IOWA STANDARDIZED MODEL STRUCTURE (ISMS)

General Travel Demand Modeling/Forecasting Protocols and Procedures

October 28, 2020

Version 1.1

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1: EXECUTIVE SUMMARY

The Iowa Department of Transportation (Iowa DOT) and the Metropolitan Planning Organizations (MPO) that are partially or wholly within the state of Iowa collectively work to provide transportation planning and traffic forecasting services for a variety of purposes. To this end, the organizations develop, maintain and utilize computerized traffic forecasting tools including travel demand models (TDM). TDM's are nationally recognized tools used by nearly all MPO's and DOT's across the United States. TDM's utilize attributes about the economy and transportation system to estimate demand for moving people and goods in conjunction with the transportation system's ability to serve that demand.

The partnership between the Iowa DOT and the MPO's across Iowa has been successful in developing and maintaining the TDM's for more than 30 years, and all indicators point to a need for this partnership to continue into the foreseeable future. However, over the last 10 years, the MPO's have seen more turnover in travel demand modeling staff, leading to a deficit of seasoned professionals that are able to develop, maintain and apply the travel demand models. Over time the MPO models have become inharmonious in nature and has led to an increasing lack of credibility.

The Iowa Standardized Model Structure (ISMS) provides a standardized yet scalable travel demand modeling architecture for use by all MPO's across Iowa. The standardization of ISMS promotes consistency between models, promoting the following benefits:

- Reduced learning curve for DOT and MPO staff
- Transferability of data between MPO's
- Credibility of process across MPO's
- Comparability of outputs across MPO's
- Flexibility to add more detailed analysis features
- Defensibility to analysis challenges

The ISMS development team surveyed existing TDM users across Iowa, TDM processes from peer states and national resources to quantify both the state of the practice and state of the art. Surveys highlighted the features and types of analyses most desired by the ISMS users. The ISMS Manual and TransCAD prototype incorporate those priorities.

ISMS embraces the continued partnership of DOT and MPO staff, and defines demand modeling roles and responsibilities for both DOT and MPO staff. To that end, ISMS provides a workplan to accomplish each task in model development, including overview and details of the step, guidance on data and data processing, and timeline and level of effort estimates. ISMS also provides guidance on the use of TDM data in various planning and forecasting applications.

Iowa DOT's vision for ISMS is to provide continued guidance and assistance to the MPO's across the state. As the needs of the MPO's evolve, so to can the ISMS standards and components.

2: INTRODUCTION AND PURPOSE

The purpose of this manual is to provide technical guidance for Iowa's Metropolitan Planning Organizations (MPO) that are responsible for developing, calibrating, validating, and applying travel demand models in support of long-range plan development and project analysis. The manual describes the standardized architecture that is recommended for each MPO model while allowing for additional modules to serve varying analytical needs in each metropolitan region. The manual is written for readers who have a basic understanding of travel demand modeling concepts, procedures and software familiarity. The common travel demand modeling software in Iowa is TransCAD and therefore this manual and the model prototype are based on that software platform.

2.1 Regulatory requirements and need for travel demand modeling

Federal legislation originally passed in the 1960's, and most recently updated in the current MAP-21 funding bill requires that any urbanized area with a population greater than 50,000 have a Metropolitan Planning Organization[1] in place to ensure that existing and future transportation expenditures are based on a continuing, cooperative and comprehensive (3C) planning process. In that process, MPOs coordinate with state and local governments, public transportation operators and tribal agencies to set spending levels for Federal transportation funds. The six core functions of an MPO are:

1. Establish a setting for effective decision making;
2. Identify and evaluate transportation improvement options;
3. Prepare and maintain a Metropolitan Transportation Plan (MTP);
4. Develop a Transportation Improvement Plan (TIP);
5. Identify performance measure targets and monitor whether implemented projects are achieving targets; and
6. Involve the public.

While travel demand modeling is not specifically referenced within the federal legislation, their use is typically viewed as the state of the practice for achieving the second objective listed above, the identification and evaluation of transportation improvement options, along with an evaluation platform for the prioritizing projects to develop the MTP and TIP.

Federal law governing the metropolitan planning process is stated in Title 23 of the Code of Federal Regulations, Part 450, Subpart C, "Metropolitan Transportation Planning and Programming." (23 CFR 450.300-338). Travel demand models are one of the most commonly used analytical tools to support the transportation planning process and satisfy metropolitan planning requirements. Of those requirements, the one that affects the travel demand model is as follows.

- The metropolitan transportation plan shall, at a minimum, include the projected transportation demand of persons and goods in the metropolitan planning area over the period of the transportation plan.

[1] http://www.fhwa.dot.gov/planning/publications/briefing_book/part01.cfm#ftn1

Additionally, Appendix A to Part 450 – Linking the Transportation Planning and NEPA Processes, provides additional information to explain the linkage between transportation planning and project development and the National Environmental Policy Act (NEPA) processes. It also places focus on congressional intent that statewide and metropolitan transportation planning should be the foundation for highway and transit projects. This is accomplished by recommendations that "assumptions have a rational basis and are up-to-date" and that "data, analytical methods, and modeling techniques are reliable, defensible, and reasonably current, and meet data quality requirements."

The Iowa Department of Transportation (Iowa DOT) also utilizes the travel demand modeling tools developed for the MPOs for use in forecasting future traffic demand for various roadway facilities within urbanized areas. In addition, Iowa DOT maintains a statewide travel demand model (iTRAM) that provides a framework for evaluating projects and developing traffic forecasts outside urbanized areas.

2.2 Mission statement

Provide a consistent, comprehensive, and standardized framework of best practices for the development and application of travel demand modeling and traffic forecasting tools. The tools will facilitate collaboration in planning and designing transportation systems and facilities for the State of Iowa, promote sharing, and encourage continuing cooperation and good practice across the state.

2.2.1 Goals and objectives

The Iowa DOT sponsored a survey of Midwest Travel Model User Group (MTMUG) participants following the 9/2/2015 MTMUG meeting held in Ames. Based on the results of the survey and the findings of the literature review/scan, five basic goals were identified. Those five goals, in no order of importance, are:

1. Institutionalize the use of travel demand model in the MPO planning and prioritization processes;
2. Increase technical capabilities and understanding of MPO staff with respect to travel demand model development and application;
3. Develop clear guidance and expectations with respect to the roles and responsibilities of travel demand modelers;
4. Achieve a consistent approach to travel demand modeling across the state of Iowa's 9 MPOs; and
5. Implement ongoing development and maintenance practices to ensure continual readiness and currency of MPO travel demand models.

Model users also identified various functions required and desired of the travel demand modeling tools to be developed as part of the ISMS project. These functions are shown in Table 1 1.

Table 2-1: Objectives of travel demand models through ISMS project

FUNCTION	IMPORTANCE TO MPO	IMPORTANCE TO DOT
Long range transportation plan development	Critical	Important
System-wide performance assessment	Important	Important
Traffic (auto and truck) forecasting	Important	Critical
Transit forecasting	Desired	Some value
Freight analysis	Some value	Important
Land use testing	Important	Important
Corridor planning	Desired	Important
Environmental justice analysis	Desired	Desired
Air/noise analysis	Desired	Desired
Accessibility analysis	Some value	Some value
Project prioritization	Important	Important
Road pricing/toll studies	Limited value	Limited value
University campus planning	Important	Desired
Traffic Impact Studies (impacts of schools)	Desired	Some value
Parking studies	Desired	Some value

2.3 User surveys and survey findings

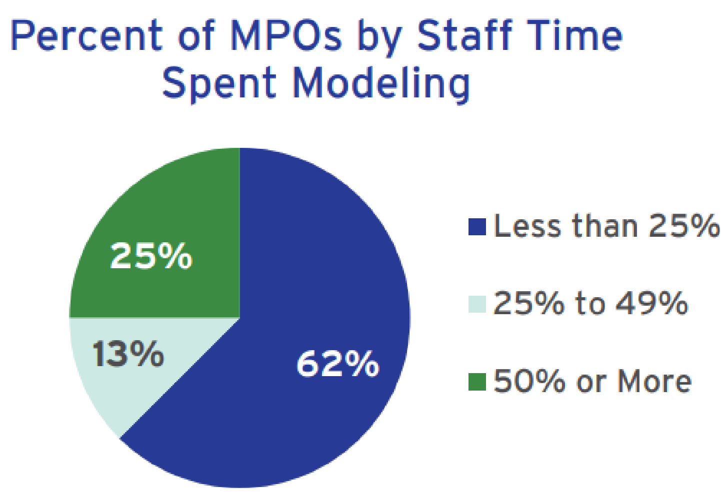
Concurrent with the development of the ISMS, the Iowa DOT conducted a survey of MTMUG participants following the September 2, 2015 MTMUG meeting held in Ames, Iowa. At the meeting, the ISMS project was introduced to attendees and survey questions were reviewed prior to dissemination of the survey to the MTMUG listserv.

The survey consisted of 21 questions to gauge the modeling experience of staff, current issues, needs, applications, and role of the respondents regarding travel demand modeling. Additional questions gathered feedback on the role of the respondent organization in model development and expectations of the ISMS project.

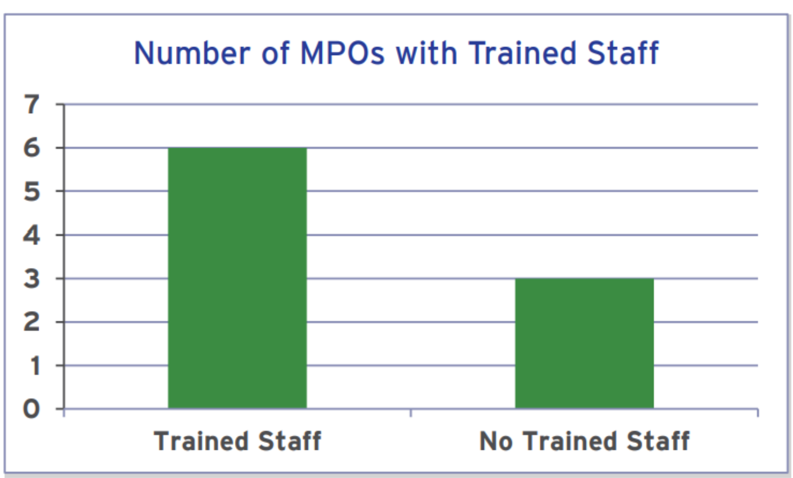
Overall, all nine MPOs with jurisdiction in the State of Iowa, one consulting firm, and one State Agency responded to the survey. A summary of each response is included in Appendix A and the individual responses are included in Appendix B.

Major findings from the survey include:

- Do you work for a public or private agency?
  - All nine MPOs responded
  - One MTMUG at-large response
  - Iowa DOT responded
- Portion of time allocated to TDM?



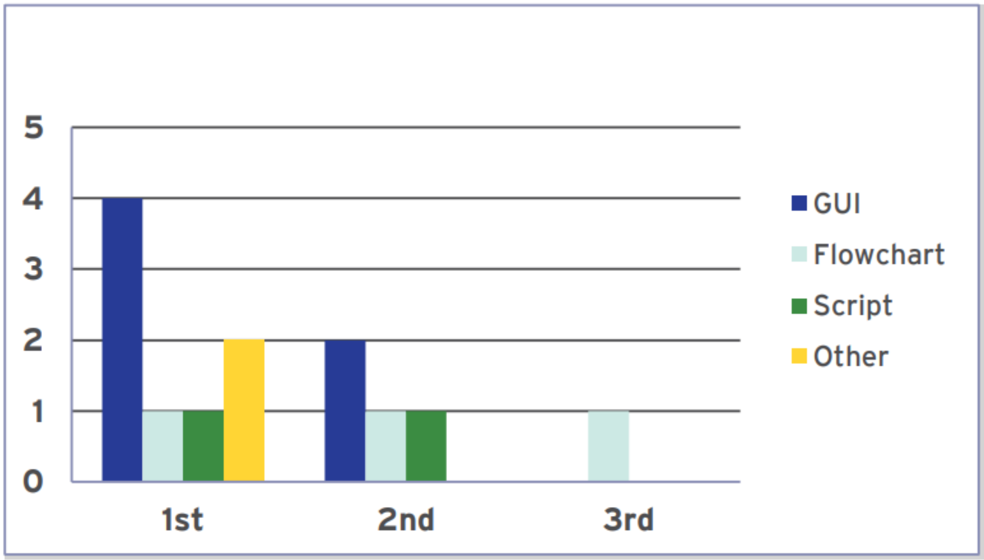
  - DOT has four staff at nearly 100%
- Level of proficiency in TDM?



- Problems in use of TDM?
  - Employment data accuracy
  - Communication
  - Policy issues related to datasets
  - Model compatibility with version 7.0 of TransCAD
  - Turning movement data not incorporated
  - Limited time and knowledge to refine model
  - File management
  - Ease of running reports
- Agency's role in model development/application?
  - Four of nine MPOs state that they have a role in SE data processing
  - Four indicated interest in more involvement
- Process for potential project development/evaluation?
  - Eight of nine MPOs use model
  - Use of TDM varies by MPO; multiple scenarios for each project individually; LOS or benefit/cost
- Process for HH/EMP data and projections?
  - Census widely used
  - Future SE developed in various ways
  - Several MPOs noted future SE uses community feedback or land use planning docs
- How often is model data updated?
  - Typically every five years
  - Two MPOs perform intermediate updates when new data or project opportunities arise.
- What survey data is used?
  - Sources include NHTS, CTPP, on-board transit surveys, Census data, and Bureau of Labor Statistics
- Sources of traffic count data?
  - Typically use DOT and some local municipal counts
- Current uses of TDM and data?
  - Project selection
  - LRTP development and scenario analysis
  - Sensitivity testing

- EJ analysis
- Peak period analysis
- Accessibility contours
- New development proposals/new road scenarios
- Travel time analysis
- Forecasting
- Traffic count data and turning movements
- Congestion indicators
- STP evaluation
- TIP evaluation
- Fire department response time maps
- Traffic impact studies
- Develop traffic growth rate

- Future uses of TDM?
  - Two MPOs: evaluate projects in planning documents
  - Two MPOs: transit planning
  - Interest in performance measures, congestion, management and land use/transit scenarios
- Functionalities to aid your model?
  - Multimodal data, modal data, more scripting, intermediate years, peak hour, smaller zone data
- Use of intermediate year models?
  - Several MPOs have intermediate years
  - Those that don't have intermediate years indicate potential uses:
    - Evaluate fiscal constraint process
    - Sensitivity testing
    - Scenario planning
    - Peak hour forecasting
    - Project prioritization
- How do you prefer to interact with TransCAD?



