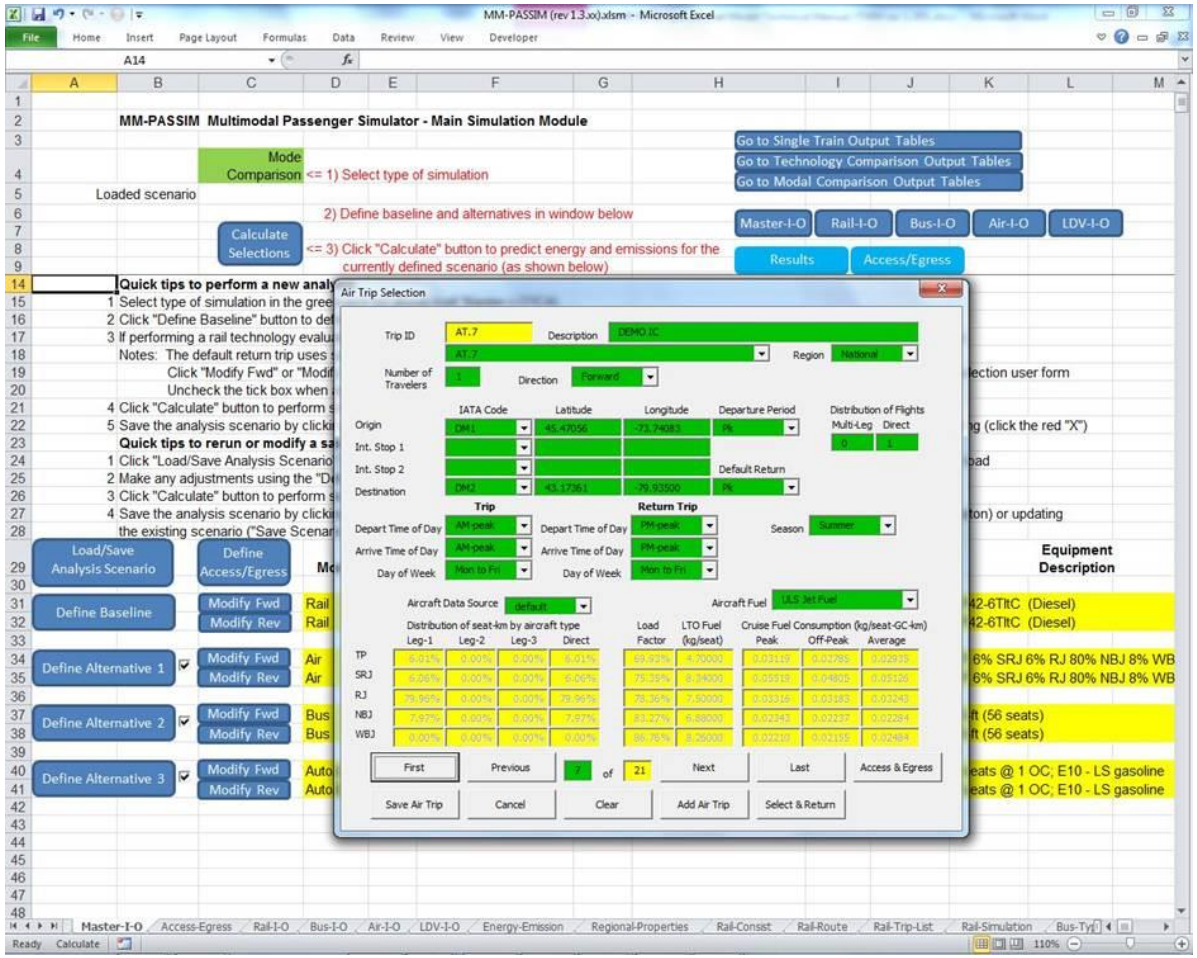


Figure A-28 Defining the Air Mode Round Trip

Usage Notes:

- Either select an existing Air trip from the green "Trip ID" drop-down list and click "Select and Return"

or

- Create a new Air trip by clicking the "Add Air Trip" button
- Enter description
- Pick direction of travel
- Pick IATA codes for all airports in trip
- Pick departure and arrival time of day and day of week (outbound & inbound)
- Pick Season
- Pick aircraft data source and fuel type
- Set/adjust aircraft data as required (double click yellow field to modify)
- Assign access/egress legs by clicking "Access & Egress" button
- Save the new Air trip by clicking "Save Air Trip" button
- Select the newly added Air Trip by clicking "Select & Return" button

An air trip is configured by adjusting the green fields on the 'Air Trip Selection' user form, shown in Figure A-28, to suit the desired scenario. The yellow "Trip ID" and green "Description" fields identify the currently displayed air trip. The gray navigation buttons at the bottom of the user form facilitate access to all previously defined air tips for review and potential use either as the desired trip or to serve as a template upon which to build a new trip. An existing air trip may also be selected from the green drop-down list located immediately below the "Trip ID" and "Description" information fields. The region, number of travelers and direction of travel are all set using green fields in the top portion of the user form. To define an air trip, the origin and destination cities and up to two optional intermediate stops are selected from the green drop-down list fields which choose from location data stored in the 'Air-Default-Data' worksheet. Airport latitude and longitude are automatically filled in when an airport code is selected. The user may add to that list of cities following the pre-defined tabular format (see cells 'Air-Default-Data'!B4:G8) by inputting the IATA code, city name, latitude and longitude. The 'Air-Simulation' worksheet automatically calculates the great circle distance between cities from those coordinates during the simulation. The air trip may also be represented using a distribution of multi-leg and direct flights as defined by the green user input fields to the right of the trip leg definitions. The user also must define the flight departure and default return service period which can only have values of "Pk" for peak period or "OffPk" for anytime outside the peak air travel service period. The air trip departure and arrival times, day of week and season are defined for both the outbound and return air trips using the set of seven green drop-down lists in the area below the air trip definition area. Please note that these departure and arrival time periods refer to periods of city activity which differ from the air travel service period for use in the intensities of highway access/egress modes.

Specifying Aircraft Parameters

The aircraft parameters are specified in the lower portion of the 'Air Trip Selection' user form. The aircraft fuel type is set from the list available in the green drop-down list. The remaining primary simulation inputs are provided for five (5) broad aircraft categories which include turboprop (TP), small regional jet (SRJ), regional jet (RJ), narrow body jet (NBJ) and wide body jet (WBJ). The aircraft simulation parameters include a default distribution of seat-kilometers by aircraft category for a given trip length as well as passenger load factors, the landing and takeoff (LTO) fuel consumption and the cruise fuel consumption intensity for each aircraft category. Default values for these parameters are provided in the 'Air-Default-Data' worksheet and are automatically loaded into the fields of the "Air Trip Selection" user form when the green "Aircraft Data Source" on the left hand side is set to "default". Changing the "Aircraft Data Source" field to "user" will toggle the fields from yellow to green and allow user modifications of any of the green data fields. The main modification expected by users is from the default distribution of aircraft used for that distance to a single selected aircraft type. However, all characteristics of each aircraft category can also be accessed and modified from the menu when displaying the "user" data. Double clicking on any green cell in the five columns on the right hand side (load factor, LTO fuel and cruise fuel consumptions) will toggle that cell's view to display the default data in a yellow box. Double clicking the yellow box will toggle the view back to the user configured data.

Defining Access & Egress

The method of passenger access and egress to and from an airport may be specified by clicking the “Access & Egress” button in the lower right hand quadrant to open the “Trip Access and Egress Leg Selection” user form (Figure A-29). The access and egress legs currently defined for the displayed air trip will be shown and the user may adjust all green fields accordingly. If a leg is not required then it should be removed by selecting “none” in the green drop-down list for that leg. The user can also scroll through the access and egress legs configured for any existing air trips using the navigation buttons. This allows any existing access/egress configuration to be used as a template for the current trip. Clicking the “Select & Return” button will associate the currently displayed access & egress leg configurations with the air trip being defined.

Access and egress legs are defined separately in the ‘Trip Access and Egress Leg Selection’ form. The region, city size and time of day may all be selected to best characterize the origin and destination of a trip. Clicking on the green ‘Region’ drop-down list permits selection of any region defined in the ‘Regional-Properties’ worksheet. A table of fuel and emissions intensity values for all access and egress modes is provided for each defined region presented in the drop-down list. The green ‘City Size’ and ‘Time of Day’ selections offer a limited number of choices to further tailor the access or egress modes. The choices of ‘City Size’ may be ‘Small Cities’, ‘Large Cities’, ‘Rural Municipality’ or ‘All Cities’ while the choices for ‘Time of Day’ include ‘Peak’, ‘Off-peak’ and ‘All’. Those values guide the VBA macro when choosing the most appropriate values from the table for a selected access/egress mode. The user is advised that the VBA macro expects every unique access/egress mode to be defined within the top portion of that table which would normally be associated with ‘All Cities’.

Access and egress leg are selected by picking from the modes presented in the green drop-down lists. When a mode is selected, the user form automatically fills five of the remaining seven green data fields with default values selected from the region’s data table. These default data include speed, fuel source, fuel intensity, energy intensity and GHG intensity. Although the inserted default data fields are yellow, the values may be adjusted to meet the user’s requirements. The user must manually provide data for the green fields specifying the distance to be traveled using that access/egress mode (in miles) and a dwell time (in minutes) for that leg. Once these access/egress data have been saved with a trip, they will appear green the next time they are loaded. The user is cautioned that the simulation dynamically calculates Auto/LDV access/egress mode intensities using the number of travelers as displayed in the pink cell in the on line 64 of the ‘Regional-Properties’ worksheet in the area associated with the currently selected region. That number is set to correspond with the number of travelers indicated in the green field when the ‘Trip Access and Egress Leg Selection’ user form loads. If the number of travelers is manually changed, then a user must also change the region selection to force the macro to update the number of travelers written to the ‘Regional-Properties’ worksheet.

Advanced users may also manually adjust the access and egress leg specifications for an air trip directly on the ‘Air-I-O’ worksheet by clicking on the blue “Air-I-O Access/Egress” button in the upper left region of the ‘Air-I-O’ worksheet to change the display focus to the appropriate area of the worksheet. The access legs are defined in the green fields of the left hand table while the egress legs are defined in the green fields of the table to the right (the user must scroll the screen to view it). Clicking the blue “Air-I-O” button will return to the main Air Simulation Module user’s interface. The currently configured air mode simulations may then be executed directly from the ‘Air-I-O’ worksheet by clicking the blue “Calculate Air” button or the user can return to the main user interface on the ‘Master-I-O’ worksheet by clicking the blue “Master-I-O” button in the upper right quadrant of the display.

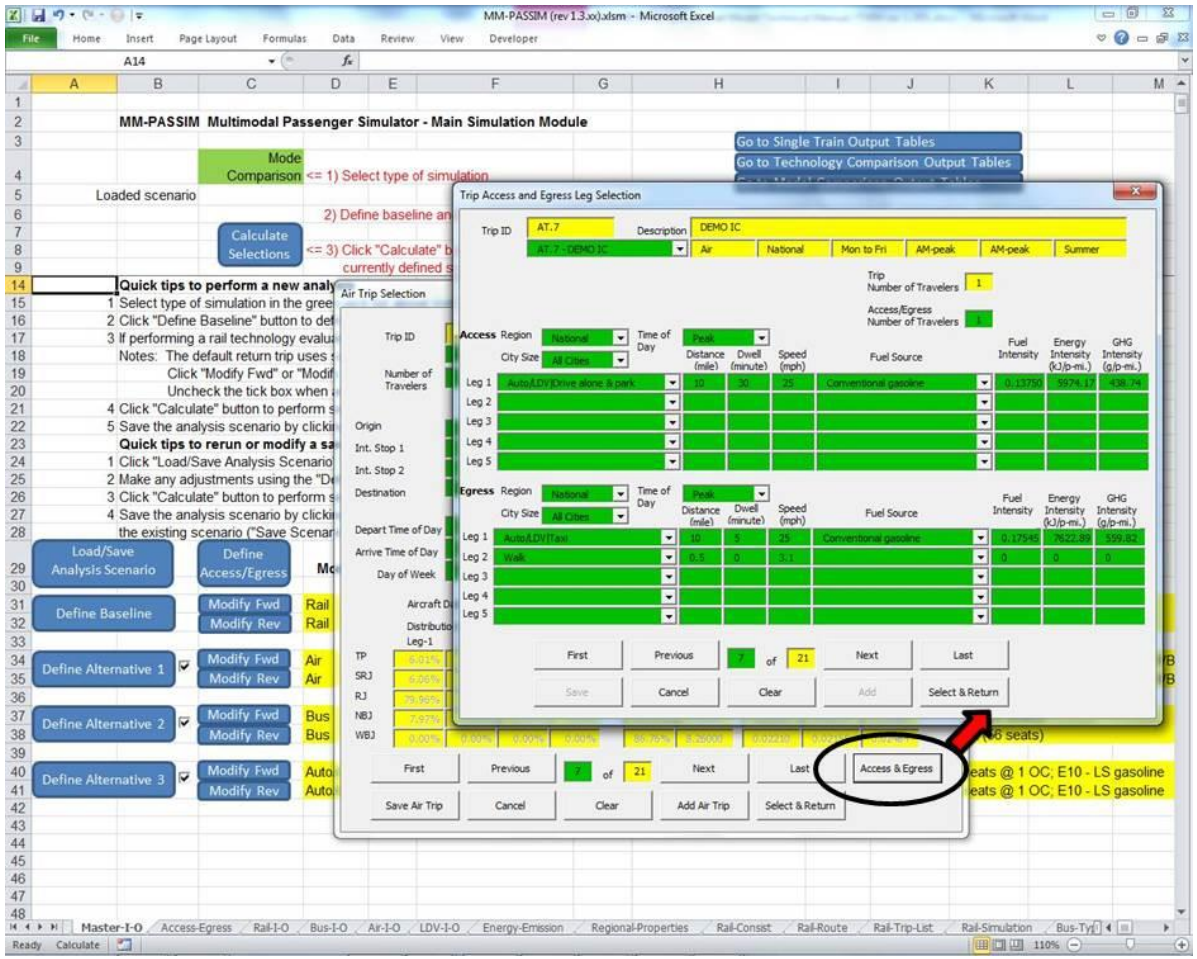


Figure A-29 Assigning Access & Egress Legs from Air Trip Selection User Form

To view and modify access/egress legs from the "Air Trip Selection" form:

On the "Air Trip Selection" user form:

a) Click on the gray "Access & Egress" button (see oval highlight and arrow) to open the "Trip Access and Egress Leg Selection" form – the form will display the access & egress legs configured for the current trip.

On "Access and Egress Leg Selection" Form:

b) Select any trip from the green "Trip ID" drop-down list

or

Use the gray navigation buttons to display the access/egress legs for any saved air trip.

c) Make any required adjustments in the green fields

d) Click on the gray "Select & Return" button to pass the currently displayed access & egress leg configuration back and returns to the "Air Trip Selection" user form.

Clicking the blue “Calculate Selections” button at the upper left of the ‘Master-I-O’ display or the blue “Calculate Air” button at the upper left of the ‘Air-I-O’ display will trigger the VBA macros to perform the currently configured simulations. Executing an analysis from the ‘Master-I-O’ display will cause the display focus to switch to the simulation results summary table appropriate for the type of analysis being performed and the numbers will be updated as the simulation process proceeds. Executing from the ‘Air-I-O’ worksheet does not automatically switch display focus and the results summary tables may be accessed by clicking the appropriate blue navigation button in the top right hand quadrant.

Simulation results are reported in the ‘Master-I-O’ worksheet in a location dedicated to the specific type of analysis being performed. As previously mentioned, the VBA macro automatically changes the focus of the worksheet window to the relevant data output area. Figure A-30 illustrates the tabular format of results provided after a mode comparison analysis is performed. The unit system displayed in these tables may be selected from the green pulldown list at ‘Master-I-O’!AE805. The highlighted arrow in the figure indicates a blue shortcut button located in the upper frozen pane which may be clicked to jump directly the mode comparison summary results table. Clicking on the blue ‘Master-I-O’ button will return window focus to the trip definition area on the ‘Master-I-O’ worksheet.

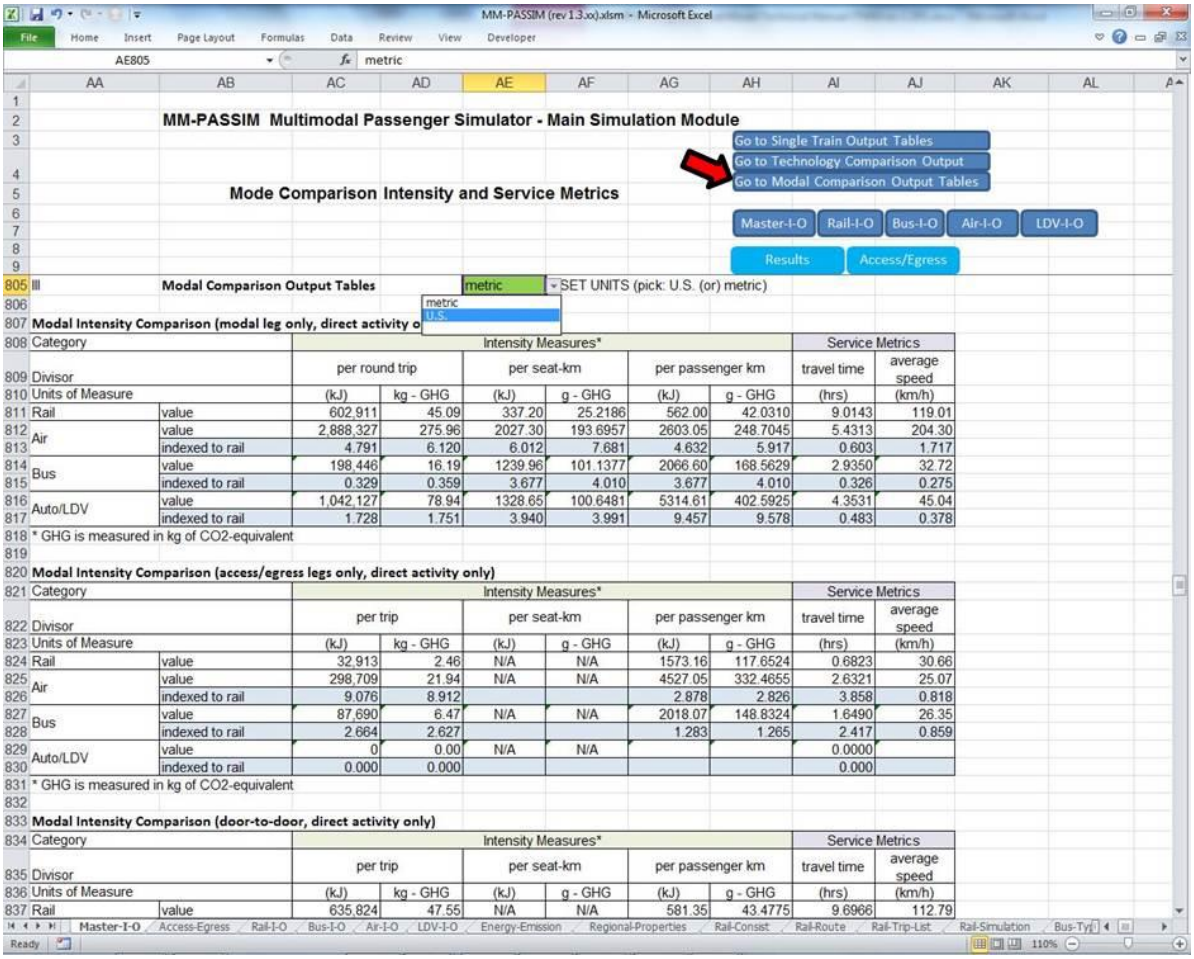


Figure A-30 ‘Master-I-O’ Air Mode Comparison Output Tables Area

A modal comparison analysis organizes results into four tables. The rail related numbers on the first line of each table correspond with those calculated for the rail mode baseline trip. The first table presents a modal intensity comparison for the direct activity on the main modal leg of each mode simulated and includes energy and GHG emission intensities for a passenger round trip, per seat-distance and also per passenger-distance. Travel time and average speed for a round trip on the main modal leg are also shown. The intensity measures and service metrics for each non-rail mode are also indexed to the baseline rail mode case. The second output table presents a modal intensity comparison for the direct activity of the access/egress legs involved required for a round trip of each selected transportation mode. Seat-distance intensities are not calculated in this table, as indicated by "N/A" in the column, because the number of seats is not defined in the access/egress mode data. The third table calculates the intensities and service metrics for the door-to-door direct activity of the main trip's transportation mode and the access/egress legs. Finally, the fourth table presents the overall door-to-door intensities and service metrics including both direct activity as well as indirect well-to-pump consumption,

A.5.3 Configuring and Running a Bus Mode Comparison

The Bus-Simulation module is implemented in eleven (11) worksheets which together with the 'Master-I-O' worksheet provide for simulation configuration, user input and results output of bus mode comparison analyses. The user accessible worksheets include the 'Bus-I-O', 'Energy-Emission', 'Regional-Properties', 'Bus-Type', 'Bus-Route', 'Bus-Drive-Schedules' and 'Bus-Trip-List' worksheets. The 'Bus-Trip-List' worksheet maintains the list of all configured bus mode trips and is typically maintained by the VBA macro code via the system of coordinated user forms although it may also be directly modified by an experienced user. The 'Energy-Emission' worksheet specifies the energy and emissions characteristics of all fuel/energy sources used for all transportation modes and is therefore shared by all transportation mode sub-models. The 'Regional-Properties' worksheet defines those parameters which may vary by geographical area. The 'Bus-Type', 'Bus-Route' and 'Bus-Drive-Schedules' worksheets contain most of the user configurable data for a bus mode simulation. The 'Bus-Trip', 'Bus-Resist', 'Bus-Engine' and 'Bus-Simulation' worksheets are all used internally to perform a bus mode simulation and should not normally be modified by a user.

A one-way bus mode trip is constructed by concatenating several specified lengths of bus operation. These are governed by pre-defined drive schedules representing driving in urban areas with varying speed limits and traffic densities. There is also a generally much longer segment of cruise in which the vehicle seeks to maintain a speed limit while ascending and descending grades. The 'Bus-Simulation' worksheet predicts the energy use, GHG emissions produced and travel time associated with any one individual portion of a bus mode trip at a time. VBA macros use the information on the 'Bus-I-O' worksheet to automatically manage the transfer of data to and from the 'Bus-Simulation' worksheet for successive portions which together comprise the total distance of a one-way trip.

Defining a bus mode simulation can be accomplished using the VBA macros and system of pop-up user forms available from the 'Master-I-O' worksheet when "Mode Comparison" has been selected in the green drop-down list at the top of the display or alternatively it may be configured directly from the 'Bus-I-O' worksheet. Clicking any of the blue "Define Alternative #" buttons available on the left hand side of the 'Master-I-O' worksheet while the "'Mode Comparison" has been selected will prompt the user to choose a transportation mode for comparison. Selecting "Bus" from the green drop-down list, as depicted in Figure A-31, and then clicking on the "Select & Edit" button will open the "Bus Trip Selection" user form as shown

in Figure A-32. Clicking on the “Select & Return” button directly selects the bus trip which is currently defined on the ‘Bus-I-O’ worksheet without opening the “Bus Trip Selection” user form. Table A-5 lists the steps required to configure a bus trip.

Table A-6 Configuration Steps Required for a Bus Trip

Define Bus Case	Configuration Steps Required
Bus Trip Selection Form	• Either select an existing Bus trip from the ‘Trip ID’ drop-down list and click “Select & Return” or • Create a new Bus trip by clicking “Add Bus Trip” button • Enter a description for the new trip • Pick a Bus route from the “Route ID” drop-down list • Set the scheduled trip time (in hours) • Set the average stop duration (in minutes) • Set the number of travelers • Pick direction of travel • Pick season for both outbound and return trips • Pick freeway drive schedule mix for Urban Area 1 (the origin) • Pick freeway drive schedule mix for Urban Area 2 (the destination) • Pick urban arterial drive schedule mix (for origin and destination) • Pick time of day for departure of outbound trip • Pick time of day for arrival of outbound trip • Pick day of week for outbound trip • Pick time of day for departure of return trip • Pick time of day for arrival of return trip • Pick day of week for return trip • Pick a bus type from the “Coach ID” drop-down list • Set the load factor (between 0 and 1) • Set number of passengers • Pick the bus fuel type • Assign access and egress legs by clicking the “Access & Egress” button • Save the new Bus trip by clicking “Save Bus Trip” button • Select the newly added Bus trip by clicking “Select & Return” button

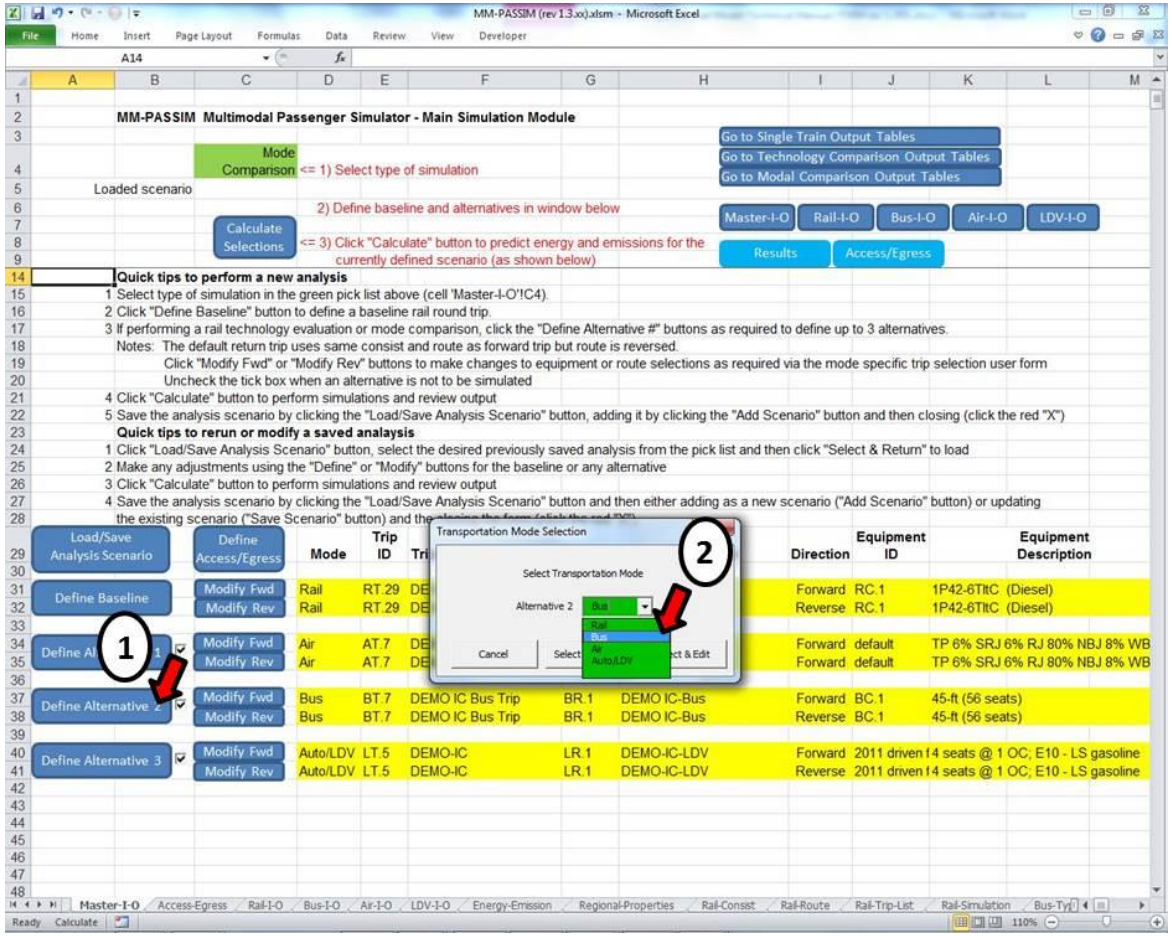


Figure A-31 Selecting a Bus Mode Round Trip

To select a Bus mode trip:

On "Master-I-O" worksheet:

a) Click blue "Define Alternative #' button on left hand side of worksheet (see highlight 1).

On "Transportation Mode Selection" form:

b) Click on gray arrow on right hand side of the green transportation mode drop-down list and then select the "Bus" mode from the list (see highlight 2)

c) Click gray "Select & Edit" button at right to open the "Bus Trip Selection" form.

or

Click gray "Select & Return" button in centre to use trip currently defined on the "Bus-I-O" worksheet

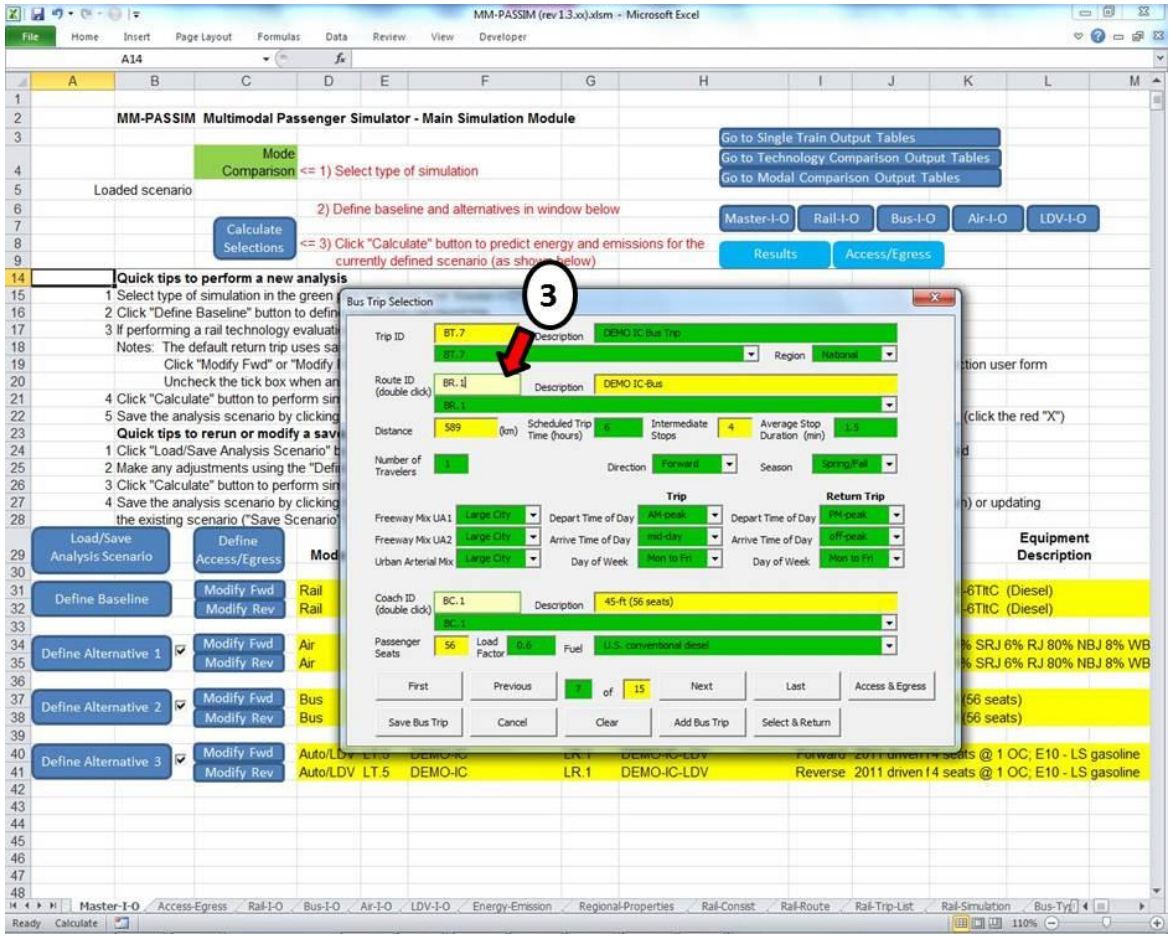


Figure A-32 Defining a Bus Mode Alternative Trip

Usage Notes:

On the "Bus Trip Selection" form:

a) Pick a bus trip from the green "Trip ID" drop-down list at the top.
or
Use the gray navigation buttons at the bottom to display a desired trip

b) Click gray "Add" button if you wish to create a new trip by modifying the currently displayed trip.

c) Double click on light yellow "Route ID" box (see highlight 3) to open the "Bus Route Selection" form and make a route selection.
or
Select a route from the green "Route ID" drop-down list.

d) Double click on light yellow "Coach ID" box to open the "Bus Type Selection" form and make a bus selection
or
Select a bus type from the green "Coach ID" drop-down list.

e) Make any changes to green fields (trip times, day of week, season, number of travelers, etc.).

f) Click on the gray "Save" button to save the modifications.

g) Click on the gray "Select & Return" button to return trip information back to "Master-I-O".

A bus trip is configured by adjusting the green fields in the 'Bus Trip Selection' form to the desired trip characteristics. The navigation buttons at the bottom of the form access all previously defined bus trips to use as the desired trip or as a template for a new trip. A trip may also be selected from the green drop-down list immediately below the yellow "Trip ID" field.

A bus trip combines a route specification with a bus type. A trip is identified by its unique 'Trip ID' (upper left yellow field) and a user modifiable 'Description' (upper right green field). The main trip leg is assumed to occur in a single geographic region, selected with the green "Region" drop-down list. The 'Route ID' associated with a trip is displayed in the light yellow field below the 'Trip ID' field (see highlight 3 in Figure A-32). Immediately right of the Route ID is the route "Description" field.

While complete specification of a bus route involves many parameters and is built on the 'Bus-Route' worksheet, a few are presented on the 'Bus Trip Selection' user form. These include the route distance and number of intermediate stops (in yellow cells which cannot be edited); the scheduled trip time (hours), average stop duration (minutes) and direction of travel which are in green fields and can be adjusted on this form.

The 'Route ID' is changed by double clicking inside the 'Route ID' field (see highlight 4 in Figure A-33) which will open the 'Bus Route Selection' pop up form. Navigation buttons at the bottom of this form allow the user to scroll through all the currently defined bus routes. Once the desired route is displayed, clicking on 'Select & Return' will select that 'Route ID' and return the user to the 'Bus Trip Selection' form. A route may also be selected from the green drop-down list immediately below the "Route ID" and "Description" fields.

Most parameters of a route specification defined in the 'Bus-Route' worksheet are not modifiable from the 'Bus Route Selection' user form. The 'Route ID', 'Description', number of intermediate stops and the distance fields are filled in by the VBA macro to offer sufficient information to the user to identify and confirm the route selection. The scheduled trip time (hour) and average stop duration (min) may be adjusted in the green fields on this form. The route distance summary breaks down the total distance traveled into intercity and urban segments. The overall length and net elevation change of the intercity grade distribution also indicated for information purposes. A user may expand the number of defined routes available for bus mode simulations by adding columns to the 'Bus-Route' worksheet following the pattern of previous entries.

Caution: *Routes added into the 'Bus-Route' worksheet must be offset by 12 columns to the right of the last defined route and the 'Route ID' should be unique and follow the indicated naming convention.*

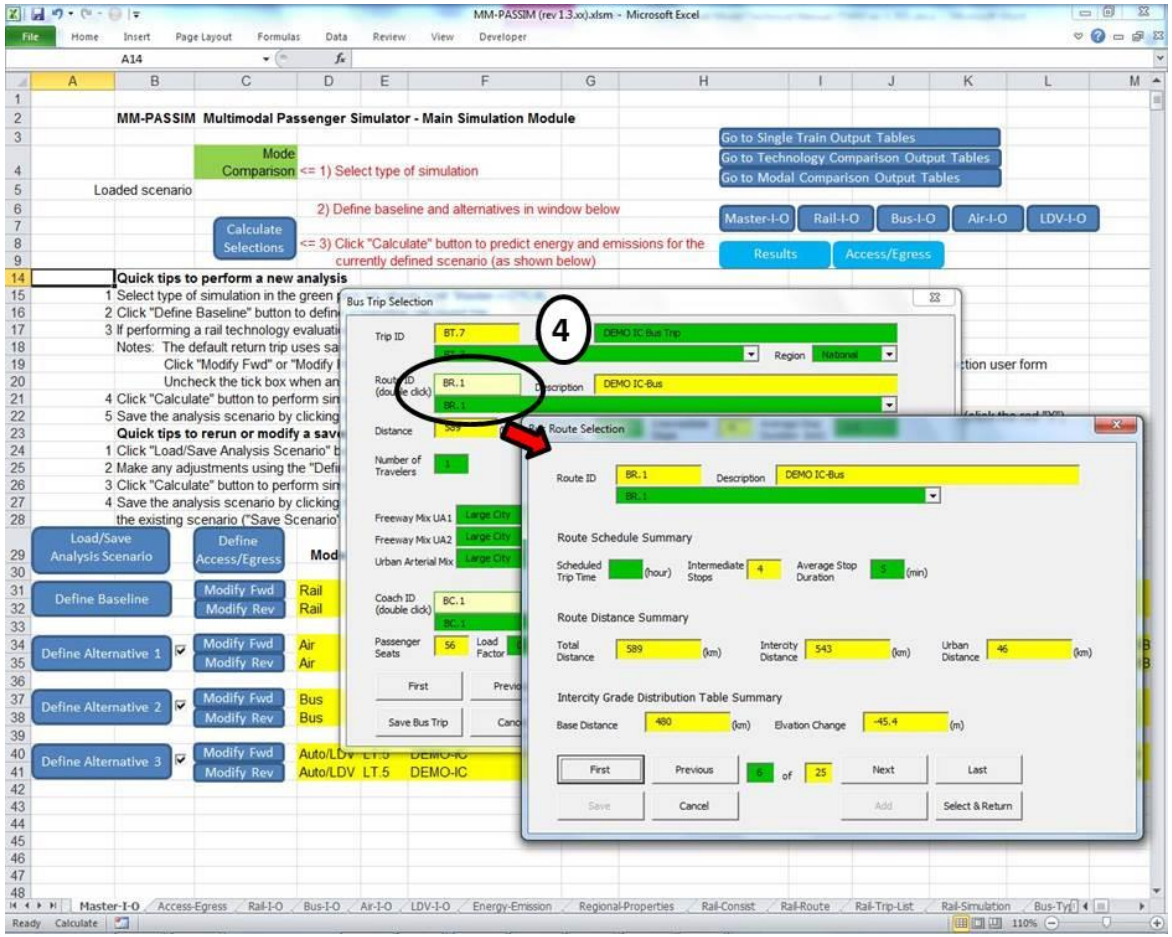


Figure A-33 Selecting a Bus Route

Usage Notes:

On the "Bus Trip Selection" form:

a) Pick a bus route from the green "Route ID" drop-down list.

or

Double click on the light yellow "Route ID" box (see highlight 4) to open the "Bus Route Selection" form and make a route selection.

On the "Bus Route Selection" form:

b) Pick a bus route from the green "Route ID" drop-down list (at top).

or

Use gray navigation buttons to display desired bus route.

c) Adjust scheduled trip time (hours) and average stop duration (minutes) as required.

d) Click gray "Select & Return" button to return to the "Bus Trip Selection" form.

The central portion of the 'Bus Trip Selection' user form contains user adjustable green drop-down list fields which define general characteristics affecting the simulation of bus movements in the origin and destination urban centers. The three fields on the left hand side allow the user to select from three possible configurations of duty cycles used to represent the freeway mix assumed for travel within the origin and destination cities as well as a mix of urban arterial duty cycles to be used for both urban centers. The choices of "Small City", "Large City" or "User Defined" refer to three data tables defined in the 'Bus-Drive-Schedules' worksheet. The "User Defined" table is provided to allow a user to customize the mix of duty cycles for their particular application without having to modify the defaults provided for small and large urban centers. Within these tables, a different mix of duty cycles is provided for 5 time periods which encompass the busy a.m. and p.m. peak periods, the lighter midday and off-peak (or shoulder) periods and finally a mix representing overnight travel. The user's selections from the green 'Depart Time of Day' and 'Arrive Time of Day' drop-down lists provided for the forward and return trips on the 'Bus Trip Selection' user form determines the VBA macro's choice of duty cycle mix to use. Additional green drop-down lists are provided to define the day of week for the forward and return trips as well as the season assumed for both trips.

The 'Coach ID' associated with a bus trip is displayed in the green-bordered light yellow field located in the lower portion of the 'Bus Trip Selection' user form. A coach is selected by either double clicking on the yellow 'Coach ID' field or by selecting it from the green drop-down list immediately below that information field. The yellow "Passenger Seats" and green "Load Factor" and "Fuel" fields provide a basic description of the currently selected coach. Only the load factor and fuel type may be adjusted directly on this form. If a coach is selected by double clicking on the 'Coach ID' field then the 'Bus Type Selection' pop up user form will be displayed (see Figure A-34). Using that form a user accesses the desired 'Coach ID' by navigating through the available list of defined bus coaches using the gray navigation buttons or alternatively by selecting it from the green drop-down list located below the yellow 'Coach ID' field. Clicking on the 'Select & Return' button will pass that selection back to the 'Bus Trip Selection' form. Please note that only the bus load factor may be modified on this form. All bus coach parameters are specified in the 'Bus-Type' worksheet which is accessible to the user.

Caution: *The relative position of parameters within the 'Bus-Type' worksheet must not be altered except to create a new coach which should be positioned relative to the last coach definition using a fixed 7 column offset.*

A new bus trip may be added by clicking the 'Add' button on the 'Select Bus Trip' form. This creates a new 'Trip ID' while preserving the values in the other data fields. A user can clear all data fields by clicking on the 'Clear' button if they so desire, however this should not normally be required as the process of selecting a 'Route ID' and 'Coach ID' will result in the replacement of most of the data fields.

Note: *Any changes made to the data fields on the 'Select Bus Trip' are not automatically saved and the user must explicitly save them by clicking the 'Save' button. Doing so will update the internally stored list of trip definitions (in the 'Bus-Trip-List' worksheet) but will not modify the trip definitions displayed in the bus trip definition area on the 'Master-I-O' sheet. To do so, the user must click on the 'Select & Return' button which will write the trip definitions on the 'Master-I-O' sheet. It is therefore possible to configure and run one-off simulated trips without modifying the trip list.*

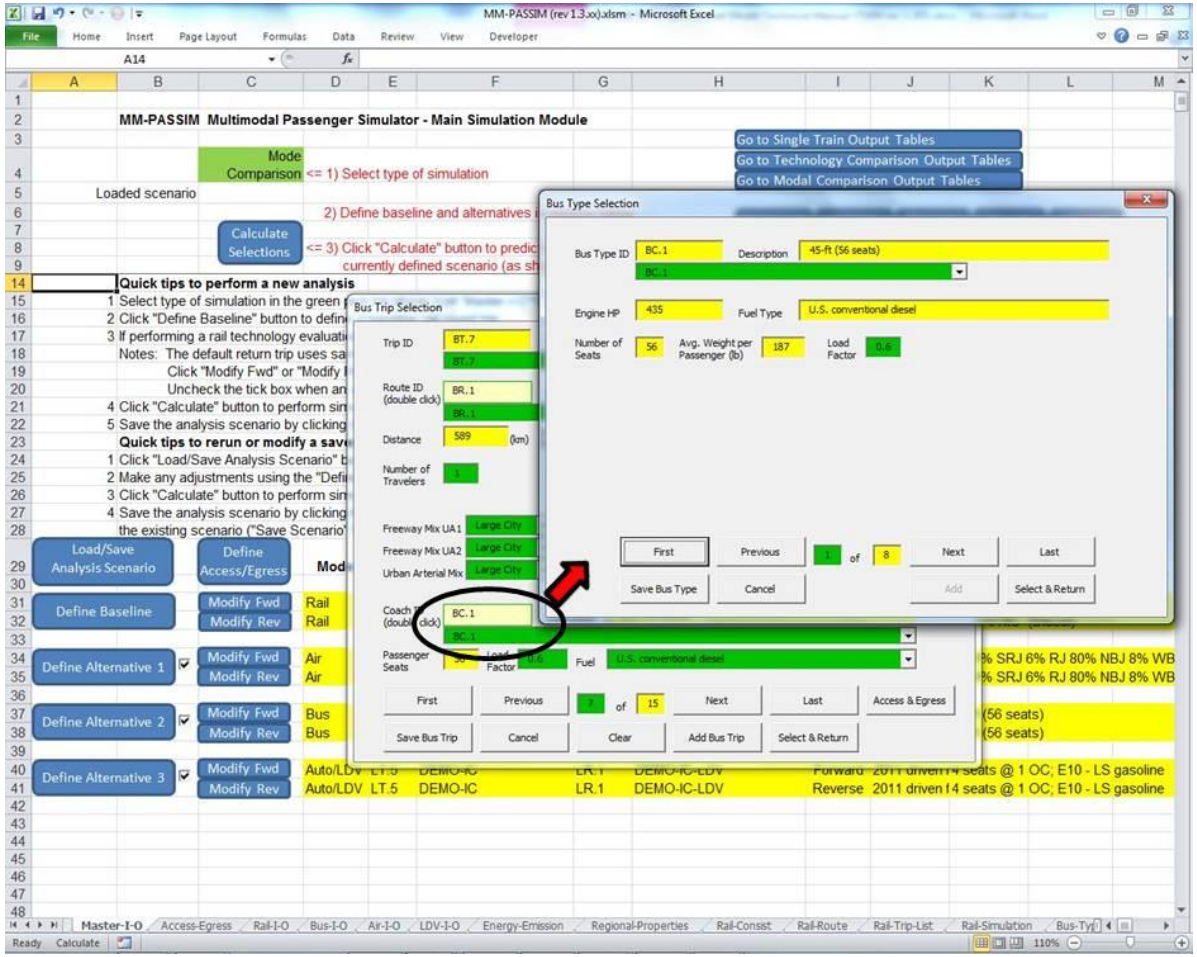


Figure A-34 Selecting a Bus Type

Usage Notes:

On the "Bus Trip Selection" form:

a) Pick a bus type from the green "Coach ID" drop-down list.

or

Double click on the light yellow "Coach ID" box (see oval highlight) to open the "Bus Type Selection" form and make a bus type selection.

On the "Bus Type Selection" form:

b) Pick a bus type from the green "Bus Type ID" drop-down list at the top.

or

Use gray navigation buttons to display the desired bus type.

c) Change the bus load factor (green input field) if required.

d) Click gray "Save Bus Type" button to save changes.

e) Click gray "Select & Return" button to return to the "Bus Trip Selection" form.

Defining a bus mode alternative will automatically assign both the forward and return trips using the same coach and route selections, but the direction of the return trip is reversed from that of the forward trip. In situations where this default return trip definition is not desired, the user can modify either the forward trip or the return trip individually by clicking on the blue "Modify Fwd" or "Modify Rev" buttons as required to access the 'Bus Trip Selection' form (see Figure A-35). It is not necessary that a return trip be run in the reverse direction should a different route be selected for the return trip which has been properly defined for the forward direction. In such a case, set the required direction in the drop-down list (see left pointing arrow highlight in Figure A-35).

Caution: *Users should not directly modify any of the yellow highlighted fields associated with the trip selections listed on the 'Master-I-O' worksheet. This list is used by the VBA macros during the sequencing of the simulation steps and any invalid data or moved items may cause invalid predictions or program failure.*

The passenger's access to the bus mode departure station and their egress from the bus mode arrival station may both be characterized with up to five (5) access/egress legs each. This may be conveniently configured using the pop-up user forms accessed by clicking the blue "Define Access/Egress" button on the 'Master-I-O' worksheet to activate the "Trip Access and Egress Leg Selection" user form. Any currently defined access or egress legs for the selected bus trips can be displayed by using the navigation buttons and all green fields may be adjusted to meet the user's requirements. Note that the access and egress legs are defined separately for each direction of a bus trip.

A user may also assign the access/egress legs for a bus trip by clicking the "Access & Egress" button on the right hand side of the "Bus Trip Selection" user form (Figure A-36). The access and egress legs currently defined for the displayed bus trip will be presented and the user may adjust all green fields accordingly. If all five legs are not required then the extra legs should be removed by selecting "none" from the left most green drop-down list for that leg. The user can also scroll through the access and egress legs configured for any existing bus trips using the navigation buttons. This allows any existing access/egress configuration to be used as a template for the current trip. Clicking the "Select & Return" button will associate the currently displayed access & egress leg configurations with the bus trip being defined.

Note: *Be sure to click the "Save Bus Trip" button on the 'Bus Trip Selection' menu after returning from the 'Trip Access & Egress Leg Selection' menu when any changes were made to the access/egress leg definitions.*

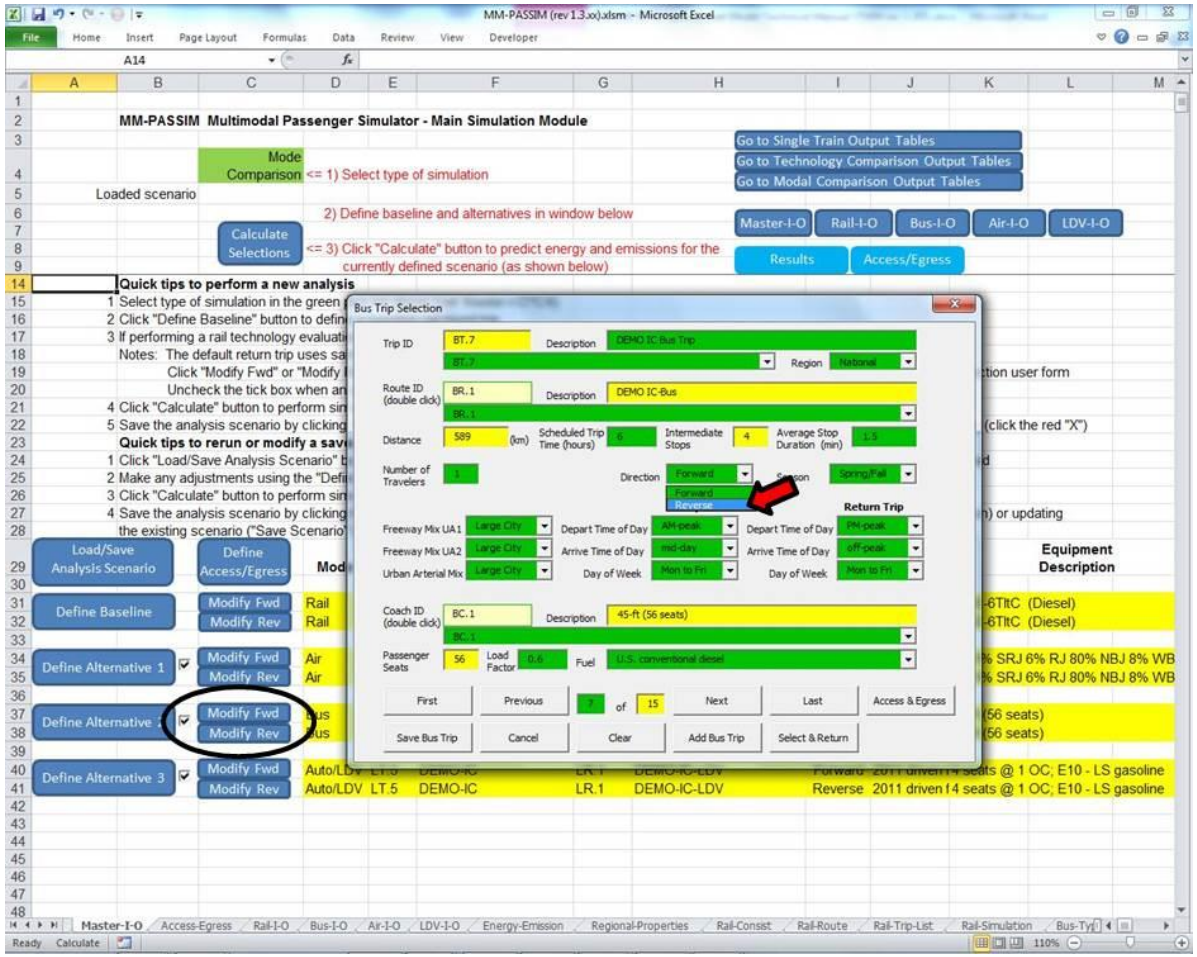


Figure A-35 Modifying a Return Bus Trip

Usage Notes:

On the "Master-I-O" worksheet:

a) Click on either a blue "Modify Fwd" or "Modify Rev" button adjacent to a trip you wish to modify to open the "Bus Trip Selection" form – it will display the currently configured trip.

On the "Bus Trip Selection" form:

b) Pick a rail trip from the green "Trip ID" drop-down list at the top.

or

Use gray navigation buttons to display a desired trip.

c) Use the Click gray "Add Bus Trip" button if you wish to create a new trip by modifying the displayed trip.

d) Click on the gray arrow on the right side of the green "Direction" drop-down list to modify direction of travel (see red arrow).

e) Make any other required adjustments to the green fields in the middle of the form.

f) Click gray "Save Bus Trip" button to save changes to the displayed trip.

g) Click gray "Select & Return" button to return to the "Master-I-O" worksheet.

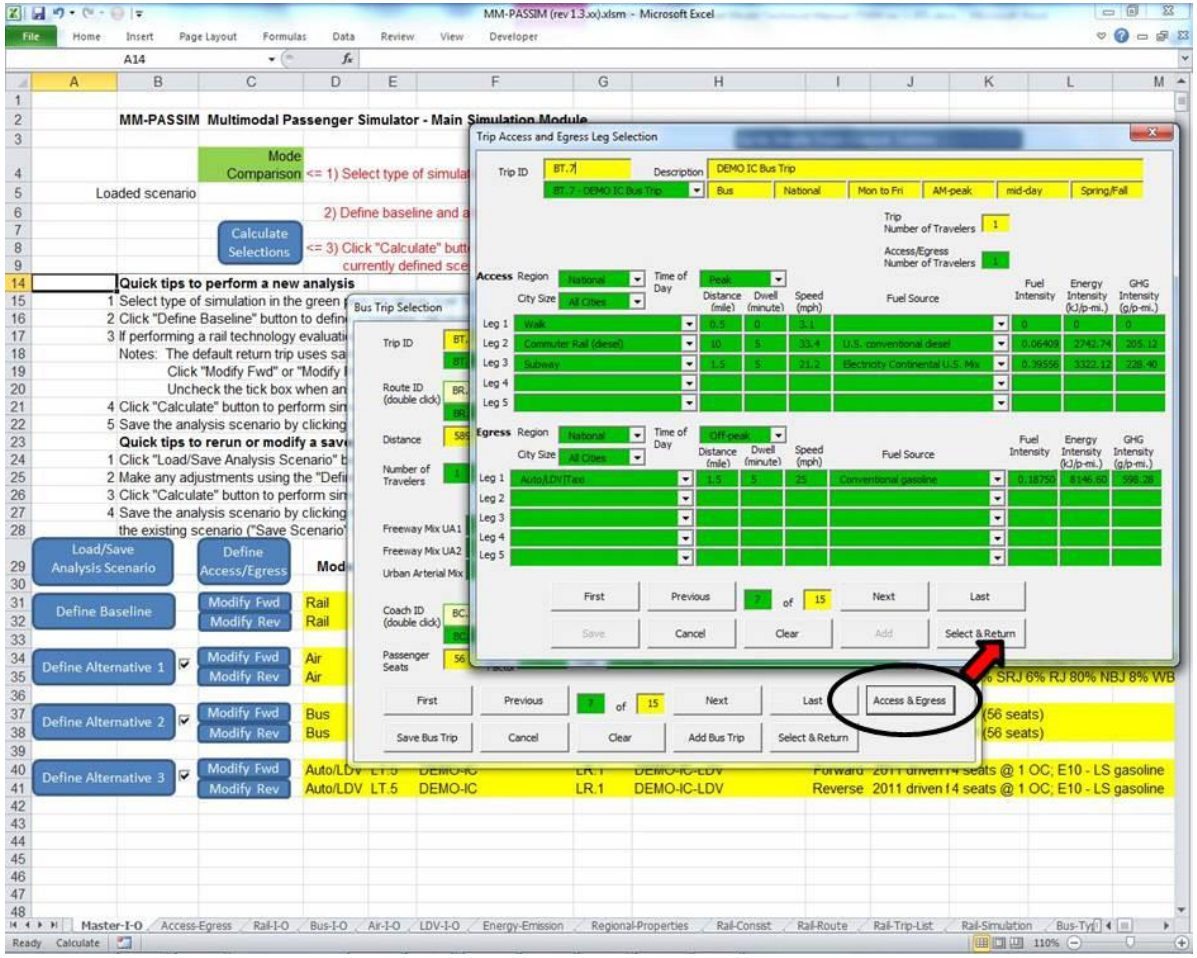


Figure A-36 Assigning Access & Egress Legs from Bus Trip Selection User Form

To view and modify access/egress legs from the "Bus Trip Selection" form:

On the "Bus Trip Selection" user form:

a) Click on the gray "Access & Egress" button (see oval highlight and arrow) to open the "Trip Access and Egress Leg Selection" form – the form will display the access & egress legs configured for the current trip.

On "Access and Egress Leg Selection Form:

b) Select any trip from the green "Trip ID" drop-down list

or

Use the gray navigation buttons to display the access/egress legs for any saved bus trip.

c) Make any required adjustments in the green fields

d) Click on the gray "Select & Return" button to pass the currently displayed access & egress leg configuration back and returns to the "Bus Trip Selection" user form.

Access and egress legs are defined separately in the 'Trip Access and Egress Leg Selection' form. The region, city size and time of day may all be selected to best characterize the origin and destination of a trip. Clicking on the green 'Region' drop-down list permits selection of any region defined in the 'Regional-Properties' worksheet. A table of fuel and emissions intensity values for all access and egress modes is provided for each defined region presented in the drop-down list. The green 'City Size' and 'Time of Day' selections offer a limited number of choices to further tailor the access or egress modes. The choices of 'City Size' may be 'Small Cities', 'Large Cities', 'Rural Municipality' or 'All Cities' while the choices for 'Time of Day' include 'Peak', 'Off-peak' and 'All'. Those values guide the VBA macro when choosing the most appropriate values from the table for a selected access/egress mode. The user is advised that the VBA macro expects every unique access/egress mode to be defined within the top portion of that table which would normally be associated with 'All Cities'.

Each access and egress leg is selected by picking from the modes presented in the green drop-down lists. When a mode is selected, the user form automatically fills five of the remaining seven green user modifiable data fields with default values selected from the region's data table. These default data include speed, fuel source, fuel intensity, energy intensity and GHG intensity. Although the inserted default data fields are yellow, the values may be adjusted to meet the user's requirements. The user must manually provide data for the green fields specifying the distance to be traveled using that access/egress mode (in miles) and a dwell time (in minutes) for that leg. Once these access/egress data have been saved with a trip, they will appear green the next time they are loaded.

Caution: *The simulation dynamically calculates Auto/LDV access/egress mode intensities using the number of travelers as displayed in the pink cell in the on line 64 of the 'Regional-Properties' worksheet in the area associated with the currently selected region. That number is set to correspond with the number of travelers indicated in the green field when the 'Trip Access and Egress Leg Selection' user form loads. If the number of travelers is manually changed, then a user must also change the region selection to force the macro to update the number of travelers written to the 'Regional-Properties' worksheet.*

Advanced users may also manually adjust the access and egress leg specifications for a bus trip directly on the 'Bus-I-O' worksheet. Clicking on the blue "Bus-I-O Access/Egress" button in the upper left region of the 'Bus-I-O' worksheet will change the display focus to the appropriate area of the worksheet. The access legs are defined in the green fields of the left hand table while the egress legs are defined in the green fields of the table to the right (the user must scroll the screen to view it). Clicking the blue "Bus-I-O" button will return to the main Bus Simulation Module user's interface. The currently configured bus mode simulations may then be executed directly from the 'Bus-I-O' worksheet by clicking the blue "Calculate Bus" button or the user can return to the main user interface on the 'Master-I-O' worksheet by clicking the blue "Master-I-O" button in the upper right area.

Clicking the blue "Calculate Selections" button at the upper left of the 'Master-I-O' display or the blue "Calculate Bus" button at the upper left of the 'Bus-I-O' display will trigger the VBA macros to perform the currently configured simulations. Executing an analysis from the 'Master-I-O' display will cause the display focus to switch to the simulation results summary table appropriate for the type of analysis being performed and the numbers will be updated as the

simulation process proceeds. Executing from the 'Bus-I-O' worksheet does not automatically switch display focus and the results summary tables may be accessed by clicking the appropriate blue navigation button in the top right hand quadrant. Simulation results for a bus mode comparison analysis are reported in a summary table on the 'Master-I-O' worksheet as depicted in Figure A-37. Select the desired system of output units from the green pulldown list at 'Master-I-O'!AE805.

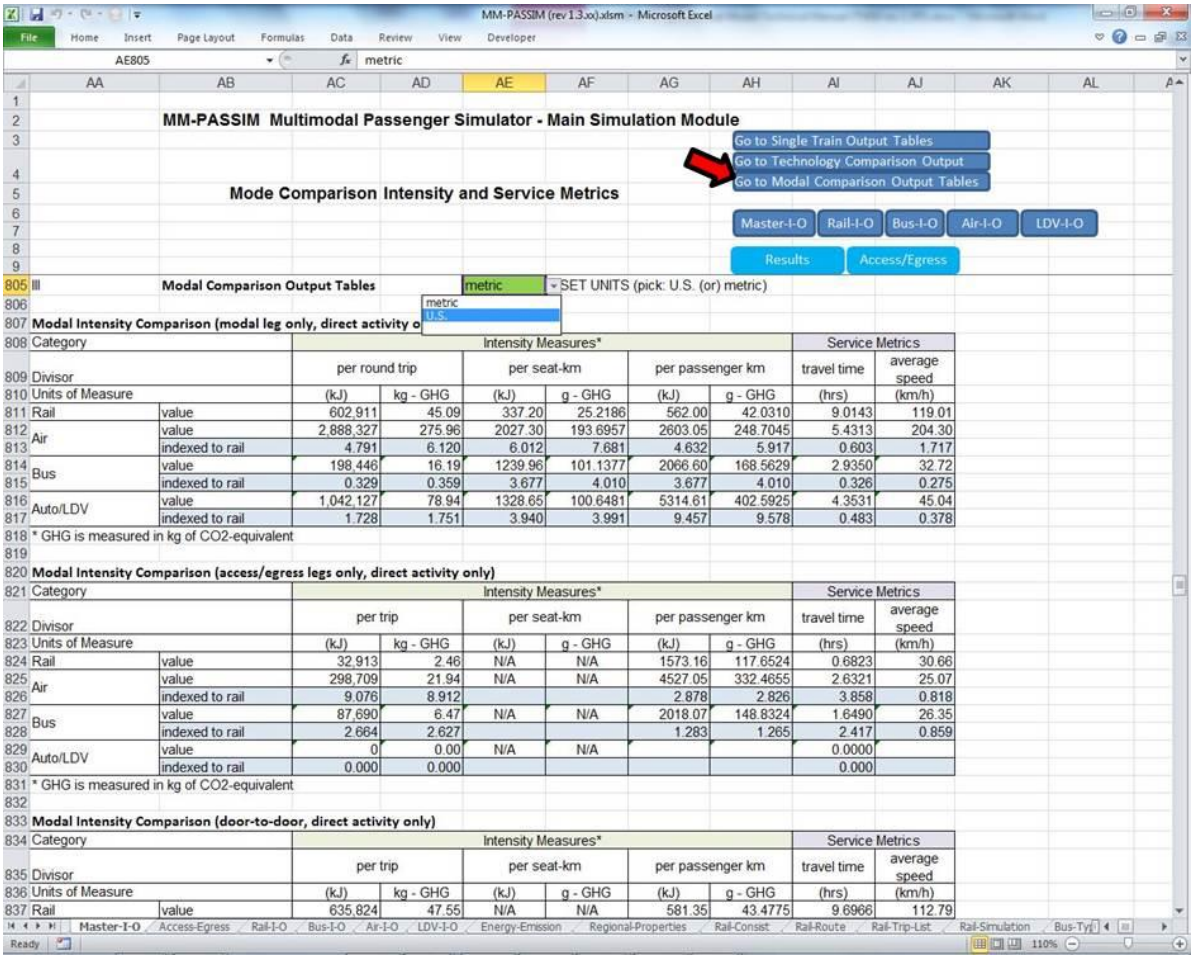


Figure A-37 'Master-I-O' Bus Mode Comparison Output Tables Area

A modal comparison analysis organizes results into four tables. The rail related numbers on the first line of each table correspond with those calculated for the rail mode baseline trip. The first table presents a modal intensity comparison for the direct activity on the main modal leg of each mode simulated and includes energy and GHG emission intensities for a passenger round trip, per seat-distance and also per passenger-distance. Travel time and average speed for a round trip on the main modal leg are also shown. The intensity measures and service metrics for each non-rail mode are also indexed to the baseline rail mode case. The second output table presents a modal intensity comparison for the direct activity of the access/egress legs required for a round trip of each selected transportation mode. We note that per seat-distance intensities are not calculated in this table, as indicated by "N/A" in the column, because the number of

seats is not defined in the access/egress mode data. The third table calculates the intensities and service metrics for the door-to-door direct activity of the main trip's transportation mode and the access/egress legs. Finally, the fourth table presents the overall door-to-door intensities and service metrics including both direct activity as well as indirect well-to-pump consumption.

A.5.4 Configuring and Running a Light Duty Vehicle (LDV) Mode Comparison

The LDV-Simulation module is implemented in eleven (11) worksheets which together with the 'Master-I-O' worksheet provide for simulation configuration, user input and results output of Auto/LDV mode comparison analyses. The user accessible worksheets include the 'LDV-I-O', 'Energy-Emission', 'Regional-Properties', 'LDV-Type', 'LDV-Route', 'LDV-Drive-Schedules' and 'LDV-Trip-List' worksheets. The 'LDV-Trip-List' worksheet maintains the list of all configured light duty vehicle mode trips and is typically maintained by the VBA macro code via the system of coordinated user forms although it may also be directly modified by an experienced user. The 'Energy-Emission' worksheet specifies the energy and emissions characteristics of all fuel/energy sources used for all transportation modes and is therefore shared by all transportation mode sub-models. The 'Regional-Properties' worksheet defines parameters which vary with geographical region under consideration and is also shared with the other transportation sub-models. The 'LDV-Type', 'LDV-Route' and 'LDV-Drive-Schedules' worksheets contain most of the user configurable data for an Auto/LDV mode simulation. The 'LDV-Trip', 'LDV-Resist', 'LDV-Engine' and 'LDV-Simulation' worksheets are all used internally to perform a light duty vehicle mode simulation and should not normally be modified by a user.

A one-way light duty vehicle mode trip is constructed by concatenating several specified lengths of light duty vehicle operation that are governed by pre-defined drive schedules. These drive schedules represent driving in urban areas with varying speed limits and traffic densities. There is also a generally much longer segment of cruise in which the vehicle seeks to maintain a speed limit while ascending and descending grades. The 'LDV-Simulation' worksheet predicts the energy use, GHG emissions produced and travel time associated with any one individual portion of a light duty vehicle mode. VBA macros use the information on the 'LDV-I-O' worksheet to automatically manage the transfer of data to and from the 'LDV-Simulation' worksheet for successive portions which together comprise the total distance of a one-way trip.

Defining a light duty vehicle mode simulation can be accomplished using the VBA macros and system of pop-up user forms available from the 'Master-I-O' worksheet when "Mode Comparison" has been selected in the green drop-down list at the top of the display. Alternatively it may be configured directly from the 'LDV-I-O' worksheet. Clicking any of the blue "Define Alternative #" buttons available on the left hand side of the 'Master-I-O' worksheet while the "'Mode Comparison" has been selected will prompt the user to choose a transportation mode for comparison. Selecting "Auto/LDV" from the green drop-down list, as depicted in Figure A-38, and then clicking on the "Select & Edit" button will open the "Auto/LDV Trip Selection" user form as shown in Figure A-39. Clicking on the "Select & Return" button will select the Auto/LDV mode without opening that user form and the simulation will be configured to use the trips currently defined in the 'LDV-I-O' worksheet. Table A-7 itemizes the steps required to configure an auto/LDV trip.

Table A-7 Configuration Steps Required for an Auto/LDV Trip

Define Auto/LDV Case	
Auto/LDV Trip Selection Form	• Either select an existing LDV trip from the 'Trip ID' drop-down list and click "Select & Return" or • Create a new Auto/LDV trip by clicking "Add LDV Trip" button • Enter a description for the new trip • Pick an Auto/LDV route from the "Route ID" drop-down list • Pick direction of travel • Pick season for both outbound and return trips • Set number of travelers • Pick freeway drive schedule mix for Urban Area 1 (the origin) • Pick freeway drive schedule mix for Urban Area 2 (the destination) • Pick urban arterial drive schedule mix (for origin and destination) • Pick time of day for departure of outbound trip • Pick time of day for arrival of outbound trip • Pick day of week for outbound trip • Pick time of day for departure of return trip • Pick time of day for arrival of return trip • Pick day of week for return trip • Pick an Auto/LDV type from the "Auto/LDV" drop-down list • Set number of passenger seats • Set number of passengers • Pick Auto/LDV fuel type • Assign access and egress legs by clicking the "Access & Egress" button • Save the new Auto/LDV trip by clicking "Save LDV Trip" button • Select the newly added Auto/LDV trip by clicking "Select & Return" button

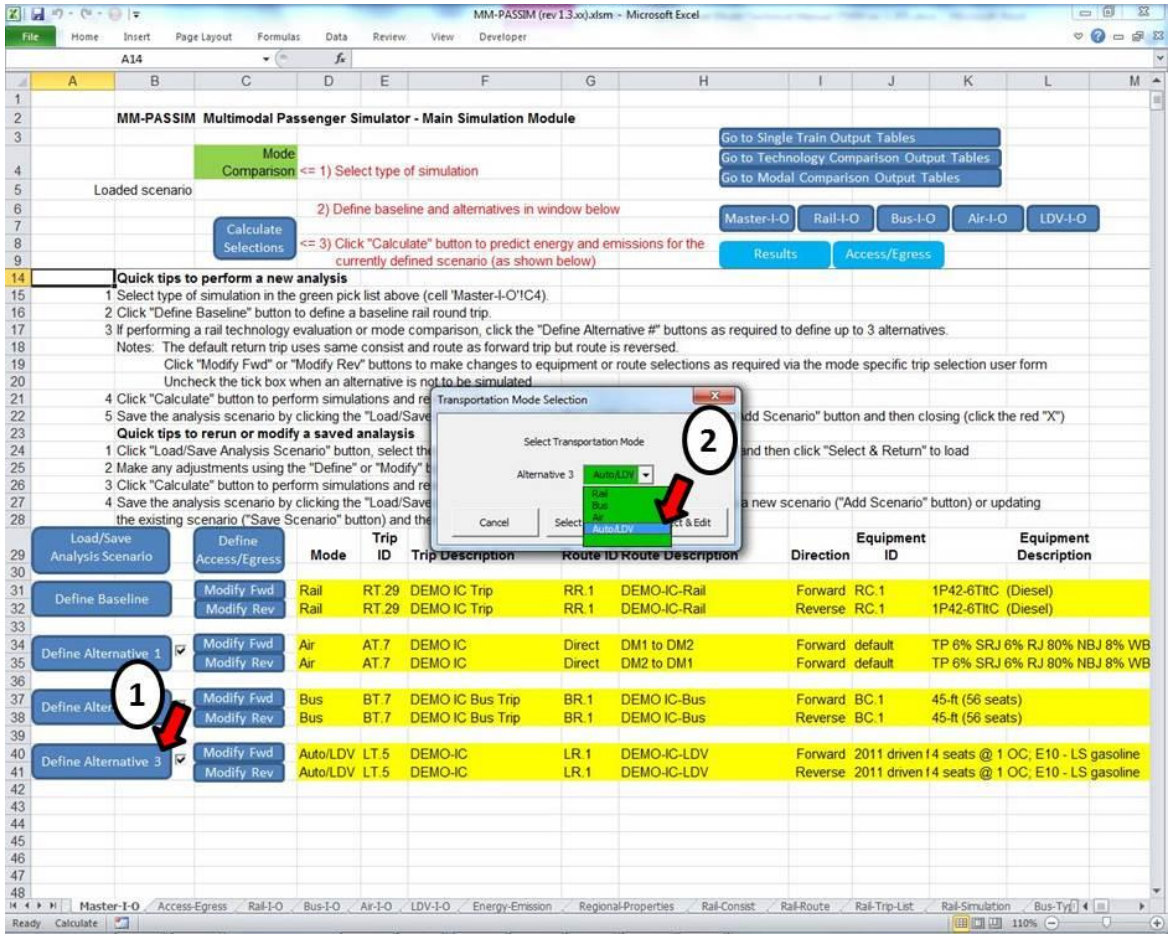


Figure A-38 Selecting an Auto/LDV Mode Round Trip

To select an Auto/LDV mode trip:

On "Master-I-O" worksheet:

a) Click blue "Define Alternative #' button on left hand side of worksheet (see highlight 1).

On "Transportation Mode Selection" form:

b) Click on gray arrow on right hand side of the green transportation mode drop-down list and then select the "Auto/LDV" mode from the list (see highlight 2)

c) Click gray "Select & Edit" button at right to open the "Auto/LDV Trip Selection" form.

or

Click gray "Select & Return" button in centre to use trip currently defined on the "LDV-I-O" worksheet

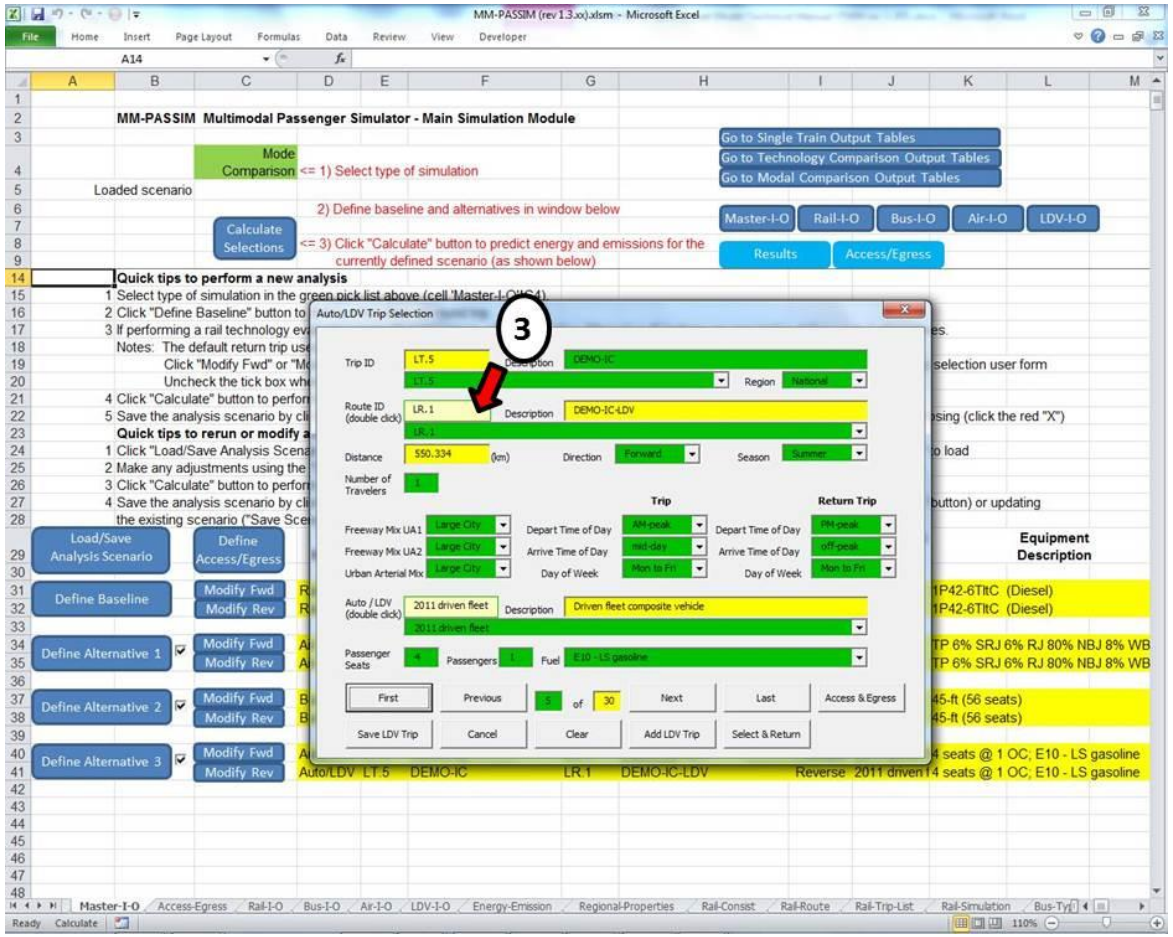


Figure A-39 Defining an Auto/LDV Mode Alternative Trip

Usage Notes:

On the "Auto/LDV Trip Selection" form:

a) Pick an Auto/ LDV trip from the green "Trip ID" drop-down list at the top.
or
Use the gray navigation buttons at the bottom to display a desired trip

b) Click gray "Add LDV Trip" button if you wish to create a new trip by modifying the currently displayed trip.

c) Double click on light yellow "Route ID" box (see highlight 3) to open the "Auto/LDV Route Selection" form and make a route selection.
or
Select a route from the green "Route ID" drop-down list.

d) Double click on light yellow "Auto/LDV" box to open the "Auto/LDV Type Selection" form and make an Auto/LDV selection
or
Select an Auto/LDV type from the green "Auto/LDV" drop-down list.

e) Make any changes to green fields (trip times, day of week, season, number of travelers, etc.).

f) Click on the gray "Save LDV Trip" button to save the modifications.

g) Click on the gray "Select & Return" button to return trip information back to "Master-I-O".

A light duty vehicle trip is configured by adjusting the green fields to suit the desired scenario. The navigation buttons at the bottom of the user form allow access to all previously defined light duty vehicle tips for review and potential use either as the desired trip or to serve as a template upon which to build a new trip. A trip may also be directly selected from the green drop-down list located immediately below the yellow "Trip ID" and green "Description" fields.

A light duty vehicle trip combines a route specification with a light duty vehicle type. The trip being displayed is identified by its unique "Trip ID" (upper left yellow field) and a user modifiable "Description" (upper right green field). The main trip leg is assumed to occur in a single geographic region which is specified in the green "Region" drop-down list. The "Route ID" associated with a trip is displayed in the green-bordered light yellow field located immediately below the "Trip ID" field (see highlight 3 in Figure A-39) and a description is provided in the yellow field immediately to its right. The light duty vehicle route distance is indicated in the yellow information field and can't be modified from this form (it must be modified in the 'LDV-Route' worksheet, see Section A.7.13). A route to be used for a light duty vehicle trip may be changed either by selecting it from the green drop-down list or by using the 'Auto/LDV Route Selection' user form.

The yellow "Route ID" field is not directly modifiable by a user, but is changed using the 'Auto/LDV Route Selection' pop up user form which is accessed by double clicking the "Route ID" field (see highlight 4 in Figure A-40). The navigation buttons at the bottom of the form allow the user to scroll through all of the currently defined light duty vehicle routes and once the desired route is displayed, clicking on the 'Select & Return' will return the selected 'Route ID' back to the previous 'Auto/LDV Trip Selection' form. A route may also be directly selected from those presented in the green drop-down list positioned immediately below the "Route ID" and "Description" fields.

Most parameters of a route specification are defined in the 'LDV-Route' worksheet and are not modifiable from either user form. The yellow 'Route ID', 'Description' and 'Distance' fields are filled in by the VBA macro to offer sufficient information to the user to identify and confirm the route selection. The route distance summary breaks down the total distance to be traveled into intercity and urban segments. The length and net elevation change of the intercity grade distribution characterization for the route is also provided for information purposes. A user may expand the number of defined routes available for light duty vehicle mode simulations by adding columns to the 'LDV-Route' worksheet following the pattern of previous entries.

Caution: *Additional routes added to the 'LDV-Route' worksheet must be offset by 12 columns to the right of the last defined route and the 'Route ID' should be unique and follow the indicated naming convention.*

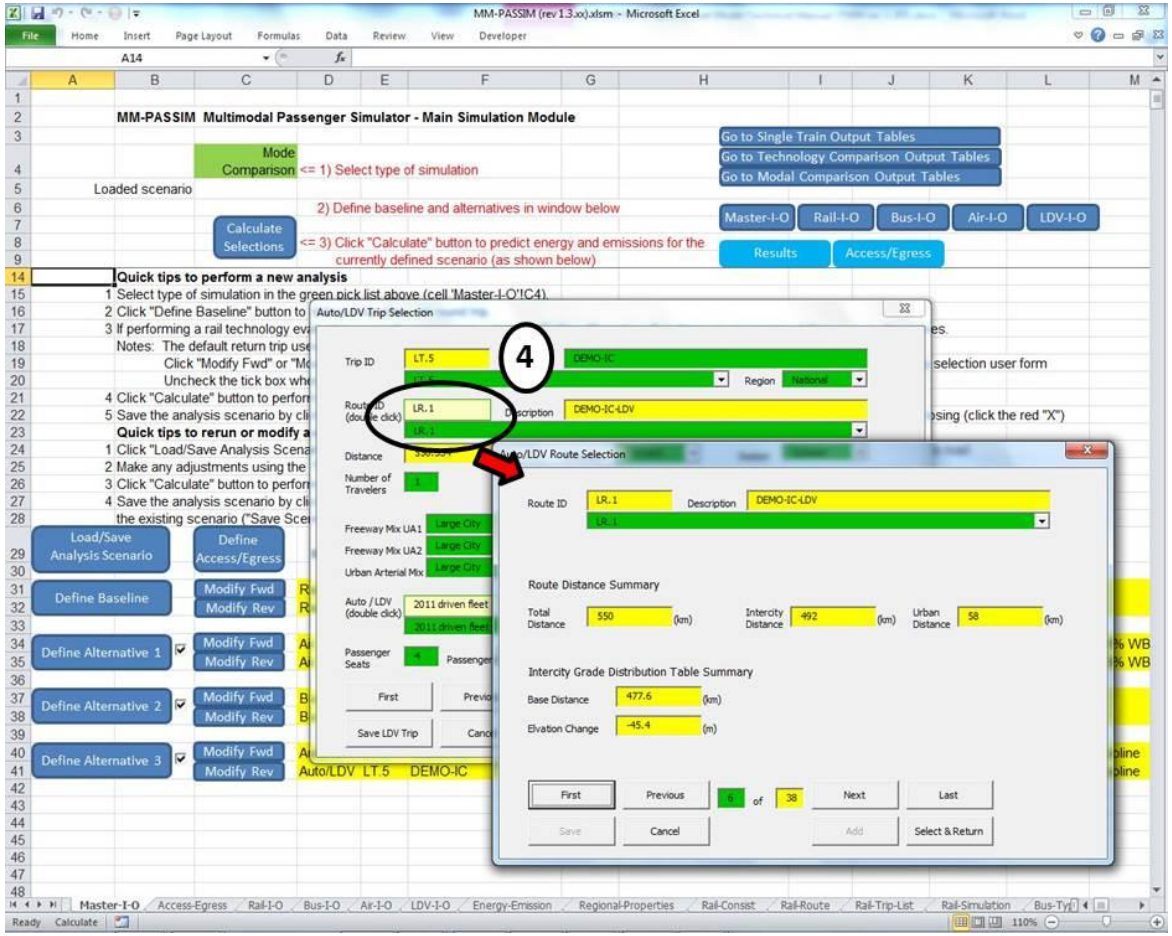


Figure A-40 Selecting an Auto/LDV Route

Selecting an Auto/LDV Route

On the "Auto/LDV Trip Selection" form:

a) Pick an Auto/LDV route from the green "Route ID" drop-down list.

or

Double click on the light yellow "Route ID" box (see highlight 4) to open the "Auto/LDV Route Selection" form and make a route selection.

On the "Bus Route Selection" form:

b) Pick a bus route from the green "Route ID" drop-down list (at top).

or

Use gray navigation buttons to display desired bus route.

c) Click gray "Select & Return" button to return to the "Auto/LDV Trip Selection" form.

Note: There are no use configurable values on the "Auto/LDV Route Selection" form

The central portion of the 'Auto/LDV Trip Selection' user form presents many green user modifiable data fields. The "Direction" field specifies in which direction the light duty vehicle will operate through the defined route. The number of travelers should also be specified. Additionally, there are a number of user adjustable green drop-down list fields which define general characteristics affecting how light duty vehicle movements are simulated in the origin and destination urban areas. The three fields on the left hand side allow the user to select from three possible configurations of duty cycles used to represent the freeway mix assumed for travel within the origin and destination cities as well as a mix of urban arterial duty cycles to be used for both urban centers. The choices of "Small City", "Large City" or "User Defined" refer to three data tables defined in the 'LDV-Drive-Schedules' worksheet. The "User Defined" table is provided to allow a user to customize the mix of duty cycles for their particular application without having to modify the defaults provided for small and large urban centers. Within these tables, a different mix of duty cycles is provided for 5 time periods which encompass the busy a.m. and p.m. peak periods, the lighter midday and off-peak (or shoulder) periods and finally a mix representing overnight travel. The user's selections from the green 'Depart Time of Day' and 'Arrive Time of Day' drop-down lists provided for the forward and return trips on the 'Bus Trip Selection' user form determines the VBA macro's choice of duty cycle mix to use. Additional green drop-down lists are provided to define the day of week for the forward and return trips as well as the season assumed for both trips.

The 'Auto / LDV Type' associated with a trip is displayed in the green-bordered light yellow field located in the lower portion of the 'Auto/LDV Trip Selection' form. A vehicle type is selected either by choosing it from the green drop-down list of all available light duty vehicles or by using the 'Auto/LDV Type Selection' pop-up form which is activated by double clicking on the 'Auto / LDV Type' field (see Figure A-41). When selecting from the drop-down list the green "Passenger Seats", "Passengers" and "Fuel" fields will be updated according to the selected vehicle type and the user may change those parameters as required. If the 'Auto / LDV Type' was double clicked the user accesses the desired 'Auto / LDV Type' by navigating through the available list of defined vehicle types and then clicking on the 'Select & Return' button to pass that selection back to the 'Auto/LDV Trip Selection' user form. The vehicle can also be selected from the green drop-down list located below the yellow "LDV Type ID" and "Description" fields. Using the 'Auto/LDV Type Selection' user form provides a bit more information about the vehicle such as the year associated with the configuration data and the engine type. A user is also able to control whether the simulation assumes the simulated vehicle to be a hybrid, non-hybrid or a default mix of hybrid and non-hybrid vehicles by selecting from those options in the green 'Engine Option' field. Most light duty vehicle parameters are currently specified in the 'LDV-Resist' worksheet and some adjustments may be made with care. The 'LDV-Type' worksheet is used by the 'Auto/LDV Type Selection' user form and mainly contains pointers to data fields on the 'LDV-Resist' worksheet.

Caution: *Some parameters may be modified in the 'LDV-Type' worksheet but care must be taken to preserve the relative position of parameters (successive vehicle types must maintain a fixed 4 column offset from one another).*

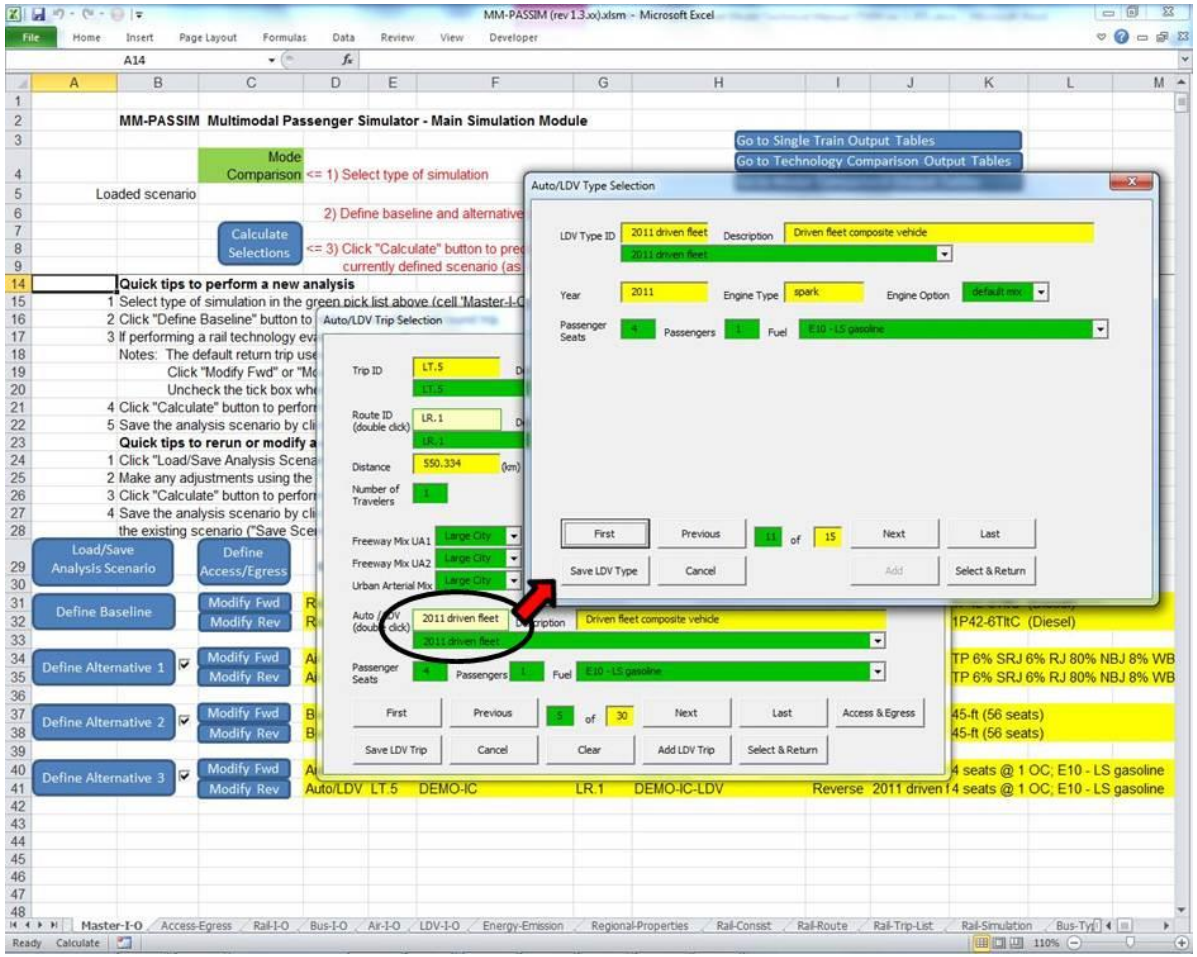


Figure A-41 Selecting the Auto/LDV Type

On the "Auto/LDV Trip Selection" form:

a) Pick an Auto/LDV type from the green "Auto/LDV" drop-down list.

   or

   Double click on the light yellow "Auto/LDV" box (see oval highlight) to open the "Auto/LDV Type Selection" form and make an Auto/LDV type selection.