- Tech/policy board inclusion in TDM process?
  - Varies by MPO
    - No involvement
    - Review/approval of SE
    - Approval of all steps in TDM
- Educate member jurisdictions on TDM use?
  - Typically done with LRTP process
  - Several MPOs interested in more education
- Training/resources to improve use of TDM?
  - Documentation
  - Interpretation
  - Scripting
  - Basic scenario testing
- How will you benefit from ISMS?
  - Increased consistency between MPOs
  - Improve documentation, data accuracy and quality
- How can TDM in Iowa be improved?
  - Interest in on-call consultant assistance
- Additional comments

- Appreciation of Iowa DOT's assistance
- Continued progress report on ISMS

In summary, the user surveys revealed that there is inconsistency across Iowa MPOs with respect to how travel demand modeling is conducted. Some agencies are very disconnected with the modeling process, relying completely on the Iowa DOT staff, while other agencies self-sufficient, using Iowa DOT staff as an occasional technical resource. Similarly, MPOs vary in technical ability, the level of involvement of their MPO boards, and the use of the modeling as an analytical tool in evaluating transportation policies, programs, and projects in their region. MPOs see opportunities to improve the state of the practice in modeling through a more consistent process and a demand modeling platform that provides more functionality.

2.4 Literature review

2.4.1 State of the practice scan

Travel demand modeling standards from 6 peer states were reviewed. A detailed summary of each state's manual is available in Appendix C. Key points for consideration are listed below.

VIRGINIA TRANSPORTATION MODELING POLICIES AND PROCEDURE MANUAL, VERSION 2.00

- Define role and responsibility in supporting modeling statewide.
- Develop a statement of the purpose and need for modeling and the regulations that necessitate the development and application of travel models.
- Implement model version control and distribution protocols.
- Establish model documentation standards.
- Include an appendix listing transportation planning references.
- Include a "quick reference" card that briefly covers all major topics covered by the manual in bullet point format.

WISCONSIN DOT TRANSPORTATION PLANNING MANUAL

- Development of the manual as a web-based tool.
- Provide hyperlinks to other resources at Wisconsin DOT and to where more in-depth information can be found on topics introduced in the planning manual.
- Outline the roles and responsibilities of DOT staff with respect to developing forecasts statewide and its interaction with MPOs.
- Development of a mission statement to aid in the definition of roles and responsibilities.
- Provide standard forms and procedures with respect to forecast preparation and reviews.
- Provide standards for designing and conducting surveys.

THE FLORIDA STANDARD URBAN TRANSPORTATION MODELING STRUCTURE (FSUTMS) STANDARDS AND POLICIES

- Establish web portal for the exchange and sharing of data, information, ideas, and standards among the transportation modelers in Florida.
- Development of a master geodatabase.
- Development of standards for delineating traffic analysis zones.
- Implementation of a program to generate standard reports for model input and output.
- Development and implementation of standards presented in the documents cited above.

GEORGIA DOT SUMMARY OF RECOMMENDED TRAVEL DEMAND MODEL DEVELOPMENT PROCEDURES

- Implementation of a checklist for preparing highway networks.
- Implementation of a checklist for preparing socio-economic data.
- Institution of file naming conventions.
- Development of standards for delineating traffic analysis zones.
- Adopt standardized approach for development of trip generation/distribution, mode choice, and trip assignment models.
- Adopt model calibration/validation standards.

NEVADA DEPARTMENT OF TRANSPORTATION TRAFFIC FORECASTING GUIDELINES

- Guidelines focus on forecast preparation, considering volumes and other information from travel demand models as one source of information. There is no discussion regarding travel model development, calibration, validation, or model maintenance; although there are recommendations for the expected accuracy of travel models for use in forecasting.
- Provide principals and standards regarding the documentation of the traffic forecasting process, including forecast uncertainties and rounding conventions with respect to reported numerical values.
- Include a glossary, or section, that defines technical terms used throughout the document.
- Document preferred tools (other than models) including spreadsheets, programs, etc. used in the preparation and development of forecasts.

NORTH CAROLINA DOT PROJECT-LEVEL TRAFFIC FORECASTING PROCEDURES

- Guidelines focus on forecast preparation, considering volumes and other data from travel demand models as one source of information.
- There is no discussion regarding travel model development, calibration, validation or model maintenance.
- Guidelines regarding “administrative procedures” for travel forecast requests are detailed and may serve as a starting point for Iowa DOT in processing forecast requests from MPOs or others.

2.4.2 Additional references

Four national recognized travel demand modeling reference manuals are outlined in Appendix C. Additionally, peer reviews were conducted to review demand modeling practices for Iowa DOT, Bi-State Regional Planning Commission, East Central Intergovernmental Association and Metropolitan Area Planning Agency. These reports are also located in Appendix C. Most noteworthy are the recommendations for the Iowa DOT's travel demand modeling program:

- Develop an overall framework for statewide modeling support;
- Establish guidelines for standardization of trip generation/distribution/assignment, network speeds/capacities, and transferability of model parameters;
- Research needs for continuing training of participant agency staff;
- Define and implement a standard model user interface;
- Develop a technical support facility;
- Standardize data development and travel behavior surveys statewide;
- Move toward a person-based modeling environment; and
- Move toward time-of-day based trip tables and assignment.

These recommendations are primary focus-points for the ISMS project.

2.4.3 Summary of literature review findings

- Scope of guidance varies state to state
- Survey requirements and frequency generally not codified
- Prevalent trip generation and distribution methods have not changed
- Only "glancing" references to activity-based models
- No state guidance with regard to data distribution among MPOs
- Analytical land use development and/or feedback not addressed
- States largely silent on guidance for use of feedback loops
- Equilibrium trip assignment prevalent
- Truck-based freight models prevalent
- Mature guidance of model validation procedures and standards

2.5 Current modeling status in Iowa

A review of travel demand modeling architecture, assumptions, and processes was also completed, comparing each of Iowa's nine MPO travel demand models. The information collected represents a historical point of reference for the standardized model platform that will ultimately be recommended and implemented across Iowa's MPOs. The review showed inconsistencies in architecture between models, with some elements consistent across several, but not all model sets. For the models and methods currently implemented across Iowa's MPOs, the attributes listed below are covered in more detail in **Error! Reference source not found.**.

TRIP GENERATION:

- Trip Purposes: Home-based work and Home-based other are standard, one or more additional auto purposes, most models have truck purpose(s)
- Trip Generation Rates: models use autos owned and household size for productions, varied attraction parameters
- Special Generators: varied by model including colleges, hospitals and malls
- Trip Balancing: method of balancing varied by model (e.g., some MPOs balance certain purposes to trip productions, others may balance same purpose to weighted sum of productions and attractions)
- External Trips: typically pivot from ADT's, processes vary
- Other Parameters: varied by model (e.g. assignment parameters/methods, use of future year turn penalties, usage of peak period and directional factors, etc., vary across MPOs)

TRIP DISTRIBUTION:

- Methods: typically a version of the gravity model
- K-Factors: select models utilize K-factors, primarily to eliminate external productions and attractions from forming unintended E-E trips.
- Variables: some variations in distribution for select purposes are noted

MODE SPLIT/MODE CHOICE:

- Methods: 4 models include a mode choice element
- Constants: varied by model
- Coefficients: varied by model

ROUTE CHOICE/ASSIGNMENT:

- Methods: several models use assignment only for preloading trucks, equilibrium used for autos
- Parameters: use of turn penalties, alpha/beta factors vary by model

Select elements of the ISMS prototype were developed from existing Iowa MPO model architecture. Most notable are the University sub-model process and the parking and transit modeling elements as developed in Ames and Iowa City. The parcel-based land use files were initially tested with work conducted for the Des Moines model.

3: OVERVIEW OF RECOMMENDED STANDARD MODEL ARCHITECTURE

3.1 Current national model architecture practices

3.1.1 Survey and survey findings

A web-based review of travel demand model architecture frameworks currently in use for select MPOs around the country was conducted to help inform the development of a recommended standard model architecture for Iowa's MPOs. For purposes of the broader ISMS project, model architecture refers to how travel demand models and underlying data are organized, how individual models are structured, and how the software (TransCAD) is implemented. This section of the manual focuses on the structure of models.

To gain as broad a perspective as possible, examples of model architecture were considered from a range of MPOs, in terms of size of region (small, medium, large), as well as model complexity (simple, standard practice, state of the art). In all, a total of 15 MPOs were surveyed. Flow charts depicting model architectures can be found in **Error! Reference source not found.**.

The large MPOs surveyed included:

- Atlanta Regional Commission (ARC)
- Chicago Metropolitan Agency for Planning (CMAP)
- Maricopa (Phoenix) Association of Governments (MAG)
- Metropolitan Washington, DC Council of Governments (MWCOG)
- Metropolitan Council (Minneapolis-Saint Paul, MN)
- North Central Texas (Dallas) Council of Governments (NCTGOG)
- Southwestern Pennsylvania (Pittsburgh) Commission (SPC)
- Puget Sound (Seattle) Regional Council (PSRC)
- San Diego Association of Governments (SANDAG)

The small/medium MPOs surveyed included:

- Cedar Rapids, IA (CMPO)
- Fredericksburg, VA (FAMPO)
- Hagerstown, MD/Eastern Panhandle (HEMPO)
- Loudon County, VA
- Lynchburg, VA (CVMPO)

- Omaha-Council Bluffs Metropolitan Area Planning Agency (MAPA)

The project team examined and discussed the examples of model architecture during a brainstorming session conducted in October 2015. The main purpose of the review was to look beyond the traditional 4-step architecture and identify unique and innovative practices that might serve to benefit travel demand modeling in Iowa. Specific architectural practices and/or features of particular interest (in no particular order) to the project team included:

- Type and scale of land use data for trip generation step
- Integration of land use models
- Market segmentation based on income
- Detailed high school and college enrollment and/or housing data to inform those trip purposes
- Destination choice model within trip distribution step
- Mode "split" versus a mode "choice" models
- Time of day representation
- Non-motorized modes
- Volume-delay functions incorporating intersection operational characteristics
- Reliability representation in route choice
- Global feedback loops
- Convergence testing for equilibrium
- Automated reporting and/or post-processing of model results

3.2 Recommended ISMS model architecture

Following the review of existing model architecture practices, project team collaboratively recommended a standard model architecture for further testing and evaluation. In addition to borrowing some ideas currently in use in other MPO models, the initial model architecture seeks to incorporate the feedback received and the priorities identified from the MPO User Survey.

3.2.1 Architecture definition

The various elements of the recommended standard model architecture are characterized in the form of a flow or process chart. Figure 3-1 provides the key to how each process is represented. Five types of general processes are used:

- Inputs
- Standard Processes
- Optional Processes
- Potential Processes (to be evaluated);

- Outputs or Intermediate Results for Subsequent Processes

Figure 3-2 through Figure 3-5 show the details of the recommended standard model architecture. They are ordered in a manner consistent with the sequence of the traditional four-step travel demand model – trip generation, trip distribution, mode choice, and trip assignment.