On the "Auto/LDV Type Selection" form:

b) Pick an Auto/LDV type from the green "LDV Type ID" drop-down list at the top.

   or

   Use gray navigation buttons to display the desired Auto/LDV type.

c) Change the green input fields as required (engine option, passenger seats, passengers and fuel type).

d) Click gray "Save LDV Type" button to save changes.

e) Click gray "Select & Return" button to return to the "Auto/LDV Trip Selection" form.

A new light duty vehicle trip may be added by clicking the 'Add' button on the 'Select Auto/LDV Trip' form. This creates a new 'Trip ID' while preserving the values in the other data fields. A user may clear all data fields by clicking on the 'Clear' button if they so desire, however this should not normally be required as the process of selecting a 'Route ID' and 'Auto/LDV Type' will result in the replacement of most of the data fields.

Note: *Any changes made to the data fields on the 'Select Auto/LDV Trip' are not automatically saved and the user must explicitly save them by clicking the 'Save' button. Doing so will update the internally stored list of trip definitions (in the 'LDV-Trip-List' worksheet) but will not modify the trip definitions displayed in the Auto/LDV trip definition area on the 'Master-I-O' sheet. To do so, the user must click on the 'Select & Return' button which will write the trip definitions on the 'Master-I-O' sheet. It is therefore possible to configure and run one-off simulated trips without modifying the trip list.*

Defining an Auto/LDV mode alternative automatically assigns both the forward and return trips where the vehicle type and route selections are the same, but the direction of the return trip is reversed from that of the forward trip. In situations where this default return trip definition is not desired, the user can modify either the forward trip or the return trip individually by clicking on the blue "Modify Fwd" or "Modify Rev" buttons as required to access the 'Auto/LDV Trip Selection' form (see Figure A-42). It is not necessary that a return trip be run in the reverse direction should a different route be selected for the return trip which has already been defined for the forward direction. In such a case, set the required direction in the drop-down list (see left pointing arrow highlight in Figure A-42). The user should take note that the Auto/LDV simulation assigns a small portion of fuel use, energy consumption and emissions to vehicle startup and the return trip assigns smaller values since it is assumed that the engine has not fully cooled to ambient temperature. Therefore it may be more correct to use two forward trips when the return trip occurs on a subsequent day.

Caution: *Users should not directly modify any of the yellow highlighted fields associated with the trip selections listed on the 'Master-I-O' worksheet. This list is used by the VBA macros during the sequencing of the simulation steps and any invalid data or moved items may cause invalid predictions or program failure.*

In general, passenger access to the departure location and egress from the arrival location of Auto/LDV trips may not be applicable since many light duty vehicle trips will be from door to door. However, there are cases such as car-pooling from road-side parking lots that may involve additional passenger access to the departure point and/or egress from the arrival location which may both be characterized with up to five (5) access/egress legs each. This may be conveniently configured using the pop-up user forms accessed by clicking the blue "Define Access/Egress" button on the 'Master-I-O' worksheet to activate the "Trip Access and Egress Leg Selection" user form. Any currently defined access or egress legs for the selected light duty vehicle trips can be displayed by using the navigation buttons and all green fields may be adjusted to meet the user's requirements. Note that the access and egress legs are defined separately for each direction of an Auto/LDV trip.

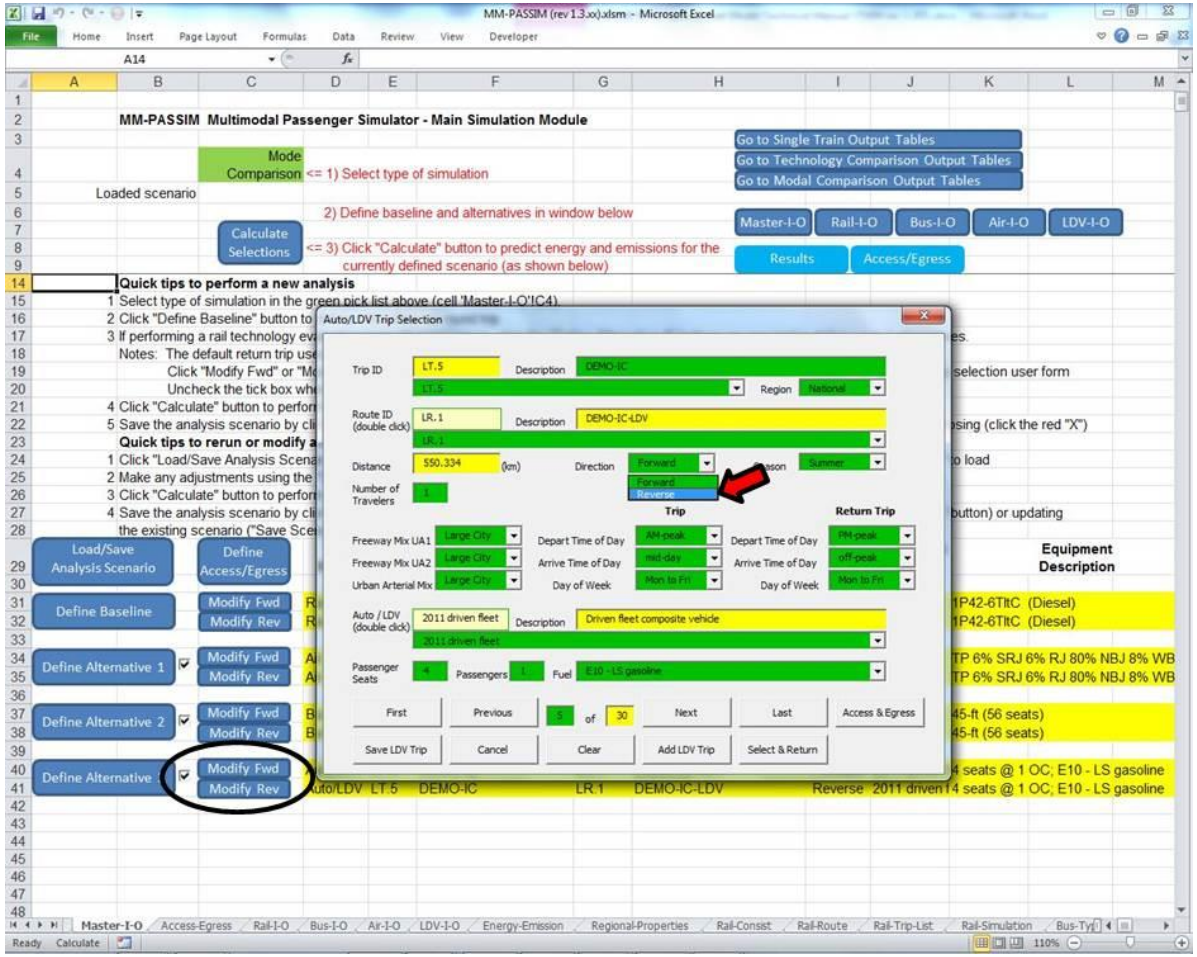


Figure A-42 Modifying a Return Auto/LDV Trip

On the "Master-I-O" worksheet:

a) Click on either a blue "Modify Fwd" or "Modify Rev" button adjacent to a trip you wish to modify to open the "Auto/LDV Trip Selection" form (see oval highlight) – it will display the currently configured trip.

On the "Auto/LDV Trip Selection" form:

b) Pick an Auto/LDV trip from the green "Trip ID" drop-down list at the top.

or

Use gray navigation buttons to display a desired trip.

c) Click the gray "Add LDV Trip" button if you wish to create a new trip by modifying the displayed trip.

d) Click on the gray arrow on the right side of the green "Direction" drop-down list to modify direction of travel (see red arrow).

e) Make any other required adjustments to the green fields in the middle of the form.

f) Click gray "Save LDV Trip" button to save changes to the displayed trip.

g) Click gray "Select & Return" button to return to the "Master-I-O" worksheet.

A user may also assign the access/egress legs for an Auto/LDV trip by clicking the "Access & Egress" button on the right hand side of the "Auto/LDV Trip Selection" user form (see Figure A-43). For personal vehicle use the access/egress legs will often be blank (i.e. the door to door trip is made in one vehicle); however, rental vehicles, carpool trips and destination urban access via commuter train are examples of LDV trips involving access or egress legs. The access and egress legs currently defined for the displayed light duty vehicle trip will be presented and the user may adjust all green fields accordingly. If a leg is not required then it should be removed by selecting "none" in the left most green drop-down list for the leg. The user can also scroll through the access and egress legs configured for any of the existing light duty vehicle trips using the navigation buttons. This allows any existing access/egress configuration to be used as a template for the current trip. Clicking the "Select & Return" button will associate the currently displayed access & egress leg configurations with the light duty vehicle trip being defined.

Access and egress legs are defined separately in the 'Trip Access and Egress Leg Selection' form. The region, city size and time of day may all be selected to best characterize the origin and destination of a trip. Clicking on the green 'Region' drop-down list permits selection of any region defined in the 'Regional-Properties' worksheet. A table of fuel and emissions intensity values for all access and egress modes is provided for each defined region presented in the drop-down list. The green 'City Size' and 'Time of Day' selections offer a limited number of choices to further tailor the access or egress modes. The choices of 'City Size' may be 'Small Cities', 'Large Cities', 'Rural Municipality' or 'All Cities' while the choices for 'Time of Day' include 'Peak', 'Off-peak' and 'All'. Those values guide the VBA macro when choosing the most appropriate values from the table for a selected access/egress mode. The user is advised that the VBA macro expects every unique access/egress mode to be defined within the top portion of that table which would normally be associated with 'All Cities'.

Each access and egress leg is selected by picking from the modes presented in the green drop-down lists. When a mode is selected, the user form automatically fills five of the remaining seven green user modifiable data fields with default values selected from the region's data table. These default data include speed, fuel source, fuel intensity, energy intensity and GHG intensity. Although the inserted default data fields are yellow, the values may be adjusted to meet the user's requirements. The user must manually provide data for the green fields specifying the distance to be traveled using that access/egress mode (in miles) and a dwell time (in minutes) for that leg. Once these access/egress data have been saved with a trip, they will appear green the next time they are loaded.

Caution: *The simulation dynamically calculates Auto/LDV access/egress mode intensities using the number of travelers as displayed in the pink cell in the on line 64 of the 'Regional-Properties' worksheet in the area associated with the currently selected region. That number is set to correspond with the number of travelers indicated in the green field when the 'Trip Access and Egress Leg Selection' user form loads. If the number of travelers is manually changed, then a user must also change the region selection to force the macro to update the number of travelers written to the 'Regional-Properties' worksheet.*

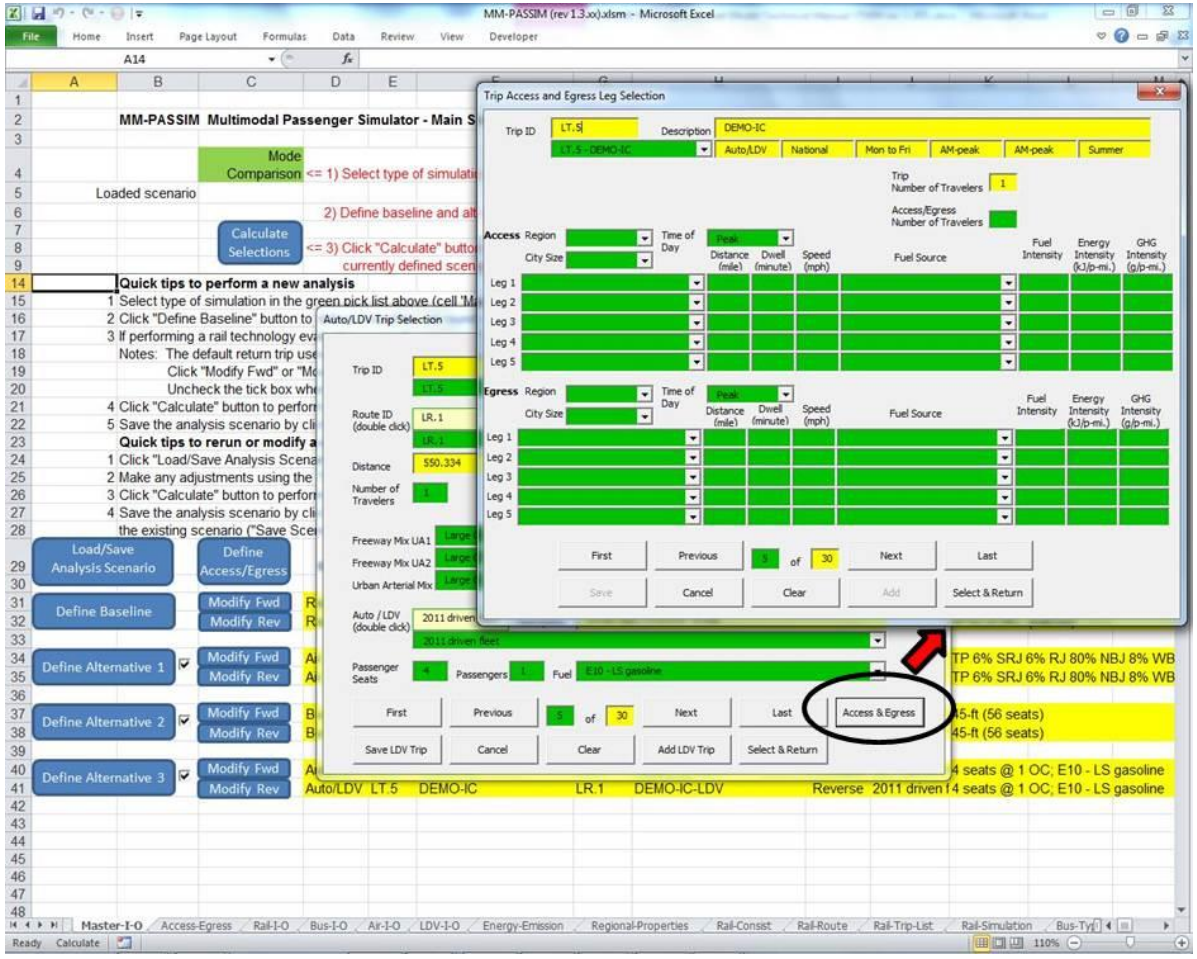


Figure A-43 Assigning Access & Egress Legs on Auto/LDV Trip Selection User Form

To view and modify access/egress legs from the "Auto/LDV Trip Selection" form:

On the "Auto/LDV Trip Selection" user form:

a) Click on the gray "Access & Egress" button (see oval highlight and arrow) to open the "Trip Access and Egress Leg Selection" form – the form will display the access & egress legs configured for the current trip.

On "Access and Egress Leg Selection Form:

b) Select any trip from the green "Trip ID" drop-down list

or

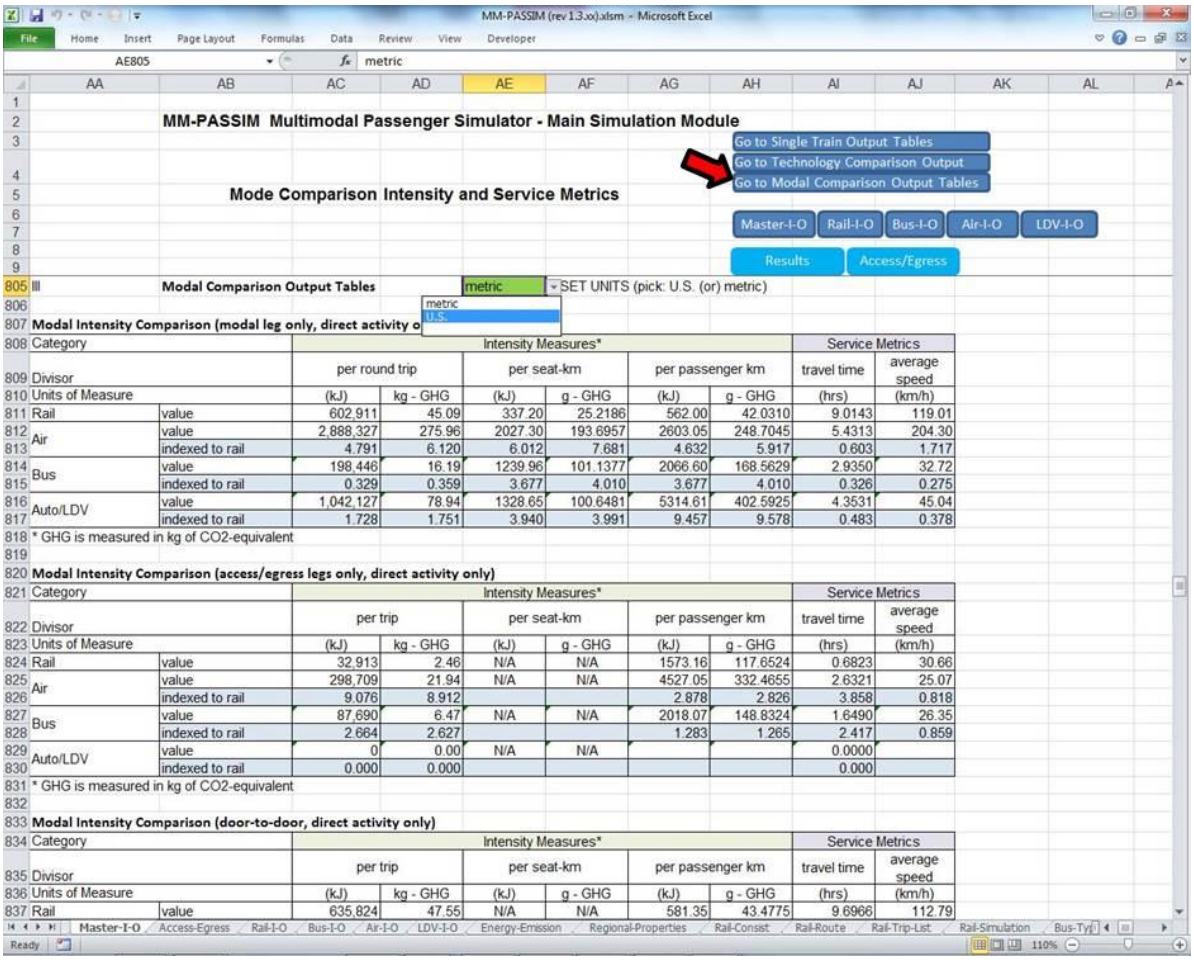
Use the gray navigation buttons to display the access/egress legs for any saved Auto/LDV trip.

c) Make any required adjustments in the green fields

d) Click on the gray "Select & Return" button to pass the currently displayed access & egress leg configuration back and returns to the "Auto/LDV Trip Selection" user form.

Advanced users may also manually adjust the access and egress leg specifications for a light duty vehicle trip directly on the 'LDV-I-O' worksheet. Clicking on the blue "LDV-I-O Access/Egress" button in the upper left region of the 'LDV-I-O' worksheet will change the display focus to the appropriate area of the worksheet. The access legs are defined in the green fields of the left hand table while the egress legs are defined in the green fields of the table to the right (the user must scroll the screen to view it). Clicking the blue "LDV-I-O" button will return to the main Auto/LDV Simulation Module user's interface. The currently configured Auto/LDV mode simulations may then be executed directly from the 'LDV-I-O' worksheet by clicking the blue "Calculate LDV" button or the user can return to the main user interface on the 'Master-I-O' worksheet by clicking the blue "Master-I-O" button in the upper right area.

Clicking the blue "Calculate Selections" button at the upper left of the 'Master-I-O' display or the blue "Calculate LDV" button at the upper left of the 'LDV-I-O' display will trigger the VBA macros to perform the currently configured simulations. Executing an analysis from the 'Master-I-O' display will cause the display focus to switch to the simulation results summary table appropriate for the type of analysis being performed and the numbers will be updated as the simulation process proceeds. Executing from the 'LDV-I-O' worksheet does not automatically switch display focus and the results summary tables may be accessed by clicking the appropriate blue navigation button in the top right hand quadrant. Simulation results for a light duty vehicle mode comparison analysis are reported in a summary table on the 'Master-I-O' worksheet as depicted in Figure A-44. You may select either "metric" or "U.S." units for display from the green pulldown list at Master-I-O'!AE805.



Category		Intensity Measures*						Service Metrics	
Divisor		per round trip		per seat-km		per passenger km		travel time	average speed
Units of Measure		(kJ)	kg - GHG	(kJ)	g - GHG	(kJ)	g - GHG	(hrs)	(km/h)
Rail	value	602.911	45.09	337.20	25.2186	562.00	42.0310	9.0143	119.01
Air	value	2,888.327	275.96	2027.30	193.6957	2603.05	248.7045	5.4313	204.30
	indexed to rail	4.791	6.120	6.012	7.681	4.632	5.917	0.603	1.717
Bus	value	198.446	16.19	1239.96	101.1377	2066.60	168.5629	2.9350	32.72
	indexed to rail	0.329	0.359	3.677	4.010	3.677	4.010	0.326	0.275
Auto/LDV	value	1,042.127	78.94	1328.65	100.6481	5314.61	402.5925	4.3531	45.04
	indexed to rail	1.728	1.751	3.940	3.991	9.457	9.578	0.483	0.378

* GHG is measured in kg of CO2-equivalent

Modal Intensity Comparison (access/egress legs only, direct activity only)

Category		Intensity Measures*						Service Metrics	
Divisor		per trip		per seat-km		per passenger km		travel time	average speed
Units of Measure		(kJ)	kg - GHG	(kJ)	g - GHG	(kJ)	g - GHG	(hrs)	(km/h)
Rail	value	32.913	2.46	N/A	N/A	1573.16	117.6524	0.6823	30.66
Air	value	298.709	21.94	N/A	N/A	4527.05	332.4655	2.6321	25.07
	indexed to rail	9.076	8.912			2.878	2.826	3.858	0.818
Bus	value	87.690	6.47	N/A	N/A	2018.07	148.8324	1.6490	26.35
	indexed to rail	2.664	2.627			1.283	1.265	2.417	0.859
Auto/LDV	value	0	0.00	N/A	N/A			0.0000	
	indexed to rail	0.000	0.000					0.000	

* GHG is measured in kg of CO2-equivalent

Modal Intensity Comparison (door-to-door, direct activity only)

Category		Intensity Measures*						Service Metrics	
Divisor		per trip		per seat-km		per passenger km		travel time	average speed
Units of Measure		(kJ)	kg - GHG	(kJ)	g - GHG	(kJ)	g - GHG	(hrs)	(km/h)
Rail	value	635.824	47.55	N/A	N/A	581.35	43.4775	9.6966	112.79

Figure A-44 'Master-I-O' Auto/LDV Mode Comparison Output Tables Area

A.6 Examples of Typical MMPASSIM Modeling Tasks

This section provides guidance for typical modeling tasks which a user will encounter while using the MMPASSIM model. These examples are supplementary to the more detailed descriptions of program functions and required data inputs which have been provided in the previous sections of this MMPASSIM user documentation.

A.6.1 Run Any Modal Simulation Using Existing Vehicles and Routes

Performing a modal simulation involving existing vehicles and routes is easily configured and run using MMPASSIM's system of built in menus.

Start by opening the 'MMPASSIM' Microsoft Excel workbook and selecting "Enable Macros" in response to the Microsoft Excel Security Notice. Macros must be enabled since the MMPASSIM workbook makes extensive use of macros to perform its analyses. The workbook will open and the worksheet which was in view at the time when the MMPASSIM workbook was last saved will be displayed. If the displayed worksheet is not the 'Master-I-O' worksheet then please click on the 'Master-I-O' worksheet tab which can be found near the lower left corner of the window (click the "first sheet" tab scroll button which looks like "|<" to find the 'Master-I-O' tab if you don't see it). Then ensure that the main model interface is in view where the 'Master-I-O'!A1 cell is aligned in the top left corner of the visible area. You can easily jump to that starting point by clicking on the blue "Master-I-O" button displayed in the upper right hand quadrant of any of the "<modal>-I-O" worksheets or manually navigate to that view using standard Microsoft Excel procedures. Clicking on a blue "Master-I-O" button will ensure that the lower split window displays the set of blue analysis configuration buttons in the lower left quadrant and the summary of the currently configured trips to be analyzed will be highlighted in yellow in the bottom right area.

If you wish to reload a previously saved analysis scenario then click on the blue "Load/Save Analysis Scenario Button" (located over 'Master-I-O'!A29:B29) which will open the 'Mode Comparison Selection' form. That form, illustrated in Figure A-45, displays the analysis configuration corresponding to the saved analysis index listed in the 'Master-I-O'!C5 cell, or it will display the first saved analysis configuration if that cell is currently blank. You can search through and display a summary of saved configurations by picking directly from the green drop-down list located immediately beneath the yellow "Configuration ID" information field at the upper left of the form, scrolling through saved configurations using the navigation buttons at the bottom of the form or by directly entering a valid configuration index number in the green input field located to the right of the navigation button labeled "Previous". The yellow "Simulation Type" information field in the upper right quadrant indicates the type of analysis. The yellow information fields below that indicate the transportation mode and give a brief summary of the outbound and return trips as configured for the baseline and any alternative trips defined in the saved analysis configuration. If one or more alternative trips were not used in the saved analysis configuration then the corresponding yellow information fields will be blank. Clicking on the "Select & Return" button instructs a macro to load the indicated set of trips into the mode specific '<modal>-I-O' worksheets, sets up the 'Master-I-O' worksheet for the required analysis type and then returns focus to the 'Master-I-O' worksheet when the form exits. Clicking the blue "Calculate Selections" button will begin the analysis process and the worksheet focus will automatically move to the results output tables appropriate for the type of analysis performed.

If setting up a new simulation, first select the desired type of analysis from the green drop-down list located at 'Master-I-O'!C4, then define the baseline trip and all required alternative trips via the menu system by clicking on the blue "Define Baseline" and the three "Define Alternative #" (where # is a "1", "2" or "3") buttons as required. The flowchart in Figure A-2 on page A-5 provides an overview of the simulation process for the three types of analyses which may be performed. Table A-2 on page A-32 itemizes the major configuration steps required. If one or more alternatives will not be included in the desired comparison then uncheck the tick box to remove it (the yellow information fields summarizing that trip will be cleared).

Single Train Simulation

A Single Train Simulation, as outlined in Figure A-4 on page A-10, requires only the baseline case be defined via the 'Rail Trip Selection' form. The configuration steps required are summarized in Table A-4 on page A-34. An existing rail trip may be selected by picking it from the green drop-down list found immediately below the yellow "Trip ID" information field. A different route may be chosen by selecting it from the green drop-down list positioned immediately below the light yellow "Route ID" information field. A different train consist may be chosen by selecting it from the list of all those currently defined in the green drop-down list positioned below the light yellow "Consist ID" information field. Further adjustments may be made to any of the green input fields on the form. Some require numerical input while others are selected from the values presented on the drop-down list. If changes have been made, the currently displayed trip may be saved under a new name by clicking on the "Add Rail Trip" button which automatically increments its "Trip ID", then edit the green "Description" field as required and finally click on the "Save Rail Trip" button to store the new trip – please note that an added trip is not saved until the "Save Rail Trip" button has been clicked. Clicking the "Select & Return" button passes the current baseline rail trip configuration to the baseline trip definition area on the 'Rail-I-O' worksheet and returns focus to the 'Master-I-O' worksheet. Clicking the blue "Calculate Selections" button executes the Single Train Simulation and displays the Single Train output tables.

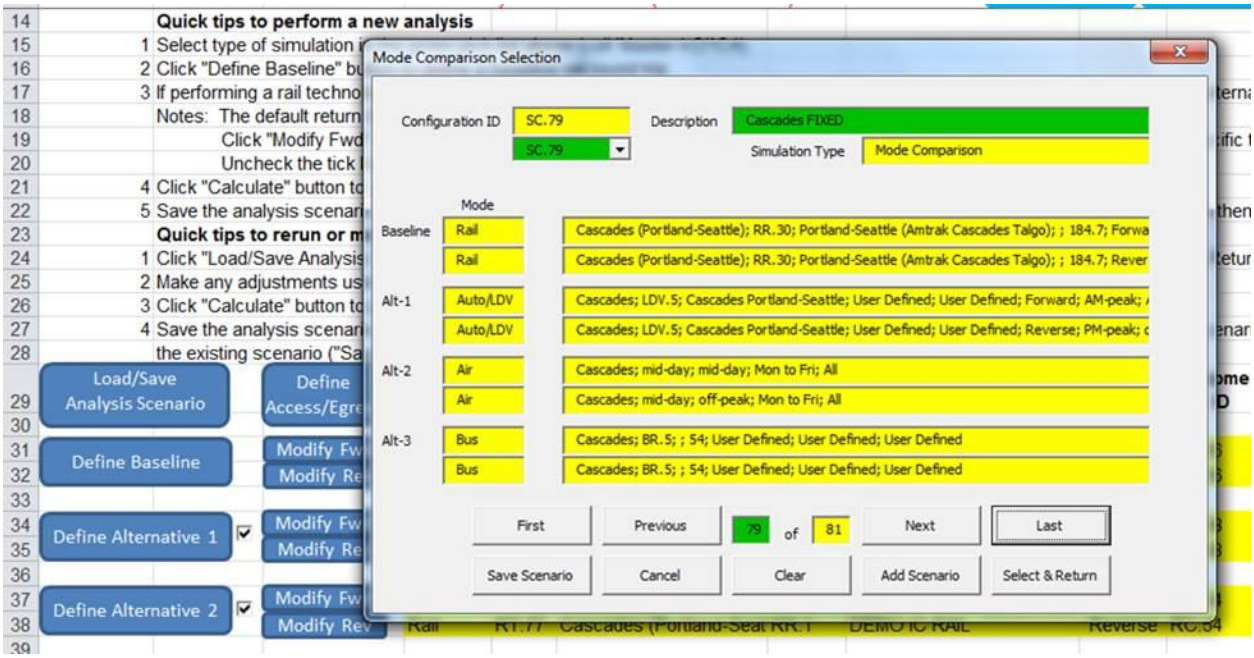


Figure A-45 Mode Comparison Selection Form

Rail Technology Evaluation

A Rail Technology Evaluation, as outlined in Figure A-5 on page A-11, requires definition of a baseline rail trip and up to three additional rail trips, all of which are defined using the 'Rail Trip Selection' form. The baseline rail trip is defined by clicking the blue "Define Baseline" button located at 'Master-I-O'!A29:B30 and then following the same procedure as outlined for defining the baseline rail trip for a Single Train Simulation (see Figure A-4 on page A-10 and Table A-4 on page A-34). Definition of each alternative rail trip is initiated by clicking on the corresponding "Define Alternative #" button on the 'Master-I-O' worksheet and again following the same process through the 'Rail Trip Selection' form to define the trip and then upon clicking the "Select & Return" button the trip definition is passed back to be stored on the 'Rail-I-O' worksheet. Once all trips are defined, clicking on the blue "Calculate Selections" button which overlays 'Master-I-O'!C7:C8 instructs a macro to start the Rail Technology Evaluation which will sequentially set up and execute each rail trip simulation and finish by displaying the Rail Technology Evaluation output tables for review.

Mode Comparison

A Mode Comparison requires definition of a baseline rail trip and up to three additional two-way trips for comparison which may include a single return bus trip, a single return LDV trip, a single return air trip and alternate return rail trips as required (where the term return trip refers to a complete two-way trip comprised of an outbound trip from the origin to destination and then an inbound trip from the outbound trip's destination back to its origin).

> ***Note:*** *Only one two-way trip for each non-rail transportation mode may be selected for analysis in a mode comparison but several two-way alternative rail trips can be specified if desired.*

Begin by selecting "Mode Comparison" from the drop-down list at 'Master-I-O'!C4 and then defining the baseline rail trip case by clicking the blue "Define Baseline" button and then selecting a rail trip, rail routes and rail consists as required from the 'Rail Trip Selection' user form. The procedure for selecting the baseline trip for a Mode Comparison is outlined in Figure A-6 on page A-13 (refer to the discussion on a *Single Train Simulation* above for more explanation).

Then, define up to three alternative mode two-way trips for comparison by:

a) clicking on a blue Define Alternative #" button, selecting the desired transportation mode from the green drop-down list presented and clicking the "Select & Edit" button (see Table A-3) making your desired selection of trip, route and equipment from the mode-specific trip selection form presented (see Table A-4 on page A-34, Table A-5 on page A-49, Table A-6 on page A-57 and Table A-7on page A-70).

b) clicking the "Select & Return" button to store the trip definition on the mode-specific '<modal>-I-O' worksheet and return you back to the 'Master-I-O' worksheet.

This procedure is outlined in Figure A-8 (page A-15) for bus mode trips, Figure A-9 (page A-16) for air mode trips and Figure A-10 (page A-17) for auto/light duty vehicle trips. Both the 'Bus Trip Selection' and 'Auto/LDV Trip Selection' user forms are similar to the 'Rail Trip Selection' in that they allow a user to select trips, routes and vehicles from green drop-down lists presenting all currently defined choices. The 'Air Trip Selection' user form allows users

to select trips from a green drop-down list presenting all currently defined air-mode trips, but changes to route and equipment are configured on the form itself rather than by selecting from lists of stored routes and equipment types. If you will be including less than three alternatives in a comparison then you must uncheck the tick box to deactivate analysis for the alternatives which will not be used – the yellow information fields for that alternative will be cleared. Click on the blue "Calculate Selections" button at 'Master-I-O'!C7:C8 to instruct a macro to initiate the mode comparison and then display the Mode Comparison output tables for review.

A.6.2 Build a New Train from an Existing Base Train

The parameters used to represent the characteristics of a train consist in the MMPASSIM model are stored in the 'Rail-Consist' worksheet. The data is organized into sets of columns defining the values associated with a particular rail. These are located at intervals of seven (7) columns starting in column I for the first rail consist. The first column (A) in the worksheet contains color coded descriptions of the parameter(s) which are stored on that row. Columns B through H are hidden and contain a template of the rail consist input data which define named ranges used by the VBA macros to address data items in the 'Rail-Consist' worksheet and must not be deleted or modified. The first column of the data set describing the characteristics of the first train defined in the 'Rail-Consist' worksheet must be located in column I, the second data set begins at column P, the third data set begins at column W and so it continues onward in seven (7) column increments for all trains defined in the worksheet.

The process of building a new train based upon the characteristics of an existing train essentially involves appending a new copy of the columns of data which currently describe the base train to the right of the set of columns representing the last train already defined in the worksheet and then making any required changes to the user configurable green coloured fields. This can be quickly done manually by copying and pasting a block of columns but care must be taken to strictly maintain the seven (7) column interval between train consist data. The "Consist ID" in row 2 of the first column of a newly pasted data set must be edited so that it contains a unique character string since that string is used by the VBA macros to locate the data associated with a specific rail consist. If two identical IDs are used then the VBA macros will only ever locate the columns of data associated with the first instance when looking up the parameters associated with that train. The default "Consist ID" naming convention for trains is "RC.#" where # is an integer incrementing by 1 for each rail consist defined.

A new train can more be conveniently added into the 'Rail-Consist' data set using the "Add Rail Consist" button which is found on the 'Rail Consist Selection' form. This has the advantage of automatically assigning the next available "Consist ID" index, the macro will always properly align the appended columns at the start of the next 7 column interval and the macro provides some user guidance in presenting options for fuel, hotel power and energy recovery provisions compatible with the selected propulsion technology.

To access the 'Rail Consist Selection' form, click on the "Define Baseline" button which is located on both the 'Master-I-O' and the 'Rail-I-O' worksheets to open the 'Rail Trip Selection' form. Then, double clicking on the light yellow "Consist ID" field down towards the bottom left will open the 'Rail Consist Selection' form. Then navigate to display the desired base rail consist by either picking it from the green drop-down list located just below the

yellow 'Consist ID' field or using the navigation buttons at the bottom of the form. Once the desired consist is displayed, clicking on the "Add Rail Consist" button will create a new "Consist ID" based on the index of the last consist currently defined in the 'Rail-Consist' worksheet and a copy of the columns defining the source rail consist is appended to the 'Rail-Consist' worksheet. Changes can then be made to the green "Propulsion Type", "Primary Fuel", "Secondary Fuel", "Hotel Power" and "Energy Recovery" fields. The macro will provide a list of all available selections for a given field which are compatible with the current choice of "Propulsion Type". For electric propulsion, please be sure to select an electricity generation mix appropriate for the region in which this train will be operating. Finally, clicking on the "Save Rail Consist" button will update the newly added rail consist definition to reflect any changes which have been made using any of the green drop-down lists.

Note: *Exiting the 'Rail Consist Selection' form before clicking on the "Save Rail Consist" button will result in the newly added consist being a direct copy of the source consist but with a new "Consist ID" field.*

There are numerous user adjustable parameters associated with a rail consist, most of which can only be modified directly by editing the data contained in the green coloured cells of the 'Rail-Consist' worksheet. The description of the new train can be input in the green cell on row 3. The desired system of input units, either U.S. or metric, must be declared using the drop-down list on row 4 and all further user specified values must be input using the appropriate units as indicated on the worksheet. The number of locomotives and coaches, the number of powered and unpowered axles, physical parameters such as masses and rolling inertia and the train length are specified in the green fields on rows 5 through 20.

The train resistance coefficients are input in the green fields on rows 26 through 28. Transmission efficiencies may be set on rows 38 and 39. The five segment tractive effort curve, specifying the relationship between locomotive traction and speed, is defined in the green cells on rows 44 through 48. The fuel rate is specified by setting the series of parameters in the green fields on rows 52 through 60. The green flag value on row 63 determines whether or not dynamic braking will be used. The locomotive auxiliary power requirement is set on row 68. The auxiliary power diesel generator set fuel consumption is defined by the coefficients in the green cells on rows 70 and 71. The low speed tractive effort limit is specified on row 73 and the locomotive speed limit is specified on row 90. Please note that some of the pink cells are populated by the VBA macro according to the selections made on the 'Rail Consist Selection' user form while others, such as the seasonal adjustments on rows 29 through 32, are populated at the time an analysis is run based on data for the selected region.

Note: *If a train consist was added manually by copying columns then the user should take care that the pink values on rows 40, 41, 65 through 67, 81 and 85 are set appropriately if the type of propulsion was manually changed. It is therefore recommended that changes in propulsion system selection, hotel power provisions and energy recover options be made through the 'Rail Consist Selection' user form.*

A.6.3 Build a New Train with a New Locomotive

Building a new train with a new locomotive requires modification of data stored in the 'Rail-Consist' worksheet. This can be done by directly editing the locomotive-specific input fields in the set of seven (7) columns associated with an existing train, also termed a rail consist, or by creating a new train as a new consist by adding a new complete set of columnar data (7 columns in width) to the 'Rail-Consist' worksheet to the right of the last one currently defined and then modifying the locomotive data as required. If adding columns directly to the 'Rail-Consist' worksheet by copying and pasting, highlight a set of 7 complete columns by clicking the header of the first column of a source consist data set and then clicking the header of the 7th column to the right while pressing the shift key, then right click anywhere on the highlighted area and select "Copy" from the pop-up menu, then right click on the header of the 8th column to the right of the column declaring the last "Consist ID" (yellow cell on row 2) defined on the worksheet and select the "Paste (P)" icon (the first on the list) to paste the copy.

Caution: *Some cells in the columns defining rail consist data use formulae which necessitate pasting the cells contents rather than values. Also, you must edit the yellow "Consist ID" to provide it with a unique alphanumeric identifier (following along with the default naming scheme of "RC.#" where # is an integer number one greater than the consist to the left is recommended).*

You can also add a new rail consist based upon any previously defined consist using the 'Rail Consist Selection' user form by first displaying the desired existing consist and then clicking on the "Add Rail Consist" button to automatically create a copy with a new "Consist ID" and then clicking on the "Save Rail Consist" button to save it to the end of the list on the 'Rail-Consist' worksheet. The 'Rail Consist Selection' user form is accessed by double clicking the light yellow "Consist ID" information field on the 'Rail Trip Selection' user form.

By default, the window view of the 'Rail-Consist' worksheet is split to permit display of the input data descriptions provided in column A and the "Consist ID" (yellow cell on row 2), "Description" (green cell on row 3) and unit selections (green drop-down list on row 4) for the currently displayed columns while scrolling through and editing the data in the large window in the lower right of the display. Set the number of locomotives (or powered cars) in the green cell on row 5, the total number of powered axles on all locomotives in the green cell on row 7, the total weight carried on all powered axles in the green cell on row 10 and the mass-equivalent rotational inertia of each powered axle in the green cell on row 18. Note that all locomotives in a train are modeled using one set of physical characteristics in the input so in cases where different locomotive equipment are used in one train the values entered must represent the blend of locomotives in that train.

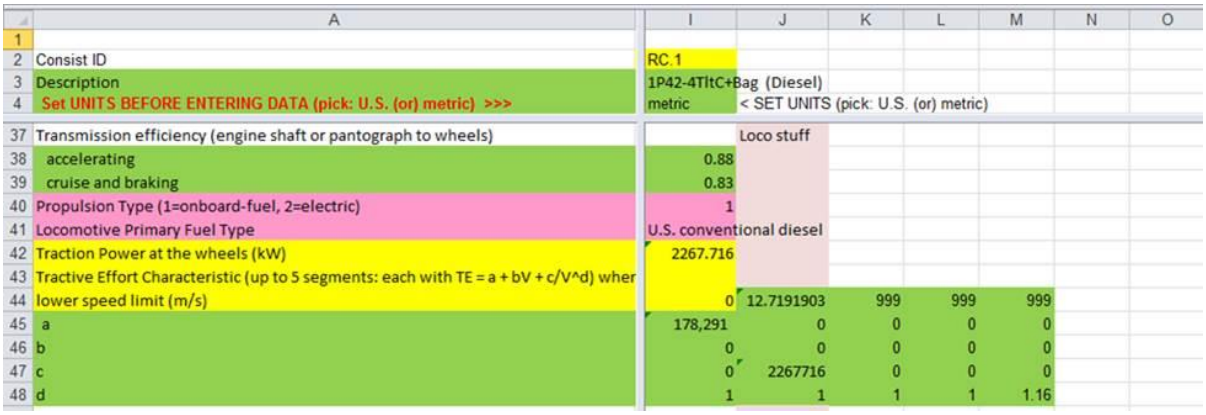
Train resistance is modeled using a quadratic equation which relates the train's total resistive force to the speed of travel. The three coefficients are entered in the green cells on rows 26 through 28 (see Figure A-46) and must represent the total contribution to resistance of all vehicles in the train. Therefore, the magnitude of each coefficient should be changed appropriately as the number of vehicles included in the train changes. The first term is a constant related to the train's resistance to rolling (row 26), the second coefficient represents a dynamic resistance term which is proportional to speed (row 27) while the third coefficient represents aerodynamic resistance which varies with the square of speed (row 28). Modifications of these coefficients to accommodate changes of locomotive equipment

will require a reasonable estimate of the magnitude of individual contributions of locomotive and coach equipment to the total train resistance terms. Also, please note that the aerodynamic resistance term is automatically adjusted for the influence of headwind and ambient temperature and the modified value used by the simulation is shown in the orange cell on row 34. The adjustment depends on the season defined in the pink cell on row 29 to look up the appropriate seasonal data in the small table on rows 30 through 36. The contents of the pink cells in 'Rail-Consist' are loaded by the macro for a train at the time a rail simulation is performed based upon the user selected season for a rail trip.

	A	I	J	K	L	M	N	O
1								
2	Consist ID	RC.1						
3	Description	1P42-4TItC+Bag (Diesel)						
4	Set UNITS BEFORE ENTERING DATA (pick: U.S. (or) metric) >>>	metric	< SET UNITS (pick: U.S. (or) metric)					
25	TRAIN RESISTANCE COEFFICIENTS (a+bV+cV^2)		Resistance stuff					
26	a	4.286	(N)					
27	b	0.000	(N/(km/h))					
28	c	0.718	(N/(km/h)^2)					
29	Season adjustments for selected season	Other	Season / region common area					
30	summer heat/cool index	0.92691691		winter	summer	other		
31	winter heat/cool index	1.28		27.60243	75.00187	52.87353	deg F	
32	other (i.e. Spring or Fall) heat/cool index	0.02243614		-2.4431	23.88993	11.59641	deg C	
33	CdA impact	1.03		1.08	0.99	1.03	temperature and wi	
34	seasonal modified CdA; and average effective headwind speed (km/h)	0.740	1.870829	1.87	1.87	1.87	<< effective average	
35				31	25.90375	18	<< hotel Pwr (kW)	
36	Coach avg hotel power per coach (kW)	18		31.2	25.04445	18	<< user input	

Figure A-46 Train Resistance Coefficients in 'Rail-Consist' Worksheet

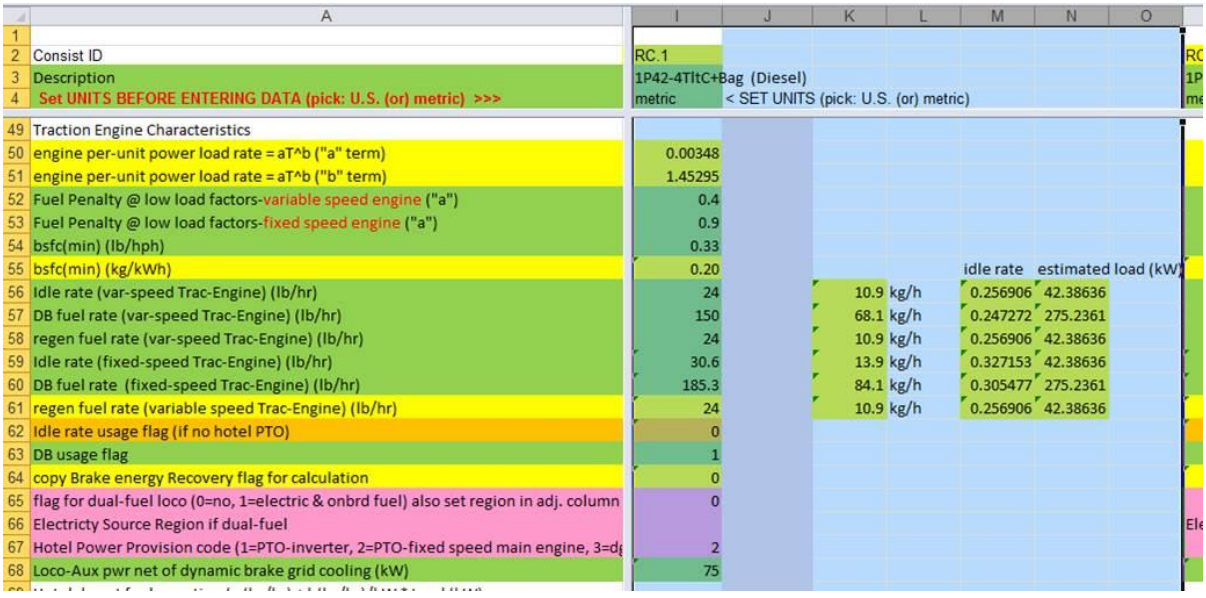
Transmission efficiencies and traction motor capabilities are defined on rows 37 through 48 as depicted in Figure A-47. The transmission efficiency when accelerating is input in the green cell on row 38 and when cruising and braking in the green cell on row 39. The traction characteristics of the locomotive are input as a multi-segment approximation of a tractive effort curve using the green fields of a 5-row by 5-column data table specified on rows 44 through 48. The first row identifies the lower speed (in m/s) associated with a maximum of 5 segments and a value of 999 should be entered if a segment is not used. Rows 45 through 48 hold sets of the four (4) coefficients used to define the tractive effort curve for each segment. The first term (a) is a constant, the second coefficient (b) defines a linear variation with speed, the third coefficient (c) represents an inverse variation with a power of speed defined by the fourth coefficient (d). Figure 3 on page 41 of Section 4.1.3.1 provides illustrations of a conventional diesel electric tractive effort curve represented using only 2 segments and a more complex VHSR electric power car tractive effort curve over 5 speed segments. There is also a low speed tractive effort limit applied to the traction characteristics which is specified on a per-powered-axle basis in the green cell on row 73.