Figure 3-1: Model architecture process key

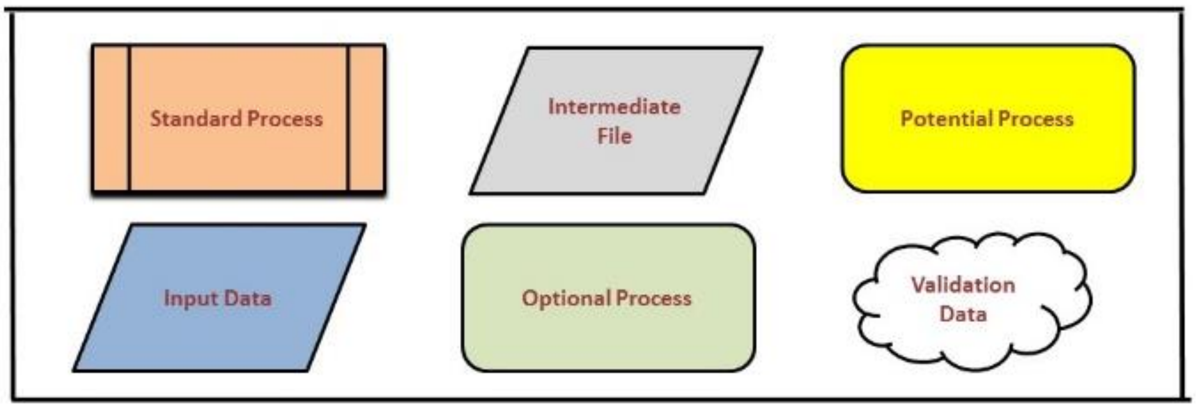


Figure 3-2: Trip generation model architecture

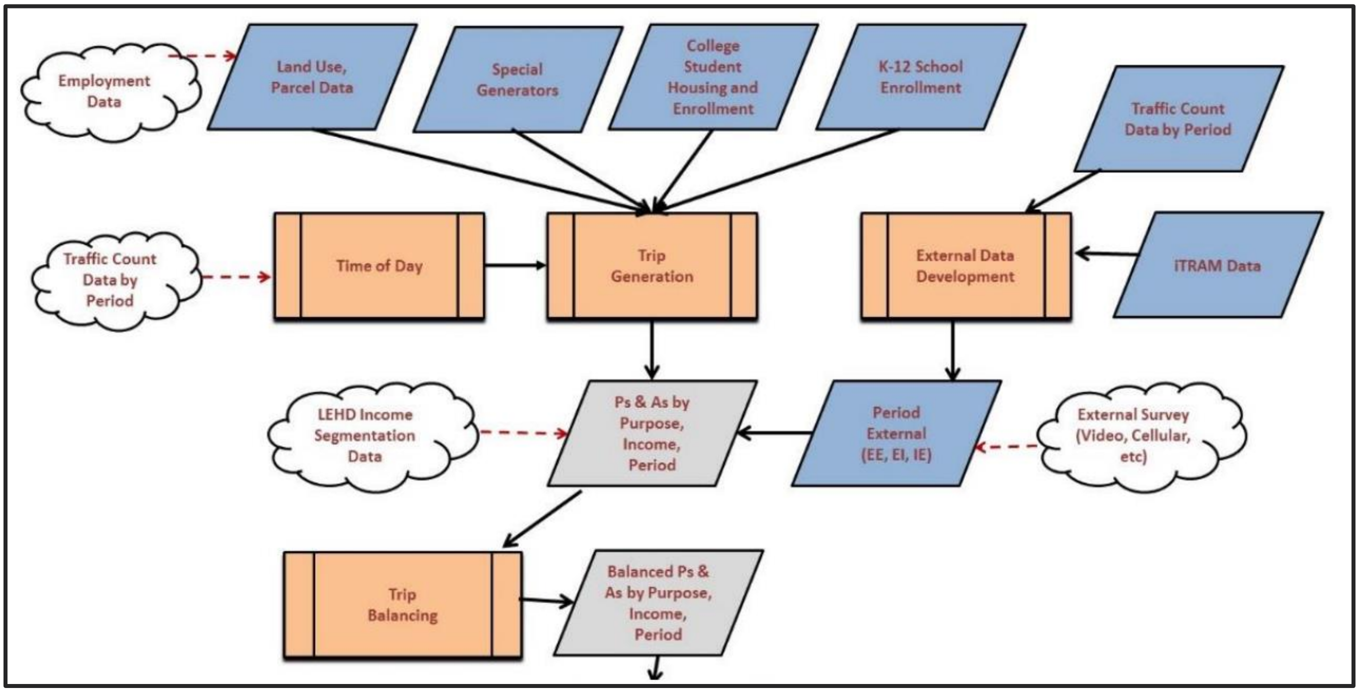


Figure 3-3: Trip distribution model architecture

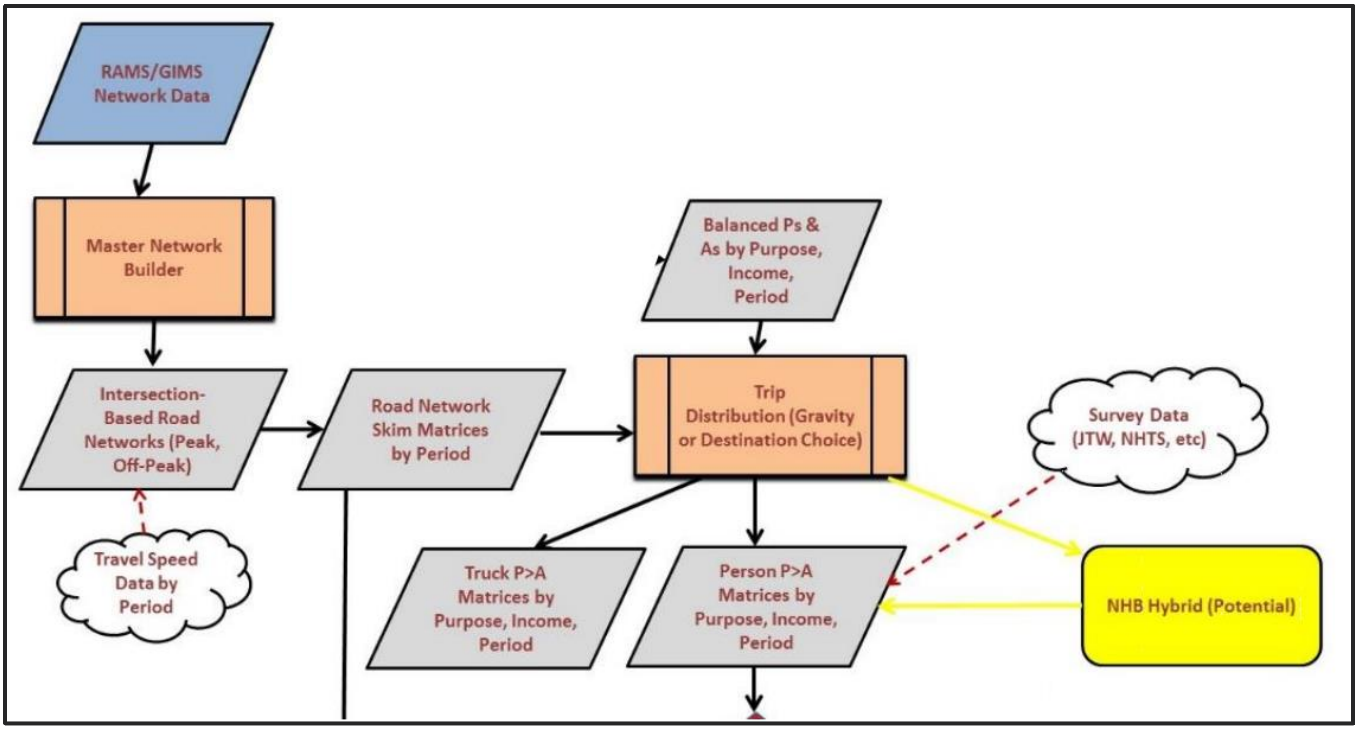


Figure 3-4: Mode choice/split model architecture

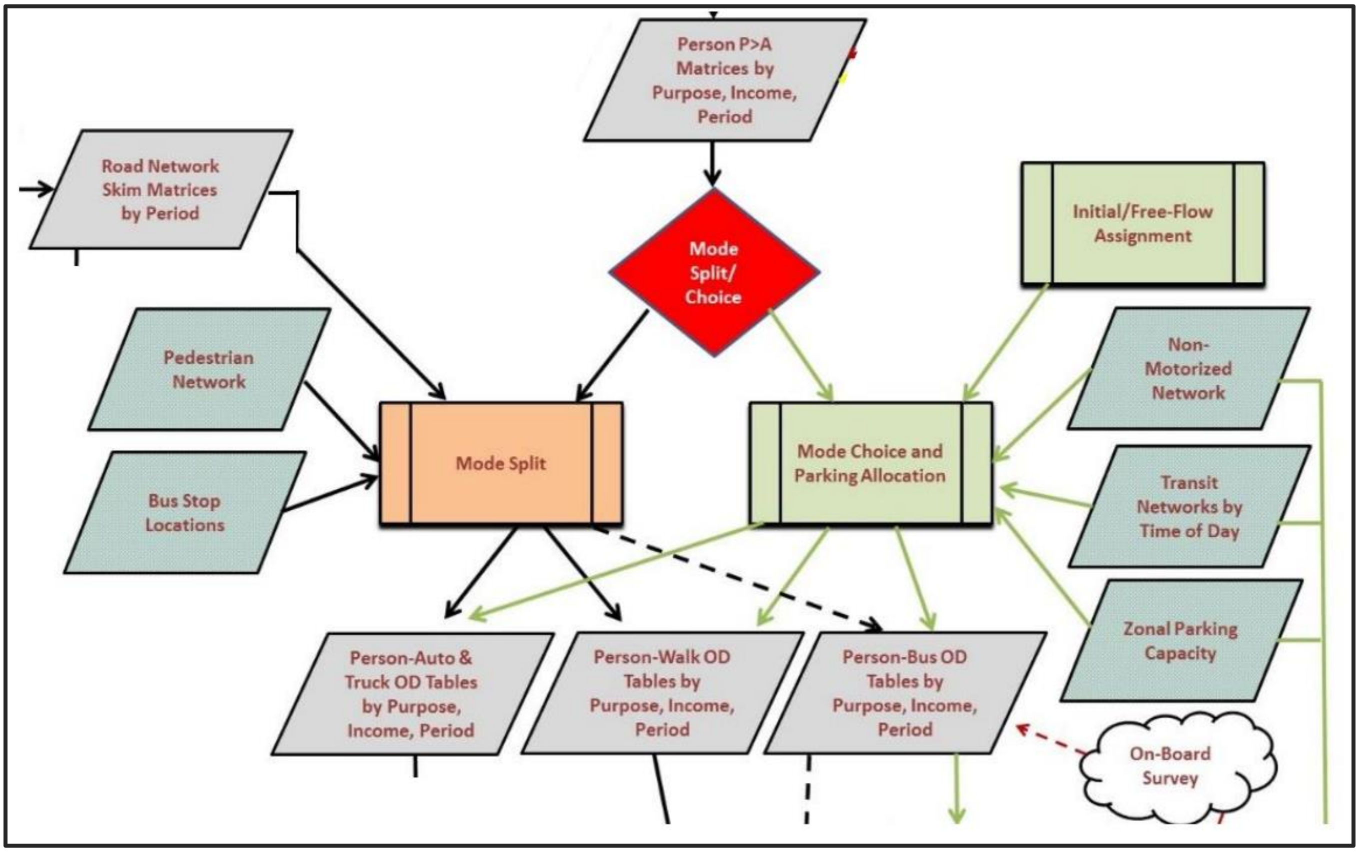
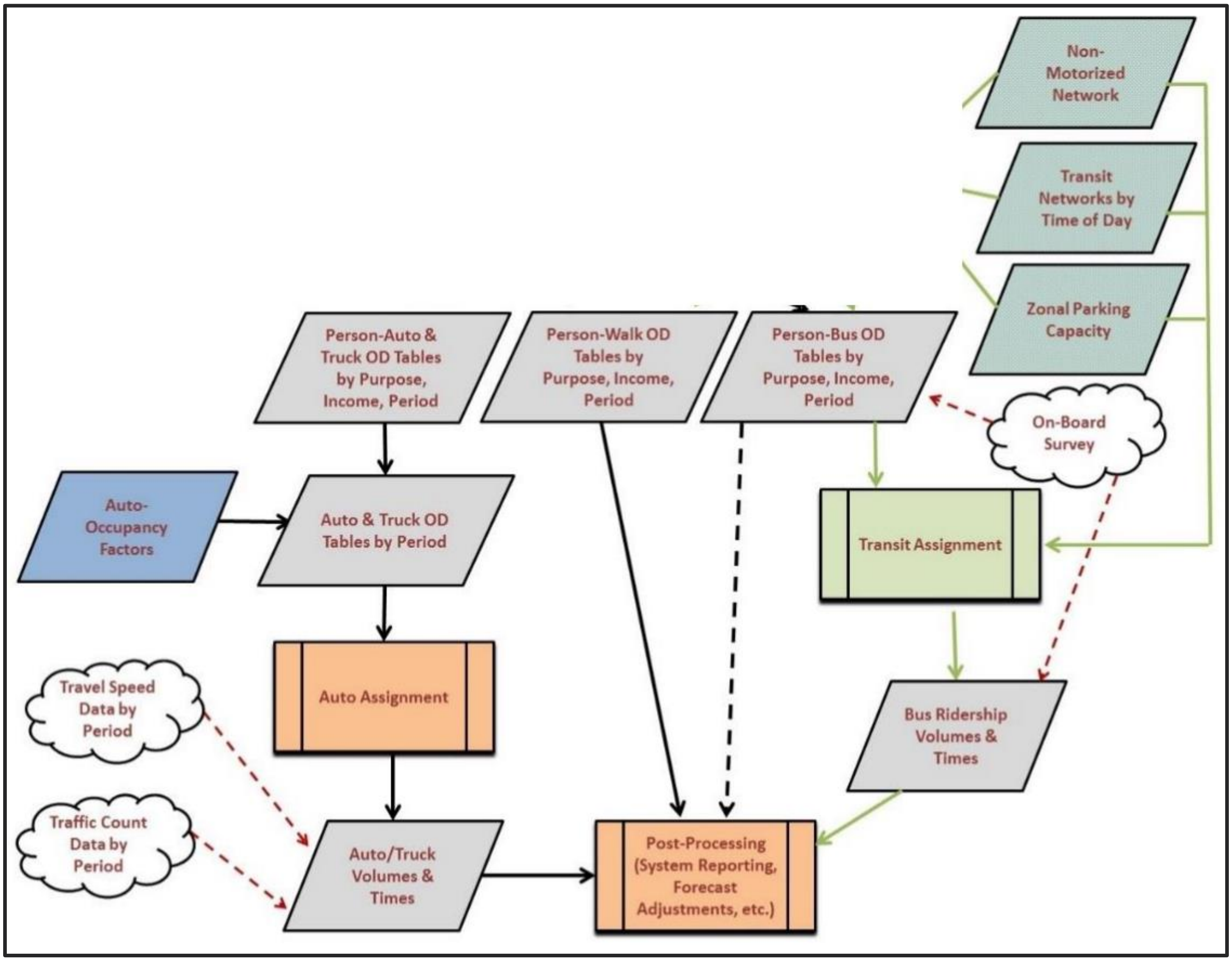


Figure 3-5: Traffic and Transit assignment model architecture



3.2.2 Model Installation

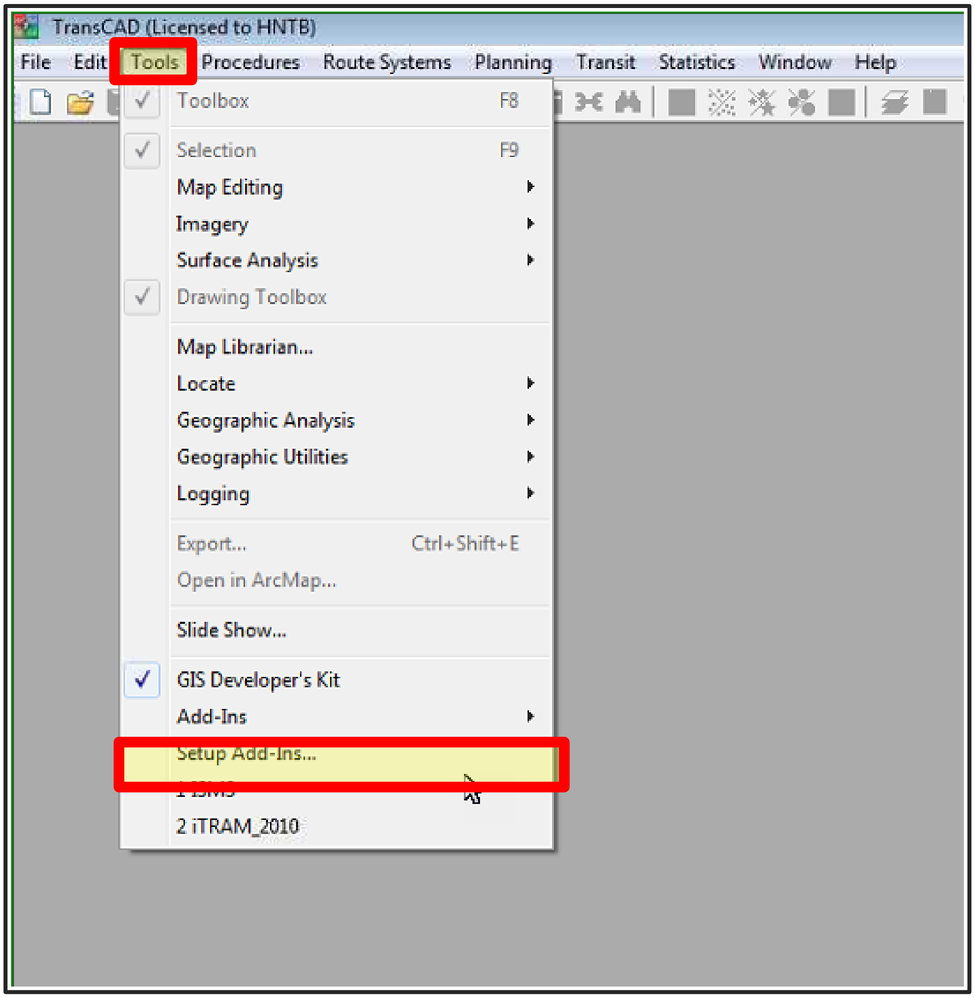
The ISMS prototype model is built for use on the Caliper TransCAD software platform, using Version 7. The prototype works using a customized scenario management screen as described below. The file naming convention and typical file structure of various model folders and files is depicted in a later section (3.2.3) of Chapter 3.

ADD-IN

The model must be setup as an add-in within *TransCAD*. To accomplish this, first start *TransCAD*, then click the "**Tools**" menu, then the "**Setup Add-Ins...**" sub menu (see Figure 3-6).

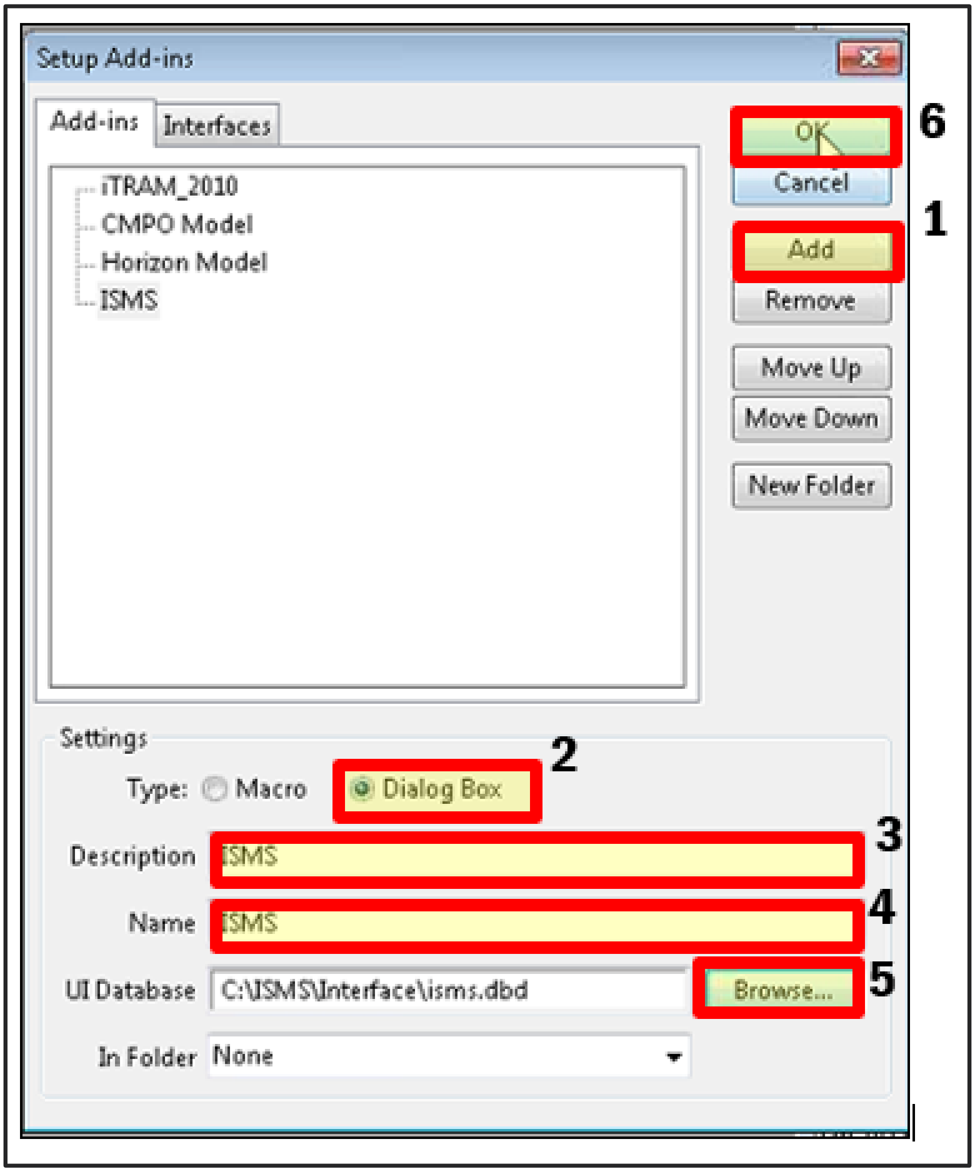
While the interface does not need any other information, reference images and model images need to be saved in the "C:\Program Files\TransCAD 7.0\bmp" or equivalent TransCAD 7.0 installation folder (Administrator privileges to install and save files and modify directories like the "Program Files" folder might be required to complete some of the above tasks).

Figure 3-6: Accessing "Setup Add-Ins…" Sub Menu in TransCAD



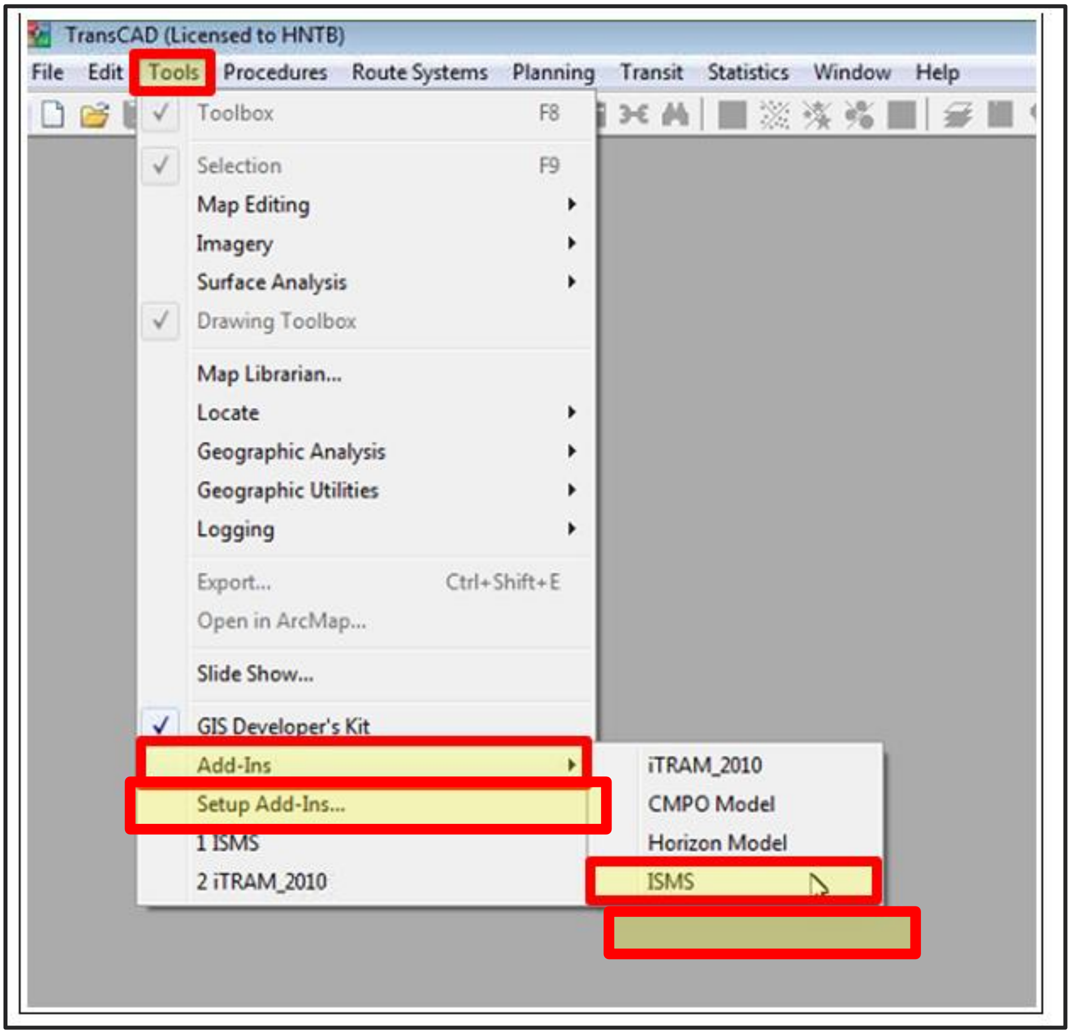
Once the Setup Add-ins dialog box opens, click the "**Add**" button to create a new add-in. An untitled Add-in is added under the "Add-ins" tab. Under Settings click the radial button for "**Dialog Box**" and type "**ISMS**" into the "Description" and "Name" Fields. Note that the name "ISMS" is used for this example. The description can be populated with any text. Click the "**Browse…**" button and select the location of the installed UI database file. The name of the UI database is "**isms.dbd**". Open the UI Database. Once the UI Database is opened, the Setup Add-ins Dialog box reappears. Click the "**OK**" button to finish the add-in process and close the add-ins dialog box. The model is now installed (see Figure 3-7).

Figure 3-7: TransCAD Setup Add-ins Dialog Box



To verify that the ISMS add-in has been completed click the "**Tools**" menu and hover over the "**Add-Ins**" sub menu. ISMS should now appear as a selectable value under the "Add-Ins" sub menu (see Figure 3-8).

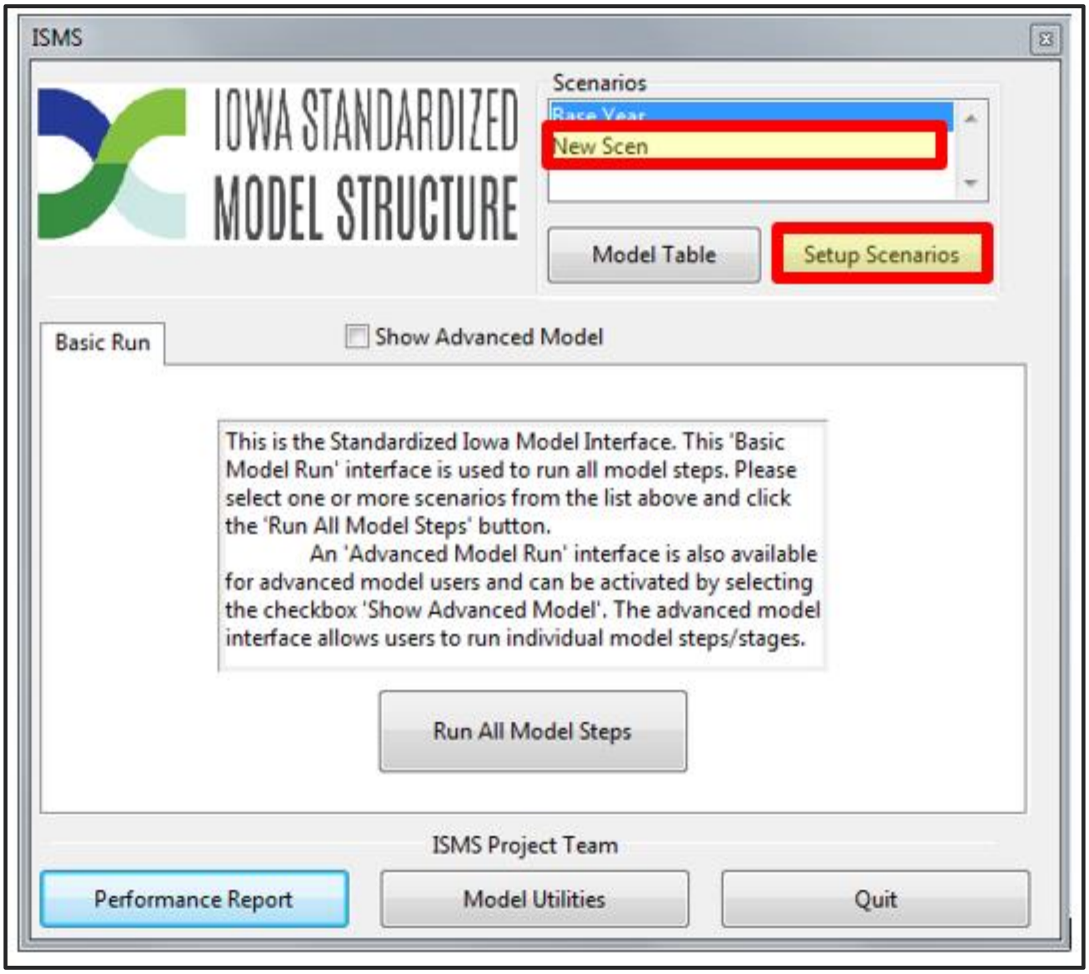
Figure 3-8: TransCAD Tools Menu Showing Add-Ins Sub Menu



STARTING THE MODEL

To start the model, begin by starting *TransCAD* if it is not already open. It is recommended that the model be run with no other files or layers open to eliminate the possibility of other files interfering with the model run. Load the add-in by clicking "**Tools**", "**Add-Ins...**", and "**ISMS**" (or other text identifier that was entered into the Description and Name fields of the previous step). The ISMS Splash Screen dialog box will appear the first time the add-in is started (See Figure 3-9).