	A	I	J	K	L	M	N	O
1								
2	Consist ID	RC.1						
3	Description	1P42-4TltC+Bag (Diesel)						
4	Set UNITS BEFORE ENTERING DATA (pick: U.S. (or) metric) >>>	metric	< SET UNITS (pick: U.S. (or) metric)					
37	Transmission efficiency (engine shaft or pantograph to wheels)		Loco stuff					
38	accelerating	0.88						
39	cruise and braking	0.83						
40	Propulsion Type (1=onboard-fuel, 2=electric)	1						
41	Locomotive Primary Fuel Type	U.S. conventional diesel						
42	Traction Power at the wheels (kW)	2267.716						
43	Tractive Effort Characteristic (up to 5 segments: each with TE = a + bV + c/V^d) wher							
44	lower speed limit (m/s)	0	12.7191903	999	999	999		
45	a	178,291	0	0	0	0		
46	b	0	0	0	0	0		
47	c	0	2267716	0	0	0		
48	d	1	1	1	1	1.16		

Figure A-47 Traction Motor Characteristics in 'Rail-Consist' Worksheet

Traction engine characteristics are defined on rows 49 through 68 as illustrated in Figure A-48. Coefficients defining the engine per-unit power load rate are declared in the yellow cells on rows 50 and 51. The green cells on rows 52 and 53 specify the fuel penalty at low load factors for variable and for fixed speed engines, respectively. The locomotive's brake specific fuel consumption is defined in the green cell on row 54. The green cells on rows 56 through 60 specify other fuel rates for the traction engine – rows 56 through 58 apply for variable-speed engines and 59 and 60 apply to fixed-speed engines. The green cell on row 63 indicates whether dynamic braking is to be used (a flag value of 1) or not. The locomotive auxiliary power requirement, excluding dynamic braking resistance grid cooling, is specified in the green cell on row 68 and should be adjusted for locomotive type. By default, this power requirement is calculated as 35 kW for electric locomotives and 75 kW for diesel-electric locomotives.



	A	I	J	K	L	M	N	O
1								
2	Consist ID	RC.1						
3	Description	1P42-4TltC+Bag (Diesel)						
4	Set UNITS BEFORE ENTERING DATA (pick: U.S. (or) metric) >>>	metric	< SET UNITS (pick: U.S. (or) metric)					
49	Traction Engine Characteristics							
50	engine per-unit power load rate = aT^b ("a" term)	0.00348						
51	engine per-unit power load rate = aT^b ("b" term)	1.45295						
52	Fuel Penalty @ low load factors-variable speed engine ("a")	0.4						
53	Fuel Penalty @ low load factors-fixed speed engine ("a")	0.9						
54	bsfc(min) (lb/hph)	0.33						
55	bsfc(min) (kg/kWh)	0.20				idle rate	estimated load (kW)	
56	Idle rate (var-speed Trac-Engine) (lb/hr)	24		10.9	kg/h	0.256906	42.38636	
57	DB fuel rate (var-speed Trac-Engine) (lb/hr)	150		68.1	kg/h	0.247272	275.2361	
58	regen fuel rate (var-speed Trac-Engine) (lb/hr)	24		10.9	kg/h	0.256906	42.38636	
59	Idle rate (fixed-speed Trac-Engine) (lb/hr)	30.6		13.9	kg/h	0.327153	42.38636	
60	DB fuel rate (fixed-speed Trac-Engine) (lb/hr)	185.3		84.1	kg/h	0.305477	275.2361	
61	regen fuel rate (variable speed Trac-Engine) (lb/hr)	24		10.9	kg/h	0.256906	42.38636	
62	Idle rate usage flag (if no hotel PTO)	0						
63	DB usage flag	1						
64	copy Brake energy Recovery flag for calculation	0						
65	flag for dual-fuel loco (0=no, 1=electric & onbrd fuel) also set region in adj. column	0						
66	Electricty Source Region if dual-fuel							
67	Hotel Power Provision code (1=PTO-inverter, 2=PTO-fixed speed main engine, 3=d	2						
68	Loco-Aux pwr net of dynamic brake grid cooling (kW)	75						

Figure A-48 Traction Engine Characteristics in 'Rail-Consist' Worksheet

Particular care must be taken when specifying the 'Rail-Consist' data inputs which configure: the locomotive type, a dual-fuel locomotive, the fuel type(s) used, the method by which a locomotive generates hotel power and the type of brake energy recovery, if any, which may be used on the locomotive. This is because valid choices for some of these parameters depend upon the value of other parameters while others, such as fuel type selections, can only be from a defined list. It is preferable for users to make these selections using the 'Rail Consist Selection' form which will only present valid choices for each parameter value and a macro will automatically set the correct flags and values in the 'Rail-Consist' worksheet. These data inputs are coloured pink to signify that they can be set by a macro and also serves as a reminder to users to exercise caution when setting the values. The 'Rail Consist Selection' form is accessed by double clicking the light yellow "Consist ID" field on the 'Rail Trip Selection' user form.

Note: *Always remember to click on the "Save Rail Consist" button to save any changes made to the data on the 'Rail-Consist' worksheet.*

A.6.4 Build a New Train with New Coaches

Building a new train with new passenger coaches requires modification of data stored in the 'Rail-Consist' worksheet. A new train, also termed a rail consist, can be easily added into the 'Rail-Consist' worksheet by clicking the "Add Rail Consist" button available on the 'Rail Consist Selection' user form. This will append a copy of the currently displayed rail consist to the next available set of columns in the 'Rail-Consist' worksheet and assign a unique "Consist ID". You can scroll through all currently defined trains to select one which is similar to the train you wish to create. Alternatively, the set of seven (7) columns associated with an existing train can be manually copied to a new location to the right of set of columns defining the last "Consist ID" in the 'Rail-Consist' worksheet.

Note: *If a train configuration is manually copied be sure to paste the cell contents rather than pasting cell values as some cells contain formulas. Also, the "Consist ID" in the yellow cell on row 2 must be given a unique alphanumeric identifier and the default "RC.#" format should be followed.*

Once a new consist is added, you must manually edit the green input fields in the set of seven (7) columns associated with the newly added train in the 'Rail-Consist' worksheet to adjust its parameters as necessary using the information in the following discussion and also in Section A.7.3 as a guide. By default, the window view of the 'Rail-Consist' worksheet is split to permit display of the input data descriptions provided in column A and the "Consist ID" (yellow cell on row 2), "Description" (green cell on row 3) and unit selections (green drop-down list on row 4) for the currently displayed columns while scrolling through and editing the data in the large window in the lower right of the display. Set the number of coaches in the green cell on row 4, the total number of unpowered axles (for all coaches) in the green cell on row 6 and the total number of axles in the train in the green cell on row 9.

For the purposes of a rail simulation, all coaches in a consist are considered to be the same (when coaches are different, the parameters input are for a "representative" coach). The total tare weight of all coaches is input in the green field on row 11, the average passenger weight (including luggage) is input in the green field on row 17, the total number of passenger seats in the consist is input in the green cell on row 12 and the passenger load

factor is input in the green field on row 16. The mass-equivalent rotational inertia of each unpowered axle is input in the green cell on row 19. Note that the average seat pitch and common area inputs (rows 13 and 14) are unused. The total consist length, including all locomotives and coaches, is entered in the green input cell on row 20.

Train resistance is modeled using a quadratic equation which relates the train's total resistive force to the speed of travel (see Equation 5 on page 39 of Section 4.1.3.1). The three coefficients are entered in the green cells on rows 26 through 28 (see Figure A-46 on page A-89) and must represent the total contribution to resistance of all vehicles in the train. Therefore, the magnitude of each coefficient should be changed appropriately as the number of vehicles included in the train changes. The first term is a constant related to the train's resistance to rolling (row 26), the second coefficient represents a dynamic resistance term which is proportional to speed (row 27) while the third coefficient represents aerodynamic resistance which varies with the square of speed (row 28). Modifications of these coefficients to accommodate changing the type or number of coaches will require a reasonable estimate of the magnitude of individual contributions of locomotive and coach equipment to the total train resistance terms. Also, please note that the aerodynamic resistance term is automatically adjusted for the influence of headwind and ambient temperature and the modified value used by the simulation is shown in the orange cell on row 34. The adjustment depends on the season defined in the pink cell on row 29 to look up the appropriate seasonal data in the small table on rows 30 through 36. The contents of the pink cells in 'Rail-Consist' are loaded by the macro for a train at the time a rail simulation is performed based upon the user selected season for a rail trip.

It is also possible to build a simple rail consist using the 'Simple Rail Consist Selection' menu which is accessed by clicking on the blue "Save to 'Rail-Consist'" button on the 'Build-Simple-Rail-Trip' worksheet. This allows a user to build a train by selecting types and quantities of locomotives and coaches to be included. However, this utility only supports inclusion of a limited number of diesel-electric locomotives and only a few coach types. Please refer to the discussion previously provided in Section A.4.1 on page A-18 for more details.

A.6.5 Fit Train Performance to a Known Trip Schedule or Energy Efficiency

Rail schedules are developed on the basis of expected minimum run time performance of the train consist being operated plus an allowance for delays. The total scheduled trip time and the station sit/dwell times are specified via the trip data inputs on the Master-IO or Rail-IO sheets (the form is brought up via the 'define baseline' or 'define alternatives' blue buttons). Unscheduled delays are specified in the rail-route sheet (row 87 – row 96 for TSOs and row 98 – 100 for unscheduled stops.

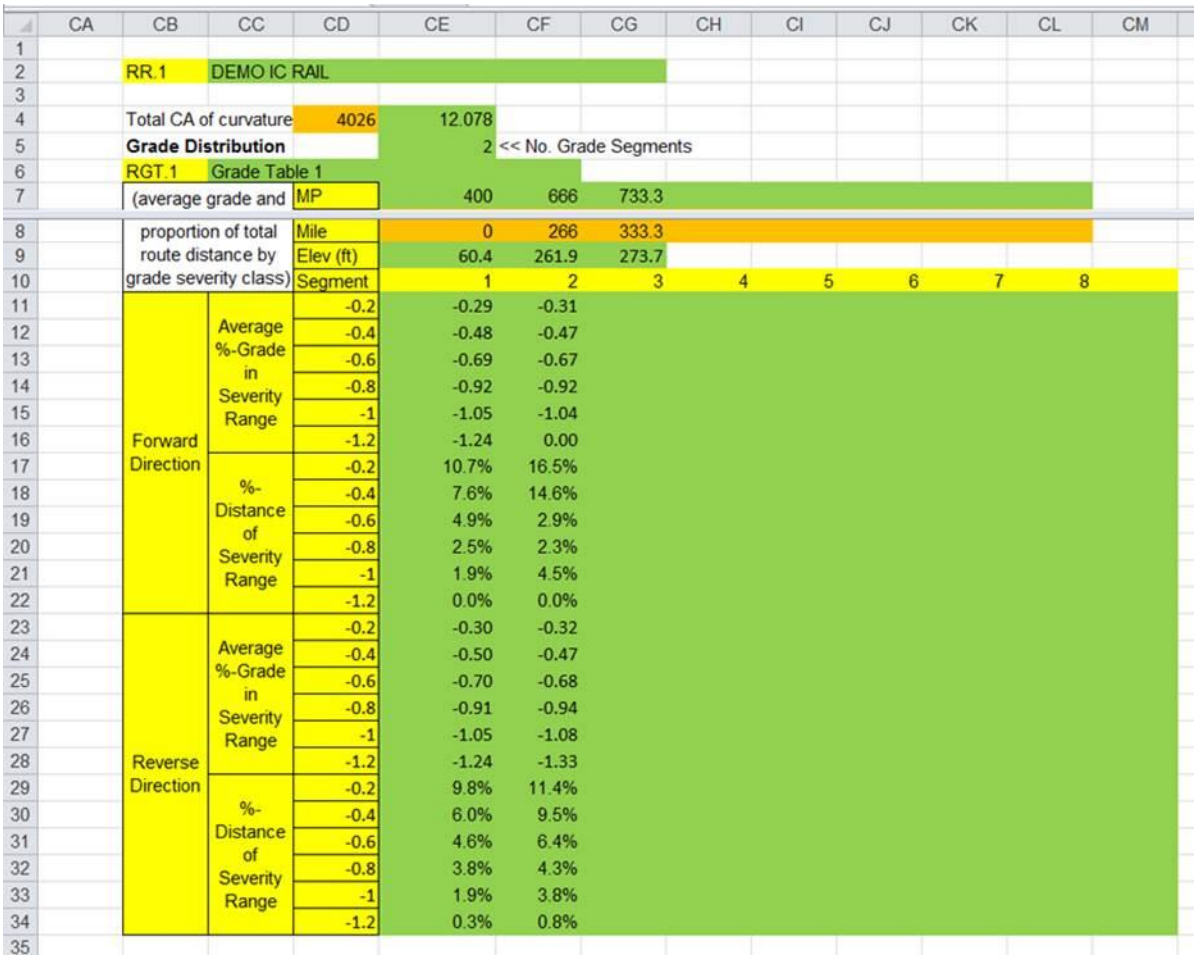
The elapsed time information for a simulated rail trip is shown at Rail-Simulaiton!K4:K11. The simulated minimum run time, excluding dwell time at scheduled stops and any unscheduled stops or temporary slow orders is shown at K5. The total available slack in the schedule based on the user-specified values (in the rail-trip sheet) for scheduled trip time and dwell time at scheduled stops included is shown at K8.

If one is matching actual time and or energy performance data for a trip with known slow orders and unscheduled stops, the data inputs should be based on those data. If one is selecting values for average operating conditions, information on the operation's 'on-time-performance' is a useful guide. For example if on-time-performance is 95%, then the data

input at row 100 for unscheduled stops could be set at 0.05 for the number of stops expected per trip and the average duration of that stop when incurred could be set to exceed the total available slack in the schedule (i.e. %-slack/100 X scheduled trip time X 60 min/hr); and the TSOs could be set such that part of the schedule slack is frequently used. Through an iterative process, the unscheduled delays can be set to provide reasonable operating values for the total average simulation run time (K9 of the simulation sheet) and available slack (K10 of the simulation sheet). As a guide, a 6% to 10% slack might exist prior to allocating unscheduled delays and 4% to 6% slack might remain on average after unscheduled delays are input to the route sheet. Worse on-time performance will require higher frequency and/or magnitude of unscheduled delays.

A.6.6 Build a New Track Profile

The columns of the 'Rail-Route' worksheet hold all data used by MMPASSIM to represent the physical characteristics of a rail route. The influence of vertical track profile is represented using a condensed Grade Distribution Table input in the green fields on rows 4 through 34 of that worksheet as illustrated in Figure A-49. This table requires the vertical track profile be characterized into a maximum of eight (8) segments, where the downward grades in each segment and in each direction of travel, are binned into six (6) severity ranges by percent-grade. The downward percent-grade ranges used are: 0.2% to 0.4%, 0.4% to 0.6%, 0.6% to 0.8%, 0.8% to 1.0%, 1.0% to 1.2% and finally anything greater than 1.2% downgrade. The table requires entries which specify both the actual average percent-grade for all of a segment's track falling within each bin (rows 11 through 16 for the forward direction and rows 23 through 28 for the reverse direction) and the percentage of a segment's track length with grades falling within each percent-grade bin (rows 17 through 22 for the forward direction and rows 29 through 34 for the reverse direction). The mile post (green fields on row 7) and elevation in feet (green fields on row 9) at the start and end location of each track segment must also be defined. The influence of horizontal alignment is assessed in the model using the average degrees of central angle per unit mile of track length (the sum of central angle for all curves divided by the total track length) and is input in the green field on row 4.



	CA	CB	CC	CD	CE	CF	CG	CH	CI	CJ	CK	CL	CM
1													
2		RR.1	DEMO IC RAIL										
3													
4		Total CA of curvature		4026	12.078								
5		**Grade Distribution**			2	<< No. Grade Segments							
6		RGT.1	Grade Table 1										
7		(average grade and		MP	400	666	733.3						
8		proportion of total		Mile	0	266	333.3						
9		route distance by		Elev (ft)	60.4	261.9	273.7						
10		grade severity class)		Segment	1	2	3	4	5	6	7	8	
11		Forward Direction	Average %-Grade in Severity Range	-0.2	-0.29	-0.31							
12				-0.4	-0.48	-0.47							
13				-0.6	-0.69	-0.67							
14				-0.8	-0.92	-0.92							
15				-1	-1.05	-1.04							
16				-1.2	-1.24	0.00							
17			%-Distance of Severity Range	-0.2	10.7%	16.5%							
18				-0.4	7.6%	14.6%							
19				-0.6	4.9%	2.9%							
20				-0.8	2.5%	2.3%							
21				-1	1.9%	4.5%							
22				-1.2	0.0%	0.0%							
23		Reverse Direction	Average %-Grade in Severity Range	-0.2	-0.30	-0.32							
24				-0.4	-0.50	-0.47							
25				-0.6	-0.70	-0.68							
26				-0.8	-0.91	-0.94							
27				-1	-1.05	-1.08							
28				-1.2	-1.24	-1.33							
29			%-Distance of Severity Range	-0.2	9.8%	11.4%							
30				-0.4	6.0%	9.5%							
31				-0.6	4.6%	6.4%							
32				-0.8	3.8%	4.3%							
33				-1	1.9%	3.8%							
34				-1.2	0.3%	0.8%							
35													

Figure A-49 Example of a Grade Distribution Table in the 'Rail-Route' Worksheet

A track preprocessor is provided in a separate Microsoft Excel workbook to assist users through the process of converting track profile data as typically available in track charts into the condensed grade distribution table format required by MMPASSIM. Essentially this involves populating columns of the preprocessor's 'Track Data' worksheet (see Figure A-50) with the start (column C) and end (column D) milepost, grade (column G), degree of curvature (column F) and applicable speed limits (columns H and I) of the successive track sections comprising a subdivision and then segmenting the subdivision when obvious significant transitions in grade trends occur. The 'Readme' worksheet included in the track preprocessor workbook provides details on how to segment a track profile and create the condensed grade distribution table.

	A	B	C	D	E	F	G	H	I	J	K	L
1	IDX	LS	MPBEG	MPEND	LEN (mi)	CRVDEG	GRADE (%	Conv PASS	Tilt-body Pas	FRT	BEGSTA	ENDSTA
2	1	7400	0	0.3	0.3	0	0	79		49		
3	2	7400	0.3	0.5	0.2	2	1.08	79		49		
4	3	7400	0.5	0.7	0.2	0	1.08	79		49		
5	4	7400	0.7	1	0.3	0	0.96	79		49		
6	5	7400	1	1.1	0.1	0	0.83	79		49		
7	6	7400	1.1	1.2	0.1	0	0.66	79		49		
8	7	7400	1.2	1.4	0.2	1.5	0.66	79		49		
9	8	7400	1.4	1.6	0.2	0	0.71	79		49		
10	9	7400	1.6	1.7	0.1	0	0.8	79		49		
11	10	7400	1.7	1.8	0.1	0.7	0.8	79		49		
12	11	7400	1.8	1.9								
13	12	7400	1.9	2								
14	13	7400	2	2.1								
15	14	7400	2.1	2.6								
16	15	7400	2.6	2.9								
17	16	7400	2.9	3								
18	17	7400	3	3.2								
19	18	7400	3.2	3.9								
20	19	7400	3.9	4.2								
21	20	7400	4.2	4.3								
22	21	7400	4.3	4.5								
23	22	7400	4.5	4.7								
24	23	7400	4.7	4.8								
25	24	7400	4.8	5								
26	25	7400	5	5.3								
27	26	7400	5.3	5.6	0.3	1	0.03	79		49		
28	27	7400	5.6	5.7	0.1	1	-0.33	79		49		

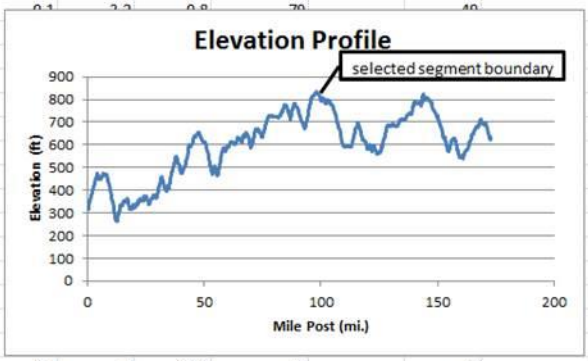


Figure A-50 Example of Track Preprocessor's Input Columns

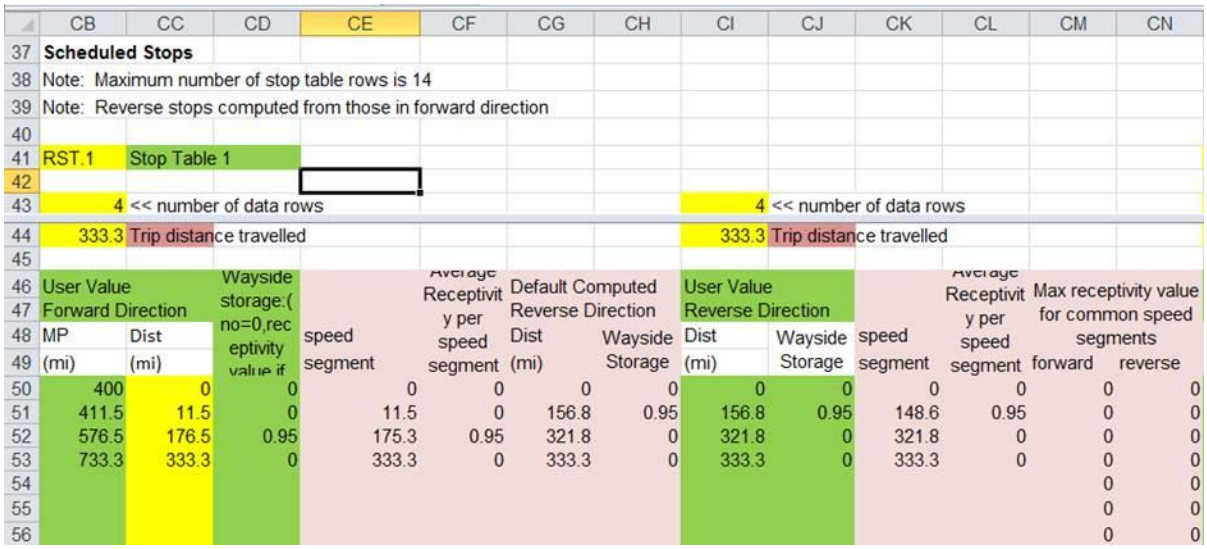
Once the grade distribution table is created (see Figure A-51), a user simply copies the grade segment boundaries from 'Track Data'!AN112:AV112 in the preprocessor and pastes their ***values*** (using the paste special menu) into the target column on row 7 of the 'Rail-Route' worksheet and copies the balance of the grade distribution table from 'Track Data'!AN113:AV138 in the preprocessor and again pastes their ***values*** (using the paste special menu) into the target columns on row 9 of the 'Rail-Route' worksheet. The first rail route's grade table is inserted in column R of the 'Rail-Route' worksheet with tables for subsequent routes input in 13 column intervals (columns AE, AR, BE etc…). The track preprocessor also converts degree of curvature into degrees of central angle (column P) which can be summed and divided by the total subdivision length to derive the rail simulation's required curvature input expressed in terms of degrees of central angle per mile of the total track length.

	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU	AV
112				MP	0	101	173						
113				Elev (ft)	315	805.88	627.84						
114				Segment	1	2	3	4	5	6	7	8	
115		Forward Direction	Average %-Grade in Severity Range	-0.2	-0.31	-0.35							
116				-0.4	-0.50	-0.49							
117				-0.6	-0.72	-0.71							
118				-0.8	-0.92	-0.75							
119				-1	-1.06	-0.80							
120				-1.2	-1.32	0.00							
121			%-Distance of Severity Range	-0.2	5%	10%							
122				-0.4	10%	9%							
123				-0.6	8%	15%							
124				-0.8	10%	5%							
125				-1	1%	0%							
126				-1.2	0.4%	0.0%							
127		Reverse Direction	Average %-Grade in Severity Range	-0.2	-0.29	-0.32							
128				-0.4	-0.53	-0.48							
129				-0.6	-0.68	-0.65							
130				-0.8	-0.91	-0.79							
131				-1	-1.05	-0.94							
132				-1.2	-1.35	0.00							
133			%-Distance of Severity Range	-0.2	9%	8%							
134				-0.4	9%	12%							
135				-0.6	8%	7%							
136				-0.8	17%	5%							
137				-1	4%	2%							
138				-1.2	0.3%	0.0%							
139													
140		% not effectively flat			82%	73%							

Figure A-51 Example of Track Preprocessor's Output Grade Distribution Table

Scheduled stops are input separately for the forward and reverse directions in the green fields of the Scheduled Stop Table located on rows 50 through 85 of the 'Rail-Route' worksheet (a sample is illustrated in Figure A-52 on page A-97). The first green column of input for a route (column CB in the example) declares the milepost of each stop to be made in the forward direction of travel. The second green input column (column CD in the example) declares the receptivity for wayside energy storage at the stop if available and should be set to zero where there is no wayside energy storage. Columns CC and CE through CH (in the example) contain automatically calculated values. For the reverse direction, stop locations are input in terms of miles from the start of the reverse trip (not milepost) in the third green input column (column CI in the example) and the receptivity of wayside storage, if any, in the fourth green input column (column CJ in the example). A maximum of 36 stops, including the origin and destination, may be specified for a route.

Note: *The green fields associated with any unused records in the stop list must be cleared.*



	CB	CC	CD	CE	CF	CG	CH	CI	CJ	CK	CL	CM	CN
37	**Scheduled Stops**												
38	Note: Maximum number of stop table rows is 14												
39	Note: Reverse stops computed from those in forward direction												
40													
41	RST.1	Stop Table 1											
42													
43	4	<< number of data rows						4	<< number of data rows				
44	333.3	Trip distance travelled						333.3	Trip distance travelled				
45													
46	User Value		Wayside		Average	Default Computed		User Value			Average	Max receptivity value	
47	Forward Direction		storage:(		Receptivit	Reverse Direction		Reverse Direction			Receptivit	for common speed	
48	MP	Dist	no=0,rec	speed	y per	Dist	Wayside	Dist	Wayside	speed	y per	segments	
49	(mi)	(mi)	eptivity	segment	speed	(mi)	Storage	(mi)	Storage	segment	speed	forward	reverse
50	400	0	0	0	0	0	0	0	0	0	0	0	0
51	411.5	11.5	0	11.5	0	156.8	0.95	156.8	0.95	148.6	0.95	0	0
52	576.5	176.5	0.95	175.3	0.95	321.8	0	321.8	0	321.8	0	0	0
53	733.3	333.3	0	333.3	0	333.3	0	333.3	0	333.3	0	0	0
54												0	0
55												0	0
56												0	0

Figure A-52 Example of a Scheduled Stop Table in the 'Rail-Route' Worksheet

Slow orders and other speed reductions associated with train interference are input in the Slow Order Table using the green input fields on rows 90 through 96 of the 'Rail-Route' worksheet (see example in Figure A-53 on page A-98). Three columns of data are required to specify a speed reduction. The first identifies the average number of times which a speed reduction will be applied during a trip, the second data value declares the speed (in mph) to which travel will be limited while the third value specifies the average length of track (in miles) over which the speed reduction will apply. A maximum of seven (7) slow orders may be defined.

Note: *All green fields not in use for a route definition should be cleared.*

In addition to slow orders, a user may also characterize unscheduled stops which may occur over a one way trip using the four green input fields on row 100. The first value declares the average number of unscheduled stops per trip, the second input declares the siding speed limit (in mph), the third input declares the average siding length (in miles) and the fourth input specifies the average duration of an unscheduled stop (in minutes). These fields should be cleared when no unscheduled stops are anticipated. Extra idle time at the origin and destination stations, layover idle and additional non-revenue travel for a route are input in the green fields on rows 103 through 105.

	CB	CC	CD	CE	CF	CG	CH	CI	CJ	CK	CL	CM	CN
87	**Average Expected Slow Orders and/or interference speed reductions per one-way trip**												
88	RSO.1												
89	avg #/trip		speed (mph)		average length(mi)								
90	1.5	of	25		0.1								
91	3.3	of	40		0.1								
92	0.5	of	80		7								
93													
94													
95													
96													
97													
98	**Average Expected Unscheduled Stops per one-way trip (show speed in siding and length of siding if applicable)**												
99	avg #/trip		siding speed (mph)		avg siding length (mi)		avg stop duration (min)						
100	1.5		25		2.1		12						
101													
102	**Extra Idle and Non-revenue travel**												
103	0.5	<< combined pre-start/post arrival idle time (hr) at start and final stations											
104	0.5	<< layover idle time allocated per one-way trip (hr)											
105	1.023	<< ratio of non-revenue/revenue train miles											

Figure A-53 Example of Slow Orders and Unscheduled Stops in the 'Rail-Route' Worksheet

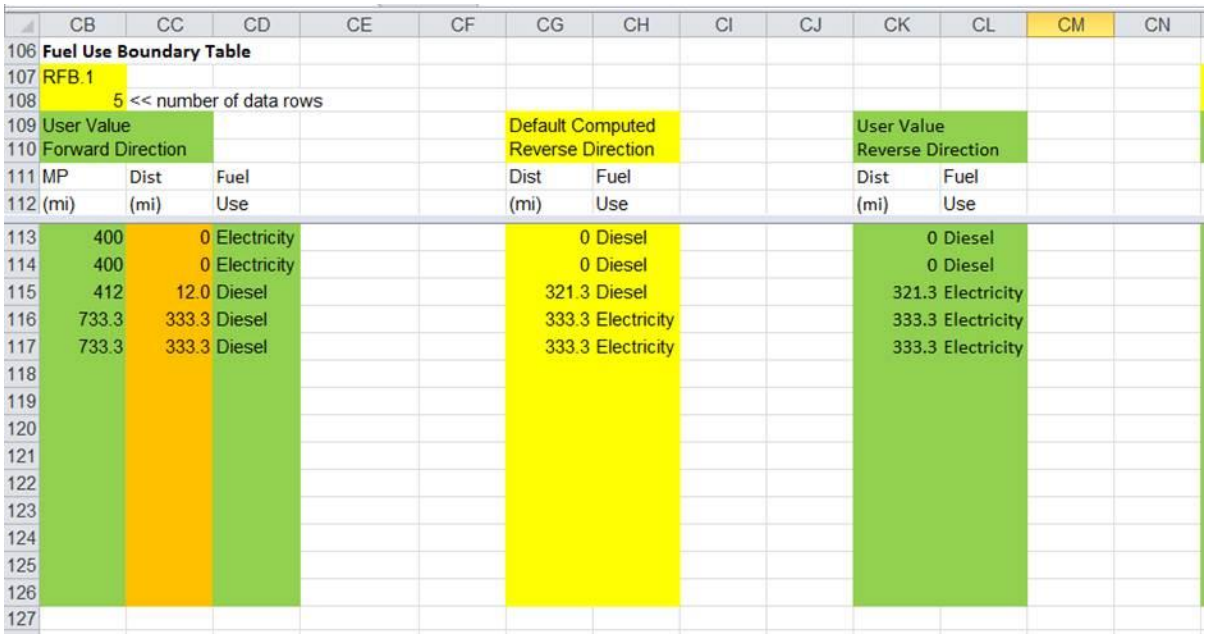
In situations where rail travel involves dual-fuel equipment used along combinations of electrified and non-electrified territories, a user must define where each fuel is to be used. This is specified in the Fuel Use Boundary table on rows 113 through 126 of the 'Rail-Route' worksheet. An example of this table is shown in Figure A-54. For each route there are four green input data columns and three columns which are automatically populated from user inputs (one orange and two yellow columns). The first green column of user input (column CB in the example) must declare the milepost of the boundary where a fuel type is to be changed.

Note: *The starting location of the first boundary and the ending location of the last boundary must be repeated to support formula logic – therefore a maximum of 14 rows of input can declare up to 12 fuel use boundaries.*

The second green input column (CD in the example) identifies the fuel type, as either 'Electricity' or 'Diesel', which will be used starting at the indicated milepost until the next defined boundary is encountered. The keyword 'Electricity' is used by formula logic in the 'Rail-Simulation' worksheet to distinguish between pantograph electricity consumption and onboard fuel use – although there may be several onboard fuels defined in the 'Energy-Emission' worksheet for locomotive use, the 'Diesel' keyword should be used for all forms of onboard fuels. The third and fourth green input columns (CK and CL in the example) specify the location, in miles, of a fuel boundary from the start of a return trip and the keyword describing the fuel to be used beginning at that boundary.

Note: *Although the yellow columns (CG and CH in the example) automatically calculate fuel use boundaries for the reverse direction based upon the*

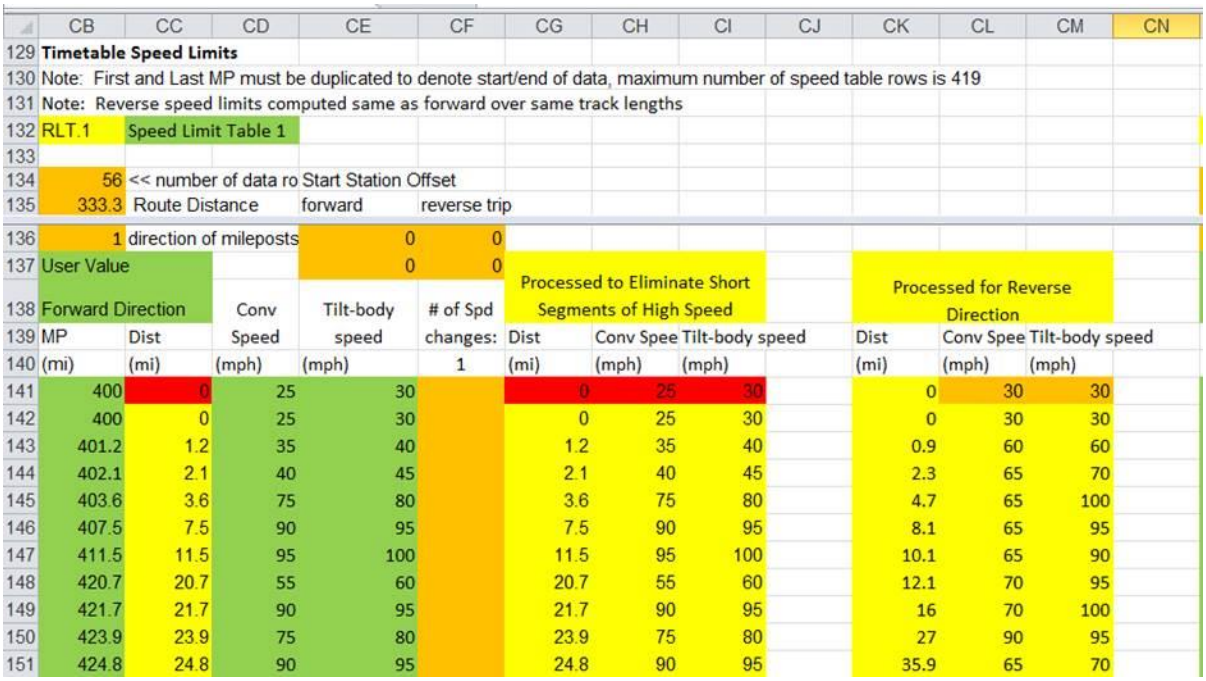
definitions entered for the forward direction, the user must still supply the reverse direction boundaries in the green input columns, either by highlighting the automatically generated columns and pasting by value (using paste special menu) definitions or entering them manually. This allows flexibility in defining reverse direction boundaries independent of the forward direction boundaries if required. All green user input fields on rows not required to define the current Fuel Use Boundary table must be cleared.



	CB	CC	CD	CE	CF	CG	CH	CI	CJ	CK	CL	CM	CN
106	**Fuel Use Boundary Table**												
107	RFB.1												
108	5	<< number of data rows											
109	User Value					Default Computed				User Value			
110	Forward Direction					Reverse Direction				Reverse Direction			
111	MP	Dist	Fuel			Dist	Fuel			Dist	Fuel		
112	(mi)	(mi)	Use			(mi)	Use			(mi)	Use		
113	400	0	Electricity			0	Diesel			0	Diesel		
114	400	0	Electricity			0	Diesel			0	Diesel		
115	412	12.0	Diesel			321.3	Diesel			321.3	Electricity		
116	733.3	333.3	Diesel			333.3	Electricity			333.3	Electricity		
117	733.3	333.3	Diesel			333.3	Electricity			333.3	Electricity		
118													
119													
120													
121													
122													
123													
124													
125													
126													
127													

Figure A-54 Example of a Fuel Use Boundary Table in the 'Rail-Route' Worksheet

The final data table in a rail route definition specifies the location and speed limits to be observed for conventional and tilt-body passenger rail equipment. Figure A-55 illustrates the format of this table. The speed limit location and values in mph are specified in the three green user input columns (columns CB, CD and CE of the example) on rows 141 through 561 of the 'Rail-Route' worksheet. The first green input column defines the starting milepost of each speed limit encountered in the forward direction of travel. The second green input column defines the speed limit, in mph, to be observed for conventional passenger equipment while the third green input column declares the speed limit, again in mph, to be applied when tilt-body passenger equipment is used.

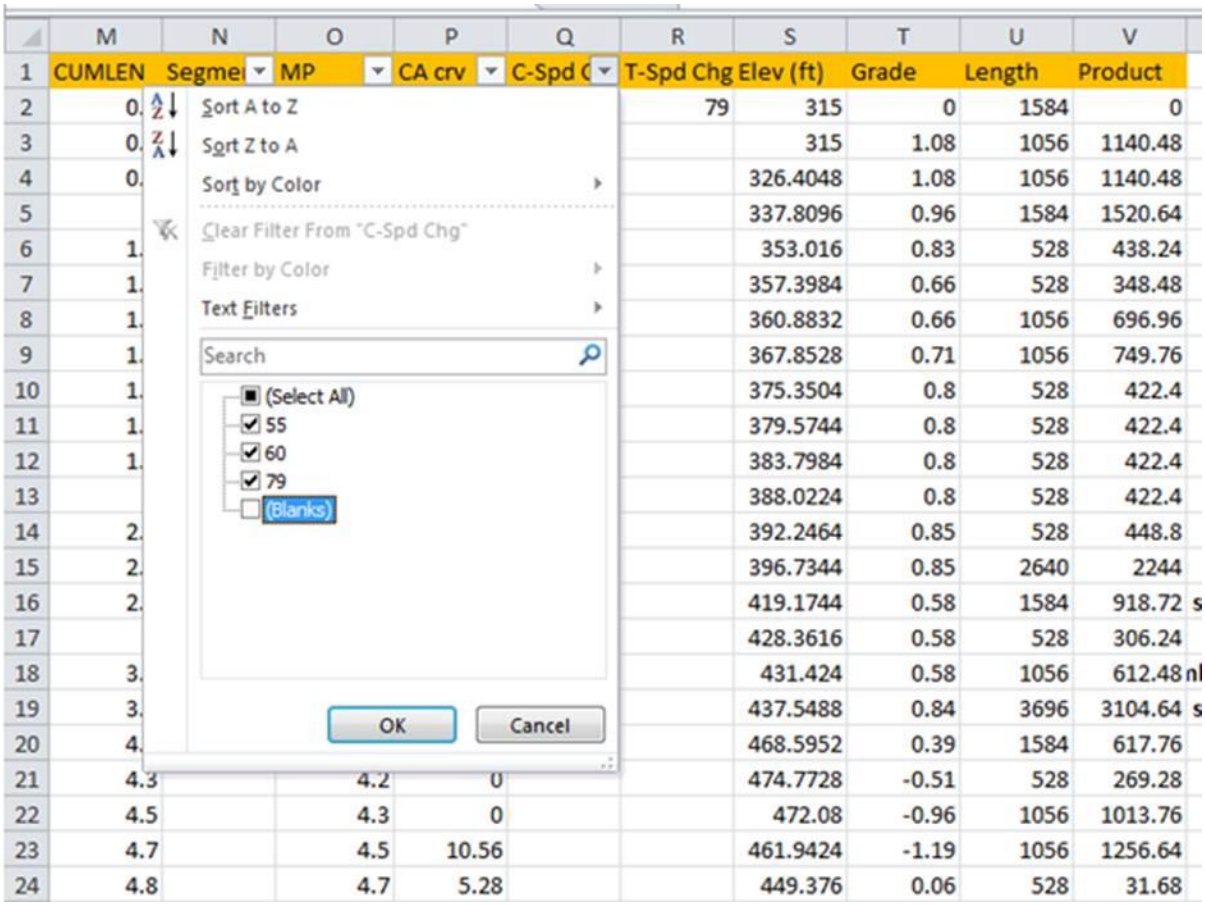


	CB	CC	CD	CE	CF	CG	CH	CI	CJ	CK	CL	CM	CN
129	**Timetable Speed Limits**												
130	Note: First and Last MP must be duplicated to denote start/end of data, maximum number of speed table rows is 419												
131	Note: Reverse speed limits computed same as forward over same track lengths												
132	RLT.1	Speed Limit Table 1											
133													
134	56	<< number of data ro		Start Station Offset									
135	333.3	Route Distance		forward	reverse trip								
136	1	direction of mileposts		0	0								
137	User Value			0	0	Processed to Eliminate Short Segments of High Speed				Processed for Reverse Direction			
138	Forward Direction		Conv	Tilt-body	# of Spd								
139	MP	Dist	Speed	speed	changes:	Dist	Conv Spee	Tilt-body speed		Dist	Conv Spee	Tilt-body speed	
140	(mi)	(mi)	(mph)	(mph)	1	(mi)	(mph)	(mph)		(mi)	(mph)	(mph)	
141	400	0	25	30		0	25	30		0	30	30	
142	400	0	25	30		0	25	30		0	30	30	
143	401.2	1.2	35	40		1.2	35	40		0.9	60	60	
144	402.1	2.1	40	45		2.1	40	45		2.3	65	70	
145	403.6	3.6	75	80		3.6	75	80		4.7	65	100	
146	407.5	7.5	90	95		7.5	90	95		8.1	65	95	
147	411.5	11.5	95	100		11.5	95	100		10.1	65	90	
148	420.7	20.7	55	60		20.7	55	60		12.1	70	95	
149	421.7	21.7	90	95		21.7	90	95		16	70	100	
150	423.9	23.9	75	80		23.9	75	80		27	90	95	
151	424.8	24.8	90	95		24.8	90	95		35.9	65	70	

Figure A-55 Example of a Speed Limit Table in the 'Rail-Route' Worksheet

The track preprocessor may also be used to assist in extracting the table of speed limits from speed limit data as typically provided in columnar track chart data, This can be achieved using Excel's filtering capability on the preprocessor's two columns which identify changes in the conventional speed limit ('Track Data' column Q) and tilt-body speed limit ('Track Data' column R) for all non-blank values. This is done by clicking the gray down arrow in the orange "C-Spd Chg" header in cell 'Track-Data'!Q1, as shown in Figure A-56. This will open a filter menu where the check box corresponding with "(blanks)" should be cleared and then click the "OK" button to apply the filter. Once the speed change column is filtered, as depicted in Figure A-57, copy the mileposts from 'Track Data' column O, the conventional speed limits from 'Track Data' column Q and the tilt-body speed limits from 'Track Data' column R of the track preprocessor and paste their values (using the "Paste Special" menu) into the appropriate column in 'Rail-Route' worksheet.