Figure 3-9: ISMS Splash Screen

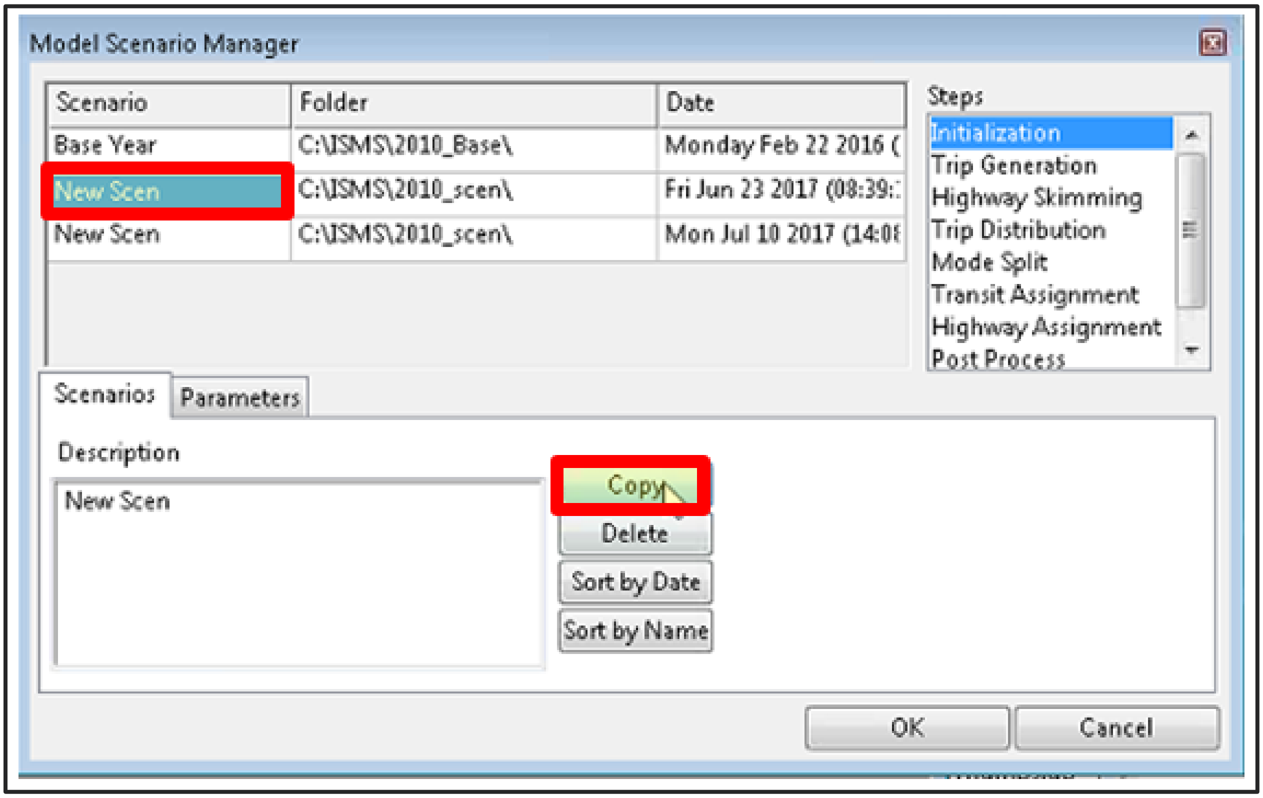


ADDING & MODIFYING SCENARIOS

To add a scenario, begin by selecting a scenario template from the “Scenarios” list box then click the “Setup Scenarios” button (see Figure 3-9). In the example shown, two scenario templates are shown: “Base Year” and “New Scen”. Once the “Set Up Scenarios” button is clicked the Model Scenario Manager Dialog Box opens. Select the desired scenario from the Scenario column and click “**Copy**” from the “Scenarios” tab (see Figure 3-10). A new Scenario is created and appears under the previously selected scenario. Note the names of the new scenario can be edited by double clicking on the name of the scenario. Similarly, the folder location where the output file will be saved can be modified by double clicking on the folder corresponding in the new scenario created.

In order to run a new scenario, a new folder will need be created within Windows, and then the model user will need to point to that new folder structure within the interface in TransCAD.

Figure 3-10: Model Scenario Manager Dialog Box Showing Scenarios Tab



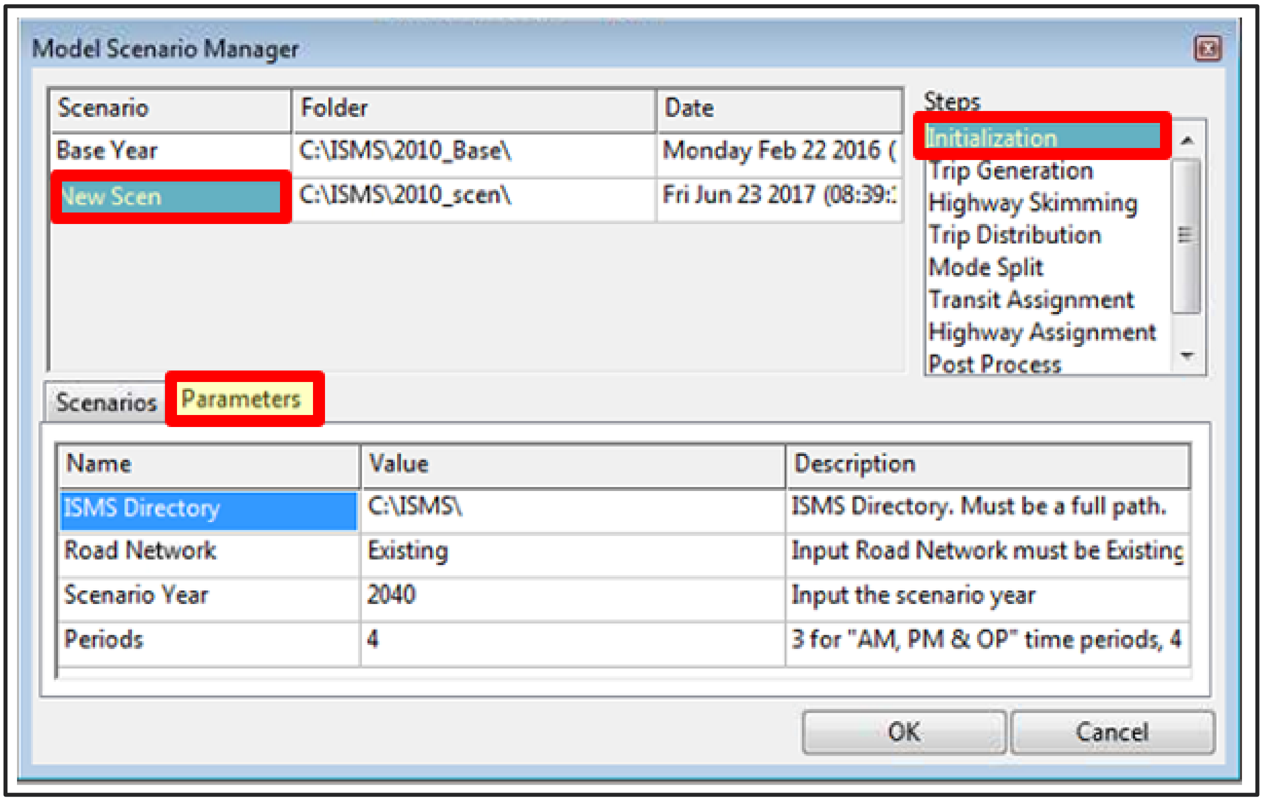
The model consists of the following eight user configurable modules (i.e., steps). These modules or steps in the model appear in the scroll box in Figures XXX-5 and XXX-6, and are listed below.

- Initialization
- Trip Generation
- Highway Skimming
- Trip Distribution
- Mode Split
- Transit Assignment
- Highway Assignment
- Post Process

To tweak the parameters associated with an individual module first select the desired scenario, then the desired module/step. With the desired scenario and module/step highlighted, click the
"**Parameters**" tab to view the associated parameters associated with the module (see Figure 3-11). Double click on the

numbered value under the value column to adjust the value. Click "**OK**" to save edits when finished. The new scenario is saved is now available to be run from the ISMS splash page.

Figure 3-11: Model Scenario Manager Dialog Box Showing Parameters Tab



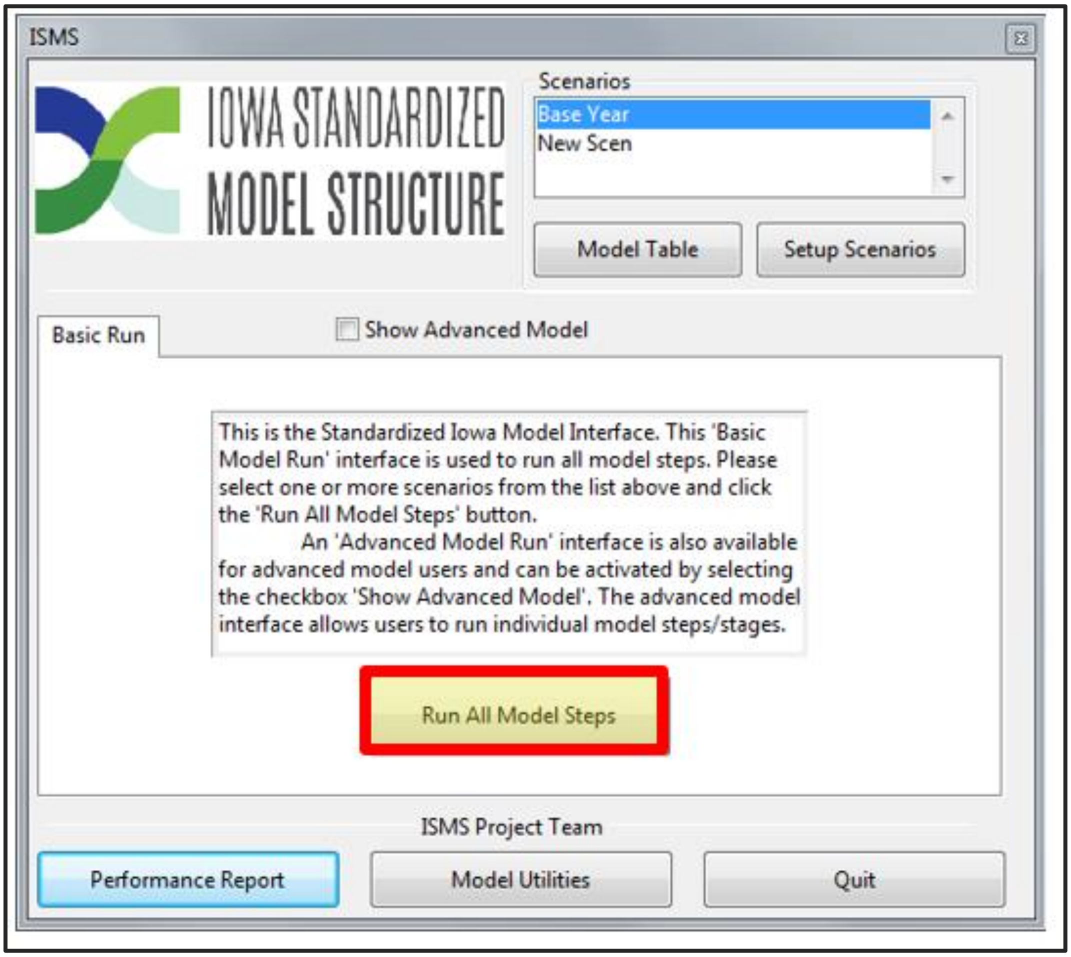
As Figure 3-11 indicates, the value of the ISMS directory name can be changed to the MPO name. From a file management perspective, this is useful because it eliminates possible confusion by DOT staff in getting confused between different MPO models.

RUNNING SCENARIOS

There are two ways to run the model for a selected scenario; a basic model run and advanced model run.

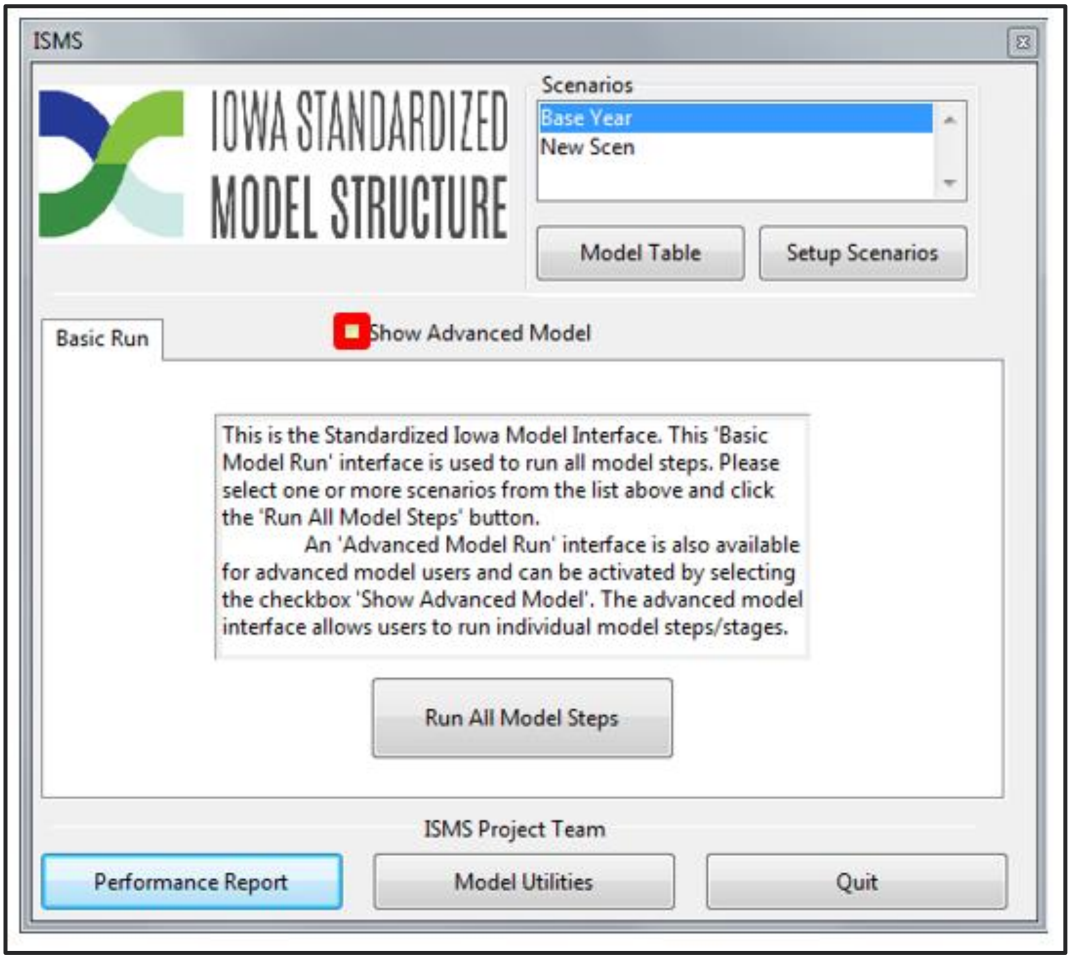
To perform a basic model run click "**Run All Model Steps**" from the ISMS dialog box (see Figure 3-12). Running the model in this fashion will result in all modules of the model being run. The user will not have the option to select/unselect specific modules or macros that run within each module when running the model in this fashion.

Figure 3-12: ISMS Splash Screen with the "Run All Model Steps" Box Highlighted



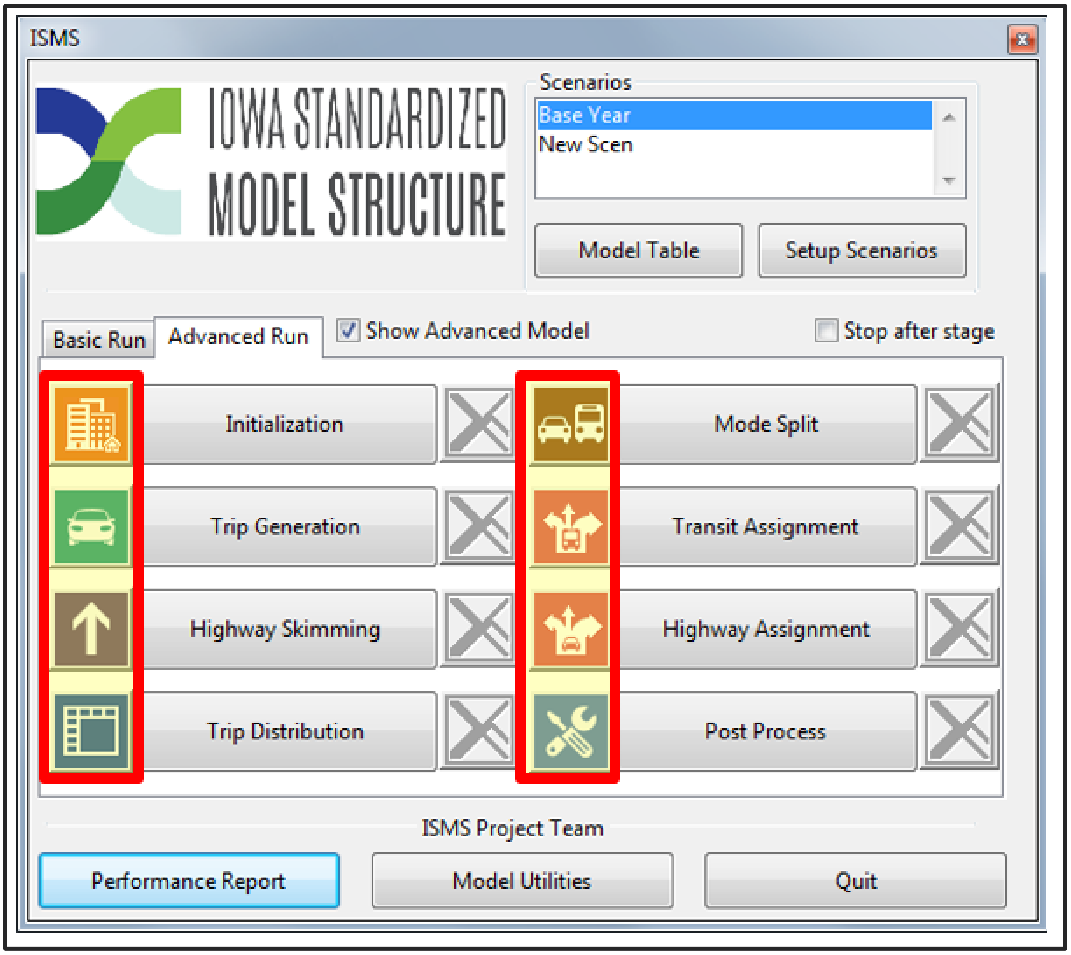
To perform an advanced model run, click the check box next to "Show Advanced Model" within the ISMS dialog box (see Figure 3-13).

Figure 3-13: ISMS Splash Screen with the "Show Advanced Model" Check Box Highlighted



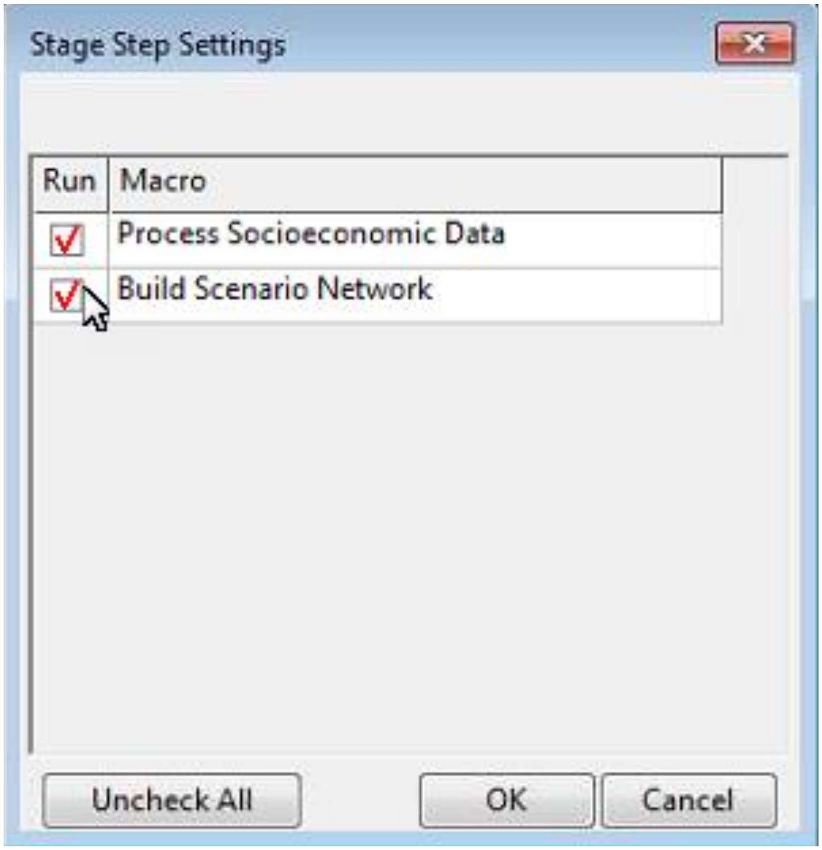
A note indicating that the advanced model is intended for advanced model users should appear. Click "**OK**" within the Note dialog box. The advanced model run tab appears within the ISMS dialog box showing the individual modules associated with the Model (see Figure 3-14).

Figure 3-14: ISMS Splash Screen Showing the Advanced Model Run Tab and Associated Modules Highlighted



Each module has specific macros associated with it. Macros can be turned on or off by clicking the colored icon immediately to the left of each module. For example, clicking the icon next to the Initialization module box will result in the Stage Step Setting Dialog Box to appear for this module (see Figure 3-15).

Figure 3-15: Stage Step Settings Dialog Box



Within the Stage Step Setting Dialog Box macros specific to the module can be turned on and off by clicking the corresponding run check boxes next to the name of each module. When finished selecting modules to run click "**Ok**" to return to the ISMS splash screen showing the advanced model run tab. To run the model for only the modules and macros selected select the tab for "**Basic Model Run**" and click "**Run All Model Steps**". When the "Run All Model Steps" button is clicked the model will only run through the modules and macros selected.

Another feature that is available is the ability to run batch model runs. Different scenarios using a different combination of inputs can be set up by the user and run in series automatically.

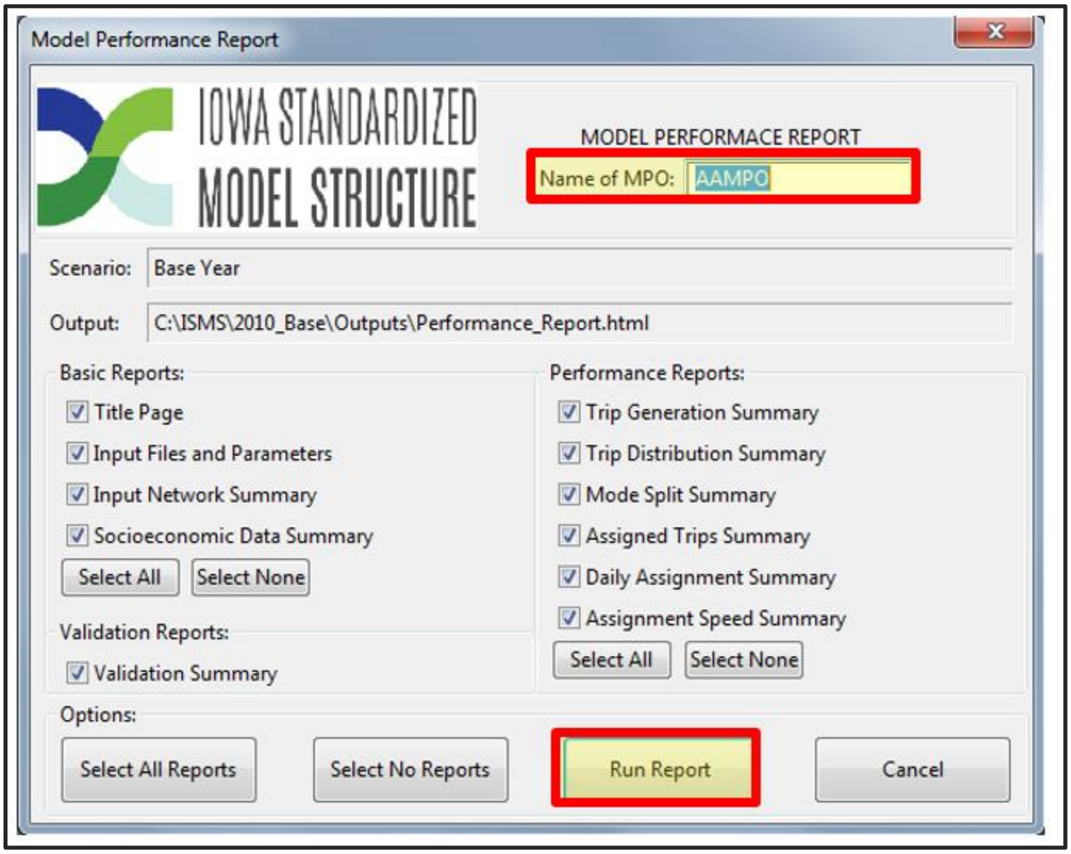
REPORTING

The ISMS prototype outputs various reports in HTML format for use in diagnosing and documenting the model performance. The performance reporting is accessed through the Performance Report button, as shown in Figure 3-16.

Figure 3-16: Accessing the Performance Reporting

Various reports can be selected for output, as shown in Figure 3-17. Also, the name of the MPO input in this screen will be used in the reporting.

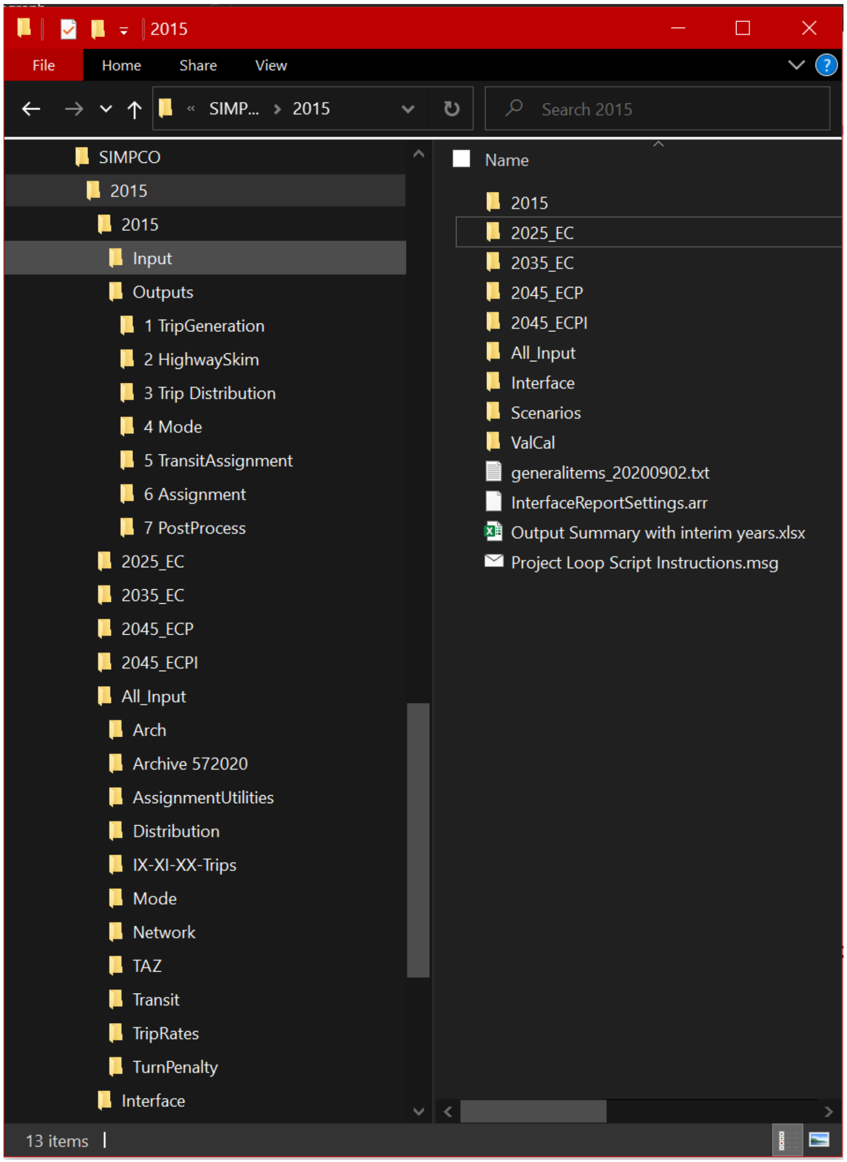
Figure 3-17: Defining Measures and MPO Name for Reporting



3.2.3 File Conventions

The ISMS prototype uses a standardized folder and file name structure. This allows the user to maintain model input and output for various scenarios in an organized and consistent manner. The standard file structure is shown in Figure 3-18. Standard input files are stored in their appropriate subfolders under the All_Input folder. Data specific to any model scenario is stored within the scenario-specific folder.