Note: *The first row of green user inputs and the last row of green user inputs specified in the Timetable Speed Limits table must be repeated to accommodate the formula logic used for automatic calculations. Therefore, a maximum of 419 speed limits may be assigned for any route. Also, all green user input fields should be cleared on any unused row in the table after pasting a column of data.*



	M	N	O	P	Q	R	S	T	U	V
1	CUMLEN	Segme	MP	CA crv	C-Spd C	T-Spd Chg	Elev (ft)	Grade	Length	Product
2	0.					79	315	0	1584	0
3	0.						315	1.08	1056	1140.48
4	0.						326.4048	1.08	1056	1140.48
5							337.8096	0.96	1584	1520.64
6	1.						353.016	0.83	528	438.24
7	1.						357.3984	0.66	528	348.48
8	1.						360.8832	0.66	1056	696.96
9	1.						367.8528	0.71	1056	749.76
10	1.						375.3504	0.8	528	422.4
11	1.						379.5744	0.8	528	422.4
12	1.						383.7984	0.8	528	422.4
13							388.0224	0.8	528	422.4
14	2.						392.2464	0.85	528	448.8
15	2.						396.7344	0.85	2640	2244
16	2.						419.1744	0.58	1584	918.72 s
17							428.3616	0.58	528	306.24
18	3.						431.424	0.58	1056	612.48 nl
19	3.						437.5488	0.84	3696	3104.64 s
20	4.						468.5952	0.39	1584	617.76
21	4.3		4.2	0			474.7728	-0.51	528	269.28
22	4.5		4.3	0			472.08	-0.96	1056	1013.76
23	4.7		4.5	10.56			461.9424	-1.19	1056	1256.64
24	4.8		4.7	5.28			449.376	0.06	528	31.68

Figure A-56 Finding Speed Limit Changes Using Column Filter in Track Preprocessor

	M	N	O	P	Q	R	S	T	U	V
1	CUMLEN	Segme	MP	CA crv	C-Spd C	T-Spd Chg	Elev (ft)	Grade	Length	Product
2	0.3		0	0	79	79	315	0	1584	0
392	64.5		64.2	33.264	55	55	623.5632	0.61	1584	966.24
395	65		64.9	0	79	79	625.0416	0.4	528	211.2
407	66.5		66.4	0	55	55	624.672	0.71	528	374.88
411	66.9		66.8	7.92	79	79	636.8688	0.69	528	364.32
605	96.2		96.1	0	55	55	808.944	0.6	528	316.8
621	98.3		98.2	0	79	79	832.4928	0.32	528	168.96
654	103		102.8	0	55	55	798.7536	-0.18	1056	190.08
671	105.5		105.3	0	79	79	767.6016	-0.72	1056	760.32
717	114.5		114.3	15.84	60	60	645.4752	0.67	1056	707.52
734	116.5		116.4	0	79	79	685.0752	-0.6	528	316.8
1136	173.1		173.1	0	79	79	630.9024	0	0	0
1137	173.1		173.1	0	79	79	630.9024	0	0	0
6012										

Figure A-57 Column of Speed Limit Changes Once Filtered in Track Preprocessor

A.6.7 Train Technology Comparison by Modifying an Existing Train/Route

Performing train technology comparisons based upon modifications to the propulsion type, provision of hotel power and implementation of energy recovery capabilities of an existing train consist and route are straight forward using MMPASSIM's "Rail Technology Evaluation" analysis mode. These types of analyses may be set up and run from either the 'Master-I-O' or the 'Rail-I-O' worksheet by selecting "Rail Technology Evaluation" from the green drop-down list at cell C4 of either worksheet and then configuring a baseline trip and up to three other rail trips for comparison. Configure the trips by clicking the blue "Define Baseline" and "Define Alternative #" buttons as required to access the 'Rail Trip Selection' menu allowing configuration of each trip. The trips could all specify a common route but different consists, or the route can also be different if a particular technology alternative also requires route modifications.

The characteristics of locomotives, or power cars, in a train are characterized by parameters stored in the columns of the 'Rail-Consist' worksheet. The 'Rail Consist Selection' menu provides a convenient means to create new trains from existing definitions in the 'Rail-Consist' worksheet (using the "Add Rail Consist" button) and selecting key features and capabilities which are supported by the train data. The 'Rail Consist Selection' menu, depicted in Figure A-58, is accessed by double clicking the light yellow "Consist ID" located in the bottom right quadrant of a 'Rail Trip Selection' menu. Open the 'Rail Trip Selection' menu by clicking a blue "Define Baseline" or one of the "Define Alternative #" button associated with a rail trip definition on the 'Master-I-O' or the 'Rail-I-O' worksheets.

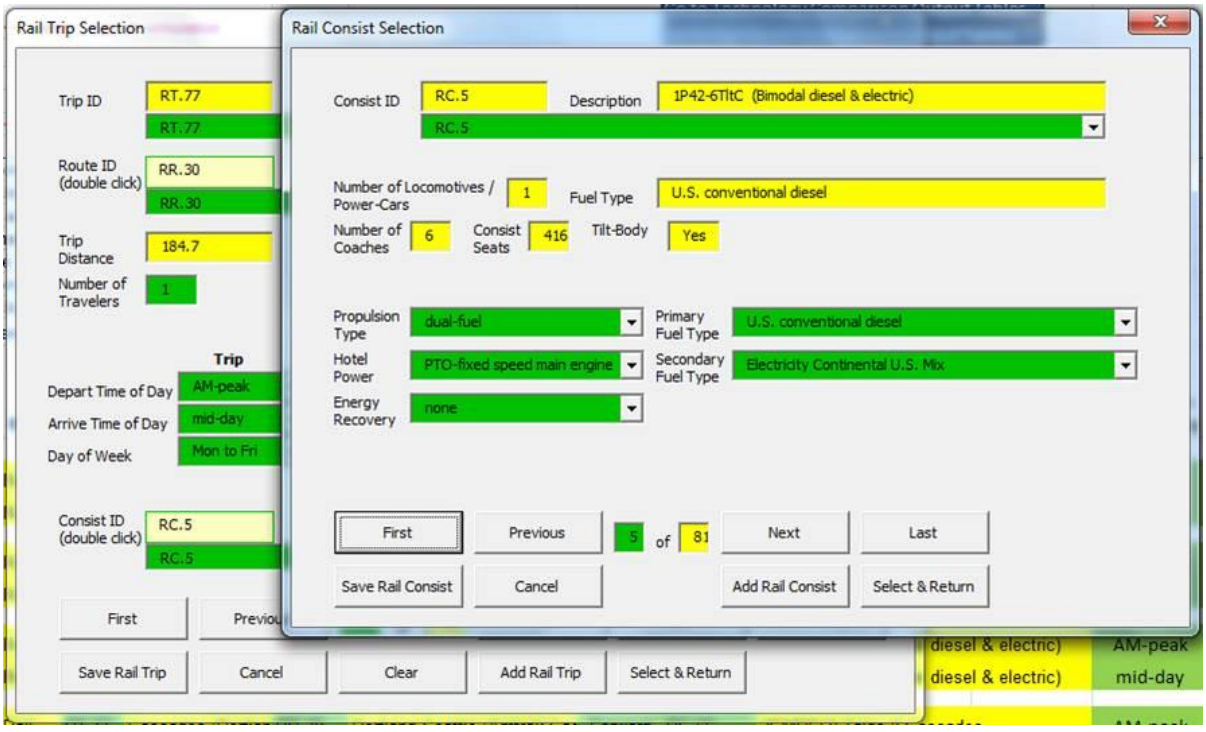


Figure A-58 Rail Consist Selection Menu

The ‘Rail Consist Selection’ menu presents five green drop-down lists which describe a locomotive’s basic characteristics. These are initially read from cells in the columns of the ‘Rail-Consist’ worksheet associated with the displayed “Consist ID”.

The green “Propulsion Type” drop-down list presents only three options:

- “onboard-fuel”
- “electric”
- “dual-fuel”.

The selected “Propulsion Type” is represented in the pink cells on rows 40 and 65 of the column in ‘Rail-Consist’ associated with the displayed “Consist ID” (also stored in the yellow cell on row 2 of ‘Rail-Consist’). The pink cell on row 65 of ‘Rail-Consist’ is a dual-fuel locomotive flag which is set to “1” only when the “Propulsion Type” is selected to be “dual-fuel”, otherwise it is “0”. The pink cell on row 40 of ‘Rail-Consist’ is set to “2” when the “Propulsion Type” selection is “electric”, otherwise it is set to “1” indicating a “propulsion Type” of either “onboard-fuel” or “dual-fuel”.

The “Primary Fuel Type” and “Secondary Fuel Type” drop-down lists are coordinated with the current selection of “Propulsion Type” such that they only display valid fuel sources appropriate for a selected propulsion type. For locomotives using an onboard-fuel the list of options for the “Primary Fuel Type” are from the locomotive fuels table in ‘Energy-Emission’!E37:E45. For electric locomotives the “Primary Fuel Type” presents grid electricity sources from the regional mixes defined in ‘Energy-Emission’!E61:E77. The “Secondary Fuel Type” is only used to select the grid electricity when a “dual-fuel” locomotive has been selected. The “Primary Fuel Type” selection is stored in the pink cell on row 41 of ‘Rail-Consist’ while the “Secondary Fuel Type” is stored in the pink cell on row 66.

The green “Hotel Power” drop-down list presents the following 4 options:

- “PTO-inverter”
- “PTO-fixed speed main engine”
- “Diesel genset”
- “Electric Loco”

The first three options are applicable to locomotives declared as using “onboard” and “dual-fuel” sources. The “Electric Loco” option should only be selected when a “Propulsion Type” of “electric” has been declared. The selection is stored in the pink cell on row 67 of ‘Rail-Consist’ as a flag value with “1” corresponding to “PTO-inverter”, “2” with “PTO-fixed speed main engine”, “3” with “Diesel genset” and “4” with “Electric Loco”. Choosing to take hotel power off of the main traction engine (one of the “PTO” options) affects both the power available for traction and the calculated fuel consumption. These impacts are calculated from the traction engine characterization defined on rows 49 through 68 of ‘Rail-Consist’ (Figure A-59). Using a diesel genset to provide hotel power will not reduce traction power and the fuel consumption is calculated by a fuel equation with coefficients defined in cells on rows 69 through 70 of ‘Rail-Consist’ (Figure A-60).

	A	I	J	K	L	M	N	O
1								
2	Consist ID	RC.1						
3	Description	1P42-4TItC+Bag (Diesel)						
4	Set UNITS BEFORE ENTERING DATA (pick: U.S. (or) metric) >>>	metric	< SET UNITS (pick: U.S. (or) metric)					
49	Traction Engine Characteristics							
50	engine per-unit power load rate = aT^b ("a" term)	0.00348						
51	engine per-unit power load rate = aT^b ("b" term)	1.45295						
52	Fuel Penalty @ low load factors-variable speed engine ("a")	0.4						
53	Fuel Penalty @ low load factors-fixed speed engine ("a")	0.9						
54	bsfc(min) (lb/hph)	0.33						
55	bsfc(min) (kg/kWh)	0.20				idle rate	estimated load (kW)	
56	Idle rate (var-speed Trac-Engine) (lb/hr)	24		10.9	kg/h	0.256906	42.38636	
57	DB fuel rate (var-speed Trac-Engine) (lb/hr)	150		68.1	kg/h	0.247272	275.2361	
58	regen fuel rate (var-speed Trac-Engine) (lb/hr)	24		10.9	kg/h	0.256906	42.38636	
59	Idle rate (fixed-speed Trac-Engine) (lb/hr)	30.6		13.9	kg/h	0.327153	42.38636	
60	DB fuel rate (fixed-speed Trac-Engine) (lb/hr)	185.3		84.1	kg/h	0.305477	275.2361	
61	regen fuel rate (variable speed Trac-Engine) (lb/hr)	24		10.9	kg/h	0.256906	42.38636	
62	Idle rate usage flag (if no hotel PTO)	0						
63	DB usage flag	1						
64	copy Brake energy Recovery flag for calculation	0						
65	flag for dual-fuel loco (0=no, 1=electric & onbrd fuel) also set region in adj. column	0						
66	Electricty Source Region if dual-fuel							
67	Hotel Power Provision code (1=PTO-inverter, 2=PTO-fixed speed main engine, 3=dg	2						
68	Loco-Aux pwr net of dynamic brake grid cooling (kW)	75						

Figure A-59 Traction Engine Characteristics in 'Rail-Consist'

	A	I	J	K	L	M	N	O
1								
2	Consist ID	RC.1						
3	Description	1P42-4TItC+Bag (Diesel)						
4	Set UNITS BEFORE ENTERING DATA (pick: U.S. (or) metric) >>>	metric	< SET UNITS (pick: U.S. (or) metric)					
69	Hotel dg-set fuel equation (a (kg/hr) + b(kg/hr)/kW * Load (kW)							
70	hotel DG fuel rate "a" term (kg/hr)	16.8						
71	hotel DG fuel rate "b" term ((kg/hr)/kW)	0.2016						

Figure A-60 Diesel Genset Fuel Use Characteristics in 'Rail-Consist'

The green “Energy Recovery” drop-down list presents the following 5 options:

- “none”
- “onboard”
- “wayside”
- “electrical grid”
- “optimal coasting”

The selection of an “Energy Recovery” option is stored in the pink cell on row 85 of ‘Rail-Consist’ using a flag value where “0” corresponds with “none”, “1” with “onboard”, “2” with “wayside”, “3” with electrical grid and “4” with “optimal coasting” selections. When “none” is selected then the simulation uses the air brake system which may be assisted by dynamic braking when the flag in the green cell on row 63 of ‘Rail-Consist’ is set to “1”.

The “onboard” energy recovery option is applicable only where locomotives are equipped with electrical systems to store the energy generated during braking. This is characterized using the overall storage capacity in kW-hr and the power capacity at the wheels in Watts

(specified in the yellow cells on rows 86 and 87 in 'Rail-Consist' worksheet) and may be used on any route.

The "wayside" energy recovery option can only be used with suitably equipped locomotives operating along routes which provide facilities to accept that wayside power at stop locations. The amount of energy recovered is assumed to only be limited by the locomotive's power regeneration capability specified in Watts in the yellow cell on row 89 of 'Rail-Consist'.

Note: *Using "wayside" energy recovery also requires non-zero receptivity values be declared for all wayside storage sites in the appropriate columns of the Table of Scheduled Stops declared on rows 50 through 85 in the 'Rail-Route' worksheet.*

The "electrical grid" energy recovery option can be used with electrified propulsion systems and on the electrified portions of track traversed by a dual-fuel locomotive. Unlike the "wayside" option, the "electrical grid" option does not require specification of wayside receptivity as it is assumed that regeneration occurs during all braking and that it is returned to the grid for consumption by other users. However, like the "wayside" option, the energy recovery to the electrical grid during braking is limited by the locomotive's power regeneration capability as specified in the yellow cell on row 89 of 'Rail-Consist'.

The "optimal coasting" energy recovery option may be used with all propulsion system types. When used, the simulation allows coasting over a configurable proportion of schedule slack to reduce traction energy consumption. The yellow cell on row 88 of 'Rail-Consist' sets the proportion where slack and coast advice will be followed.

MMPASSIM also supports technology comparisons well beyond the suite of user-selectable propulsion types, fuels, hotel power provision and energy recovery options mentioned above. Typically a new train technology may be introduced into the model by creating a new train consist in the 'Rail-Consist' worksheet (by appending columns to the right) and then modifying the new train's characteristics specified in those new columns as influenced by the introduction of the new technology to the train. The characteristics you may wish to modify include:

- train physical properties (rows 5 through 20)
- tilt-body coach flag (uses higher speed limits) (set flag on row 15)
- train resistance coefficients (rows 25 through 28)
- transmission efficiency (rows 37 through 39)
- traction power and effort characteristics (rows 42 through 48)
- traction engine fuel consumption characteristics (rows 49 through 68)
- minimum brake specific fuel consumption (row 54)
- train braking characteristics (rows 72 through 80)

After adding a new train into the 'Rail-Consist' worksheet and making all desired data adjustments, the MMPASSIM macros will detect the new consist definition and make it available for selection from both the 'Rail Consist Selection' and the 'Rail Trip Selection' menus. Running a technology comparison using the newly included technology then

requires defining a new trip which operates the newly created train over a route for comparison and then selecting it as one of the three alternatives in a rail technology comparison analysis.

A.6.8 Update the Light Duty Vehicle to a New MY Fleet

The 'LDV-Resist' worksheet contains a table at 'LDV-Resist'!C29:AB48 which defines the default characteristics of light duty vehicles used by the 'LDV-Simulation' worksheet from which fuel consumption and emissions are calculated. Updating the light duty vehicle simulation with composite 'sales weighted' and 'driven-fleet' data for a model year beyond 2013 requires manual addition of data to that table. As depicted in Figure A-61, the first column (column C) of that table describes the parameter entered along one row while the next six columns (columns D through I) hold default values for each parameter associated with a particular class of light duty vehicle (as indicated in the yellow cells on row 31) for the base 2011 model year. The next three columns (columns J through L) provide default data calculated to represent composite vehicles used in 'local', 'intercity' and 'taxi' trips in the 2011 base year. The next two columns (columns M through N) provide parameter values which are calculated to represent a 'sales weighted' and a 'driven fleet' composite vehicle in the 2011 base year.

	C	D	E	F	G	H	I	J	K	L	M	N
27							Post 2011 Sales-weighted and Driven Fuel Economy (indexed to 2011 MY)				1.00	0.92
28								Derived Scale Factor (indexed to 2011 MY)			1	-0.079
29	Index	1	2	3	4	5	6	7	8	9	10	11
30	Year	2011	2011	2011	2011	2011	2011	2011	2011	2011	2011	2011
31	Name	small	mid/SW	MV/smSUV	Lg/mSUV/smP	PU-truck	LgSUV	Local	Intercity	Taxi	2011 sales w	2011 driven f
32	Description	Small automobile	Mid-size auto	Minivan or sm	Large auto or r	Pickup truck	Large Sport Utili	Composite lc	Composite ir	Composite t	Sales weight	Driven fleet
33	engine (hp)	162.49	178.18	217.99	253.30	312.90	339.10	222.53	239.63	205.60	226.3	239.2
34	drivetrain loss reduction	-0.01	0.04	-0.01	0.05	-0.05	0.01	0.02	0.02	0.02	0.02	-0.02
35	tare (kg)	1516.73	1524.39	1850.60	1939.86	2512.39	2519.73	1828.13	1928.92	1729.04	1877.50	1951.63
36	spark or diesel	spark	spark	spark	spark	spark	spark	spark	spark	spark	spark	spark
37	kW/kW-100km/h	1.55	1.68	1.68	1.84	1.78	1.94	1.72	1.76	1.70	1.73	1.75
38	drive ratio	51.04	47.17	47.02	42.94	44.47	40.86	46.21	45.30	46.67	45.86	45.20
39	shift factor	1.00	0.92	0.92	0.84	0.87	0.80	0.91	0.89	0.91	0.90	0.89
40	a (N)	143.78	164.19	166.87	201.31	236.46	235.47	182.35	191.57	169.24	187.10	194.51
41	b (Nm^-1s)	2.44	2.32	3.30	4.24	6.25	6.27	3.61	4.01	3.00	3.83	3.98
42	c (Nm^-2s^2)	0.42	0.44	0.57	0.60	0.70	0.66	0.53	0.56	0.52	0.54	0.56
43	CdA (m^2)	0.703	0.724	0.953	0.992	1.166	1.101	0.876	0.923	0.865	0.900	0.936
44	%-Hybrid	8.00%	1.88%	0.40%	1.88%	0.40%	0.40%	3.86%	3.86%	10%	2.2%	1.3%
45	% non-hybrid CVTs	4.00%	9.99%	6.90%	9.99%	6.90%	6.90%	6.74%	6.74%	8.00%	7.8%	2.9%
46	Cold-Start Fuel Increment (kg)	0.095219497	0.096619828	0.118189719	0.116006847	0.14855653	0.139258018	0.11	0.12	0.11	0.11356175	0.1225
47	(N2O+CH4) CO2e increment (kg/kg)	0.00565	0.00565	0.00565	0.00565	0.00565	0.00565	0.00565	0.00565	0.00565	0.00565	0.01839
48	(N2O+CH4) CO2e increment (kg/start)	0.00437	0.00437	0.00437	0.00437	0.00437	0.00437	0.00437	0.00437	0.00437	0.00437	0.01589
49	passenger seats	4	4	5	5	3	7	4	4	3	4	4
50	passengers carried (default)	1	1	1	1	1	1	1	1	1	1	1
51	fuel	E10 - LS gasoline	E10 - LS gasoli	E10 - LS gasoli	E10 - LS gasoli	E10 - LS gaso	E10 - LS gasoline	E10 - LS gaso	E10 - LS gaso	E10 - LS gaso	E10 - LS gaso	E10 - LS gaso

Figure A-61 Default 2011 Model Year Light Duty Vehicle Characteristics

The balance of the light duty vehicle characteristics table (columns O through AB), as illustrated in Figure A-62, provide parameters representing 'sales weighted' and 'driven' fleet composite vehicles for the year 2012 and later which are entered in sets of two columns for each year. Note that the post 2011 "sales weighted" and "drive" fleet composite vehicle parameters are calculated in each column from the 2011 base year values using a scale factor derived from estimates of each future year's fuel economy relative to the 2011 base year. Pre-processed default composite values for the 'sales weighted' and 'driven' fleets for the years 2011, 2012 and 2013 are already provided in MMPASSIM. The future year scale factors are loaded in 'LDV-Resist'!M27:AB28 from data generated in a preprocessor located further down on the 'LDV-Resist' worksheet.

	C	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB
27	weighted and Driven Fuel Economy (indexed to 2011 MY)	1.05	0.94	1.07	0.95										
28	Derived Scale Factor (indexed to 2011 MY)	0.055	-0.065	0.070	-0.050										
29	Index	12	13	14	15	16	17	18	19	20	21	22	23	24	25
30	Year	2012	2012	2013	2013	2014	2014	2015	2015	2016	2016	2017	2017	2018	2018
31	Name	2012 sales	2012 drive	2013 sales	2013 drive	2014 sales	2014 drive	2015 sales	2015 drive	2016 sales	2016 drive	2017 sales	2017 drive	2018 sales	2018 drive
32	Description	Sales weig	Driven fle	Sales weig	Driven fle	Sales weig	Driven fle	Sales weig	Driven fle	Sales weig	Driven fle	Sales weig	Driven fle	Sales weig	Driven fle
33	engine (hp)	218.2	237.1	215.8	234.7										
34	drivetrain loss reduction	0.05	-0.01	0.06	0.00										
35	tare (kg)	1825.96	1939.04	1812.08	1925.01										
36	spark or diesel	spark	spark	spark	spark										
37	kW/kW-100km/h	1.71	1.75	1.70	1.74										
38	drive ratio	46.36	45.31	46.51	45.43										
39	shift factor	0.91	0.89	0.91	0.89										
40	a (N)	181.99	193.26	180.60	191.86										
41	b (Nm^-1s)	3.72	3.95	3.69	3.92										
42	c (Nm^-2s^2)	0.53	0.56	0.52	0.56										
43	CdA (m^2)	0.876	0.930	0.869	0.923										
44	%-Hybrid	3.1%	1.5%	4.2%	1.9%										
45	% non-hybrid CVTs	8.5%	3.6%	10.0%	4.4%										
46	Cold-Start Fuel Increment (kg)	0.1073	0.1210	0.1056	0.1193	0.1136	0.1136	0.1136	0.1136	0.1136	0.1136	0.1136	0.1136	0.1136	0.1136
47	(N2O+CH4) CO2e increment (kg/kg)	0.005654	0.015745	0.005654	0.013873	0.005654	0.012253	0.005654	0.010885	0.005654	0.009769	0.005654	0.008904	0.005654	0.008292
48	(N2O+CH4) CO2e increment (kg/start)	0.004368	0.013962	0.004368	0.012251	0.004368	0.010755	0.004368	0.009475	0.004368	0.008411	0.004368	0.007562	0.004368	0.006928
49	passenger seats	4	4	4	4										
50	passengers carried (default)	1	1	1	1										
51	fuel	E10 - LS ga	E10 - LS ga	E10 - LS ga	E10 - LS gasoline										

Figure A-62 Sales-Weighted and Driven-Fleet Light Duty Vehicle Characteristics

To add future year composite data for 'sales-weighted' and 'driven' fleets, the 'LDV-Resist' worksheet provides a preprocessor which determines appropriate scale factors from data which is published annually by the U.S. EPA and entered into the Fuel Economy Table at 'LDV-Resist'!D61:M112. Figure A-63 illustrates the top portion of this table. The data in columns E to K came from Table 10.1 while the data in columns L and M came from Appendix A of the EPA's 2013 Carbon Dioxide Emissions and Fuel Economy Trends report. Users can fill in the rows of the Fuel Economy Table for years 2014 to 2023 as data becomes available. The calculations performed in the orange cells at 'LDV-Resist'!P64:T73 (see Figure A-64) determine the data used for both the sales-weighted composite vehicle (column P) and the driven-fleet composite vehicle (column Q) for the indicated year. The driven-fleet derivation for all future years applies the age distribution which existed in 2011 (in 'LDV-Resist'!X64:X94 for the corresponding vehicle ages given in 'LDV-Resist'!U64:U94) and presumes a 60% automobile and 40% light duty truck split (entered in 'LDV-Resist'!V62:W62). If a different age distribution is desired for any given year then the desired distribution would need to be brought into a new location on the worksheet and the formula for that year modified to use the replacement data from that new data location.

	D	E	F	G	H	I	J	K	L	M
60	Future Year Fuel Economy and Driven Fleet Calculator (input data for future MY in Table below)									
61	Source: EPA, 2013 Carbon Dioxide Emissions and Fuel Economy Trends Report, Section 10 Tables, Table 10.1								Source: Appendix K of same EPA 2013 report	
62										
63	Model Year	Unadjusted City (MPG)	Unadjusted Highway (MPG)	Unadjusted Combined (55/45) (MPG)	Adjusted City (MPG)	Adjusted Highway (MPG)	Adjusted Combined (43/57) (MPG)	Ratio of Adjusted Combined to Unadjusted Combined	%-Hybrid	%-CVT
64	*2023*									
65	*2022*									
66	*2021*									
67	*2020*									
68	*2019*									
69	*2018*									
70	*2017*									
71	*2016*									
72	*2015*									
73	*2014*									
74	*2013*	*25.5*	*39.3*	*30.3*	*20.2*	*28.1*	*24.0*	*78.8%*	4.2%	14.2%
75	2012	25.1	38.6	29.8	19.9	27.6	23.6	78.9%	3.1%	11.6%
76	2011	23.6	36.4	28.1	18.8	26.1	22.4	79.4%	2.2%	10.0%
77	2010	24.1	36.6	28.4	19.1	26.2	22.6	79.0%	3.8%	10.9%
78	2009	23.8	36.4	28.2	18.9	26.0	22.4	79.1%	2.3%	9.4%
79	2008	22.1	34.0	26.3	17.7	24.4	21.0	79.5%	2.5%	7.9%
80	2007	21.8	33.4	25.8	17.4	24.0	20.6	79.6%	2.2%	7.2%
81	2006	21.2	32.6	25.2	17.0	23.4	20.1	79.8%	1.5%	2.8%
82	2005	21.0	32.1	24.8	16.8	23.1	19.9	79.8%	1.1%	2.3%
83	2004	20.2	31.0	24.0	16.3	22.4	19.3	80.2%	0.5%	1.2%

Figure A-63 'LDV-Resist' Worksheet Fuel Economy Input Table

	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
60							Source: EPS GHG Inventory, Table A- 98: VMT Distribution by Vehicle Age and Vehicle/Fuel Type, a 2011									
61							Vehicle miles travelled by age (2011 reference)									
62								0.6	0.4		capped at 18 years from 2011					
63		MY sales-weighted FE, (indexed to 2011-MY)	driven fleet FE (indexed to 2011-MY)	driven fleet FE	driven fleet %Hyb	driven fleet %CVT	Vehicle Ag	LDGV	LDGT	composite	LDGV	LDGT	composite			
64	2023	N/A	N/A	N/A	N/A	N/A	0	10.31%	10.21%	10.27%	10.31%	10.21%	10.27%			
65	2022	N/A	N/A	N/A	N/A	N/A	1	8.59%	8.74%	8.65%	8.59%	8.74%	8.65%			
66	2021	N/A	N/A	N/A	N/A	N/A	2	6.83%	5.73%	6.39%	6.83%	5.73%	6.39%			
67	2020	N/A	N/A	N/A	N/A	N/A	3	7.22%	6.69%	7.01%	7.22%	6.69%	7.01%			
68	2019	N/A	N/A	N/A	N/A	N/A	4	7.59%	9.20%	8.23%	7.59%	9.20%	8.23%			
69	2018	N/A	N/A	N/A	N/A	N/A	5	7.30%	8.62%	7.83%	7.30%	8.62%	7.83%			
70	2017	N/A	N/A	N/A	N/A	N/A	6	6.72%	8.34%	7.37%	6.72%	8.34%	7.37%			
71	2016	N/A	N/A	N/A	N/A	N/A	7	6.10%	7.41%	6.62%	6.10%	7.41%	6.62%			
72	2015	N/A	N/A	N/A	N/A	N/A	8	5.67%	6.39%	5.96%	5.67%	6.39%	5.96%			
73	2014	N/A	N/A	N/A	N/A	N/A	9	5.54%	5.47%	5.51%	5.54%	5.47%	5.51%			
74	2013	1.071429	0.951252	21.30804	1.9%	6.2%	10	5.25%	4.77%	5.06%	5.25%	4.77%	5.06%			
75	2012	1.053571	0.936109	20.96885	1.5%	5.1%	11	5.02%	4.02%	4.62%	5.02%	4.02%	4.62%			
76	2011	1	0.922855	20.67196	1.3%	4.3%	12	4.15%	3.16%	3.75%	4.15%	3.16%	3.75%			
77	2010	1.008929	0.915718	20.51208	1.2%	3.5%	13	3.15%	2.55%	2.91%	3.15%	2.55%	2.91%			
78	2009	1	0.90674	20.31098	0.9%	2.7%	14	2.53%	1.94%	2.29%	2.53%	1.94%	2.29%			
79	2008	0.9375	0.897823	20.11123	0.7%	2.0%	15	2.02%	1.56%	1.84%	2.02%	1.56%	1.84%			
80	2007	0.919643					16	1.55%	1.20%	1.41%	1.55%	1.20%	1.41%			
81	2006	0.897321					17	1.21%	0.98%	1.12%	1.21%	0.98%	1.12%			
82	2005	0.888393					18	0.85%	0.71%	0.79%	3.26%	3.03%	3.17%			
83	2004	0.861607					19	0.60%	0.50%	0.56%						
84	2003	0.875					20	0.44%	0.36%	0.41%						
85	2002	0.870536					21	0.36%	0.32%	0.34%						
86	2001	0.875					22	0.28%	0.26%	0.27%						
87	2000	0.883929					23	0.21%	0.22%	0.21%						
88	1999	0.879464					24	0.15%	0.16%	0.15%						
89	1998	0.897321					25	0.12%	0.14%	0.13%						
90	1997	0.901786					26	0.09%	0.12%	0.10%						
91	1996	0.910714					27	0.06%	0.09%	0.07%						
92	1995	0.915179					28	0.04%	0.06%	0.05%						
93	1994	0.910714					29	0.03%	0.04%	0.03%						
94	1993	0.933036					30	0.03%	0.05%	0.04%						
95	1992	0.928571														
96	1991	0.950893					Total	100%	100%	100%						

Figure A-64 'LDV-Resist' Worksheet Vehicle Fuel Efficiency Calculation Block

Once data for future years has been added into the Fuel Economy Table, then the columns of composite 'sales-weighted' and 'driven-fleet' parameters (see Figure A-62) associated with that newly added year may be added by first copying the 2 columns of formulae calculating the 'sales-weighted' and 'driven' fleet values for a previously defined year from rows 27, 28 and rows 33 through 45 into the two columns associated with the new year being added. Given the year specified in row 30 and the fleet type (either "Sales weighted composite vehicle" or "Driven fleet composite vehicle") specified in row 32, the formulae copied into rows 27 to 28 and 33 to 45 will provide the necessary characterization data to simulate the specified year's composite vehicle.

A.6.9 Introduce a New Light Duty Vehicle

The 'LDV-Resist' worksheet contains a table at 'LDV-Resist'!C29:AB48 which defines the default characteristics of all light duty vehicles available for simulation. The first six sets of parameters in this table represent default values applicable to different classes of 2011 model year light duty vehicles. The parameters are defined in the yellow columns D through I as depicted in Figure A-61 on page A-106. These default 2011 model year vehicles include:

- small automobile (Index 1)
- midsize automobile or station wagon (Index 2)
- minivan or small sport utility vehicle (Index 3)
- large auto or medium SUV or small pickup (Index 4)
- pickup truck (Index 5)
- large sport utility vehicle (Index 6)

In addition to these basic six vehicle types, there are also three sets of composite vehicle parameters provided to represent local trips (Index 7), intercity trips (Index 8) and taxi trips (Index 9). These three trip-type-specific composite vehicles are derived from the six default 2011 model year vehicles using the fleet distribution as specified in the yellow table at 'LDV-Resist'!I19:L25. The rest of the columns in the vehicle definition table are used to provide vehicle parameters representative of 'sales-weighted' and 'driven-fleet' composite vehicles for the baseline 2011 model year and beyond.

While it is possible to modify and/or add to these light duty vehicle definitions, the user must take into careful consideration the many interdependencies which the fleet and future year composite vehicle parameters have with the set of six default 2011 vehicle types (the first six vehicles defined in the table). Modifying the parameters of any of the six default vehicle types will result in changes to the parameters of the fleet and future year vehicles from which they are derived. You can explore these data interdependencies using Microsoft Excel's cell dependency tracing ability available in the Formula Auditing area of the Formula tab. Nevertheless, if a user wishes to update one or more of the first six fundamental vehicle types for use in simulating trips using a light duty vehicle for which they have detailed input data then they can freely do so provided they do not select any of the derived vehicle types (as those derived data will no longer be correct). This could be used, for example, to quickly input and simulate a new light duty vehicle type or to update one or more of the default vehicle types with characteristics of a particular model year.

An alternate, but more complicated, procedure can be used to add new light duty vehicles into the model without disrupting the 2011 fleet and future-year 'sales-weighted' and 'driven-fleet' composite vehicles. This requires inserting columns into the table somewhere to the right of the last base 2011 vehicle type (column I) and to the left of the 2011 'sales-weighted' composite vehicle (column M).

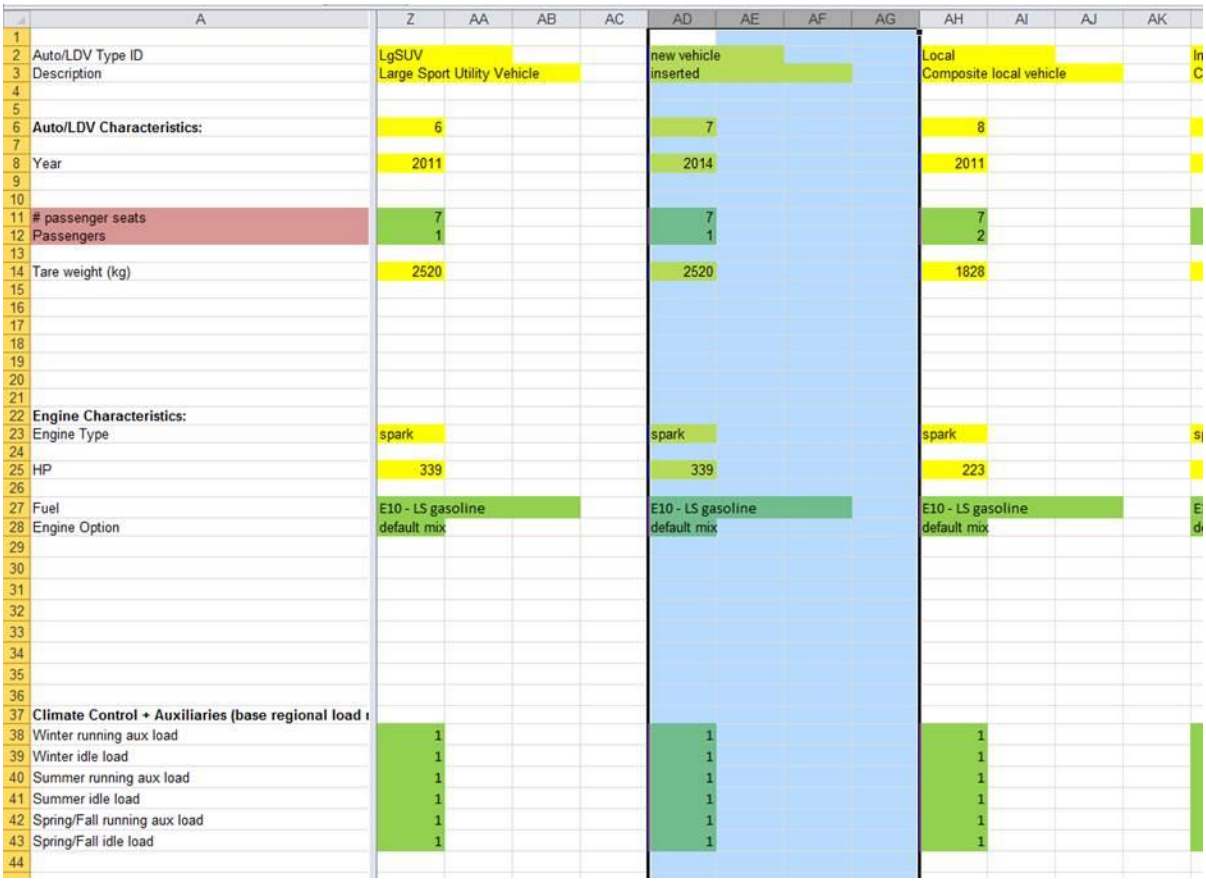
Caution: *This cannot be done by inserting a column into the entire sheet, but must be done by highlighting the cells in rows 27 through 51 in the column which is to be kept to the immediate right of the inserted column, then right clicking, selecting insert from the pop-up, selecting*

*shift cells to the right and then clicking "OK". A good place to insert would be column J (highlight 'LDV-Resist'!J27:J51 in Figure A-65). After inserting the column, each inserted cell **must** be populated with data – the macros will fail to correctly find all vehicles in the list if blank cells are encountered before the end of the table. Pay particular attention to updating the "Index" values on row 29 so that they continue to increment by "1" in the added cell and each cell which follows to the right.*

	C	D	E	F	G	H	I	J	K	L	M	N
27							Post 2011 Sales-we	ghted and Dr	en Fuel Economy (indexed to 2011 MY)			1.00
28									ived Scale Factor (indexed to 2011 MY)			1
29	Index	1	2	3	4	5	6	7	8	9	10	11
30	Year	2011	2011	2011	2011	2011	2011	2014	2011	2011	2011	2011
31	Name	small	mid/SW	MV/smSUV	Lg/mSUV/smF	PU-truck	LgSUV	new vehicle	Local	Intercity	Taxi	2011 sales w
32	Description	Small automobile	Mid-size auto	Minivan or sn	Large auto or	Pickup truck	Large Sport Utili	inserted	Composite l	Composite i	Composite t	Sales weight
33	engine (hp)	162.49	178.18	217.99	253.30	312.90	339.10	339.10	222.53	239.63	205.60	226.8
34	drivetrain loss reduction	-0.01	0.04	-0.01	0.05	-0.05	0.01	0.01	0.02	0.02	0.02	0.02
35	tare (kg)	1516.73	1524.39	1850.60	1939.86	2512.39	2519.73	2519.73	1828.13	1928.92	1729.04	1877.90
36	spark or diesel	spark	spark	spark	spark	spark	spark	spark	spark	spark	spark	spark
37	kW/kW-100km/h	1.55	1.68	1.68	1.84	1.78	1.94	1.94	1.72	1.76	1.70	1.73
38	drive ratio	51.04	47.17	47.02	42.94	44.47	40.86	40.86	46.21	45.30	46.67	45.85
39	shift factor	1.00	0.92	0.92	0.84	0.87	0.80	0.80	0.91	0.89	0.91	0.90
40	a (N)	143.78	164.19	166.87	201.31	236.46	235.47	235.47	182.35	191.57	169.24	187.10
41	b (Nm^-1s)	2.44	2.32	3.30	4.24	6.25	6.27	6.27	3.61	4.01	3.00	3.83
42	c (Nm^-2s^2)	0.42	0.44	0.57	0.60	0.70	0.66	0.66	0.53	0.56	0.52	0.58
43	CdA (m^2)	0.703	0.724	0.953	0.992	1.166	1.101	1.101	0.876	0.923	0.865	0.906
44	%-Hybrid	8.00%	1.88%	0.40%	1.88%	0.40%	0.40%	0.40%	3.86%	3.86%	10%	2.2%
45	% non-hybrid CVTs	4.00%	9.99%	6.90%	9.99%	6.90%	6.90%	6.90%	6.74%	6.74%	8.00%	7.8%
46	Cold-Start Fuel Increment (kg)	0.095219497	0.096619828	0.118189719	0.116006847	0.14855653	0.139258018	0.13925802	0.11	0.12	0.11	0.11356175
47	(N2O+CH4) CO2e increment (kg/kg)	0.00565	0.00565	0.00565	0.00565	0.00565	0.00565	0.00565	0.00565	0.00565	0.00565	0.00565
48	(N2O+CH4) CO2e increment (kg/start)	0.00437	0.00437	0.00437	0.00437	0.00437	0.00437	0.00437	0.00437	0.00437	0.00437	0.00437
49	passenger seats	4	4	5	5	3	7	7	4	4	3	4
50	passengers carried (default)	1	1	1	1	1	1	1	1	1	1	1
51	fuel	E10 - LS gasoline	E10 - LS gasoli	E10 - LS gasoli	E10 - LS gasoli	E10 - LS gasol	E10 - LS gasoline	E10 - LS gaso	E10 - LS gasol	E10 - LS gaso	E10 - LS gasol	E10 - LS gasol

Figure A-65 Inserting New Vehicle into 'LDV-Resist' Vehicle Parameter Table

One last modification is required in the 'LDV-Type' worksheet. You must insert a set of 4 columns into the 'LDV-Type' worksheet at the same index location (yellow cell on row 6). For example, if a column was inserted at 'LDV-Resist'!J27:J51, which corresponds with an "Index" of 7 (the value in 'LDV-Resist'!J27), then columns must be inserted at AD through AJ which correspond with the 7th vehicle position index on the worksheet and then the data items need to be appropriately populated (see Figure A-66). If the column in 'LDV-Resist' is inserted correctly and fully populated with data and the columns in 'LDV-Type' are properly inserted, then the newly added vehicle will appear in the green "Auto / LDV" drop-down list displayed in the 'Auto/LDV Trip Selection' menu and also in the green "LDV Type ID" drop-down list displayed in the 'Auto/LDV Type Selection' menu. Any changes made to the user modifiable green fields on the 'Auto/LDV Type Selection' menu are stored on the 'LDV-Type' worksheet (hence the necessity of inserting the new columns into that worksheet).