Figure 3-18: Standard file structure



As shown above, each scenario folder also contains an 'Input' folder. Within the scenario-specific input folder are any input files that have been edited specifically for the scenario. This facilitates edits such as scenario-specific land use. This also facilitates efficient review of model data that was edited as part of any specific scenario.

For creating a new scenario, the user must copy any input layers or datasets intended to be modified within the scenario into the Input folder in the specific scenario's directory. The user then makes updates to the input file(s) from the scenario's Input folder. If any input file is not found in the scenario's Input folder, the interface locates the file from the All_Input directory.

The 'Interface' folder contains the file used by the ISMS Interface to manage the location and metadata of each scenario.

3.3 Description of Model Steps

3.3.1 Overview

Each step in the ISMS recommended model architecture is described in detail in Chapter 4: with an overview of the intent of the modeling step.

3.3.2 Recommended Architecture

This section identifies the specific equations, parameters, constants, etc. that are used by the ISMS script to complete the modeling step.

3.3.3 Model Data Usage and Development

Each step in the ISMS recommended model architecture involves data. The data is classified in one of four ways:

Input – Data used directly in the model step to generate outputs for subsequent use in the demand modeling process. The source of the data varies depending upon the specific step. The format for this data is prescribed by the ISMS format.

Estimation – Data used to develop the architecture or to estimate parameters used in the modeling step. This data requires additional analyses to determine further action, and is provided in this document as a reference only.

Validation – Data that is used to measure the output of the model step for reasonableness. It is desirable that validation data be independent of input data sets.

Output – Data developed by the ISMS script, either as final output or intermediate files.

3.3.4 MPO Responsibility and Tasks

As outlined in Section 1, the nine MPO's across Iowa have a responsibility to identify and evaluate transportation improvement options. The state of the practice across the country, and within Iowa is to utilize a TDM to complete this mandate. To this end, the MPO's are responsible for the development, maintenance and application of the TDM tools.

Given the highly technical nature of TDM development, a cooperative agreement between the Iowa DOT and the MPOs will be established. The MPO's also have responsibilities as part of the cooperative agreement. This ISMS project identifies various input data sets which require MPO staff to collect, review, analyze, format and certify for use within their respective TDM. Housing, parcel and network inputs described in **Error! Reference source not found.** are the responsibility of the MPO's to develop. While Iowa DOT staff may provide data and review, it is the MPO's responsibility to certify these data sets as accurate, valid and reasonable for use in the modeling process.

MPO staff are also responsible for developing the list of potential projects to be tested within the TDM. MPO will then code these potential projects into the TDM, execute the TDM and evaluate the effectiveness of the projects toward meeting the MPO's needs.

3.3.5 DOT Responsibility and Tasks

The Iowa DOT's Systems Planning Bureau provides technical support for development of travel demand modeling tools used by MPO across the State of Iowa. Iowa DOT staff regularly work with model data sets, model inputs, model code, model outputs and subsequent interpretation of the model outputs, giving these staff a high level of technical competence in the demand modeling area. Iowa DOT staff also use the modeling tools to evaluate other components of the Iowa DOT's functions, including assessing Interstate Access requests, traffic forecasting and traffic operations items.

As was previously mentioned, TDM development is of a highly technical nature, as a result a cooperative agreement between the Iowa DOT and the MPOs has been established. This agreement indicates that the Iowa DOT will provide the technical support through DOT staff and consultant expenditures to provide the MPO's with this Iowa standard modeling structure (ISMS), within which the TDM data sets, inputs, parameters and procedures exist. Furthermore, Iowa DOT provides DOT staff and consultant expenditures to lead the technical refinement of the TDM for each MPO such as to meet the technical requirements of a reasonable and valid model as set forth in Chapter 4s 'Validation/Calibration Standards and Techniques.' Iowa DOT also provides training to MPO staff to help maintain their TDM proficiency as described in Section 3.6 'Training and Version Management Procedures.' Iowa DOT has prepared a working timeline for TDM development to align with LRTP development. This timeline anticipates 30-36 months are required for efforts associated with data collection, model development, calibration, validation and application of the TDM.[2]

3.3.6 ISMS Application

The ISMS recommended architecture is implemented within the ISMS TransCAD GISDK Scripting Environment. A description of the process to execute the step is highlighted, including options for basic or advanced functionality.

3.3.7 Validation, Calibration, and Reasonableness Checking

Model calibration is the adjustment of model constants to better replicate observed results. An example is modifying trip generation coefficients estimated from a household travel survey such that when the coefficients are applied to the surveyed households, the result is the number of trips reported by the survey.

Model validation is the comparison of a model to observed data not directly used in the model development. An example is comparing trip length distributions from Journey to Work data against the distributions calculated by a model derived from a household travel survey.

Model reasonableness is comparing model outputs to expected results. The expected results may be ranges of outputs from other models across the country or outputs from other mathematical means such as linear regression or professional experience. An example is checking the reasonableness of projected traffic growth between the base and future model sets against traffic growth calculated from 20 years of historical traffic counts taken at the same location.

Each step in the ISMS recommended model architecture includes guidance on model calibration, validation and reasonableness checks. Many reference industry standards from publications such as the Model Validation and Reasonableness Checking Manual.

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2 http://www.Iowa DOT.gov/systems_planning/pr_guide/Long%20Range%20Transportation%20Plan/MPO%20LRTP%20Flowchart.pdf

3.3.8 Future Year Considerations

The focus of travel demand modeling is the use of the tool for estimating impacts to the transportation system based on changes in future conditions. Typically, inputs are modified based on anticipated future changes, such as new land developments or a new roadway facility. Each step in the ISMS architecture defines what elements may be modified as part of a future year analysis run.

3.3.9 Documentation Standards

Understanding the impacts of potential transportation and land use changes often requires more than the change in traffic assignment at a particular location. Metrics are identified within each step of the ISMS recommended architecture to document how the model responds to the input stream.

Items that document the inputs and specifics of each step of the ISMS process are defined in Chapter 4.

3.3.10 Quality Assurance and Control

Each step in the ISMS recommended model architecture influences subsequent steps in the modeling process. Therefore, it is vitally important that a quality assurance and quality control process be implemented. Each step in an ISMS Model has a responsible party, namely the MPO or the Iowa DOT staff. The model development team recommends each step be led by one entity, and reviewed by the other. Additionally, intra-agency review should be performed as staff availability permits. A set of quality checks are included in each step of the ISMS recommended model architecture to help facilitate quality checks.

3.4 Recommended Workplan for ISMS Implementation

ISMS embraces the continued partnership of DOT and MPO staff, and defines demand modeling roles and responsibilities for both DOT and MPO staff. To that end, ISMS provides a workplan to accomplish each task in model development, including overview and details of the step, guidance on data and data processing, and timeline and level of effort estimates. The workplan identifies those elements that at a minimum must be reviewed and approved by the MPO and DOT staff respectively. Within these MPO and DOT tasks are some elements that must be accomplished solely by the respective agency; however, the majority of technical tasks may be physically completed by staff from the MPO, DOT or a third party such as consultants or university research staff.

During the model kick-off discussions, the ISMS Gantt Chart template shall be consulted to determine the recommended and optional tasks that would add value to the MPO's long range planning process or the DOT's traffic forecasting needs within the model area. The discussion should also highlight the appropriate party to complete the work for each task deemed appropriate to include within the specific MPO's travel demand model. For example, a discussion on parcel data may determine that while the MPO needs to review and approve the data, a consultant is needed to assemble and process the data.

3.5 Maintenance and Updates

The Iowa DOT and the nine MPOs collectively work to provide transportation planning and traffic forecasting services for a variety of purposes. The policies, recommendations, and procedures developed during the ISMS process were developed to support the collective effort. However, the transportation planning and traffic forecasting needs of both the Iowa DOT and MPOs will undoubtedly change over time as transportation needs, technologies, and funding continue to evolve. To facilitate this evolution, ISMS is considered a living process with ongoing opportunities to explore new directions, modify policies, and update recommended procedures.

The existing Midwest Travel Model Users Group (MTMUG) provides a regular forum to discuss the needs that both the Iowa DOT and MPOs have of ISMS, and debate the appropriateness of changes to ISMS functionality. Additional opportunity to discuss ISMS updates occurs with each MPO's annual work plan review with Iowa DOT staff. ISMS improvements will also be generated during regular modeling efforts undertaken by Iowa DOT staff, MPO staff, and consultants.

Iowa DOT will facilitate the implementation of updates and improvements to ISMS, then distribute the revisions to affected parties. As discussed in Version Management below, any changes to the ISMS procedures should be noted within project documentation.

3.6 Version Management Procedures

Travel demand models often take on a life of their own, with changes in data, assumptions and processes that correspond with a dynamic environment impacted by changing political priorities, technological advances, staffing changes, and changing nature of future land use forecasts.

An official travel demand model shall be maintained for each MPO area. It is recommended the latest, approved model version be hosted on the Iowa DOT's ProjectWise site. A major revision of the demand model is conducted periodically in conjunction with MPO/Iowa DOT staff and typically coincides with the development of the MPO's long range transportation plan. The major revision involves a thorough review of all model inputs and assumptions, a full revalidation of the regional model outputs and a model validation report.

Minor revisions are anticipated during the useful life of a travel demand model and are documented as versions. The minor revisions do not significantly impact the usefulness of the model to perform traffic planning and forecasting exercises, but will change the specific results of the model. A new version of the official demand model may be required, but not limited to, if:

- A change to ISMS is required per the 'Maintenance and Updates' section above,
- A change to model inputs deemed important to model performance is identified

In the event a new model version is deemed necessary, a record should be completed in a table similar to Table 3-1. A description of the items includes:

- New version number
- Effective date of new version
- Official approval date by MPO (if necessary)
- Cause for new version (describe what prompted decision for new version)

- Items modified with new version (name of files; ID of link, node, row, column; rows in GISDK code, etc. that were edited)
- Name and contact info for modeler responsible for creating new version

Table 3-1: Example Model Version Tracking Table

VERSION NUMBER	EFFECTIVE DATE	MPO APPROVAL DATE	CAUSE FOR NEW VERSION	ITEMS MODIFIED	MODELER INFO
2	1/1/2018	12/29/2017	Western bypass project changed from 2 lanes to 4 lanes	AB_Lanes1 and BA_Lanes1 changed from 1 to 2	Reginald S, reg@dot.us

3.7 Model Training

The ISMS script was developed to operate within the TransCAD software platform. Use of ISMS therefore requires a basic level of skill in operating TransCAD. Specifically in creating, opening, and editing tables & geographic files. ISMS-specific tables and geographic files are described within this ISMS manual. General TransCAD usage questions can be addressed through consultation with online help documents, communications with the TransCAD developer, Caliper, or through discussions with Iowa DOT staff.

Previous training on the development and decision-making process used in developing ISMS have been covered during MTMUG meetings. The MTMUG forum is anticipated to be the primary venue for on-going high to mid-level training, covering topics such as:

- Steps to develop Parcel Data
- Steps to develop Master Roadway Network
- How to evaluate Distribution Models
- Transit Scenario Testing with Mode Split Model

Detailed training is best accomplished on a more personal basis during the application of ISMS through model updates and project application.

3.8 Model Data Use Conditions

Data used to develop models within ISMS rely heavily on publicly available data; however, some data sets such as University student housing may be provided to the model development team under a confidentiality agreement. Care should be taken to avoid disclosing data used in the development of ISMS models that would violate confidentiality agreements.

The use of ISMS models should be monitored by the MPO and Iowa DOT agencies responsible for the models. A mutual understanding between the MPO/DOT staff and third parties intending to use the model should be established prior to providing ISMS model sets. An example agreement is below.

To Be Completed by Requestor

Name of Requestor:_________________________

Requesting Organization: _________________________

Name of Project: _________________________

Project Sponsor: _________________________

Date of Request: _________________________

Intended Use of Travel Demand Model: _________________________

Terms of Agreement

The travel demand modeling set requested by the above party will be used strictly for the project identified. Under no circumstances shall the model input data or output values be used for purposes not directly affiliated with the identified project. Furthermore, no data, TransCAD code or model outputs may be distributed to a third party without the written consent of the Iowa Department of Transportation and the MPO.

Any identified errors or suggested modifications to the model shall be submitted in writing to the Iowa Department of Transportation. Upon consultation with Iowa DOT and MPO staff, further steps will be taken to incorporate changes or revisions to the provided model.

The Iowa DOT and MPO are not responsible for model outputs resulting from a travel demand model scenario that has been altered by the above requestor.

To Be Completed by Iowa DOT Staff

Name of Approver of Model Distribution: _________________________

Date of Model Distribution: _________________________

Version of Model Distributed: _________________________

Scenarios Included in Distributed Model: _________________________

4: ISMS MODEL ARCHITECTURE DETAILS

4.1 Model Definitions

4.1.1 Overview

Prior to initiating the development of a travel demand modeling tool, various definitions of the model need to be determined. These definitions will serve as guides and bounds for the remaining model development process.

4.1.2 Recommended Architecture

GEOGRAPHIC LIMITS

Travel demand models are intended to model a finite geographic limit. This typically corresponds with the metropolitan planning organization's (MPO) planning boundary, but may include a limited area beyond this boundary to aid the model in analyzing impacts from potential scenarios that modify conditions at or near that planning boundary. Model limits may also be extended to correspond with government boundaries such as counties or towns. In the cases where multiple states are involved, it may be beneficial to include externals or even some limited portions of towns into the model, without including larger outside jurisdiction sections where data may not readily be available.

MPO staff should discuss the needs for their metropolitan area in terms of geographic extents as part of a demand modeling kick-off meeting with DOT staff. Consider potential analysis scenarios for the long-range plan and major infrastructure projects within the MPO area to help determine probable geographic limits.