	A	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK
1													
2	Auto/LDV Type ID	LgSUV				new vehicle				Local			
3	Description	Large Sport Utility Vehicle				inserted				Composite local vehicle			
4													
5													
6	**Auto/LDV Characteristics:**	6				7				8			
7													
8	Year	2011				2014				2011			
9													
10													
11	# passenger seats	7				7				7			
12	Passengers	1				1				2			
13													
14	Tare weight (kg)	2520				2520				1828			
15													
16													
17													
18													
19													
20													
21													
22	**Engine Characteristics:**												
23	Engine Type	spark				spark				spark			
24													
25	HP	339				339				223			
26													
27	Fuel	E10 - LS gasoline				E10 - LS gasoline				E10 - LS gasoline			
28	Engine Option	default mix				default mix				default mix			
29													
30													
31													
32													
33													
34													
35													
36													
37	**Climate Control + Auxiliaries (base regional load**												
38	Winter running aux load	1				1				1			
39	Winter idle load	1				1				1			
40	Summer running aux load	1				1				1			
41	Summer idle load	1				1				1			
42	Spring/Fall running aux load	1				1				1			
43	Spring/Fall idle load	1				1				1			
44													

Figure A-66 Inserting New Vehicle into 'LDV-Type' Worksheet

A.6.10 Build a New Light Duty Vehicle or Bus Drive Schedule Allocation Matrix

The light duty vehicle and bus simulations (referred to collectively as “highway-mode” simulations) represent the total distances traveled on arterial roads and urban freeways in the origin and destination locations using time-of-day specific combinations of eight drive schedules representing the speed-time driving profile characteristics of travel over different road types with different average speeds. The available drive schedule combinations are configured in a matrix, as depicted in Figure A-67, which declares the percentages of the total travel distance within a region and during a time-of-day periods which are to be simulated using each of the eight drive schedules available.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1			Creep ~0.9 km/h	Urban LOS-F ~14 km/h	Urban City ~25 km/h	Urban Arterial ~40 km/h	Urban FW LOS-E ~75 km/h	Urban-FW LOS-A ~119 km/h	Urban-FW LOS-B/C ~105 km/h	FW-short US06 ~100 km/h		AVG km/h	Avg mph	time (hr/ 10-km)	delay (min/ 10-km)		
2	Arterial (O and D)	a.m. pk	3%	7%	25%	65%	0%	0%	0%	0%	100%	15.6	9.7	0.6	23.8		
3	User Defined	p.m. pk	3%	10%	12%	75%	0%	0%	0%	0%	100%	15.8	9.8	0.6	23.5		
4		midday	0%	0%	15%	85%	0%	0%	0%	0%	100%	37.7	23.4	0.3	1.4		
5		shoulders	0%	0%	5%	95%	0%	0%	0%	0%	100%	40.0	24.8	0.2	0.5		
6		overnight	0%	0%	0%	100%	0%	0%	0%	0%	100%	41.3	25.6	0.2	0.0	<< delay free trip	
7	Urb Freeway Urb-A(1)	a.m. pk	0%	0%	0%	8%	27%	0%	55%	10%	100%	84.9	52.7	0.1	1.8		
8	User Defined	p.m. pk	0%	0%	0%	6%	35%	0%	51%	9%	100%	84.8	52.6	0.1	1.8		
9		midday	0%	0%	0%	0%	16%	0%	72%	13%	100%	97.9	60.7	0.1	0.8		
10		shoulders	0%	0%	0%	0%	27%	0%	62%	11%	100%	93.9	58.2	0.1	1.1		
11		overnight	0%	0%	0%	0%	5%	80%	10%	5%	100%	113.0	70.0	0.1	0.0	<< delay free trip	
12	Urb Freeway Urb-A(2)	a.m. pk	0%	0%	0%	0%	0%	0%	85%	15%	100%	104.1	64.5	0.1	0.5		
13	User Defined	p.m. pk	0%	0%	0%	0%	6%	0%	80%	14%	100%	101.6	63.0	0.1	0.6		
14		midday	0%	0%	0%	0%	4%	0%	82%	14%	100%	102.4	63.5	0.1	0.5		
15		shoulders	0%	0%	0%	0%	0%	0%	85%	15%	100%	104.1	64.5	0.1	0.5		
16		overnight	0%	0%	0%	0%	5%	80%	10%	5%	100%	113.0	70.0	0.1	0.0	<< delay free trip	
17	Queue Delay		100%								100%						
18	Garage/Terminal property									100%	100%						
19	Intermediate LH urban				100%						100%						
20	Freeway LH Construction/weather delay (with one stop)						100%				100%						
21	Intermediate LH Toll-booth/border		100%								100%						

Figure A-67 Highway-Mode Drive Schedule Allocation Matrix

The same matrix format is used for bus simulations and for auto/LDV simulations but both are configured separately in cells C2:J21 in the 'Bus-Drive-Schedules' and the 'LDV-Drive-Schedules' worksheets respectively. The orange cells in the table at C2:J21 contain formulae which load data from other source tables based on the city-size identifiers loaded into the pink cells at A3, A8 and A13.

Caution: *It is important that those orange cells not be over-written with any data since the pink city-size identifiers point those cell's to the contents of individual tables provided for a "**Small City**" at AC2:AJ21, for a "**Large City**" at AQ2:AX21 and for a "**User Defined**" city at BE2:BL21 (the city-size identifier must be one of those three quoted text strings). The pink city-size identifier cells are automatically loaded with the user-selected city-size identifiers for a highway-mode trip by an internal macro when setting up the highway-mode simulation to run.*

Highway-mode simulations use the same set of drive schedule combinations to represent travel along arterial roads in both the origin or destination locations (rows 2 through 6 in the '<modal>-Drive-Schedules' worksheet) while separate combinations are provided to represent freeway travel in the origin city (rows 7 through 11) and in the destination city (rows 12 through 16). For each of the three travel route categories (arterial, origin freeway and destination freeway) there are five time-of-day specific drive schedule combinations available which encompass "am peak", "pm peak", "midday", "shoulder" and "overnight" travel periods. The particular combination of drive schedules, in percent of travel length, that comprise a trip in each of these time-of-day periods is declared on a separate row thus constituting an allocation matrix. As previously indicated, the MMPASSIM model does offer different default characterizations for use in large cities and small cities as well as providing a facility for users to define and select their own set of user defined drive schedule combinations.

Customization of the drive schedule allocation matrix for a highway mode simulation is done by editing values in three data tables contained on the 'Bus-Drive-Schedules' and 'LDV-Drive-Schedules' worksheets (depending on the type of simulation). The data table locations and formats on both worksheets are identical. Default drive schedule allocations

are provided to represent small and large cities and the model also offers a “User Defined” city type. The drive schedule allocations specified for all three of these city types may be freely modified by a user. Modifications to the “Small City” configuration are made to cells AC2:AJ21 and for the “Large City” configuration modify the cells in AQ2:AX21.

Note: *Be aware that any modifications made to the “Small City”, “Large City” and “User Defined” drive schedule allocations are global in nature and will affect all subsequent simulations using that mode of travel.*

Note: *Always ensure that the eight columns specifying the percentages for each drive schedule in each row of an allocation table sum to 100%.*

To modify the drive schedule allocation associated with “User Defined” cities for a highway mode, edit the percentage values in cells BX2:CE21 of the ‘<modal>-Drive-Schedules’ worksheet. Figure A-68 gives an example of a “User Defined” city allocation matrix.

Note: *The descriptive text string in cell BV1 must always be “User Defined”.*

	BU	BV	BW	BX	BY	BZ	CA	CB	CC	CD	CE	CF
1		User Defined		Creep ~0.9 km/h	Urban LOS-F ~14 km/h	Urban/ City ~40 km/h	Urban FW LOS-E ~49 km/h	Urban FW LOS-E ~75 km/h	Urban-FW MD ~117 km/h	FW LOS-B/C ~100 km/h	FW-access/egress EPA-US06 ~100 km/h	
2		Arterial (O	a.m. pk	3%	7%	25%	65%					100%
3			p.m. pk	3%	10%	12%	75%					100%
4			midday			15%	85%					100%
5			shoulders			5%	95%					100%
6			overnight				100%					100%
7	Urb Freeway	Urb-A(1)	a.m. pk	1%	10%		30%	24%	5%	15%	15%	100%
8			p.m. pk	1%	5%		25%	29%	5%	10%	25%	100%
9			midday				20%	25%	30%	5%	20%	100%
10			shoulders					35%	50%		15%	100%
11			overnight					5%	85%		10%	100%
12	Urb Freeway	Urb-A(2)	a.m. pk	1%			32%	25%	5%	20%	17%	100%
13			p.m. pk	1%			22%	35%	12%	10%	20%	100%
14			midday					20%	60%		20%	100%
15			shoulders					10%	70%		20%	100%
16			overnight					5%	85%		10%	100%
17		Queue Delay		100%								100%
18		Garage/Terminal property									100%	100%
19		Intermediate LH urban				100%						100%
20		Freeway LH Construction/weather delay (with one stop)						100%				100%
21		Intermediate LH Toll-b		100%								100%

Figure A-68 User Defined Drive Schedule Allocation Matrix

You can also create drive schedule allocation matrices and associate them with particular cities which you may wish to reference in an MMPASSIM analysis. These allocation matrices follow the same format illustrated for the “User Defined” city type and are placed in the ‘<modal>-Drive-Schedules’ worksheet to the right of the “User Defined” allocation matrix in 19 column intervals. The first begins in column CQ, the next in column DJ and so on. Each city-specific drive schedule allocation matrix must be given a unique name which is

placed in the cell 2 columns to the left and one row up with respect to the allocation matrix (cell CO1 for the first, cell DH1 for the next, etc.).

Note: *After adding one or more city-specific drive schedule allocation matrices you must click the blue "Update User Defined List" button located at cells AY1:BA1 to run a VBA macro which will register those new user defined city types and make them available on city size pulldown lists.*

A.6.11 Fit Bus or LDV Performance to a Known Trip Schedule

As described in the previous section, highway congestion is accommodated in the model by selection of a range of drive schedules. A number of drive-schedule distributions were developed in the case study process. A new allocation matrix can be adjusted to fit knowledge of the route taken and the average travel time incurred. The allocation matrix (shown in Figure A-67) has a feedback calculator (green cells at the right of the data matrix) that indicates the average speed, total trip time and travel delay per 10-km (6 miles) of travel for the selected distribution in each row of the drive schedule matrix. In calibrating a trip to known travel times, one can shift proportions from higher-speed drive schedules to lower speed drive schedules to increase the travel time, and vice versa to decrease travel times, as appropriate for each row of the matrix (i.e. time of day and location). The matrix only applies to the congested portions of the trip – the rural freeway portion of an intercity trip is not included in the matrix or in the travel time calculations. If one is only interested in simulating an a.m. peak trip with a p.m. peak return, only those rows of the matrix need to be calibrated. The overnight trip is used as the congestion-free travel time and should be left congestion free in most cases.

A.6.12 Swap Out an Existing Light Duty Vehicle or Bus Drive Schedule

The drive schedules used in highway-mode simulations are stored in tables in the 'Bus-Drive-Schedules' and 'LDV-Drive-Schedules' worksheets. The tables are located in the yellow cells spanning B23:K1182 on either of those worksheets. As depicted in Figure A-69, the drive schedule table holds ten (10) columns. The first ten (10) lines of data (rows 23 through 32) provide headings and specify parameters related to the drive schedule in that column while the remaining 1150 rows list the vehicle speed profile to be followed in one second intervals. The first column of data (column B) indicates the elapsed time through a drive schedule and is shared by all drive schedules ***– it should not be changed***. The second column defines the characteristics of the first drive schedule available to a highway-mode simulation and the seven subsequent columns correspond with the second through eighth drive schedule used by highway-mode simulations.

Note: The last column (K) represents a special cruise drive schedule which is used internally and should not be modified.

	B	C	D	E	F	G	H	I	J	K
23		Creep	Urban	Urban	Urban	Urban FW	Urban-FW	Urban-FW	FW-short	CRUISE
24			LOS-F	City	Arterial	LOS-E	LOS-A	LOS-B/C	US06	LH-enroute
25		~0.9 km/h	~14 km/h	~25 km/h	~40 km/h	~75 km/h	~119 km/h	~105 km/h	~100 km/h	N.A.
26	Speed(mph)	0.6	8.7	15.7	25.6	46.1	73.8	65.1	61.5	
27	Dist (km)	0.0								
28	Vel (km/h)	0.9	14.1	25.3	41.3	74.3	119	105.0	99.3	82.20
29	Dur (sec)	607	853	869	984	972	568	568	363	1149
30	Max Vel (km/h	14.2	71.2		81.8				129.2	LDV-CRUI
31	Time	Speed	Speed	Speed	Speed	Speed	Speed	Speed	Speed	Speed
32	(sec)	(m/s)	(m/s)	(m/s)	(m/s)	(m/s)	(m/s)	(m/s)	(m/s)	(m/s)
33	0	0.0	0.0	4.506172	0.0	24.98064	33.83205	29.85181	0.0	0.0
34	1	0.0	0.0	4.506172	0.0	24.98064	33.83205	29.85181	0.0	0.5
35	2	0.0	0.0	3.808788	0.0	25.74061	33.71135	29.74531	0.0	0.9
36	3	0.0	0.0	3.911608	0.0	26.36647	33.59065	29.63881	0.0	1.4
37	4	0.0	0.0	4.684988	0.0	26.74198	33.42972	29.49681	1.2	1.9
38	5	0.0	0.0	5.386842	0.0	26.77775	33.33584	29.41397	4.1	2.4
39	6	0.1	0.0	5.959055	0.0	26.54082	33.18384	29.27986	7.2	2.8
40	7	0.0	0.0	6.56256	0.0	25.95966	33.07655	29.18519	10.1	3.1
41	8	0.2	0.0	7.246532	0.0	25.24887	32.86197	28.99586	13.1	3.4
42	9	0.8	0.0	7.943916	0.0	24.63195	32.66081	28.81836	15.3	3.7
43	10	1.7	0.0	8.64577	0.0	24.20726	32.32552	28.52252	17.3	4.0
44	11	2.5	0.0	9.124104	0.0	24.07315	31.89189	28.13991	19.2	4.2
45	12	2.9	0.0	9.468325	0.0	24.13127	31.70861	27.97818	20.3	5.6

Figure A-69 Highway-Mode Drive Schedule Specification

The first three rows of each drive schedule column (rows 23 through 25) provide a brief description of the main characteristics of a drive schedule. The fourth row (row26) is a calculated cell indicating the average speed in mph over the drive schedule duration – it should not be necessary to change that cell when modifying a drive schedule. The fifth row (row 27) provides space to indicate the distance traveled in kilometers over a drive schedule but is not used by the model logic and may be left blank. The sixth row (row 28) specifies the average speed in km/h over the duration of a drive schedule and must be updated if changes are made to a drive schedule profile. The seventh row (row 29) specifies the number of seconds which the highway-mode simulation will use from the drive schedule profile. The eight (row 30) provides space to declare the maximum speed attained in drive schedule but is not used by the model logic and may be left blank. The ninth and tenth rows (rows 31 and 32) are simply headings to clarify the units required for the data entered in the remaining rows of a column.

Any of the speed profiles specified over rows 33 through 1182 of columns C through J in a drive schedule specification table may be changed if a user has more appropriate data for their analysis.

Note: *The maximum drive schedule duration is limited to 1149 seconds and that cells in unused rows should be zeroed. Also, be sure to also set the average speed in km/h (row 28) and the drive schedule duration in seconds (row 29) appropriately.*

A.6.13 Modal Comparison Using Specific OD Address and Access/Egress Modes

The model allows up to five legs of the access and egress portions of a trip. The specification of these five legs can reflect a sequence used in making a single trip (e.g. from home to the commuter station or home to the airport). A number of access egress designations were developed in the case studies and are in the model for review. The Trip Access and Egress selection form is found in the Master-IO worksheet as well as the modal-IO worksheets. The process used to open the form is shown in Table A-8 while the process of selecting access legs for trips is shown in Table A-9.

Table A-8 Opening the Trip Access and Egress Selection Form

	Configuration Steps Required
Define Access/Egress Legs	• Either click "Define Access/Egress" button on 'Master-I-O' worksheet or • Click "Define Access/Egress" button on any '<modal>-I-O' worksheet or • Click "Access/Egress" button on any modal Trip Selection form then • Refer to 'Trip Access and Egress Selection Form' (Table A-9)

Table A-9 Configuration Steps Required for Access and Egress for any Modal Trip

	Configuration Steps Required
Trip Access and Egress Selection Form	• Select a "Trip ID" from the drop-down list to load any access/egress legs from an existing trip (if desired) • Set the number of travelers assumed to be travelling together for all of the access and egress legs **For Access to Departure Location** • Pick the geographical region where access legs occur • Pick the city size associated with access leg travel • Pick the time of day for access leg travel • Pick the mode for each access leg (for a maximum of 5 legs, selecting none clears that access leg) • Set the distance (miles) for each access leg if different from preloaded value • Set the dwell time (minutes) for each access leg if different from preloaded value • Set the speed (mph) for each access leg if different from preloaded value (double click a green field to load the default for mode and region) • Pick the fuel source used for each access leg • Set the fuel intensity for each access leg (double click a green field to load the default for mode and region) • Set the energy intensity for each access leg (double click a green field to load the default for mode and region) • Set the GHG emission intensity for each access leg (double click a green field to load the default for mode and region) **For Egress from Arrival Location** • Pick the geographical region where egress legs occur • Pick the city size associated with egress leg travel • Pick the time of day for egress leg travel • Pick the mode for each egress leg (for a maximum of 5 legs, selecting none clears that egress leg) • Set the distance (miles) for each egress leg if different from preloaded value • Set the dwell time (minutes) for each egress leg if different from preloaded value • Set the speed (mph) for each egress leg if different from preloaded value (double click a green field to load the default for mode and region) • Pick the fuel source used for each egress leg • Set the fuel intensity for each egress leg (double click a green field to load the default for mode and region) • Set the energy intensity for each egress leg (double click a green field to load the default for mode and region) • Set the GHG emission intensity for each egress leg (double click a green field to load the default for mode and region) • Click "Select & Return" button to pass definitions to modal trip

A.6.14 Modal Comparison Using Survey Data for Distances and Access/Egress

The model allows up to five legs of the access and egress portions of a trip. The specification of these five legs can either reflect a sequence used in making a single trip (as described in the previous section) or as the proportions of modes used by travellers determined from a passenger survey. Surveys usually ask for the principal mode of access and the distance traveled. The distance traveled on each mode by the average user is the product of the proportion using the mode and the distance traveled by the mode. Interpretation of typical survey results into the distance traveled data-inputs for each of the five access modes is illustrated in Table A-10. The resulting simulation will reflect the results of a door-to-door trip for an average user of the principal mode being simulated rather than the results associated with a specific door-to-door trip.

Table A-10 Interpretation of Passenger Survey Data for Access Modes

Access Mode	Passenger Survey Findings		Model Inputs for Access Distance (mi)
	Average distance (mi)	Proportion using	
Walk/bike	0.75	10%	0.075
Drive and park	3.2	55%	1.76
Driven	1.8	15%	0.27
Taxi	6.2	3%	0.186
City bus	3.5	17%	0.595

A.7 Simulation Model Worksheet Data

A.7.1 Contents of the 'Energy-Emissions' Worksheet

The 'Energy-Emissions' worksheet defines the energy use and GHG emission factors for both upstream well-to-pump and direct consumption for the primary trip leg of all transportation modes considered by MMPASSIM. The data is organized into seven sets of tables.

The first table, "Global Warming Potential of Greenhouse Gases" (located at 'Energy-Emissions'!C5:D7), provides the standard global warming potential of CH_4 and N_2O in terms of their CO_2-equivalency.

The second table, "Fuel/Emission Factor Lookup Reference" (located at 'Energy-Emissions'!C18:Q22), is used internally and should not be modified.

The third set of tables, "Energy Use and Emission Factors for Rail Transportation" (located at 'Energy-Emissions'!C37:BF45) characterizes all on-board fuels available for rail mode simulations.

The fourth set of tables, "Energy Use and Emission Factors for Electrified Transportation Modes" (located at 'Energy-Emissions'!C61:BF77) characterizes the electricity available for transportation use by geographical region.

The fifth set of tables, "Energy Use and Emission Factors for Bus Transportation" (located at 'Energy-Emissions'!C126:BF129) characterizes on-board fuels available for bus mode simulations.

The sixth set of tables, "Energy Use and Emission Factors for Air Transportation" (located at 'Energy-Emissions'!C145:BI148) characterizes fuels available for air mode simulations.

The seventh set of tables, "Energy Use and Emission Factors for Auto/Light Duty Vehicle Transportation" (located at 'Energy-Emissions'!C164:BF174) characterizes all fuels available for auto & light duty vehicle mode simulations.

The aforementioned sets of tables defining fuel parameters, energy use and emission factors follow a consistent format across transportation modes.

> Column C defines the applicable transportation mode and column E describes the fuel (or energy in the case of electricity).
>
> Columns H through J define the energy content where column H (yellow) is the default energy content, column I (green) is the energy content used in simulations and column J defines the units (Btu/gal or Btu/kWh-generated).
>
> Columns L through N define the fuel density where column L (yellow) is the default fuel density, column M (green) is the fuel density used in simulations and column N defines the units (kg/gal).

Columns P through R define the upstream energy use factor where column P (yellow) is the default factor, column Q (green) is the energy use factor used by simulations and column R defines the units (Btu/mmBtu).

Columns T through V define the upstream CO_2 emission factors where column T (yellow) is the default emission factor, column U (green) is the emission factor used by simulations and column V defines the units (kg/gal or kg/kWh).

Columns X through Z define the upstream CH_4 emission factors where column X (yellow) is the default emission factor, column Y (green) is the emission factor used in simulations and column Z defines the units (g/gal or g/kWh).

Columns AB through AD define the upstream N_2O emission factors where column AB (yellow) is the default emission factor, column AC (green) is the emission factor used in simulations and column AD defines the units (g/gal or g/kWh).

Columns AF through AH define the upstream CO_2-equivalent emission factors where column AF (yellow) is the default emission factor, column AG (green) is the emission factor used in simulations and column AH defines the units (kg/kg-fuel for on-board fuels or kg/kWh-electricity).

Column AL repeats the definition of the applicable transportation mode and column AN describes the fuel (or energy in the case of electricity).

Column AQ through AT define the direct-consumption CO_2 emission factors where column AQ (yellow) is a default value calculated from carbon content, column AR (yellow) is the default emission factor, column AS (green) is the emission factor used in simulations and column AT defines the units (kg/gal or kg/kWh).

Columns AV through AX define the direct-consumption CH_4 emission factors where column AV (yellow) is the default emission factor, column AW (green) is the emission factor used in simulations and column AX defines the units (g/gal or g/kWh).

Columns AZ through BB define the direct-consumption N_2O emission factors where column AZ (yellow) is the default emission factor, column BB (green) is the emission factor used in simulations and column BC defines the units (g/gal or g/kWh).

Columns BD through BF define the direct-consumption CO_2-equivalent emission factors where column BD (yellow) is the default emission factor, column BE (green) is the emission factor used in simulations and column BF defines the units (kg/kg-fuel for on-board fuels or kg/kWh-electricity).

For the air transportation mode only, columns BH (yellow default) and BI (green values as used) define multipliers for direct CO_2 emissions while at cruising altitude.

A.7.2 Contents of the 'Regional-Properties' Worksheet

The 'Regional-Properties' worksheet defines factors which vary with geographical location, such as seasonal temperatures, traffic distributions, heating/cooling loads, urban congestion and energy and emission intensities for local urban area access and egress modes. The data for any one region are defined using a maximum of 17 columns and successive region data sets begin in 18 column increments from column D.

The first data element for a region is its unique "Region ID" defined in a yellow cell on row 2. A description field is immediately below that unique identifier.

The next group of data defines seasonal travel variations for a region. The duration, in months, of the "winter", "summer" and combined "spring/fall" seasons must be specified by the user (green cells on row 10) from which the per unit seasonal distribution is calculated (yellow cells on row 11). Then, for each of these three season groupings, the per unit distribution of intercity travel (green cells on row 12) and commuter travel (green cells on row 13) must be defined.

The next group of data defines seasonal daytime temperature variations in terms of the daily average temperature (green cells on row 20) and also the percentage of time air conditioning is used in each season (green cells on row 22).

The next group of data characterizes the seasonal variation in use of climate control and vehicle auxiliaries. For buses, default auxiliary loads (in kW) are presented in the yellow cells on row 31 for winter season regular running and layover idle, summer season regular running and layover idle and finally for all operating modes in the combined spring and fall season. However, please note that the values used in simulations are read from the green cells on row 30. For automobiles and light duty vehicles, default auxiliary loads (in kW) are similarly defined in the yellow cells of row 37 for winter season running and idle, for summer season running and idle and for also for both running and idle during the combined spring and fall season. The actual values used in light duty vehicle simulations are read from the green cells on row 36. Finally, the default seasonal variation of rail consist climate control use is specified in terms of a heat/cool index for winter, summer and the combined spring and fall season in the yellow cells on row 42. The green values on row 41 are multiplied by the respective seasonal auxiliary loads provided in the 'Rail-Consist' worksheet to arrive at regionally adjusted auxiliary loads.

The next group of data (rows 48 to 51) defines congestion factors for peak and off-peak travel in large cities, small cities, rural municipalities and also provides a default for all cities. These factors are used as energy intensity multipliers for highway modes used in the access and egress legs of a trip. The base LDV fuel intensity on row 52 is used in conjunction with the pink "Number of Travelers" on row 64 to derive the direct fuel intensity of the auto/LDV modes used for access and egress.

The yellow cells on row 60 are used internally to locate selected data columns in the table of access/egress mode fuel and emission intensities and should not be modified.

The final data set provided in the 'Regional-Properties' worksheet is the table of access/egress mode fuel and emission intensities. This table defines the direct fuel intensity, the upstream and direct energy intensities and the upstream and direct CO_2-equivalent emission intensities for each access and egress mode available for use in a simulation of a particular region. These may vary with city size (large, small, rural or all) and time of day (peak or off-peak). Variations according to day of week and season are also supported. The user is advised that the VBA macro expects every unique access/egress mode available in a region to be defined within the top portion of that table and that those definitions would normally be associated with 'All Cities'. Also, the green cells on row 61 should be manually adjusted to reflect the total number of unique access/egress modes defined in the top section of the table of access/egress modes for each region. It is not necessary for each region to have the same number of access/egress modes defined or to have the same detail in terms of city size and time of day variations. However, in order for the access/egress estimation to function reliably, a definition for each access/egress mode should exist for "All Cities", for "All" time of day, for "All" day of week and for "All" season.

A.7.3 Contents of the 'Rail-Consist' Worksheet

The 'Rail-Consist' worksheet defines sets of parameters used by the rail simulation module. They are organized down the rows of the worksheet beginning in column "I" for the first defined consist and offset by 7 columns (i.e. column "P") for each additional consist defined on the worksheet. The following list identifies the data items required by the simulation. Many of the parameters are default values that can be used for most new train consists, while some are basic train-size and equipment related parameters that will change for new consists. In addition, some energy-recovery technology parameters at the bottom of the table are included even if not used in the simulation. They provide an indication of the effectiveness of using these technologies in the single-train base-run simulation. They can be copied as shown for most train consists, but should be checked and updated as appropriate if a specific simulation of a specific technology is being assessed in a technology comparison. The following table is color-coded to indicate which parameters are most often going to be required user inputs (green) and normally retained defaults (yellow) which will apply unless specific technologies are being simulated. Some values are brought in by the Macro (pink) depending on the region/season selected. Some calculated parameters (orange) follow from other inputs for convenience (as sort of a pre-processor for conventional trains). These calculations can be overridden with user inputs, as might be appropriate for integral HSR consists and/or DMU and EMU consists.

Item as Titled on the Worksheet List	Notes on the Input Required
Consist ID	Assigned by macro - must be unique
Description	An abbreviated description of the consist (e.g. 1P42-3C)
Input System of Units	Pick either "metric" or "U.S."
Number locos/power-cars	
Number of coaches/unpowered cars	DMUs and EMUs are included here.
number powered axles	
number unpowered axles	
Total Number of axles	May be calculated from previous two rows
Total Weight - all powered axles (kg) or (lb)	May be calculated from previous rows
Total Tare Wgt - all unpowered axles (kg) or (lb)	May be calculated from previous rows
Total Consist Seats	
Average Seat pitch (in)	Future use in a 'comfort index'.
Common area per consist (sq.ft)	Future use in a 'comfort index'.
Tilt-body Coaches (1=yes, 0=no)	If tilt body coaches are used, the simulation will choose the tilt-body speed column from the route speed table, otherwise it will choose the conventional speed column.
Passenger Load Factor (Route/Consist/Time-of-day)	This value must be the LF associated with the service being simulated.
Avg weight per passenger-with luggage (kg) or (lb)	
Mass-equivalent rotational inertia of Powered-axles (kg/axle) or (lb/axle)	Default can usually apply
Mass-equivalent rotational inertia of Unpowered-axles (kg/axle) or (lb/axle)	Default can usually apply

Consist Length Length (m) or (ft)	Over-writeable calculation from above data					
Consist Total Loaded Mass (kg) or (lb)	Calculated from above data					
Consist average mass-equivalent rotational inertia (kg/axle) or (lb/axle)	Calculated from above data					
Consist Length (m)	Calculated from above data					
Consist Length (mi)	Calculated from above data					
TRAIN RESISTANCE COEFFICIENTS (a+bV+cV^2)						
a (N) or (lb)						
b (N/(km/h)) or (lb/mph)						
c (N/(km/h)^2) or (lb/mph^2)						
Season adjustments for selected season	Macro loads: summer/winter/other					
Season adjustments for selected season	Loaded by macro					
Summer heat/cool index						
Winter heat/cool index						
other (i.e. Spring or Fall) heat/cool index						
CdA impact	Calculated number greater than or equal to 1.0.					
seasonal modified CdA	Calculated from above data					
Hotel Pwr (kW)	3 values: “Winter”, “Summer” and “Other” where pre-calculated values in the above row can be copied or modified.					
Coach avg hotel power per coach (kW)	Over-writeable calculation from above data					
Transmission efficiency (engine shaft or pantograph to wheels)						
Efficiency while accelerating						
Efficiency at cruise and braking						
Propulsion Type (1=onboard-fuel, 2=electric)	Set by macro					
Locomotive Primary Fuel Type	Set by macro					
Traction Power at the wheels (kW) or (hp)	A default calculation is used in some conventional consists and can be copied or over-written with known values.					
Tractive Effort Characteristic (up to 5 segments: each with TE = a + bV + c/V^d) where: TE (kN) and V is (m/s) for “metric” units and TE (lb) and V is (mph) for “U.S.” units	Up to 5 characterization regions can be defined using the coefficients in the equation at left in four 5 rows					
lower speed limit (m/s) or (mph)						
A						
B						
C						
D						
Traction Engine Characteristics						
engine per-unit power load rate = aT^b ("a" term)						
engine per-unit power load rate = aT^b ("b" term)						

Fuel Penalty @ low load factors-variable speed engine ("a")	
Fuel Penalty @ low load factors-fixed speed engine ("a")	
bsfc(min) (kg/kWh) or (lb/hph)	
bsfc(min) (kg/kWh)	Calculated from above
Idle rate (var-speed Trac-Engine) (kg/h) or (lb/hr)	
DB fuel rate (var-speed Trac-Engine) (kg/h) or (lb/hr)	DB is dynamic brake
regen fuel rate (var-speed Trac-Engine) (kg/h) or (lb/hr)	
Idle rate (fixed-speed Trac-Engine) (kg/h) or (lb/hr)	
DB fuel rate (fixed-speed Trac-Engine) (kg/h) or (lb/hr)	
regen fuel rate (variable speed Trac-Engine) (kg/h) or (lb/hr)	Same value as input 3-rows above (repeated for calculation purposes in the simulation sheet).
Idle rate usage flag (if no hotel PTO)	1 if no dynamic brakes and no hotel PTO, 0 otherwise
DB usage flag	1 if dynamic brakes used in braking, 0 if not
copy Brake energy Recovery flag for calculation	Automatically set
flag for dual-fuel loco (0=no, 1=electric & onbrd fuel) also set region in adj. column	If a dual fuel simulation is being run, this flag must be set to 1 and the route file must indicate the track segment boundary where electricity is used.
Electricity Source Region if dual-fuel	Set by macro via 'Rail Consist Selection' menu
Hotel Power Provision code **1=PTO-inverter** **2=PTO-fixed speed main engine** **3=dg-set** **4=electric-loco**	New consists should include this setting but the Macro brings in user specified values if they wish to change it on the Rail-IO forms. PTO is power takeoff from the main traction engine. An inverter permits a more efficient variable engine speed (Amtrak normal is 1). A dg-set is a separate diesel generator set for hotel power (many commuter locos use 3).
Loco-Aux pwr (kW)	Not coach hotel power, but locomotive auxiliary power (fans, air compressor, etc.)
Hotel dg-set fuel equation (a (kg/hr) + b(kg/hr)/kW * Load (kW)	
hotel DG fuel rate "a" term (kg/hr) or (lb/hr)	
hotel DG fuel rate "b" term ((kg/hr)/kW) or ((lb/hr)/kW)	
Brake Type logic (1=loco-only, 0=blended)	Can be set to one to get full potential of brake energy recovery (but a delay will be incurred due to the slower braking rate)

Low speed Tractive Effort Limit (N/pwr-axle) or (lb/pwr-axle)	
Low speed Tractive Effort Limit-all pwrd axles (N)	Calculated from above
Brake Rate (blended braking <=60 mph) (%-g)	Fraction of acceleration of gravity (also = force-fraction of total consist weight).
Maximum Friction Brake Rate (60 mph) (%-g)	Fraction of acceleration of gravity (also = force-fraction of total consist weight).
brake rate coeff (a) for speeds>60 mph	Coefficients for the quadratic equation (a+bV+cV^2) describing the normal blended brake rate for the consist (presumed to decrease with increasing speed)
brake rate coeff (b) for speeds>60 mph	
brake rate coeff (c) for speeds>60 mph	
Dynamic Brake power at wheels (Watts)	Maximum power at the wheels that can be utilized by the traction motors in dynamic or regenerative braking.
Brake Energy Recovery Usage Flag (1 if recovered, 0 if not)	1 if brake energy recovery is used, 0 if not
regen-energy acceptance ratio (by trains-or-grid)	Fraction value (<=1) applicable to the energy recovery system being simulated. For electric grid systems it is the %-time other trains are present and/or the network accepts regenerated energy into the grid; for optimal coasting it is the portion of time that train are ahead of schedule and drivers follow the coast advice; for wayside storage it is the percent time that the wayside device can accept power (i.e. is below its capacity threshold).
regen-energy cycle efficiency (for all types)	Charge and discharge cycle efficiency for the type of energy storage system being simulated.
Regen brake adhesion	Lesser of either torque or adhesion limit of low-speed regenerative braking (as a force-fraction of weight-on-powered axles)
Energy Recovery Type (1=onboard, 2=wayside, 3=elec-grid, 4=optimal coasting, 0=none)	Onboard and electric grid are used for all braking, wayside is used at scheduled stop locations as identified in the route file, optimal coasting is used at all scheduled stops based on the total slack-time available (presently input at B6 of the Rail-Simulation sheet).
Capacity of onboard storage when used (kW-hr)	
Onboard Storage Power capacity at wheels (Watts)	
portion with slack and coast advice followed	
Loco Regen Power limit to grid or wayside storage (Watts)	
Locomotive speed limit (km/h) or (mph)	

A.7.4 Contents of the 'Rail-Route' Worksheet

The 'Rail-Route' worksheet defines sets of tables used to characterize the route over which train operation will be evaluated. They are organized down the rows of the worksheet beginning in column "O" for the first defined consist and offset by 13 columns (i.e. column "AB" for next) for each additional consist defined on the worksheet. The following list identifies the data items required by the simulation.

Total CA (Central Angle) of curvature (calculated), CA per mile (user input) _____

Number of Grade Segments (user input) _____

Grade Distribution Table:MilePost											
Mile											
Elev (ft)											
Segment			1	2	3	4	5	6	7	8	Route
Forward Direction	Average %-Grade in Severity Range	-0.2									
		-0.4									
		-0.6									
		-0.8									
		-1									
		-1.2									
	%-Distance of Severity Range	-0.2									
		-0.4									
		-0.6									
		-0.8									
		-1									
		-1.2									
Reverse Direction	Average %-Grade in Severity Range	-0.2									
		-0.4									
		-0.6									
		-0.8									
		-1									
		-1.2									
	%-Distance of Severity Range	-0.2									
		-0.4									
		-0.6									
		-0.8									
		-1									
		-1.2									

Notes:

1) The MP mileage starts at zero and the grade data in each column is associated with the grades for the route segment between that MP heading on that column and the MP in the subsequent column. If only one grade classification is used there will be only one column of grade severity data under the MP = 0 column. The last segment column will be the end milepost and it will have only the elevation field filled as the gradient information past that

point is not relevant. The “Route” column is the total route average values and will be the same as column 1 if only one-segment is used to characterize the route.

2) The downgrades for the reverse direction are negative values of the upgrades in the forward direction.

A separate spreadsheet “route preprocessor” is provided to generate the data in the above grade severity Table if a user has detailed gradient and/or curvature profiles for a rail route of interest. The preprocessor uses Excel’s data-table formula to transform linear gradient data into the above formatted grade-severity Table. It also has a data column filter set to select speed limit changes along the route. The preprocessor includes a read-me sheet with a description of the steps required to process a file and there is a track file loaded as an example. However, users should have knowledge of the data table function and its application in order to effectively use the pre-processor.

Scheduled Stop Table (with example values)

4 << number of data rows

333.3 Trip distance traveled

User Value		Wayside storage: (0 or receptivity value if yes)		Default Computed			User Value	
Forward Direction				Reverse Direction			Reverse Direction	
MP (mi)	Dist (mi)			Dist (mi)	Wayside Storage		Dist (mi)	Wayside Storage
400	0	0		0	0		0	0
411.5	11.5	0		156.8	0.95		156.8	0.95
576.5	176.5	0.95		321.8	0		321.8	0
733.3	333.3	0		333.3	0		333.3	0

Notes:
The model accepts mileposts taken from a desired subdivision segment, but modifies the input MP to a zero mile beginning. It also uses the same MP locations in generating the stop file for the reverse trip. Thus, the distance traveled in the reverse direction corresponds to the station stop locations input for the forward direction. If the user wises to override this calculation, the distances from the origin of the reverse trip must be used in filling the ‘User-Value’ data columns. The ‘User Value’ data table must be filled with data as it is the data that is used in the simulation. A value copy of data from the ‘Default Computed’ table can be used if the default values are accepted.

Temporary Slow Order (TSO) data table (with example values)

avg #/trip		speed (mph)		average length(mi)
1.5	of	25		0.1
3.3	of	40		0.1
0.5	of	80		7

Notes:
Up to 7 different speeds can be selected and the associated probability or expected number of occurrences of that slow order being encountered in a one-way trip of the length input for the service being simulated is input at the first column of the table. The slow order speed (in mph) is input to the middle column and the average length of each occurrence of that slow order is input to the last column. Slow orders are applied in the simulation sheet with respect to the average cruise speed for all permanent speed limit segments of the route. Slow orders are not just maintenance based – they should include any diversions to second tracks necessitated by traffic interference. For example a diversion to a second track of equal speed rating to the main track, would be input as 2 slow orders equal to the speed limits of the cross-over switches taken and of length representative of the length of the crossovers. A diversion to a slower speed second track would increase the length of the slow order to include the length of the second track segment that is used.

Unscheduled Stop Table

avg #/trip		siding speed (mph)		avg siding length (mi)		avg stop duration (min)
0.5		25		2.1		12

Notes:
One row of data is required and provides the average/expected-number of occurrences of the passenger train being diverted to a siding or asked to stop on the mainline for any reason. The average speed in the sidings is input to the second column and the average length of the sidings is input to the third column. The last column is the average dwell time incurred for each unscheduled stop encountered. All inputs are with respect to a one-way trip over the simulated route segment.

Extra Idle and Non-revenue travel	
0.5	<< combined pre-start/post arrival idle time (hr) at start and final stations
0.5	<< layover idle time allocated per one-way trip (hr)
1.023	<< ratio of non-revenue/revenue train miles

Fuel Use Boundary Table for Dual Fuel Simulations (with example values)

User Value					Default Computed				User Value	
Forward Direction					Reverse Direction				Reverse Direction	
MP	Dist	Fuel			Dist	Fuel			Dist	Fuel
(mi)	(mi)	Use			(mi)	Use			(mi)	Use
400	0	Electricity			0	Diesel			0	Diesel
400	0	Electricity			0	Diesel			0	Diesel
412	12.0	Diesel			321.3	Diesel			321.3	Electricity
733.3	333.3	Diesel			333.3	Electricity			333.3	Electricity
733.3	333.3	Diesel			333.3	Electricity			333.3	Electricity

Notes:
The fuel use indicated in the last column is applied from the mileage in the corresponding row up to the mileage in the subsequent row. As with the stop table, the user can override the calculated reverse trip locations and data must be copied into the User Value table even if default values are accepted. If a dual-fuel simulation is desired, the 'dual-fuel' flag must be set to "1" in the consist file that is selected for simulation.

Route Speed Table (with example data)

54	<< # of data rows	Start Station Offset	
333.3	Route Distance	forward	reverse trip
1	direction of mileposts	0	0
		0	0

User Value					Processed to Eliminate Short Segments of High Speed			Processed for Reverse Direction		
Forward Direction		Conv Speed	Tilt-body speed	# of Spd changes						
MP	Dist				Dist (mi)	Conv Speed (mph)	Tilt-body speed (mph)	**Dist**	Conv Speed	Tilt-body speed (mph)
(mi)	(mi)	(mph)	(mph)	1				(mi)	(mph)	
400	0	25	30		0	25	30	0	65	70
400	0	25	30		0	25	30	0	65	70
401.2	1.2	35	40		1.2	35	40	2.3	95	100
402.1	2.1	40	45		2.1	40	45	10.5	95	95
403.6	3.6	75	80		3.6	75	80	10.7	85	90

407.5	7.5	90	95		7.5	90	95	11.1	90	95
411.5	11.5	95	100		11.5	95	100	14.8	95	100
420.7	20.7	55	60		20.7	55	60	27	90	95
421.7	21.7	90	95		21.7	90	95	35.9	65	70
423.9	23.9	75	80		23.9	75	80	36.3	90	95
424.8	24.8	90	95		24.8	90	95	41.8	85	90
449.3	49.3	95	100		49.3	95	100	42.4	95	100
462.6	62.6	80	85		62.6	80	85	62	40	45
464.1	64.1	95	100		64.1	95	100	63	90	95
512	112	75	80		112	75	80	67.3	80	85
512.6	112.6	95	100		112.6	95	100	68.4	90	95
524	124	75	80		124	75	80	71.3	95	100
527	127	90	95		127	90	95	109.5	90	95
531.5	131.5	75	80		131.5	75	80	112.1	70	70
531.8	131.8	95	100		131.8	95	100	112.2	75	80
541.4	141.4	75	80		141.4	75	80	112.3	75	80
542.9	142.9	95	100		142.9	95	100	114.3	95	100
554.3	154.3	85	90		154.3	85	90	134.2	65	70
554.9	154.9	95	100		154.9	95	100	135.2	95	100
569.5	169.5	75	80		169.5	75	80	142.2	50	50
571.4	171.4	65	70		171.4	65	70	142.28	95	100
575.3	175.3	80	85		175.3	80	85	148.6	80	85
584.7	184.7	95	100		184.7	95	100	158	65	70
591.02	191.02	50	50		191.02	50	50	161.9	75	80
591.1	191.1	95	100		191.1	95	100	163.8	95	100
598.1	198.1	65	70		198.1	65	70	178.4	85	90
599.1	199.1	95	100		199.1	95	100	179	95	100
619	219	75	80		219	75	80	190.4	75	80
621	221	100	100	75	221	75	80	191.9	95	100
621.1	221.1	70	70		221.1	70	70	201.5	75	80

Notes:

1) The milepost column is changed to mileage distance from a zero mile start point.
2) The end point of the Speed Table must correspond with the final destination on the route and the last line of data must be duplicated to indicate the end of the dataset.
3) The data are reviewed for short high-speed segments in the middle three columns. For the input data shown, one speed change was made for an unrealistically short speed segment at MP 621. The increase in speed to 100 mph is applicable only to MP 621.1 a distance of 0.1 miles. For the simulation, the higher of the two adjacent speeds is adopted for that segment. Thus, the values of 75 mph for conventional trains and 80 mph for tilt-trains are shown in the calculated table. The last 3 columns are the calculated distances for a mirror image of the forward speed table.
4) If a different track/speed table is applicable to the reverse trip, the user must create a separate route for the reverse trip and identify it in the Master IO sheet when creating the simulation scenario.

A.7.5 Contents of the 'Rail-Trip-List' Worksheet

The 'Rail-Trip-List' worksheet is used by the VBA macro system to store rail trip definitions as they are developed by a user. Normally, the VBA macros should be used to add new trips and otherwise manage updating the contents of these fields in response to a user's selections on the 'Rail Trip Selection' user form. However, the list of defined rail trips may become large and a knowledgeable user may delete trips from the list manually. Care must be taken during this process such that the top of the list is maintained on row 25 and that there are no blank rows in between the top and bottom of the list (a blank row will be interpreted as the bottom of the list). Also, the columns should not shifted.

The following list identifies the data items used by the simulation.

Item as Titled on the Worksheet List	Notes on the Data Value
ID #	Assigned by the VBA macro. Normally "RT.#" where # is equivalent to (current row number - first row number +1). Each ID # should be unique.
Trip Description	A user's description of the trip, normally some combination of the consist description and the route description.
Region	Must be a valid region identified in 'Regional-Properties' worksheet
Route ID	Must be a valid identifier referencing a defined route in the 'Rail-Route' worksheet. Normally of the form "Route.#" where # is the index of the defined route in the route list.
Route Description	Should be the same as the description given in the 'Rail-Route' list.
Trip Length	Should be the same value as specified in the 'Rail-Route' list (specified in miles).
Start MP	Should be the same value as specified in the 'Rail-Route' list.
End MP	Should be the same value as specified in the 'Rail-Route' list.
Direction	Must be either "Forward" or "Reverse".
Departure Time of Day	Departure time of forward trip - must be "AM-peak", "PM-peak", "midday", "off-peak" or "overnight"
Arrival Time of Day	Arrival time of forward trip - must be "AM-peak", "PM-peak", "midday", "off-peak" or "overnight"
Departure Day of Week	Departure day of week of forward trip – must be "Mon to Fri", "Weekend" or "Daily"
Departure Season	Season of forward trip – must be "Winter", "Summer", "Spring/Fall" or "All"
Return Trip Departure Time of Day	Departure time of return trip - must be 'AM-peak', 'PM-peak', 'midday', 'off-peak' or 'overnight'
Return Trip Arrival Time of Day	Arrival time of return trip - must be "AM-peak", "PM-peak", "midday", "off-peak" or "overnight"
Return Trip Departure Day of Week	Departure day of week of return trip – must be "Mon to Fri", "Weekend" or "Daily"
Return Trip Departure Season	Season of return trip – must be "Winter", "Summer", "Spring/Fall" or "All" (assumed same as forward trip)
Consist ID	Must be a valid identifier referencing a defined consist in the 'Rail-Consist' worksheet. Normally of the form "RC.#" where # is the index of the defined consist in the consist list.

Consist Description	Should be the same as the description given in the 'Rail-Consist' list.
Number of Travelers	Number of people assumed to be traveling together
Scheduled Trip Time	Scheduled trip time (hours).
Station Stop Dwell Time	Allowance for all station stops (minutes).
Access/Egress Number of Travelers	Number of people assumed to be traveling together (same as for main leg)
Access Leg 1 - Mode	Access mode type
Access Leg 1 - Description	Access mode description
Access Leg 1 - Distance	Access mode distance (mile)
Access Leg 1 - Dwell	Access mode dwell time (minutes)
Access Leg 1 - Average Speed	Access mode average speed (mph)
Access Leg 1 - Fuel Source	Access mode fuel source (as defined in 'Regional-Properties' for this mode)
Access Leg 1 - Fuel Intensity	Access mode fuel intensity (kg/pass-mile)
Access Leg 1 - Energy Intensity	Access mode energy intensity (kJ/pass-mile)
Access Leg 1 - CO2e Intensity	Access mode CO2e emission intensity (g/pass-mi)
Access Leg 1 - Region	Access mode region
Access Leg 1 – City Size	Access mode city size
Access Leg 1 - Time of Day	Access mode time of day
Access Leg 1 - Day of Week	Access mode day of week
Access Leg 1 - Season	Access mode season
Access Leg 2 - Mode	Access mode type
Access Leg 2 - Description	Access mode description
Access Leg 2 - Distance	Access mode distance (mile)
Access Leg 2 - Dwell	Access mode dwell time (minutes)
Access Leg 2 - Average Speed	Access mode average speed (mph)
Access Leg 2 - Fuel Source	Access mode fuel source (as defined in 'Regional-Properties' for this mode)
Access Leg 2 - Fuel Intensity	Access mode fuel intensity (kg/pass-mile)
Access Leg 2 - Energy Intensity	Access mode energy intensity (kJ/pass-mile)
Access Leg 2 - CO2e Intensity	Access mode CO2e emission intensity (g/pass-mi)
Access Leg 2 - Region	Access mode region
Access Leg 2 – City Size	Access mode city size
Access Leg 2 - Time of Day	Access mode time of day
Access Leg 2 - Day of Week	Access mode day of week
Access Leg 2 - Season	Access mode season
Access Leg 3 - Mode	Access mode type
Access Leg 3 - Description	Access mode description
Access Leg 3 - Distance	Access mode distance (mile)

Access Leg 3 - Dwell	Access mode dwell time (minutes)
Access Leg 3 - Average Speed	Access mode average speed (mph)
Access Leg 3 - Fuel Source	Access mode fuel source (as defined in 'Regional-Properties' for this mode)
Access Leg 3 - Fuel Intensity	Access mode fuel intensity (kg/pass-mile)
Access Leg 3 - Energy Intensity	Access mode energy intensity (kJ/pass-mile)
Access Leg 3 - CO2e Intensity	Access mode CO2e emission intensity (g/pass-mi)
Access Leg 3 - Region	Access mode region
Access Leg 3 – City Size	Access mode city size
Access Leg 3 - Time of Day	Access mode time of day
Access Leg 3 - Day of Week	Access mode day of week
Access Leg 3 - Season	Access mode season
Access Leg 4 - Mode	Access mode type
Access Leg 4 - Description	Access mode description
Access Leg 4 - Distance	Access mode distance (mile)
Access Leg 4 - Dwell	Access mode dwell time (minutes)
Access Leg 4 - Average Speed	Access mode average speed (mph)
Access Leg 4 - Fuel Source	Access mode fuel source (as defined in 'Regional-Properties' for this mode)
Access Leg 4 - Fuel Intensity	Access mode fuel intensity (kg/pass-mile)
Access Leg 4 - Energy Intensity	Access mode energy intensity (kJ/pass-mile)
Access Leg 4 - CO2e Intensity	Access mode CO2e emission intensity (g/pass-mi)
Access Leg 4 - Region	Access mode region (for future use)
Access Leg 4 – City Size	Access mode city size
Access Leg 4 - Time of Day	Access mode time of day
Access Leg 4 - Day of Week	Access mode day of week
Access Leg 4 - Season	Access mode season
Access Leg 5 - Mode	Access mode type
Access Leg 5 - Description	Access mode description
Access Leg 5 - Distance	Access mode distance (mile)
Access Leg 5 - Dwell	Access mode dwell time (minutes)
Access Leg 5 - Average Speed	Access mode average speed (mph)
Access Leg 5 - Fuel Source	Access mode fuel source (as defined in 'Regional-Properties' for this mode)
Access Leg 5 - Fuel Intensity	Access mode fuel intensity (kg/pass-mile)
Access Leg 5 - Energy Intensity	Access mode energy intensity (kJ/pass-mile)
Access Leg 5 - CO2e Intensity	Access mode CO2e emission intensity (g/pass-mi)
Access Leg 5 - Region	Access mode region (for future use)
Access Leg 5 – City Size	Access mode city size
Access Leg 5 - Time of Day	Access mode time of day
Access Leg 5 - Day of Week	Access mode day of week

Access Leg 5 - Season	Access mode season
Egress Leg 1 - Mode	Egress mode type
Egress Leg 1 - Description	Egress mode description
Egress Leg 1 - Distance	Egress mode distance (mile)
Egress Leg 1 - Dwell	Egress mode dwell time (minutes)
Egress Leg 1 - Average Speed	Egress mode average speed (mph)
Egress Leg 1 - Fuel Source	Egress mode fuel source (as defined in 'Regional-Properties' for this mode)
Egress Leg 1 - Fuel Intensity	Egress mode fuel intensity (kg/pass-mile)
Egress Leg 1 - Energy Intensity	Egress mode energy intensity (kJ/pass-mile)
Egress Leg 1 - CO2e Intensity	Egress mode CO2e emission intensity (g/pass-mi)
Egress Leg 1 - Region	Egress mode region (for future use)
Egress Leg 1 – City Size	Egress mode city size
Egress Leg 1 - Time of Day	Egress mode time of day
Egress Leg 1 - Day of Week	Egress mode day of week
Egress Leg 1 - Season	Egress mode season
Egress Leg 2 - Mode	Egress mode type
Egress Leg 2 - Description	Egress mode description
Egress Leg 2 - Distance	Egress mode distance (mile)
Egress Leg 2 - Dwell	Egress mode dwell time (minutes)
Egress Leg 2 - Average Speed	Egress mode average speed (mph)
Egress Leg 2 - Fuel Source	Egress mode fuel source (as defined in 'Regional-Properties' for this mode)
Egress Leg 2 - Fuel Intensity	Egress mode fuel intensity (kg/pass-mile)
Egress Leg 2 - Energy Intensity	Egress mode energy intensity (kJ/pass-mile)
Egress Leg 2 - CO2e Intensity	Egress mode CO2e emission intensity (g/pass-mi)
Egress Leg 2 - Region	Egress mode region (for future use)
Egress Leg 2 – City Size	Egress mode city size
Egress Leg 2 - Time of Day	Egress mode time of day
Egress Leg 2 - Day of Week	Egress mode day of week
Egress Leg 2 - Season	Egress mode season
Egress Leg 3 - Mode	Egress mode type
Egress Leg 3 - Description	Egress mode description
Egress Leg 3 - Distance	Egress mode distance (mile)
Egress Leg 3 - Dwell	Egress mode dwell time (minutes)
Egress Leg 3 - Average Speed	Egress mode average speed (mph)
Egress Leg 3 - Fuel Source	Egress mode fuel source (as defined in 'Regional-Properties' for this mode)
Egress Leg 3 - Fuel Intensity	Egress mode fuel intensity (kg/pass-mile)
Egress Leg 3 - Energy Intensity	Egress mode energy intensity (kJ/pass-mile)

Egress Leg 3 - CO2e Intensity	Egress mode CO2e emission intensity (g/pass-mi)
Egress Leg 3 - Region	Egress mode region (for future use)
Egress Leg 3 – City Size	Egress mode city size
Egress Leg 3 - Time of Day	Egress mode time of day
Egress Leg 3 - Day of Week	Egress mode day of week
Egress Leg 3 - Season	Egress mode season
Egress Leg 4 - Mode	Egress mode type
Egress Leg 4 - Description	Egress mode description
Egress Leg 4 - Distance	Egress mode distance (mile)
Egress Leg 4 - Dwell	Egress mode dwell time (minutes)
Egress Leg 4 - Average Speed	Egress mode average speed (mph)
Egress Leg 4 - Fuel Source	Egress mode fuel source (as defined in 'Regional-Properties' for this mode)
Egress Leg 4 - Fuel Intensity	Egress mode fuel intensity (kg/pass-mile)
Egress Leg 4 - Energy Intensity	Egress mode energy intensity (kJ/pass-mile)
Egress Leg 4 - CO2e Intensity	Egress mode CO2e emission intensity (g/pass-mi)
Egress Leg 4 - Region	Egress mode region (for future use)
Egress Leg 4 – City Size	Egress mode city size
Egress Leg 4 - Time of Day	Egress mode time of day
Egress Leg 4 - Day of Week	Egress mode day of week
Egress Leg 4 - Season	Egress mode season
Egress Leg 5 - Mode	Egress mode type
Egress Leg 5 - Description	Egress mode description
Egress Leg 5 - Distance	Egress mode distance (mile)
Egress Leg 5 - Dwell	Egress mode dwell time (minutes)
Egress Leg 5 - Average Speed	Egress mode average speed (mph)
Egress Leg 5 - Fuel Source	Egress mode fuel source (as defined in 'Regional-Properties' for this mode)
Egress Leg 5 - Fuel Intensity	Egress mode fuel intensity (kg/pass-mile)
Egress Leg 5 - Energy Intensity	Egress mode energy intensity (kJ/pass-mile)
Egress Leg 5 - CO2e Intensity	Egress mode CO2e emission intensity (g/pass-mi)
Egress Leg 5 - Region	Egress mode region (for future use)
Egress Leg 5 – City Size	Egress mode city size
Egress Leg 5 - Time of Day	Egress mode time of day
Egress Leg 5 - Day of Week	Egress mode day of week
Egress Leg 5 - Season	Egress mode season

A.7.6 Contents of the 'Air-Default-Data' Worksheet

The 'Air-Default-Data' worksheet defines the default data used in air mode simulations. These include geographical locations of airports and aircraft simulation parameters for five (5) broad aircraft categories which include turboprop (TP), small regional jet (SRJ), regional jet (RJ), narrow body jet (NBJ) and wide body jet (WBJ). The default values for aircraft characteristics are circa 2011/12 and can be used in most simulations. Only a limited number of airport codes/co-ordinates are included at the bottom of the table and users can add more as needed.

The following list identifies the data items used by the simulation.

Item as Titled on the Worksheet List	Notes on the Data Value
	In columns C through E
Lower-dist(km)	(row 15) Lower boundary of great circle (GC) distance boundary in kilometers
Lower-dist(mi)	(row 16) Lower boundary of great circle (GC) distance boundary in statute miles
segment #	(row 17) Index of great circle distance segment
TP	(row 18) Row of % seat miles for turboprop aircraft in GC segment
SRJ	(row 19) Row of % seat miles for small regional jet aircraft in GC segment
RJ	(row 20) Row of % seat miles for regional jet aircraft in GC segment
NBJ	(row 21) Row of % seat miles for narrow body jet aircraft in GC segment
WBJ	(row 22) Row of % seat miles for wide body jet aircraft in GC segment
	In rows 18 through 22
LF	(col K) Column of passenger load factor by aircraft type
LTO Fuel (kg/seat)	(col L) Column of landing and takeoff fuel intensity by aircraft type
Cruise Fuel–peak (kg/seat-GC-km)	(col M) Column of peak cruise fuel consumption by aircraft type
Cruise Fuel–off peak (kg/seat-GC-km)	(col N) Column of off peak cruise fuel consumption by aircraft type
Cruise Fuel–average (kg/seat-GC-km)	(col O) Column of average cruise fuel consumption by aircraft type
	Beginning in row 31
IATA Code	(col C) The IATA designation for an airport.
City Name	(col D) Identifies the city served by the airport.
Latitude (degrees)	(col G) The airport's latitude in decimal degrees.
Longitude (degrees)	(col H) The airport's longitude in decimal degrees.

Note: Do not delete row 31. Cells 'Air-Default-Data'!B31, 'Air-Default-Data'!C31, 'Air-Default-Data'!D21, 'Air-Default-Data'!G31 and 'Air-Default-Data'!H31 are named cells in Excel and deleting row 31 will result in those names being lost.

A.7.7 Contents of the 'Air-Trip-List' Worksheet

The 'Air-Trip-List' worksheet is used by the VBA macro system to store air trip definitions as they are developed by a user. Normally, the VBA macros should be used to add new trips and otherwise manage updating the contents of these fields in response to a user's selections on the 'Air Trip Selection' user form. However, the list of defined air trips may become large and a knowledgeable user may delete trips from the list manually. Care must be taken during this process such that the top of the list is maintained on row 24 and that there are no blank rows in between the top and bottom of the list (a blank row will be interpreted as the bottom of the list). Also, the columns should not be shifted.

The following list identifies the data items used by the simulation.

Item as Titled on the Worksheet List	Notes on the Data Value
ID #	Assigned by the VBA macro. Normally "AT.#" where # is equivalent to (current row number - first row number +1). Each ID # should be unique.
Trip Description	A user's description of the trip, normally some combination of the route description and aircraft description.
Region	As defined in 'Regional-Properties' worksheet
Fuel	As defined in 'Energy-Emissions' worksheet
Direction	Must be either "Forward" or "Reverse".
Departure Time of Day	Must be "AM-peak", "midday", "PM-peak", "off-peak" or "overnight"
Arrival Time of Day	Must be "AM-peak", "midday", "PM-peak", "off-peak" or "overnight"
Departure Day of Week	Must be "Mon to Fri", "Weekend" or "Daily"
Departure Season	Must be "Winter", "Summer", "Spring/Fall" or "All"
Return Trip Departure Time of Day	Must be "AM-peak", "midday", "PM-peak", "off-peak" or "overnight"
Return Trip Arrival Time of Day	Must be "AM-peak", "midday", "PM-peak", "off-peak" or "overnight"
Return Trip Departure Day of Week	Must be "Mon to Fri", "Weekend" or "Daily"
Return Trip Departure Season	Must be "Winter", "Summer", "Spring/Fall" or "All"
Departure Service Period	Must be either "Pk" or "OffPk" – assigned by VBA macro
Return Service Period	Must be either "Pk" or "OffPk" – assigned by VBA macro
Number of Travelers	Number of people assumed to be traveling together
Origin IATA Code	IATA designation of origin airport
Origin Latitude	Latitude of origin airport
Origin Longitude	Longitude of origin airport
Intermediate Stop 1 IATA Code	IATA designation of intermediate stop 1
Intermediate Stop 1 Latitude	Latitude of intermediate stop 1
Intermediate Stop 1 Longitude	Longitude of intermediate stop 1
Intermediate Stop 2 IATA Code	IATA designation of intermediate stop 2

Intermediate Stop 2 Latitude	Latitude of intermediate stop 2
Intermediate Stop 2 Longitude	Longitude of intermediate stop 2
Destination IATA Code	IATA designation of destination airport
Destination Latitude	Latitude of destination airport
Destination Longitude	Longitude of destination airport
Multi-leg	% of total flights which are multi-leg
Direct	% of total flights which are direct
Aircraft data flag	Must be either “Default” or “User”
TP Leg 1 Distribution (seat-km)	% of total leg seat-km by TP aircraft
SRJ Leg 1 Distribution (seat-km)	% of total leg seat-km by SRJ aircraft
RJ Leg 1 Distribution (seat-km)	% of total leg seat-km by RJ aircraft
NBJ Leg 1 Distribution (seat-km)	% of total leg seat-km by NBJ aircraft
WBJ Leg 1 Distribution (seat-km)	% of total leg seat-km by WBJ aircraft
TP Leg 2 Distribution (seat-km)	% of total leg seat-km by TP aircraft
SRJ Leg 2 Distribution (seat-km)	% of total leg seat-km by SRJ aircraft
RJ Leg 2 Distribution (seat-km)	% of total leg seat-km by RJ aircraft
NBJ Leg 2 Distribution (seat-km)	% of total leg seat-km by NBJ aircraft
WBJ Leg 2 Distribution (seat-km)	% of total leg seat-km by WBJ aircraft
TP Leg 3 Distribution (seat-km)	% of total leg seat-km by TP aircraft
SRJ Leg 3 Distribution (seat-km)	% of total leg seat-km by SRJ aircraft
RJ Leg 3 Distribution (seat-km)	% of total leg seat-km by RJ aircraft
NBJ Leg 3 Distribution (seat-km)	% of total leg seat-km by NBJ aircraft
WBJ Leg 3 Distribution (seat-km)	% of total leg seat-km by WBJ aircraft
TP Direct Distribution (seat-km)	% of total direct seat-km by TP aircraft
SRJ Direct Distribution (seat-km)	% of total direct seat-km by SRJ aircraft
RJ Direct Distribution (seat-km)	% of total direct seat-km by RJ aircraft
NBJ Direct Distribution (seat-km)	% of total direct seat-km by NBJ aircraft
WBJ Direct Distribution (seat-km)	% of total direct seat-km by WBJ aircraft
TP Load Factor	% load factor of TP aircraft
SRJ Load Factor	% load factor of SRJ aircraft
RJ Load Factor	% load factor of RJ aircraft
NBJ Load Factor	% load factor of NBJ aircraft
WBJ Load Factor	% load factor of WBJ aircraft
TP LTO Fuel Consumption	Landing and takeoff fuel (kg/seat) of TP aircraft

SRJ LTO Fuel Consumption	Landing and takeoff fuel (kg/seat) of SRJ aircraft
RJ LTO Fuel Consumption	Landing and takeoff fuel (kg/seat) of RJ aircraft
NBJ LTO Fuel Consumption	Landing and takeoff fuel (kg/seat) of NBJ aircraft
WBJ LTO Fuel Consumption	Landing and takeoff fuel (kg/seat) of WBJ aircraft
TP Peak Cruise Fuel Consumption	Peak cruise fuel (kg/seat-GC-km) of TP aircraft
SRJ Peak Cruise Fuel Consumption	Peak cruise fuel (kg/seat-GC-km) of SRJ aircraft
RJ Peak Cruise Fuel Consumption	Peak cruise fuel (kg/seat-GC-km) of RJ aircraft
NBJ Peak Cruise Fuel Consumption	Peak cruise fuel (kg/seat-GC-km) of NBJ aircraft
WBJ Peak Cruise Fuel Consumption	Peak cruise fuel (kg/seat-GC-km) of WBJ aircraft
TP Off-Peak Cruise Fuel Consumption	Off-peak cruise fuel (kg/seat-GC-km) of TP aircraft
SRJ Off-Peak Cruise Fuel Consumption	Off-peak cruise fuel (kg/seat-GC-km) of SRJ aircraft
RJ Off-Peak Cruise Fuel Consumption	Off-peak cruise fuel (kg/seat-GC-km) of RJ aircraft
NBJ Off-Peak Cruise Fuel Consumption	Off-peak cruise fuel (kg/seat-GC-km) of NBJ aircraft
WBJ Off-Peak Cruise Fuel Consumption	Off-peak cruise fuel (kg/seat-GC-km) of WBJ aircraft
TP Average Cruise Fuel Consumption	Average cruise fuel (kg/seat-GC-km) of TP aircraft
SRJ Average Cruise Fuel Consumption	Average cruise fuel (kg/seat-GC-km) of SRJ aircraft
RJ Average Cruise Fuel Consumption	Average cruise fuel (kg/seat-GC-km) of RJ aircraft
NBJ Average Cruise Fuel Consumption	Average cruise fuel (kg/seat-GC-km) of NBJ aircraft
WBJ Average Cruise Fuel Consumption	Average cruise fuel (kg/seat-GC-km) of WBJ aircraft
Access/Egress Number of Travelers	Number of people assumed to be traveling together (same as main leg)
Access Leg 1 - Mode	Access mode type
Access Leg 1 - Description	Access mode description
Access Leg 1 - Distance	Access mode distance (mile)
Access Leg 1 - Dwell	Access mode dwell time (minutes)
Access Leg 1 - Average Speed	Access mode average speed (mph)
Access Leg 1 - Fuel Source	Access mode fuel source (as defined in 'Regional-Properties' for this mode)
Access Leg 1 - Fuel Intensity	Access mode fuel intensity (kg/pass-mile)
Access Leg 1 - Energy Intensity	Access mode energy intensity (kJ/pass-mile)
Access Leg 1 - CO2e Intensity	Access mode CO2e emission intensity (g/pass-mi)
Access Leg 1 - Region	Access mode region

Access Leg 1 - City Size	Access mode city size
Access Leg 1 - Time of Day	Access mode time of day
Access Leg 1 - Day of Week	Access mode day of week
Access Leg 1 - Season	Access mode season
Access Leg 2 - Mode	Access mode type
Access Leg 2 - Description	Access mode description
Access Leg 2 - Distance	Access mode distance (mile)
Access Leg 2 - Dwell	Access mode dwell time (minutes)
Access Leg 2 - Average Speed	Access mode average speed (mph)
Access Leg 2 - Fuel Source	Access mode fuel source (as defined in 'Regional-Properties' for this mode)
Access Leg 2 - Fuel Intensity	Access mode fuel intensity (kg/pass-mile)
Access Leg 2 - Energy Intensity	Access mode energy intensity (kJ/pass-mile)
Access Leg 2 - CO2e Intensity	Access mode CO2e emission intensity (g/pass-mi)
Access Leg 2 - Region	Access mode region
Access Leg 2 - City Size	Access mode city size
Access Leg 2 - Time of Day	Access mode time of day
Access Leg 2 - Day of Week	Access mode day of week
Access Leg 2 - Season	Access mode season
Access Leg 3 - Mode	Access mode type
Access Leg 3 - Description	Access mode description
Access Leg 3 - Distance	Access mode distance (mile)
Access Leg 3 - Dwell	Access mode dwell time (minutes)
Access Leg 3 - Average Speed	Access mode average speed (mph)
Access Leg 3 - Fuel Source	Access mode fuel source (as defined in 'Regional-Properties' for this mode)
Access Leg 3 - Fuel Intensity	Access mode fuel intensity (kg/pass-mile)
Access Leg 3 - Energy Intensity	Access mode energy intensity (kJ/pass-mile)
Access Leg 3 - CO2e Intensity	Access mode CO2e emission intensity (g/pass-mi)
Access Leg 3 - Region	Access mode region
Access Leg 3 - City Size	Access mode city size
Access Leg 3 - Time of Day	Access mode time of day
Access Leg 3 - Day of Week	Access mode day of week
Access Leg 3 - Season	Access mode season
Access Leg 4 - Mode	Access mode type
Access Leg 4 - Description	Access mode description
Access Leg 4 - Distance	Access mode distance (mile)
Access Leg 4 - Dwell	Access mode dwell time (minutes)
Access Leg 4 - Average Speed	Access mode average speed (mph)
Access Leg 4 - Fuel Source	Access mode fuel source (as defined in 'Regional-

	Properties' for this mode)
Access Leg 4 - Fuel Intensity	Access mode fuel intensity (kg/pass-mile)
Access Leg 4 - Energy Intensity	Access mode energy intensity (kJ/pass-mile)
Access Leg 4 - CO2e Intensity	Access mode CO2e emission intensity (g/pass-mi)
Access Leg 4 - Region	Access mode region
Access Leg 4 - City Size	Access mode city size
Access Leg 4 - Time of Day	Access mode time of day
Access Leg 4 - Day of Week	Access mode day of week
Access Leg 4 - Season	Access mode season
Access Leg 5 - Mode	Access mode type
Access Leg 5 - Description	Access mode description
Access Leg 5 - Distance	Access mode distance (mile)
Access Leg 5 - Dwell	Access mode dwell time (minutes)
Access Leg 5 - Average Speed	Access mode average speed (mph)
Access Leg 5 - Fuel Source	Access mode fuel source (as defined in 'Regional-Properties' for this mode)
Access Leg 5 - Fuel Intensity	Access mode fuel intensity (kg/pass-mile)
Access Leg 5 - Energy Intensity	Access mode energy intensity (kJ/pass-mile)
Access Leg 5 - CO2e Intensity	Access mode CO2e emission intensity (g/pass-mi)
Access Leg 5 - Region	Access mode region
Access Leg 5 - City Size	Access mode city size
Access Leg 5 - Time of Day	Access mode time of day
Access Leg 5 - Day of Week	Access mode day of week
Access Leg 5 - Season	Access mode season
Egress Leg 1 - Mode	Egress mode type
Egress Leg 1 - Description	Egress mode description
Egress Leg 1 - Distance	Egress mode distance (mile)
Egress Leg 1 - Dwell	Egress mode dwell time (minutes)
Egress Leg 1 - Average Speed	Egress mode average speed (mph)
Egress Leg 1 - Fuel Source	Egress mode fuel source (as defined in 'Regional-Properties' for this mode)
Egress Leg 1 - Fuel Intensity	Egress mode fuel intensity (kg/pass-mile)
Egress Leg 1 - Energy Intensity	Egress mode energy intensity (kJ/pass-mile)
Egress Leg 1 - CO2e Intensity	Egress mode CO2e emission intensity (g/pass-mi)
Egress Leg 1 - Region	Egress mode region
Egress Leg 1 - City Size	Egress mode city size
Egress Leg 1 - Time of Day	Egress mode time of day
Egress Leg 1 - Day of Week	Egress mode day of week
Egress Leg 1 - Season	Egress mode season
Egress Leg 2 - Mode	Egress mode type

Egress Leg 2 - Description	Egress mode description
Egress Leg 2 - Distance	Egress mode distance (mile)
Egress Leg 2 - Dwell	Egress mode dwell time (minutes)
Egress Leg 2 - Average Speed	Egress mode average speed (mph)
Egress Leg 2 - Fuel Source	Egress mode fuel source (as defined in 'Regional-Properties' for this mode)
Egress Leg 2 - Fuel Intensity	Egress mode fuel intensity (kg/pass-mile)
Egress Leg 2 - Energy Intensity	Egress mode energy intensity (kJ/pass-mile)
Egress Leg 2 - CO2e Intensity	Egress mode CO2e emission intensity (g/pass-mi)
Egress Leg 2 - Region	Egress mode region
Egress Leg 2 - City Size	Egress mode city size
Egress Leg 2 - Time of Day	Egress mode time of day
Egress Leg 2 - Day of Week	Egress mode day of week
Egress Leg 2 - Season	Egress mode season
Egress Leg 3 - Mode	Egress mode type
Egress Leg 3 - Description	Egress mode description
Egress Leg 3 - Distance	Egress mode distance (mile)
Egress Leg 3 - Dwell	Egress mode dwell time (minutes)
Egress Leg 3 - Average Speed	Egress mode average speed (mph)
Egress Leg 3 - Fuel Source	Egress mode fuel source (as defined in 'Regional-Properties' for this mode)
Egress Leg 3 - Fuel Intensity	Egress mode fuel intensity (kg/pass-mile)
Egress Leg 3 - Energy Intensity	Egress mode energy intensity (kJ/pass-mile)
Egress Leg 3 - CO2e Intensity	Egress mode CO2e emission intensity (g/pass-mi)
Egress Leg 3 - Region	Egress mode region
Egress Leg 3 - City Size	Egress mode city size
Egress Leg 3 - Time of Day	Egress mode time of day
Egress Leg 3 - Day of Week	Egress mode day of week
Egress Leg 3 - Season	Egress mode season
Egress Leg 4 - Mode	Egress mode type
Egress Leg 4 - Description	Egress mode description
Egress Leg 4 - Distance	Egress mode distance (mile)
Egress Leg 4 - Dwell	Egress mode dwell time (minutes)
Egress Leg 4 - Average Speed	Egress mode average speed (mph)
Egress Leg 4 - Fuel Source	Egress mode fuel source (as defined in 'Regional-Properties' for this mode)
Egress Leg 4 - Fuel Intensity	Egress mode fuel intensity (kg/pass-mile)
Egress Leg 4 - Energy Intensity	Egress mode energy intensity (kJ/pass-mile)
Egress Leg 4 - CO2e Intensity	Egress mode CO2e emission intensity (g/pass-mi)
Egress Leg 4 - Region	Egress mode region
Egress Leg 4 - City Size	Egress mode city size

Egress Leg 4 - Time of Day	Egress mode time of day
Egress Leg 4 - Day of Week	Egress mode day of week
Egress Leg 4 - Season	Egress mode season
Egress Leg 5 - Mode	Egress mode type
Egress Leg 5 - Description	Egress mode description
Egress Leg 5 - Distance	Egress mode distance (mile)
Egress Leg 5 - Dwell	Egress mode dwell time (minutes)
Egress Leg 5 - Average Speed	Egress mode average speed (mph)
Egress Leg 5 - Fuel Source	Egress mode fuel source (as defined in 'Regional-Properties' for this mode)
Egress Leg 5 - Fuel Intensity	Egress mode fuel intensity (kg/pass-mile)
Egress Leg 5 - Energy Intensity	Egress mode energy intensity (kJ/pass-mile)
Egress Leg 5 - CO2e Intensity	Egress mode CO2e emission intensity (g/pass-mi)
Egress Leg 5 - Region	Egress mode region
Egress Leg 5 - City Size	Egress mode city size
Egress Leg 5 - Time of Day	Egress mode time of day
Egress Leg 5 - Day of Week	Egress mode day of week
Egress Leg 5 - Season	Egress mode season

A.7.8 Contents of the 'Bus-Type' Worksheet

The 'Bus-Type' worksheet defines sets of parameters used by the bus simulation module. They are organized down the rows of the worksheet beginning in column "F" for the first defined bus type and offset by 4 columns (i.e. column "J") for each additional consist defined on the worksheet. The following list identifies the data items required by the simulation.

Item as Titled on the Worksheet List	Notes on the Input Required
Bus Type ID	Assigned by the VBA macro. Normally "BT.#" where # is equivalent to (current row number - first row number +1). Each ID # should be unique.
Description	User assigned description
Coach Characteristics:	
# axles	Total number of axles
Length (ft)	Bus length (ft)
tare wt (lb)	Bus tare weight (lb)
Gross Vehicle Weight Rating	GVWR (lb)
# seats	Number of passenger seats
Passenger Load Factor (Route/Consist/Time-of-day)	Load factor
Avg weight per passenger-with luggage (lb)	Passenger weight including luggage (lb)
gross wt (lb)	Gross vehicle weight (lb) (calculated)
Aerodynamic Drag Characteristics	
Total Cd	Total drag coefficient (dimensionless)
Frontal Area (m^2)	Frontal drag area (m^2)
Engine Characteristics:	
Engine Type	Information purposes only
Displacement (l)	Information purposes only
HP	Engine rated horsepower (hp)
Minimum BSFC (g/kWs)	Engine's minimum brake specific fuel consumption (g/kWs)
Fuel	Fuel type from those defined in 'Energy-Emission' worksheet
Hybrid Bus Only:	
Storage Energy Capacity (kWh)	
Storage Power Capacity (kW) target use (%)	(kW) first column, (%) in second column

Storage lower / upper limts (%)	(%) lower in first column, (%) upper in second column
storage losses coeff (charge / propel)	For charging in first column, for propulsion in second column
electro-mechanical transmission efficiency (either direction)	
Coach Climate Control + Auxiliaries	
Summer load multiplier	Multiplier for regional summer base load
Summer extended idle load multiplier	Multiplier for regional summer extended idle base load
Winter load multiplier	Multiplier for regional winter base load
Winter extended idle load multiplier	Multiplier for regional winter extended idle base load
Other (Spring&Fall) load multiplier	Multiplier for regional Spring/Fall base load

A.7.9 Contents of the 'Bus-Route' Worksheet

The 'Bus-Route' worksheet contains data used to characterize the route over which a bus will operate. For every defined route the data is organized into a number of tables, some of which span up to nine (9) columns. The data for the first defined route begins at address 'Bus-Route'!N2 with each subsequent route definition offset from the previous one by twelve (12) columns.

The influence of grades along the route are accounted for by specifying the change in elevation (in meters) between the origin and destination at cell 'Bus-Route'!Q72. Then, intercity grade distributions are provided which characterize grades into per unit distances of grade classes evaluated over the base distance (in km) as defined in cell 'Bus-Route'!Q73. For descending grade forward direction these are given in table 'Bus-Route'!N77:N104 while for ascending grade forward direction these are given in table 'Bus-Route'!Q77:Q104.

The following list identifies the data items required by the simulation.

Item as Titled on the Worksheet List	Notes on the Input Required
Bus Route ID	Assigned by the VBA macro. Normally "BR.#" where # is a sequential integer value. Each ID # should be unique.
Description	User assigned description
Delay and Idle Times	
Intercity routine stops distribution	
Number of Toll booth stops in intercity-trip	Same for both directions of travel
Total queue delay at all toll-booth and traffic stand-still queuing stops (min)	Forward trip in first column, return trip in second column
Average number of intermediate wayside stops (normal)	Origin urban area in first column, inter-city highway in second column, destination urban area in third column
Average duration of each intermediate stop (min)	All areas
Origin/Destination Station Idle (hrs/one-way trip)	First column for origin, last column for destination
Scheduled Trip Time (hour)	
Layover Idle Time Allocated per one-way trip (by location)	
Layover Idle - winter (hr/trip)	First column for origin, second column for inter-city and last column for destination
Layover Idle - summer (hr/trip)	First column for origin, second column for inter-city and last column for destination
Layover Idle - spring/fall (hr/trip)	First column for origin, second column for inter-city and last column for destination

Drive schedule selection	
Rural congestion/weather delay distribution	
winter (slow) - Drive Schedule - 75km/h -LOS-E	First column is probability and second column is length (km)
non-winter (slow) - Drive Schedule - 75km/h -LOS-E	First column is probability and second column is length (km)
Urban time of Day Calculation	
Description	First two columns define time of day distribution for forward trip origin and destination, last two columns define time of day distribution for return trip origin and destination.
a.m. peak	
p.m. peak	
midday	
shoulders (calc as left over hrs)	
overnight	
TOTAL (error check)	
Urban Freeway and Arterial Distances	
Intercity avg total urban Freeway dist (forward trip / reverse trip)	First 2 columns for origin and destination city of forward trip, last two columns for origin and destination city of return trip (distances in km)
Total Intercity Urban arterial distance (forward trip / reverse trip)	First 2 columns for origin and destination city of forward trip, last two columns for origin and destination city of return trip (distances in km)
Intercity Speed Distribution	
Main inter-urban O-D route speed limits	First column distance (km) and last column posted speed (mph)
Distance at speed limit 1	
Distance at speed limit 2	
Distance at speed limit 3	
Distance at speed limit 4	
Intermediate urban bypass	
Intermediate urban Arterial	Distance (km) using “Arterial 40 km/h” drive schedule
Total One-Way Trip Distance (km)	Calculated
Actual cruise speed distribution for all but urban arterial	First column is % buses/route-km and last column is cruise speed (moh)
Actual cruise speed 1	
Actual cruise speed 2	
Actual cruise speed 3	
Actual cruise speed 4	
Actual cruise speed 5	

Actual cruise speed 6	
Forced speed reductions (from cruise speed to posted or forced lower traffic speed)	Number of reductions to lower speed (in mph)
Speed reduction 1	
Speed reduction 2	
Elevation change between forward trip Origin and Destination (m)	
Base Data Distance (km)	
Intercity Grade Distribution	
grade-class (percent)	First column is per unit distance in a grade class in descending grade forward direction, second column is per unit distance in a grade class in ascending grade forward direction
0.25 - 0.5	
0.5 - 0.75	
0.75 - 1	
1 - 1.25	
1.25 - 1.5	
1.5 - 1.75	
1.75 - 2	
2 - 2.25	
2.25 - 2.5	
2.5 - 2.75	
2.75 - 3	
3 - 3.25	
3.25 - 3.5	
3.5 - 3.75	
3.75 - 4	
4 - 4.25	
4.25 - 4.5	
4.5 - 4.75	
4.75 - 5	
5 - 5.25	
5.25 - 5.5	
5.5 - 5.75	
5.75 - 6	
6 - 6.25	
6.25 - 6.5	
6.5 - 6.75	
6.75 - 7	
>7	

A.7.10 Contents of the 'Bus-Drive-Schedules' Worksheet

The 'Bus-Drive-Schedules' worksheet defines the speed-time relationships used by the internal 'Bus-Trip' and 'Bus-Simulation' worksheets to simulate all movement of buses in urban areas (i.e. other than when cruising at high speed between urban centers). The orange table at 'Bus-Drive_Schedules'!A2:J6 defines the drive schedule mix to be used on arterial roads in both the origin and destination cities during five (5) daily time periods defined as: a.m. peak, p.m. peak, midday, shoulder periods and overnight. This table draws from drive schedule distributions defined in one of three supporting tables associated with small cities ('Bus-Drive-Schedules'!AA2:AJ6), large cities ('Bus-Drive-Schedules'!AO2:AX6) or a user defined city distribution ('Bus-Drive-Schedules'!BC2:BL6) depending on the table selector placed in the pink cell at 'Bus-Drive-Schedules'!B3. The VBA macro automatically sets the table selector based upon the user's trip configurations while performing a simulation. The orange table at 'Bus-Drive-Schedules'!A7:J11 defines the drive schedule mix used on urban freeways around the origin city during the five (5) daily time periods and draws its data from tables at 'Bus-Drive-Schedules'!AA7:AJ11 for small cities, 'Bus-Drive-Schedules'!AO7:AX11 for large cities and 'Bus-Drive-Schedules'!BC7:BL11 for a user defined city based on the table selector placed in the pink cell at 'Bus-Drive-Schedules'!B8. Finally, the orange table at 'Bus-Drive-Schedules'!A12:J16 defines the drive schedule mix used on urban freeways around the destination city during the five (5) daily time periods and draws its data from tables at 'Bus-Drive-Schedules'!AA12:AJ16 for small cities, 'Bus-Drive-Schedules'!AO12:AX16 for large cities and 'Bus-Drive-Schedules'!BC12:BL16 for a user defined city based on the table selector placed in the pink cell at 'Bus-Drive-Schedules'!B13.

A knowledgeable user may adjust the appropriate drive schedule mix to suit their analysis but must take care when doing so to ensure that the columns on each row of those tables sum to 100% so that travel at all times of the day are accounted for. Additional queue delays and operation under other specific extraordinary conditions and areas are assigned in 'Bus-Drive-Schedules'!A17:J21.

The drive schedules are defined in the yellow table 'Bus-Drive-Schedules'!B23:K5366. The first ten (10) rows of the table provide headings and summary characteristics for the drive schedules below. The drive schedules themselves specify the second-by-second speed target which the 'Bus-Simulation' worksheet will attempt to follow when assessing fuel consumption and emissions production. They are organized into yellow coloured columns starting at row 33 with column 'B' specifying the time in seconds and columns 'C' through 'J' defining the target speed in m/s.

A.7.11 Contents of the 'Bus-Trip-List' Worksheet

The 'Bus-Trip-List' worksheet is used by the VBA macro system to store bus trip definitions as they are developed by a user. Normally, the VBA macros should be used to add new trips and otherwise manage updating the contents of these fields in response to a user's selections on the 'Bus Trip Selection' user form. However, the list of defined bus trips may become large and a knowledgeable user may delete trips from the list manually. Care must be taken during this process such that the top of the list is maintained on row 25 and that there are no blank rows in between the top and bottom of the list (a blank row will be interpreted as the bottom of the list). Also, the columns should not be shifted.

The following list identifies the data items used by the simulation.

Item as Titled on the Worksheet List	Notes on the Data Value
ID #	Assigned by the VBA macro. Normally "BT.#" where # is equivalent to (current row number - first row number +1). Each ID # should be unique.
Trip Description	A user's description of the trip, normally some combination of the route description and bus type description.
Region	One of the region descriptors as defined in the 'Regional-Properties' worksheet
Route ID	Assigned by the VBA macro. Normally "BR.#" where # is equivalent to the route index in 'Bus-Route' worksheet.
Route Description	A user's description of the route.
Trip Length	Length of trip in km
Urban Area1 Freeway Mix	For origin urban area, must be "Small City", "Large City" or "User Defined"
Urban Area2 Freeway Mix	For destination urban area, must be "Small City", "Large City" or "User Defined"
Urban Area Arterial Mix	For both origin and destination urban areas, must be "Small City", "Large City" or "User Defined"
Direction	Must be either "Forward" or "Reverse".
Departure Time of Day	For forward trip, must be "AM-peak", "midday", "PM-peak", "off-peak", "overnight" or "route default"
Arrival Time of Day	For forward trip, must be "AM-peak", "midday", "PM-peak", "off-peak", "overnight" or "route default"
Departure Day of Week	For forward trip, must be "Mon to Fri", "Weekend" or "Daily"
Departure Season	For forward trip, must be "Winter", "Summer", "Spring/Fall" or "All"
Return Departure Time of Day	For return trip, must be "AM-peak", "midday", "PM-peak", "off-peak", "overnight" or "route default"
Return Arrival Time of Day	For return trip, must be "AM-peak", "midday", "PM-peak", "off-peak", "overnight" or "route default"
Return Departure Day of Week	For return trip, must be "Mon to Fri", "Weekend" or "Daily"
Departure Season	For return trip, must be "Winter", "Summer", "Spring/Fall" or "All"
Coach ID	Assigned by the VBA macro. Normally "BC.#" where # is equivalent to the coach index in 'Bus-Type' worksheet.
Coach Description	A user's description of coach type (in 'Bus-Type' worksheet)

Coach Fuel	A fuel descriptor defined in the bus fuel table of 'Energy-Emissions' worksheet
Passenger Seats	Number of passenger seats on the selected coach type
Passenger Load Factor	Must be 1 or less
Number of Travelers	Number of people assumed to be traveling together
Scheduled Trip Time (hours)	
Number of Intermediate Stops	
Station Stop Time Allowance (min)	
Access/Egress Number of Travelers	Number of people assumed to be traveling together for access/egress (normally the same as for primary trip)
Access Leg 1 - Mode	Access mode type
Access Leg 1 - Description	Access mode description
Access Leg 1 - Distance	Access mode distance (mile)
Access Leg 1 - Dwell	Access mode dwell time (minutes)
Access Leg 1 - Average Speed	Access mode average speed (mph)
Access Leg 1 - Fuel Source	Access mode fuel source (as defined in 'Regional-Properties" for access mode)
Access Leg 1 - Fuel Intensity	Access mode fuel intensity (kg/pass-mile)
Access Leg 1 - Energy Intensity	Access mode energy intensity (kJ/pass-mile)
Access Leg 1 - CO2e Intensity	Access mode CO2e emission intensity (g/pass-mi)
Access Leg 1 - Region	Access mode region
Access Leg 1 - City Size	Access mode city size
Access Leg 1 - Time of Day	Access mode time of day
Access Leg 1 - Day of Week	Access mode day of week
Access Leg 1 - Season	Access mode season
Access Leg 2 - Mode	Access mode type
Access Leg 2 - Description	Access mode description
Access Leg 2 - Distance	Access mode distance (mile)
Access Leg 2 - Dwell	Access mode dwell time (minutes)
Access Leg 2 - Average Speed	Access mode average speed (mph)
Access Leg 2 - Fuel Source	Access mode fuel source (as defined in 'Regional-Properties" for access mode)
Access Leg 2 - Fuel Intensity	Access mode fuel intensity (kg/pass-mile)
Access Leg 2 - Energy Intensity	Access mode energy intensity (kJ/pass-mile)
Access Leg 2 - CO2e Intensity	Access mode CO2e emission intensity (g/pass-mi)
Access Leg 2 - Region	Access mode region (for future use)
Access Leg 2 - City Size	Access mode city size
Access Leg 2 - Time of Day	Access mode time of day
Access Leg 2 - Day of Week	Access mode day of week
Access Leg 2 - Season	Access mode season

Access Leg 3 - Mode	Access mode type
Access Leg 3 - Description	Access mode description
Access Leg 3 - Distance	Access mode distance (mile)
Access Leg 3 - Dwell	Access mode dwell time (minutes)
Access Leg 3 - Average Speed	Access mode average speed (mph)
Access Leg 3 - Fuel Source	Access mode fuel source (as defined in 'Regional-Properties" for access mode)
Access Leg 3 - Fuel Intensity	Access mode fuel intensity (kg/pass-mile)
Access Leg 3 - Energy Intensity	Access mode energy intensity (kJ/pass-mile)
Access Leg 3 - CO2e Intensity	Access mode CO2e emission intensity (g/pass-mi)
Access Leg 3 - Region	Access mode region (for future use)
Access Leg 3 - City Size	Access mode city size
Access Leg 3 - Time of Day	Access mode time of day
Access Leg 3 - Day of Week	Access mode day of week
Access Leg 3 - Season	Access mode season
Access Leg 4 - Mode	Access mode type
Access Leg 4 - Description	Access mode description
Access Leg 4 - Distance	Access mode distance (mile)
Access Leg 4 - Dwell	Access mode dwell time (minutes)
Access Leg 4 - Average Speed	Access mode average speed (mph)
Access Leg 4 - Fuel Source	Access mode fuel source (as defined in 'Regional-Properties" for access mode)
Access Leg 4 - Fuel Intensity	Access mode fuel intensity (kg/pass-mile)
Access Leg 4 - Energy Intensity	Access mode energy intensity (kJ/pass-mile)
Access Leg 4 - CO2e Intensity	Access mode CO2e emission intensity (g/pass-mi)
Access Leg 4 - Region	Access mode region (for future use)
Access Leg 4 - City Size	Access mode city size
Access Leg 4 - Time of Day	Access mode time of day
Access Leg 4 - Day of Week	Access mode day of week
Access Leg 4 - Season	Access mode season
Access Leg 5 - Mode	Access mode type
Access Leg 5 - Description	Access mode description
Access Leg 5 - Distance	Access mode distance (mile)
Access Leg 5 - Dwell	Access mode dwell time (minutes)
Access Leg 5 - Average Speed	Access mode average speed (mph)
Access Leg 5 - Fuel Source	Access mode fuel source (as defined in 'Regional-Properties" for access mode)
Access Leg 5 - Fuel Intensity	Access mode fuel intensity (kg/pass-mile)
Access Leg 5 - Energy Intensity	Access mode energy intensity (kJ/pass-mile)
Access Leg 5 - CO2e Intensity	Access mode CO2e emission intensity (g/pass-mi)
Access Leg 5 - Region	Access mode region (for future use)

Access Leg 5 - City Size	Access mode city size
Access Leg 5 - Time of Day	Access mode time of day
Access Leg 5 - Day of Week	Access mode day of week
Access Leg 5 - Season	Access mode season
Egress Leg 1 - Mode	Egress mode type
Egress Leg 1 - Description	Egress mode description
Egress Leg 1 - Distance	Egress mode distance (mile)
Egress Leg 1 - Dwell	Egress mode dwell time (minutes)
Egress Leg 1 - Average Speed	Egress mode average speed (mph)
Egress Leg 1 - Fuel Source	Egress mode fuel source (as defined in 'Regional-Properties" for egress mode)
Egress Leg 1 - Fuel Intensity	Egress mode fuel intensity (kg/pass-mile)
Egress Leg 1 - Energy Intensity	Egress mode energy intensity (kJ/pass-mile)
Egress Leg 1 - CO2e Intensity	Egress mode CO2e emission intensity (g/pass-mi)
Egress Leg 1 - Region	Egress mode region (for future use)
Egress Leg 1 - City Size	Egress mode city size
Egress Leg 1 - Time of Day	Egress mode time of day
Egress Leg 1 - Day of Week	Egress mode day of week
Egress Leg 1 - Season	Egress mode season
Egress Leg 2 - Mode	Egress mode type
Egress Leg 2 - Description	Egress mode description
Egress Leg 2 - Distance	Egress mode distance (mile)
Egress Leg 2 - Dwell	Egress mode dwell time (minutes)
Egress Leg 2 - Average Speed	Egress mode average speed (mph)
Egress Leg 2 - Fuel Source	Egress mode fuel source (as defined in 'Regional-Properties" for egress mode)
Egress Leg 2 - Fuel Intensity	Egress mode fuel intensity (kg/pass-mile)
Egress Leg 2 - Energy Intensity	Egress mode energy intensity (kJ/pass-mile)
Egress Leg 2 - CO2e Intensity	Egress mode CO2e emission intensity (g/pass-mi)
Egress Leg 2 - Region	Egress mode region (for future use)
Egress Leg 2 - City Size	Egress mode city size
Egress Leg 2 - Time of Day	Egress mode time of day
Egress Leg 2 - Day of Week	Egress mode day of week
Egress Leg 2 - Season	Egress mode season
Egress Leg 3 - Mode	Egress mode type
Egress Leg 3 - Description	Egress mode description
Egress Leg 3 - Distance	Egress mode distance (mile)
Egress Leg 3 - Dwell	Egress mode dwell time (minutes)
Egress Leg 3 - Average Speed	Egress mode average speed (mph)
Egress Leg 3 - Fuel Source	Egress mode fuel source (as defined in 'Regional-

	Properties" for egress mode)
Egress Leg 3 - Fuel Intensity	Egress mode fuel intensity (kg/pass-mile)
Egress Leg 3 - Energy Intensity	Egress mode energy intensity (kJ/pass-mile)
Egress Leg 3 - CO2e Intensity	Egress mode CO2e emission intensity (g/pass-mi)
Egress Leg 3 - Region	Egress mode region (for future use)
Egress Leg 3 - City Size	Egress mode city size
Egress Leg 3 - Time of Day	Egress mode time of day
Egress Leg 3 - Day of Week	Egress mode day of week
Egress Leg 3 - Season	Egress mode season
Egress Leg 4 - Mode	Egress mode type
Egress Leg 4 - Description	Egress mode description
Egress Leg 4 - Distance	Egress mode distance (mile)
Egress Leg 4 - Dwell	Egress mode dwell time (minutes)
Egress Leg 4 - Average Speed	Egress mode average speed (mph)
Egress Leg 4 - Fuel Source	Egress mode fuel source (as defined in 'Regional-Properties" for egress mode)
Egress Leg 4 - Fuel Intensity	Egress mode fuel intensity (kg/pass-mile)
Egress Leg 4 - Energy Intensity	Egress mode energy intensity (kJ/pass-mile)
Egress Leg 4 - CO2e Intensity	Egress mode CO2e emission intensity (g/pass-mi)
Egress Leg 4 - Region	Egress mode region (for future use)
Egress Leg 4 - City Size	Egress mode city size
Egress Leg 4 - Time of Day	Egress mode time of day
Egress Leg 4 - Day of Week	Egress mode day of week
Egress Leg 4 - Season	Egress mode season
Egress Leg 5 - Mode	Egress mode type
Egress Leg 5 - Description	Egress mode description
Egress Leg 5 - Distance	Egress mode distance (mile)
Egress Leg 5 - Dwell	Egress mode dwell time (minutes)
Egress Leg 5 - Average Speed	Egress mode average speed (mph)
Egress Leg 5 - Fuel Source	Egress mode fuel source (as defined in 'Regional-Properties" for egress mode)
Egress Leg 5 - Fuel Intensity	Egress mode fuel intensity (kg/pass-mile)
Egress Leg 5 - Energy Intensity	Egress mode energy intensity (kJ/pass-mile)
Egress Leg 5 - CO2e Intensity	Egress mode CO2e emission intensity (g/pass-mi)
Egress Leg 5 - Region	Egress mode region (for future use)
Egress Leg 5 - City Size	Egress mode city size
Egress Leg 5 - Time of Day	Egress mode time of day
Egress Leg 5 - Day of Week	Egress mode day of week
Egress Leg 5 - Season	Egress mode season

A.7.12 Contents of the 'LDV-Type' Worksheet

The 'LDV-Type' worksheet is used by the 'Auto/LDV Type Selection' user form and contains pointers to data fields on the 'LDV-Resist' worksheet as most light duty vehicle default parameters used by the 'LDV-Simulation' worksheet are specified there. Yellow cells containing formulas should not be over-written with data values. The yellow cell at 'LDV-Type'!F6 (and at 4 column intervals to the right) identifies the index for the vehicle type in the default parameters table located at 'LDV-Resist'!C29:AB51. A knowledgeable user can make careful adjustments in the 'LDV-Resist' worksheet but data locations should not be changed.

The 'LDV-Type' worksheet contains a limited number of user modifiable parameters - notably the number of passenger seats per vehicle, the number of passengers carried, the fuel type and the user's selection of engine option. All of these may be adjusted on the 'Auto/LDV Type Selection' user form. The engine option can be either "Hybrid", "Non-hybrid" or "default mix", where the default mix is a combination of hybrid and conventional vehicles as defined in the 'LDV-Resist' data table. Data fields are also provided to adjust the regionally specified Auto/LDV climate control and auxiliary loads for a specific vehicle type. This adjustment is achieved by multiplying the running and idle auxiliary loads as specified for each season ("Winter", "Summer" and "Spring/Fall") in the 'Regional-Properties' table by the corresponding adjustment factors defined in the 'LDV-Type' column. Any changes made to the 'LDV-Type' worksheet must not alter the cell location of the first Auto/LDV type identifier at cell 'LDV-Type'!F2 and entries for successive vehicle types must maintain a fixed 4 column offset from the previous.

The following list identifies the data items in the 'LDV-Type' column for a vehicle.

Item as Titled on the Worksheet List	Notes on the Input Required
Auto/LDV Type ID	Assigned in the default data table located on the 'LDV-Resist' worksheet and used by reference
Description	Assigned in the default data table located on the 'LDV-Resist' worksheet and used by reference
Auto/LDV Characteristics:	Integer number index to a column of the default data table located on the 'LDV-Resist' worksheet
Year	Year associated with default data
# passenger seats	Total number of passenger seats in vehicle
Passengers	Number of passenger seats occupied
Tare weight (kg)	
Engine Characteristics:	
Engine Type	"spark" or "diesel"

HP	Engine horsepower
Fuel	As defined in 'Energy-Emissions' worksheet
Engine Option	"Hybrid", "Non-hybrid" or "default mix"
Climate Control + Auxiliaries (base regional load multiplier)	
Winter running aux load	Multiplier for base regionally defined load
Winter idle load	Multiplier for base regionally defined load
Summer running aux load	Multiplier for base regionally defined load
Summer idle load	Multiplier for base regionally defined load
Spring/Fall running aux load	Multiplier for base regionally defined load
Spring/Fall idle load	Multiplier for base regionally defined load

A.7.13 Contents of the 'LDV-Route' Worksheet

The 'LDV-Route' worksheet contains data used to characterize the route over which a light duty vehicle will operate. For every defined route the data is organized into a number of tables, some of which span up to nine (9) columns. The data for the first defined route begins at address 'LDV-Route'!N2 with each subsequent route definition offset from the previous one by twelve (12) columns.

The influence of grades along the route are accounted for by specifying the change in elevation (in meters) between the origin and destination at cell 'LDV-Route'!Q72. Then, intercity grade distributions are provided which characterize grades into per unit distances of grade classes evaluated over the base distance (in km) as defined in cell 'LDV-Route'!Q73. For descending grade forward direction these are given in table 'LDV-Route'!N77:N104 while for ascending grade forward direction these are given in table 'LDV-Route'!Q77:Q104.

The following list identifies the data items required by the simulation.

Item as Titled on the Worksheet List	**Notes on the Input Required**
Auto/LDV Route ID	Each ID must be unique. When assigned by the VBA macro these are of the form "LR.#" where # is a sequential integer value.
Description	User assigned description
Delay and Idle Times	
Intercity routine stops distribution	
Number of Toll booth stops in intercity-trip	Same for both directions of travel
Total queue delay at all toll-booth and traffic stand-still queuing stops (min)	First column for origin, last column for destination
Average number of intermediate wayside stops (normal)	All areas
Average cumulative duration of all intermediate stops (hr)	All areas
Origin/Destination Idle (hrs/one-way trip)	First column for forward trip, last column for return trip
% layover at location for all seasons	First column at destination, second column en route
Layover Idle Time Allocated per one-way trip (by location)	
Layover Idle - winter (hr/trip)	Inter-city layover hours per trip
Layover Idle - summer (hr/trip)	Inter-city layover hours per trip
Layover Idle - spring/fall (hr/trip)	Inter-city layover hours per trip
Drive schedule selection	
Rural Highway congestion/weather delay distribution	
winter (slow) - Drive Schedule - 75km/h -LOS-E	First column is probability and second column

	is length (km)
non-winter (slow) - Drive Schedule - 75km/h -LOS-E	First column is probability and second column is length (km)
Urban time of Day Calculation	
Description	First two columns define time of day distribution for forward trip origin and destination, last two columns define time of day distribution for return trip origin and destination.
a.m. peak	
p.m. peak	
midday	
shoulders (calc as left over hrs)	
overnight	
TOTAL (error check)	Each column should sum to 100%
Urban Freeway and Arterial Distances	
Intercity avg total urban Freeway dist (forward trip / reverse trip)	First 2 columns for origin and destination city of forward trip, last two columns for origin and destination city of return trip (distances in km)
Total Intercity Urban arterial distance (forward trip / reverse trip)	First 2 columns for origin and destination city of forward trip, last two columns for origin and destination city of return trip (distances in km)
Intercity Speed Distribution	
Main inter-urban O-D route speed limits	First column distance (km) and last column posted speed (mph)
Distance at speed limit 1	
Distance at speed limit 2	
Distance at speed limit 3	
Distance at speed limit 4	
Intermediate urban bypass	
Intermediate urban Arterial	Distance (km) using “Arterial 40 km/h” drive schedule
Total One-Way Trip Distance (Forward and Reverse)	Calculated. Forward trip in first column, return trip in last column
Actual cruise speed distribution for all but urban arterial	First column is % LDV/route-km and last column is cruise speed (mph)
Actual cruise speed 1	
Actual cruise speed 2	
Actual cruise speed 3	
Actual cruise speed 4	
Actual cruise speed 5	
Actual cruise speed 6	

Delta KE from forced speed reductions dissipated in brakes (from cruise speed to posted lower speed)	Number of reductions to lower speed in first column, lower speed (mph) in last column
Speed reduction 1	
Speed reduction 2	
Elevation change between forward trip Origin and Destination (m)	
Base Data Distance (km)	
Intercity Grade Distribution	
grade-class (percent)	First column is per unit distance in a grade class in descending grade forward direction, second column is per unit distance in a grade class in ascending grade forward direction
0.25 - 0.5	
0.5 - 0.75	
0.75 - 1	
1 - 1.25	
1.25 - 1.5	
1.5 - 1.75	
1.75 - 2	
2 - 2.25	
2.25 - 2.5	
2.5 - 2.75	
2.75 - 3	
3 - 3.25	
3.25 - 3.5	
3.5 - 3.75	
3.75 - 4	
4 - 4.25	
4.25 - 4.5	
4.5 - 4.75	
4.75 - 5	
5 - 5.25	
5.25 - 5.5	
5.5 - 5.75	
5.75 - 6	
6 - 6.25	
6.25 - 6.5	
6.5 - 6.75	
6.75 - 7	
>7	

A.7.14 Contents of the 'LDV-Drive-Schedules' Worksheet

The 'LDV-Drive-Schedules' worksheet defines the speed-time relationships used by the internal 'LDV-Trip' and 'LDV-Simulation' worksheets to simulate all movement of light duty vehicles in urban areas (i.e. other than when cruising at high speed between urban centers). The orange table at 'LDV-Drive-Schedules'!A2:J6 defines the drive schedule mix to be used on arterial roads in both the origin and destination cities during five (5) daily time periods defined as: a.m. peak, p.m. peak, midday, shoulder periods and overnight. This table draws from drive schedule distributions in one of three supporting tables associated with small cities ('LDV-Drive-Schedules'!AA2:AJ6), large cities ('LDV-Drive-Schedules'!AO2:AX6) or a user defined city distribution ('LDV-Drive_Schedules'!BC2:BL6) depending on the table selector placed in the pink cell at 'LDV-Drive-Schedules'!B3. The VBA macro automatically sets the table selector based upon the user's trip configurations while performing a simulation. The orange table at 'LDV-Drive-Schedules'!A7:J11 defines the drive schedule mix used on urban freeways around the origin city during the five (5) daily time periods and draws its data from tables at 'LDV-Drive-Schedules'!AA7:AJ11 for small cities, 'LDV-Drive-Schedules'!AO7:AX11 for large cities and 'LDV-Drive-Schedules'!BC7:BL11 for a user defined city based on the table selector placed in the pink cell at 'LDV-Drive-Schedules'!B8. Finally, the orange table at 'LDV-Drive-Schedules'!A12:J16 defines the drive schedule mix used on urban freeways around the destination city during the five (5) daily time periods and draws its data from tables at 'LDV-Drive-Schedules'!AA12:AJ16 for small cities, 'LDV-Drive-Schedules'!AO12:AX16 for large cities and 'LDV-Drive-Schedules'!BC12:BL16 for a user defined city based on the table selector placed in the pink cell at 'LDV-Drive-Schedules'!B13.

A knowledgeable user may adjust the appropriate drive schedule mix to suit their analysis but must take care when doing so to ensure that the columns on each row of those tables sum to 100% so that travel at all times of the day are accounted for. Additional queue delays and operation under other specific extraordinary conditions and areas are assigned in 'LDV-Drive-Schedules'!A17:J21.

The drive schedules are defined in the yellow table 'LDV-Drive-Schedules'!B23:K5366. The first ten (10) rows of the table provide headings and summary characteristics for the drive schedules below. The drive schedules themselves specify the second-by-second speed target which the 'LDV-Simulation' worksheet will attempt to follow when assessing fuel consumption and emissions production. They are organized into yellow coloured columns starting at row 33 with column 'B' specifying the time in seconds and columns 'C' through 'J' defining the target speed in m/s.

A.7.15 Contents of the 'LDV-Trip-List' Worksheet

The 'LDV-Trip-List' worksheet is used by the VBA macro system to store Auto/LDV trip definitions as they are developed by a user. Normally, the VBA macros should be used to add new trips and otherwise manage updating the contents of these fields in response to a user's selections on the 'Auto/LDV Trip Selection' user form. However, the list of defined light duty vehicle trips may become large and a knowledgeable user may delete trips from the list manually. Care must be taken during this process such that the top of the list is maintained on row 25 and that there are no blank rows in between the top and bottom of the list (a blank row will be interpreted as the bottom of the list). Also, the columns should not be shifted.

The following list identifies the data items used by the simulation.

Item as Titled on the Worksheet List	Notes on the Data Value
ID #	Assigned by the VBA macro. Normally "LT.#" where # is equivalent to (current row number - first row number +1). Each ID # should be unique.
Trip Description	A user's description of the trip, normally some combination of the route description and vehicle type description.
Region	A region identifier as defined in 'Regional-Properties' worksheet
Route ID	Assigned by the VBA macro. Normally "LR.#" where # is equivalent to the route index in 'LDV-Route' worksheet.
Route Description	A user's description of the route.
Route Length	Route length (km)
Urban Area1 Freeway Mix	For origin urban area, must be "Small City", "Large City" or "User Defined"
Urban Area2 Freeway Mix	For destination urban area, must be "Small City", "Large City" or "User Defined"
Urban Area Arterial Mix	For both origin and destination urban areas, must be "Small City", "Large City" or "User Defined"
Direction	Must be either "Forward" or "Reverse".
Departure Time of Day	For forward trip, must be "AM-peak", "midday", "PM-peak" or "off-peak"
Arrival Time of Day	For forward trip, must be "AM-peak", "midday", "PM-peak" or "off-peak"
Departure Day of Week	For forward trip, must be "Mon to Fri", "Weekend" or "Daily"
Departure Season	For forward trip, must be "Winter", "Summer", "Spring/Fall" or "All"
Return Departure Time of Day	For return trip, must be "AM-peak", "midday", "PM-peak" or "off-peak"
Return Arrival Time of Day	For return trip, must be "AM-peak", "midday", "PM-peak" or "off-peak"
Return Departure Day of Week	For return trip, must be "Mon to Fri", "Weekend" or "Daily"
Return Departure Season	For return trip, must be "Winter", "Summer", "Spring/Fall" or "All"
Auto/LDV ID	Must be same as an Auto/LDV ID defined in 'LDV-Type' worksheet.
Auto/LDV Description	Description of auto/LDV type (as in 'LDV-Type' worksheet)

Auto/LDV Fuel	A valid Auto/LDV fuel type as defined in 'Energy-Emission' worksheet.
Auto/LDV Engine Option	Must be "Hybrid", "Non-hybrid" or "default mix"
Passenger Seats	Number of passenger seats in vehicle
Passengers	Number of occupied passenger seats
Access/ Egress Number of Travelers	Number of people assumed to be traveling together
Access Leg 1 - Mode	Access mode type
Access Leg 1 - Description	Access mode description
Access Leg 1 - Distance	Access mode distance (mile)
Access Leg 1 - Dwell	Access mode dwell time (minutes)
Access Leg 1 - Average Speed	Access mode average speed (mph)
Access Leg 1 - Fuel Source	Access mode fuel source (as defined in 'Regional-Properties' for this access mode)
Access Leg 1 - Fuel Intensity	Access mode fuel intensity (kg/pass-mile)
Access Leg 1 - Energy Intensity	Access mode energy intensity (kJ/pass-mile)
Access Leg 1 - CO2e Intensity	Access mode CO2e emission intensity (g/pass-mi)
Access Leg 1 - Region	Access mode region (for future use)
Access Leg 1 - City Size	Access mode city size
Access Leg 1 - Time of Day	Access mode time of day
Access Leg 1 - Day of Week	Access mode day of week
Access Leg 1 - Season	Access mode season
Access Leg 2 - Mode	Access mode type
Access Leg 2 - Description	Access mode description
Access Leg 2 - Distance	Access mode distance (mile)
Access Leg 2 - Dwell	Access mode dwell time (minutes)
Access Leg 2 - Average Speed	Access mode average speed (mph)
Access Leg 2 - Fuel Source	Access mode fuel source (as defined in 'Regional-Properties' for this access mode)
Access Leg 2 - Fuel Intensity	Access mode fuel intensity (kg/pass-mile)
Access Leg 2 - Energy Intensity	Access mode energy intensity (kJ/pass-mile)
Access Leg 2 - CO2e Intensity	Access mode CO2e emission intensity (g/pass-mi)
Access Leg 2 - Region	Access mode region (for future use)
Access Leg 2 - City Size	Access mode city size
Access Leg 2 - Time of Day	Access mode time of day
Access Leg 2 - Day of Week	Access mode day of week
Access Leg 2 - Season	Access mode season
Access Leg 3 - Mode	Access mode type
Access Leg 3 - Description	Access mode description
Access Leg 3 - Distance	Access mode distance (mile)

Access Leg 3 - Dwell	Access mode dwell time (minutes)
Access Leg 3 - Average Speed	Access mode average speed (mph)
Access Leg 3 - Fuel Source	Access mode fuel source (as defined in 'Regional-Properties' for this access mode)
Access Leg 3 - Fuel Intensity	Access mode fuel intensity (kg/pass-mile)
Access Leg 3 - Energy Intensity	Access mode energy intensity (kJ/pass-mile)
Access Leg 3 - CO2e Intensity	Access mode CO2e emission intensity (g/pass-mi)
Access Leg 3 - Region	Access mode region (for future use)
Access Leg 3 - City Size	Access mode city size
Access Leg 3 - Time of Day	Access mode time of day
Access Leg 3 - Day of Week	Access mode day of week
Access Leg 3 - Season	Access mode season
Access Leg 4 - Mode	Access mode type
Access Leg 4 - Description	Access mode description
Access Leg 4 - Distance	Access mode distance (mile)
Access Leg 4 - Dwell	Access mode dwell time (minutes)
Access Leg 4 - Average Speed	Access mode average speed (mph)
Access Leg 4 - Fuel Source	Access mode fuel source (as defined in 'Regional-Properties' for this access mode)
Access Leg 4 - Fuel Intensity	Access mode fuel intensity (kg/pass-mile)
Access Leg 4 - Energy Intensity	Access mode energy intensity (kJ/pass-mile)
Access Leg 4 - CO2e Intensity	Access mode CO2e emission intensity (g/pass-mi)
Access Leg 4 - Region	Access mode region (for future use)
Access Leg 4 - City Size	Access mode city size
Access Leg 4 - Time of Day	Access mode time of day
Access Leg 4 - Day of Week	Access mode day of week
Access Leg 4 - Season	Access mode season
Access Leg 5 - Mode	Access mode type
Access Leg 5 - Description	Access mode description
Access Leg 5 - Distance	Access mode distance (mile)
Access Leg 5 - Dwell	Access mode dwell time (minutes)
Access Leg 5 - Average Speed	Access mode average speed (mph)
Access Leg 5 - Fuel Source	Access mode fuel source (as defined in 'Regional-Properties' for this access mode)
Access Leg 5 - Fuel Intensity	Access mode fuel intensity (kg/pass-mile)
Access Leg 5 - Energy Intensity	Access mode energy intensity (kJ/pass-mile)
Access Leg 5 - CO2e Intensity	Access mode CO2e emission intensity (g/pass-mi)
Access Leg 5 - Region	Access mode region (for future use)
Access Leg 5 - City Size	Access mode city size
Access Leg 5 - Time of Day	Access mode time of day
Access Leg 5 - Day of Week	Access mode day of week

Access Leg 5 - Season	Access mode season
Egress Leg 1 - Mode	Egress mode type
Egress Leg 1 - Description	Egress mode description
Egress Leg 1 - Distance	Egress mode distance (mile)
Egress Leg 1 - Dwell	Egress mode dwell time (minutes)
Egress Leg 1 - Average Speed	Egress mode average speed (mph)
Egress Leg 1 - Fuel Source	Egress mode fuel source (as defined in 'Regional-Properties' for this egress mode)
Egress Leg 1 - Fuel Intensity	Egress mode fuel intensity (kg/pass-mile)
Egress Leg 1 - Energy Intensity	Egress mode energy intensity (kJ/pass-mile)
Egress Leg 1 - CO2e Intensity	Egress mode CO2e emission intensity (g/pass-mi)
Egress Leg 1 - Region	Egress mode region (for future use)
Egress Leg 1 - City Size	Egress mode city size
Egress Leg 1 - Time of Day	Egress mode time of day
Egress Leg 1 - Day of Week	Egress mode day of week
Egress Leg 1 - Season	Egress mode season
Egress Leg 2 - Mode	Egress mode type
Egress Leg 2 - Description	Egress mode description
Egress Leg 2 - Distance	Egress mode distance (mile)
Egress Leg 2 - Dwell	Egress mode dwell time (minutes)
Egress Leg 2 - Average Speed	Egress mode average speed (mph)
Egress Leg 2 - Fuel Source	Egress mode fuel source (as defined in 'Regional-Properties' for this egress mode)
Egress Leg 2 - Fuel Intensity	Egress mode fuel intensity (kg/pass-mile)
Egress Leg 2 - Energy Intensity	Egress mode energy intensity (kJ/pass-mile)
Egress Leg 2 - CO2e Intensity	Egress mode CO2e emission intensity (g/pass-mi)
Egress Leg 2 - Region	Egress mode region (for future use)
Egress Leg 2 - City Size	Egress mode city size
Egress Leg 2 - Time of Day	Egress mode time of day
Egress Leg 2 - Day of Week	Egress mode day of week
Egress Leg 2 - Season	Egress mode season
Egress Leg 3 - Mode	Egress mode type
Egress Leg 3 - Description	Egress mode description
Egress Leg 3 - Distance	Egress mode distance (mile)
Egress Leg 3 - Dwell	Egress mode dwell time (minutes)
Egress Leg 3 - Average Speed	Egress mode average speed (mph)
Egress Leg 3 - Fuel Source	Egress mode fuel source (as defined in 'Regional-Properties' for this egress mode)
Egress Leg 3 - Fuel Intensity	Egress mode fuel intensity (kg/pass-mile)
Egress Leg 3 - Energy Intensity	Egress mode energy intensity (kJ/pass-mile)

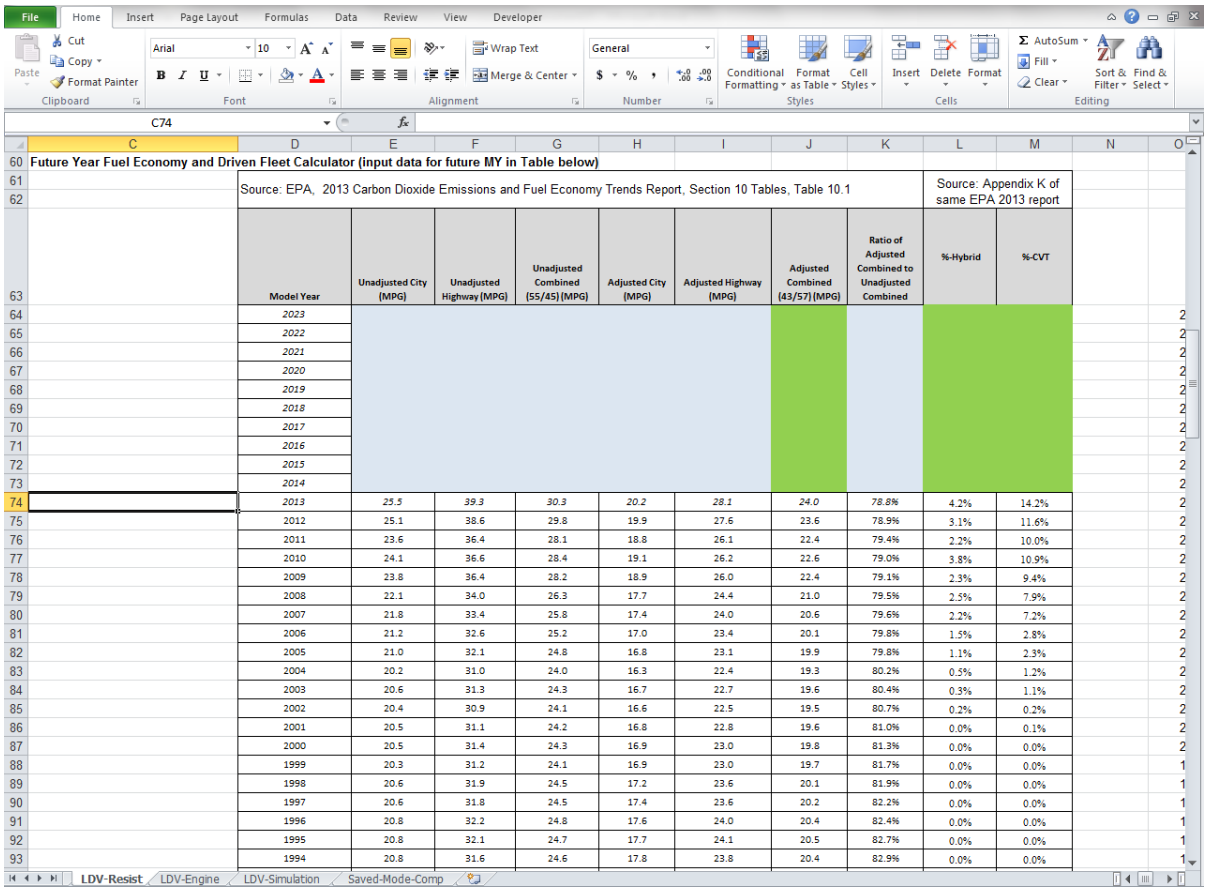
Egress Leg 3 - CO2e Intensity	Egress mode CO2e emission intensity (g/pass-mi)
Egress Leg 3 - Region	Egress mode region (for future use)
Egress Leg 3 - City Size	Egress mode city size
Egress Leg 3 - Time of Day	Egress mode time of day
Egress Leg 3 - Day of Week	Egress mode day of week
Egress Leg 3 - Season	Egress mode season
Egress Leg 4 - Mode	Egress mode type
Egress Leg 4 - Description	Egress mode description
Egress Leg 4 - Distance	Egress mode distance (mile)
Egress Leg 4 - Dwell	Egress mode dwell time (minutes)
Egress Leg 4 - Average Speed	Egress mode average speed (mph)
Egress Leg 4 - Fuel Source	Egress mode fuel source (as defined in 'Regional-Properties' for this egress mode)
Egress Leg 4 - Fuel Intensity	Egress mode fuel intensity (kg/pass-mile)
Egress Leg 4 - Energy Intensity	Egress mode energy intensity (kJ/pass-mile)
Egress Leg 4 - CO2e Intensity	Egress mode CO2e emission intensity (g/pass-mi)
Egress Leg 4 - Region	Egress mode region (for future use)
Egress Leg 4 - City Size	Egress mode city size
Egress Leg 4 - Time of Day	Egress mode time of day
Egress Leg 4 - Day of Week	Egress mode day of week
Egress Leg 4 - Season	Egress mode season
Egress Leg 5 - Mode	Egress mode type
Egress Leg 5 - Description	Egress mode description
Egress Leg 5 - Distance	Egress mode distance (mile)
Egress Leg 5 - Dwell	Egress mode dwell time (minutes)
Egress Leg 5 - Average Speed	Egress mode average speed (mph)
Egress Leg 5 - Fuel Source	Egress mode fuel source (as defined in 'Regional-Properties' for this egress mode)
Egress Leg 5 - Fuel Intensity	Egress mode fuel intensity (kg/pass-mile)
Egress Leg 5 - Energy Intensity	Egress mode energy intensity (kJ/pass-mile)
Egress Leg 5 - CO2e Intensity	Egress mode CO2e emission intensity (g/pass-mi)
Egress Leg 5 - Region	Egress mode region (for future use)
Egress Leg 5 - City Size	Egress mode city size
Egress Leg 5 - Time of Day	Egress mode time of day
Egress Leg 5 - Day of Week	Egress mode day of week
Egress Leg 5 - Season	Egress mode season

A.7.16 The 'LDV-Resist' Worksheet Pre-processor

The LDV-Resist worksheet contains the pre-processed default values for a range of 2011 vehicle classes and composite values for the 'sales-weighted' and 'driven' fleets for the years 2011, 2012 and 2013.

The worksheet also includes a preprocessor to generate future year composite parameters for sales-weighted and driven fleets. The data shown in the Fuel Economy Table at D61:M112 (see Figure A-70) is populated with data that is published annually by the EPA in its Trends Report [EPA, 2013 Carbon Dioxide Emissions and Fuel Economy Trends Report]. The data in columns E to K came from Table 10.1 and the data in columns L and M came from Appendix K of the EPA's 2013 report. Users can fill in the rows for years 2014 to 2023 as the data becomes available. The calculations performed at cells P64:T73 provide the data for the sales-weighted composite vehicle for the relevant year and the driven-fleet composite vehicle for the same year. The driven fleet is derived for the age distribution that existed in 2011 (cells X64:X94 for corresponding ages in U64:U94) and presumes a 60/40 split for autos/LDT. If a different age distribution is desired the formula for that year would have to be updated and the age distribution brought into a new location in the worksheet. When characterization data become available for a future year the appropriate row of the Fuel Economy Table can be populated with data.

Next, the formulae in cell ranges R27:R28 and R33 to R46 of the vehicle characteristics table can be separately copied into the appropriate year's location to the right of the existing vehicle characterization data (See Figure A-71). Given the year specified in row 30 and the fleet type ("Sales weighted composite vehicle" or "Driven fleet composite vehicle") specified in row 32, the formulae copied into rows 27 to 28 and 33 to 46 will provide the necessary characterization data to simulate the specified composite vehicle.



Future Year Fuel Economy and Driven Fleet Calculator (input data for future MY in Table below)

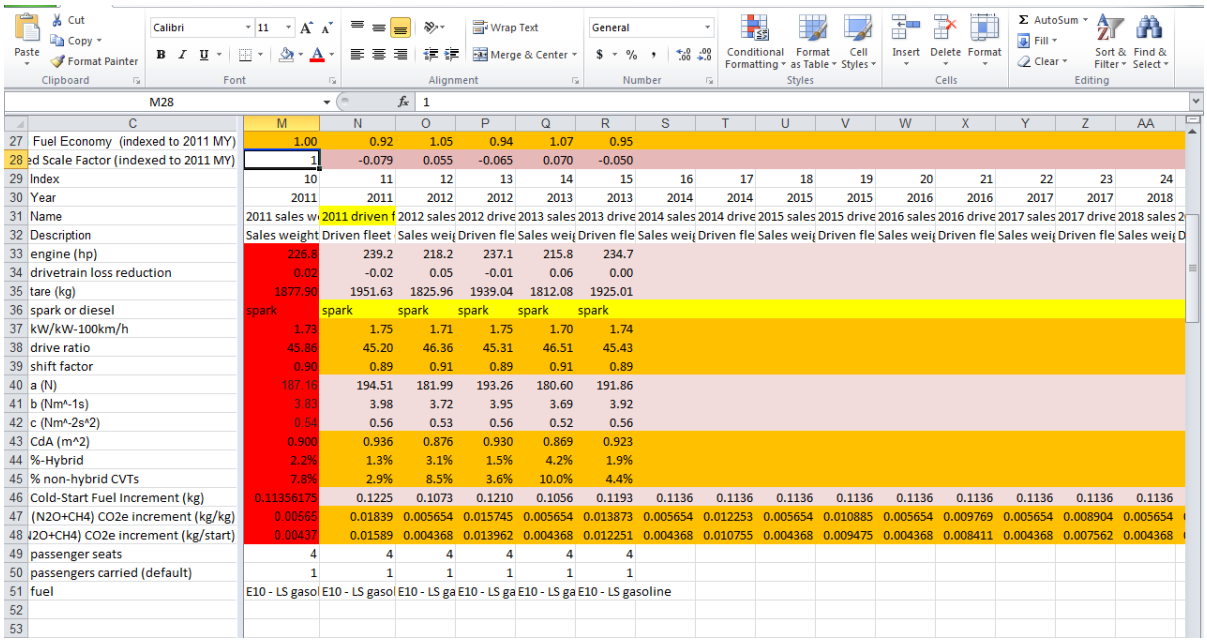
Source: EPA, 2013 Carbon Dioxide Emissions and Fuel Economy Trends Report, Section 10 Tables, Table 10.1

Source: Appendix K of same EPA 2013 report

Model Year	Unadjusted City (MPG)	Unadjusted Highway (MPG)	Unadjusted Combined (55/45) (MPG)	Adjusted City (MPG)	Adjusted Highway (MPG)	Adjusted Combined (43/57) (MPG)	Ratio of Adjusted Combined to Unadjusted Combined	%-Hybrid	%-CVT
2023									
2022									
2021									
2020									
2019									
2018									
2017									
2016									
2015									
2014									
2013	25.5	39.3	30.3	20.2	28.1	24.0	78.8%	4.2%	14.2%
2012	25.1	38.6	29.8	19.9	27.6	23.6	78.9%	3.1%	11.6%
2011	23.6	36.4	28.1	18.8	26.1	22.4	79.4%	2.2%	10.0%
2010	24.1	36.6	28.4	19.1	26.2	22.6	79.0%	3.8%	10.9%
2009	23.8	36.4	28.2	18.9	26.0	22.4	79.1%	2.3%	9.4%
2008	22.1	34.0	26.3	17.7	24.4	21.0	79.5%	2.5%	7.9%
2007	21.8	33.4	25.8	17.4	24.0	20.6	79.6%	2.2%	7.2%
2006	21.2	32.6	25.2	17.0	23.4	20.1	79.8%	1.5%	2.8%
2005	21.0	32.1	24.8	16.8	23.1	19.9	79.8%	1.1%	2.3%
2004	20.2	31.0	24.0	16.3	22.4	19.3	80.2%	0.5%	1.2%
2003	20.6	31.3	24.3	16.7	22.7	19.6	80.4%	0.3%	1.1%
2002	20.4	30.9	24.1	16.6	22.5	19.5	80.7%	0.2%	0.2%
2001	20.5	31.1	24.2	16.8	22.8	19.6	81.0%	0.0%	0.1%
2000	20.5	31.4	24.3	16.9	23.0	19.8	81.3%	0.0%	0.0%
1999	20.3	31.2	24.1	16.9	23.0	19.7	81.7%	0.0%	0.0%
1998	20.6	31.9	24.5	17.2	23.6	20.1	81.9%	0.0%	0.0%
1997	20.6	31.8	24.5	17.4	23.6	20.2	82.2%	0.0%	0.0%
1996	20.8	32.2	24.8	17.6	24.0	20.4	82.4%	0.0%	0.0%
1995	20.8	32.1	24.7	17.7	24.1	20.5	82.7%	0.0%	0.0%
1994	20.8	31.6	24.6	17.8	23.8	20.4	82.9%	0.0%	0.0%

LDV-Resist | LDV-Engine | LDV-Simulation | Saved-Mode-Comp

Figure A-70 LDV-Resist Pre-processor Inputs for Future Years



	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA
Fuel Economy (indexed to 2011 MY)	1.00	0.92	1.05	0.94	1.07	0.95									
ed Scale Factor (indexed to 2011 MY)	1	-0.079	0.055	-0.065	0.070	-0.050									
Index	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Year	2011	2011	2012	2012	2013	2013	2014	2014	2015	2015	2016	2016	2017	2017	2018
Name	2011 sales w	2011 driven f	2012 sales	2012 drive	2013 sales	2013 drive	2014 sales	2014 drive	2015 sales	2015 drive	2016 sales	2016 drive	2017 sales	2017 drive	2018 sales 2
Description	Sales weight	Driven fleet	Sales weig	Driven fle	Sales weig	Driven fle	Sales weig	Driven fle	Sales weig	Driven fle	Sales weig	Driven fle	Sales weig	Driven fle	Sales weig D
engine (hp)	226.8	239.2	218.2	237.1	215.8	234.7									
drivetrain loss reduction	0.02	-0.02	0.05	-0.01	0.06	0.00									
tare (kg)	1877.90	1951.63	1825.96	1939.04	1812.08	1925.01									
spark or diesel	spark	spark	spark	spark	spark	spark									
kW/kW-100km/h	1.73	1.75	1.71	1.75	1.70	1.74									
drive ratio	45.86	45.20	46.36	45.31	46.51	45.43									
shift factor	0.90	0.89	0.91	0.89	0.91	0.89									
a (N)	187.16	194.51	181.99	193.26	180.60	191.86									
b (Nm^-1s)	3.83	3.98	3.72	3.95	3.69	3.92									
c (Nm^-2s^2)	0.54	0.56	0.53	0.56	0.52	0.56									
CdA (m^2)	0.900	0.936	0.876	0.930	0.869	0.923									
%-Hybrid	2.2%	1.3%	3.1%	1.5%	4.2%	1.9%									
% non-hybrid CVTs	7.8%	2.9%	8.5%	3.6%	10.0%	4.4%									
Cold-Start Fuel Increment (kg)	0.11356175	0.1225	0.1073	0.1210	0.1056	0.1193	0.1136	0.1136	0.1136	0.1136	0.1136	0.1136	0.1136	0.1136	0.1136
(N2O+CH4) CO2e increment (kg/kg)	0.00565	0.01839	0.005654	0.015745	0.005654	0.013873	0.005654	0.012253	0.005654	0.010885	0.005654	0.009769	0.005654	0.008904	0.005654
2O+CH4) CO2e increment (kg/start)	0.00437	0.01589	0.004368	0.013962	0.004368	0.012251	0.004368	0.010755	0.004368	0.009475	0.004368	0.008411	0.004368	0.007562	0.004368
passenger seats	4	4	4	4	4	4									
passengers carried (default)	1	1	1	1	1	1									
fuel	E10 - LS gasol	E10 - LS gasol	E10 - LS ga	E10 - LS ga	E10 - LS ga	E10 - LS gasoline									

Figure A-71 LDV-Resist Pre-processor Calculation Columns for Future Years

Appendix B

Terms, Abbreviations and Equation Variables

B.1 Terms

Balance speed	Speed at which a train's tractive effort equals the sum of its up-grade and resistive force.
Breakeven grade	Speed at which a train's downgrade force equals the resistive force.
Cruise segment	Portion of a trip taken at constant 'cruise' speed.
Cruise speed	Speed maintained on a long haul segment of a trip.
Consist	The locomotives and cars comprising a train.
Delay	Unscheduled events that add to a trips minimum travel time.
Dg-set	Diesel generator set used to generate hotel power.
Dynamic braking	Slowing a train by using traction motors to convert kinetic energy into electricity which is then dissipated as heat in resistance grids.
Hotel power	Electrical power provided for use by passenger compartments.
Regeneration	Conversion of kinetic energy into electrical energy during braking (usually back into the electricity grid or onboard storage rather than simply dissipated as heat as in dynamic braking).
Schedule slack	Time allowance built into a schedule in excess of the minimum run time to accommodate unscheduled delays.
Steps	Segments of track processed in one calculation row of the rail simulation sheet (segments are normally based on lengths of constant posted speed).
Tractive effort	The propulsive force generated at a powered axle's wheel (mostly by electric traction motors).
Wayside	At the side of the tracks.

B.2 Abbreviations

ABA – American Bus Association
AC – Aircraft
AREMA – American Railway Engineering and Maintenance-of-Way Association
A T R I – American Transportation Research Institute
Bsfc – Brake specific fuel consumption
BTS – Bureau of Transportation Statistics
C N – Canadian National
CVT – Continuously variable transmission
CY – Calendar year
D – Destination
DEM – Digital elevation models
DMU – Diesel multiple unit
DOT – Department of Transportation
EMU – Electric multiple unit
FE – Fuel economy
FW – Freeway
GC – Great circle
GHG – Greenhouse gas
GHGeq – Greenhouse gas equivalent
HEP – Head-end power
HSR – High speed rail
ICAO – International Civil Aviation Organisation
IPCC – Intergovernmental Panel on Climate Change
IR – Inherent resistance
LDT – Light duty truck
LDV – Light duty vehicle
LOS – Level of service (a highway capacity metric)
LTO – Landing and takeoff
MBTA – Massachusetts Bay Transportation Authority
MY – Model year
NBJ – Narrow body jet
NCDC – National Climate Data Center
NTD – National Transit Database

O – Origin
OD – Origin-destination
pGCkm – passenger great circle kilometer
PL – Payload
RDC – Rail diesel car
RF – Radiative forcing
RJ – Regional jet
sGCkm – seat great circle kilometer
skm – seat kilometer
SRJ – Small regional jet
TE – Tractive effort
TP – Turboprop
TSO – Temporary slow order
UDDS – Urban Dynamometer Driving Schedule
VHSR – Very high speed rail
Vkm – vehicle kilometer
WBJ – Wide body jet
WGI – Working Group I

B.3 Equation Variables

a	Coefficient
A	Acceleration
A	Frontal area
b	Coefficient
Cd	Aerodynamic drag coefficient
Cra	Coefficient of rolling resistance & hysteresis
Crai	Tractive effort envelope coefficient
Crb	Coefficient of dynamic resistance
Crbi	Tractive effort envelope coefficient
Crc	Coefficient of aerodynamic resistance
Crci	Tractive effort envelope coefficient
Crdi	Tractive effort envelope coefficient
dt	Time step
Fh	Hotel power diesel generator set fuel consumption rate
g	Gravitational acceleration
Gbe	Breakeven down grade
Gmx	Maximum grade that can be climbed at cruise speed
IR	Inherent Resistance
Kr	Mass-equivalent rotational inertia of an axle
M	Mass
Na	Number of axles
P	Power
R	Ratio of cold-start/hot start fuel increment
SF	Scale factor for aerodynamic drag
t	Time
T	Temperature
TE	Tractive effort
TEi	Tractive effort
Ta	Ambient temperature
V	Speed
ρ	Density of air