ANALYSIS YEARS

Analysis years need to be clearly defined. The base year is typically the most crucial year for defining the model development process as many of the data sets used to estimate and apply the model are dependent upon the year in which they were collected.

Base year of analysis could align with Census data, or may be set to align with locally collected data or a recent year where a larger number of counts were collected.

Future analysis years should be selected based on the needs of the project for which the model is being developed or applied. MPOs shall determine needs for analysis years based on their long-range transportation plan, and potential air quality modeling needs. At a minimum, the planning horizon should extend 20 years beyond the last year that the plan is intended to be valid. The inclusion of interim years is highly recommended as necessary and, for example, to help support project selection and timing for the LRTP update.

YEAR OF DOLLAR

The ISMS TransCAD prototype uses US dollars as the unit of measurement for transit mode choice and roadway assignment calculations. The year of the dollar impacts the relative impact of that dollar compared to a unit of time, which is described as Value of Time. For example, $1 in 1990 has a higher equivalent time impact than $1 in 2015. Unless detailed analysis has been previously conducted with the MPO region that ties transportation decision making to a specific year, the year of dollar should correspond to the model base year.

4.1.3 Data Sets

INPUT DATA

For all data sets, a summary description of each field is suggested to be included in the binary file for quick reference. This can be copied from the ISMS document. In addition to the TAZ, network, and other geographic files, metadata should be included in any binary table (even those with no geometry stored) as well.

ESTIMATION DATA

Considerations for determining the base year of the demand model set include:

- Year(s) in which model input data is available including
  - Parcel data
  - Census data (particularly housing and demographic data)
  - Network data (lanes, posted speeds, status of roadway improvements)
- Year(s) in which travel estimation/survey data is available
  - Household or employer survey
  - External cordon survey
  - Transit user survey
- Year(s) in which model validation data is available
  - Local trip generation data
  - Journey to Work data or other big data like StreetLight data
  - Traffic counts
  - Transit counts
  - Travel speeds

VALIDATION DATA

Consumer Price Index (CPI) provides an estimate of the change in buying power of a dollar by year, which can validate the change in the Value of Time and Year of Dollar. Detailed historical data on the consumer price index is available from the Bureau of Labor Statistics (BLS).[3] Historical CPI is an index that represents the relative change in the average pricing of key goods and commodities. The relative compounded average annual rate of change in the CPI from the model base year (say 2000) to an analysis year (2017) can be considered to be the rate of inflation from 2000 to 2017. Further, future year model inputs items like parking costs and transit fares can be calculated by growing up the base year costs to the future year using the historical rate of inflation (i.e., based on the historical average annual percentage change in CPI).

OUTPUT DATA

The geographic limits of the model are used to define the Transportation Analysis Zones (TAZ) and model network limits.

Analysis years define model attributes for parcels and network.

Year of dollar defines relationships between time and money for parking cost, transit fare and operating costs, all to be defined in subsequent sections.

4.1.4 ISMS Application

Geographic extents, analysis year, and year of dollar are used to develop inputs for ISMS. Analysis year is also selected within the ISMS prototype at run time. Attributes for parcels and networks must be developed according to the analysis years.

4.1.5 Calibration, Validation and Reasonableness Checks

Review the model geographic area compared to major municipal boundaries, including county, township and city/village.

Analysis years typically align with detailed Census data, along with availability of traffic counts and parcel data.

Consumer Price Indexing can be used to verify the relative change in the value of money over time.

4.1.6 Future Year Considerations

The horizon year for the demand model is also defined during this process. Also consider an interim year(s), especially if project prioritization or air quality attainment analysis may be required.

4.1.7 Documentation Standard

Document the rationale for selecting the geographic extents of the demand model, including mapping of the limits overlaid with the urban boundary, planning boundary, or government boundaries (cities, towns, counties, states, etc.).

4.1.8 Quality Assurance and Control

MPO staff are responsible for the development of the geographic limits, analysis years, and year of dollar. DOT staff shall review the assumptions used to derive these values and provide guidance as necessary.

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[3] https://www.bls.gov/cpi/data.htm

4.2 Trip Purposes

4.2.1 Overview

Travel characteristics typically vary depending upon the reason the trip is being made. Some types of trips can only fulfill the intended purpose of that trip at very specific locations, such as schools. Other types of trips are less sensitive to the distance between the origin point and the choices of destination, such as work trips. It is therefore recommended[4] to separate the universe of trips into more homogeneous categories, or trip purposes. A simplified approach is to divide trips into 3 basic categories, Home-Based Work, Home-Based Non-Work and Non-Home Based. This simplified approach may not support detailed analysis of specific types of land uses and their impacts on travel.

4.2.2 Recommended Architecture

The ISMS prototype utilizes more detailed trip purposes, allowing for development of specific parameters to better model observed differences between unique travel needs. Table 4-1 defines the trip purposes recommended for the ISMS along with benefits of incorporating the more detailed purpose. MPO staff should review the trip purposes with Iowa DOT staff when commencing the update of the travel demand model, however no additional modifications to trip purposes are anticipated.

Table 4-1: Trip purposes

GENERIC PURPOSE	SPECIFIC PURPOSE	BENEFITS
Home-based work	Home-based work low income	Matches low income workers to low income jobs in trip distribution.
	Home-based work medium income	Matches medium income workers to medium income jobs in trip distribution.
	Home-based work high income	Matches high income workers to high income jobs in trip distribution.
Home-based non-work	Home-based K-12 school	Balance trips to known entity of school attendees. Location trip destinations to specific locations. Most trips have specific temporal pattern.
	Home-based shopping	Separates land uses that generate higher volumes of trips per unit. Establish appropriate temporal factors.
	Home-based other	Other trips with one end of the trip at the home
Non-home based		One end of trip tied to known location. Temporal characteristics more defined.
Special purposes	University	Large generator with unique generation, parking, temporal and modal characteristics.

[4] National Cooperative Highway Research Program, Report 765 , Analytical Travel Forecasting Approaches for Project-Level Planning and Design, page 25.

GENERIC PURPOSE	SPECIFIC PURPOSE	BENEFITS
	Hospital	Unique generator that draws trips from throughout and beyond the region.
	Airport	Unique generator that draws trips from throughout and beyond the region.
	Regional recreation	Unique generators that draws trips from throughout and beyond the region.
	Hotel	Unique generators that interact with both external stations and internal activities
Trucks[5]	Single-unit truck	Quick Response Freight Manual provides methodology.
	Combination truck	Quick Response Freight Manual provides methodology.
External-external	Auto	Not tied to local land use.
	Single-unit truck	Not tied to local land use.
	Combination truck	Not tied to local land use.

4.2.3 Data Sets

INPUT DATA

No input data is applicable.

ESTIMATION DATA

Estimating the need and significance of trip purposes requires analyzing a detailed household travel survey. The National Household Travel Survey (NHTS) is the typical survey instrument for assessing various demand model parameters including trip purposes. Details of the data available from the NHTS are available in **Error! Reference source not found.**. Other special purposes, such as University, Airport, regional recreation and truck/freight movement require additional survey data.

VALIDATION DATA

National publications provide reasonable ranges for the types and definitions of trip purposes, including NCHRP 365 and the Model Validation and Reasonableness Checking Manual.

OUTPUT DATA

No output data is applicable.

[5] Quick Response Freight Manual II, Federal Highway Administration, 2007. (Table 4.1)

4.2.4 ISMS Application

No user input is required if all recommended trip purposes are utilized. If a pre-specified purpose is being altered to represent a previously undefined trip purpose, a review of all subsequent inputs for the altered trip purpose is required and must be documented.

4.2.5 Calibration, Validation and Reasonableness Checking

No formal calibration or validation steps are required with respect to trip purposes. The reasonableness check is to confirm that no significantly large number of trips are made regularly within the MPO region that are not reasonably modeled within the trip purposes defined in Table 4-1. If data is not available, other comparable MPOs patterns can be reviewed to ensure relative consistency in percentages of trips by trip purpose. PUMS data can also be used as a reference, as well as other datasets like AirSage and Streetlight.

4.2.6 Future Year Considerations

No changes in trip purpose should be required with future year analysis. If changes in future conditions warrant a potential change in purposes alterations shall be documented.

4.2.7 Documentation Standards

A brief description of the standard trip purposes is recommended similar to Table 4-1. Additional documentation is required if a previously specified purpose is omitted, altered to represent a different purpose, or if changes in future conditions warrant a change.

4.2.8 Quality Assurance and Control

MPO to confirm trip purposes adequately accommodate the recurring travel patterns within their MPO region.

4.3 Time of Day

4.3.1 Overview

Based on the goals and objectives of the ISMS process, the travel demand modeling process utilizes a sub-daily timeframe. The daily person trip activities and various network elements are subdivided into three time periods, AM (6:00-8:59), PM (3:00-5:59) and off-peak(OP, 9:00 AM–2:59 PM, 6:00 PM-5:59 AM). Optionally, the midday (MD, 9:00 AM-2:59 PM) may be modeled as a fourth time period. Furthermore, weekday and weekend travel are modeled individually.

4.3.2 Recommended Architecture

Various land uses have unique travel characteristics, including the times during the day in which travel to and from the land use occurs. Shopping centers have a significant portion of their activity in the PM period, while an industrial manufacturing plant may have 3 active work shifts with activity spread throughout the 24 hours. Select land uses such as office parks have heavy weekday travel and little weekend activity, while religious centers have heavy weekend activity.

Network elements also have variations by time of day, such as limitations of on-street parking, traffic signal timings which impact travel time delay and parking availability.

Each time period that is modeled increases processing time and storage requirements. Standard ISMS architecture is based on three time periods since most model applications are focused evaluating travel in AM and PM peak periods when most congestion occurs. A single off-peak time period can be used to account for travel in the other hours of the day so that travel for the three time periods can be aggregated to obtain daily totals. However, users have the option of specifying four time periods to subdivide the off-peak period into mid-day (9:00 AM–2:59 PM) and night periods (6:00 PM-5:59 AM).

The literature review found a number of different options for placing the time-of-day component within the four-step modeling process. Most often, placement is between trip distribution and traffic assignment, as suggested by NCHRP 716. The ISMS recommended architecture conducts time of day analysis as a part of trip generation to take advantage of land use-specific temporal characteristics. **Error! Reference source not found.** provides the factors to disaggregate daily trip activity to the three time periods for each land use code for both weekday and weekend time frames.

4.3.3 Data Sets

INPUT DATA

Development of time periods is conducted outside of ISMS, using household surveys, employer survey, and traffic count data. Default time of day constants by land use code, time period and weekday/weekend combination are available for use. The specific hours included in the time periods or the duration of the periods themselves may also be modified during model development, provided sufficient data is available to justify the modification.

ESTIMATION DATA

Household or employer travel surveys, origin-destination surveys, and traffic counts can be used to estimate travel characteristics by time of day. Household surveys that provide details about the trip are most useful, specifically providing the trip purpose, land uses and income details.

below shows an example of the time of departure as reported by respondents of the 2001 Des Moines, IA Household Travel Survey; the figure shows a notable AM and PM peak for weekdays. The weekend shows low AM peak demand while the PM shows high demand. Figure 4-2 shows the volume of traffic observed at the Grand Avenue ATR location in Ames, IA. This data illustrates the travel pattern of highest traffic demands during the PM weekday period, with the weekend experiencing higher demands during the midday period.

Figure 4-1: Peak Periods Defined by Household Survey Departure Time

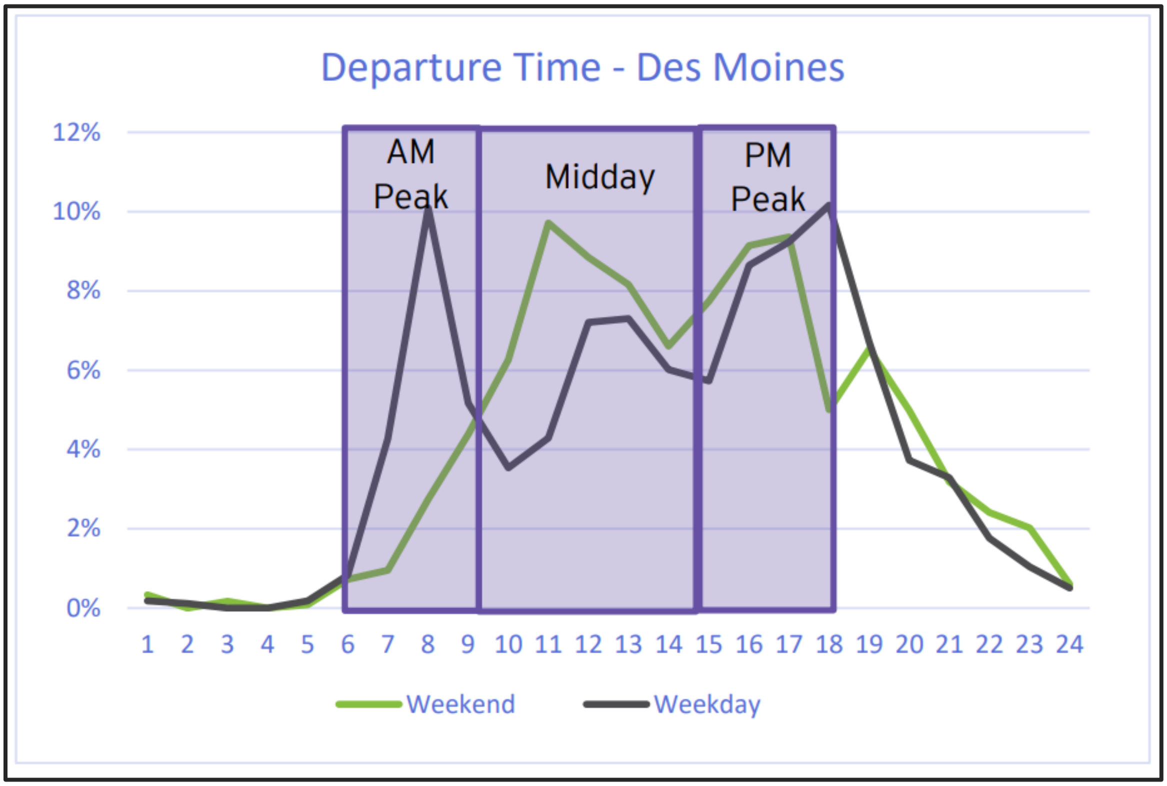
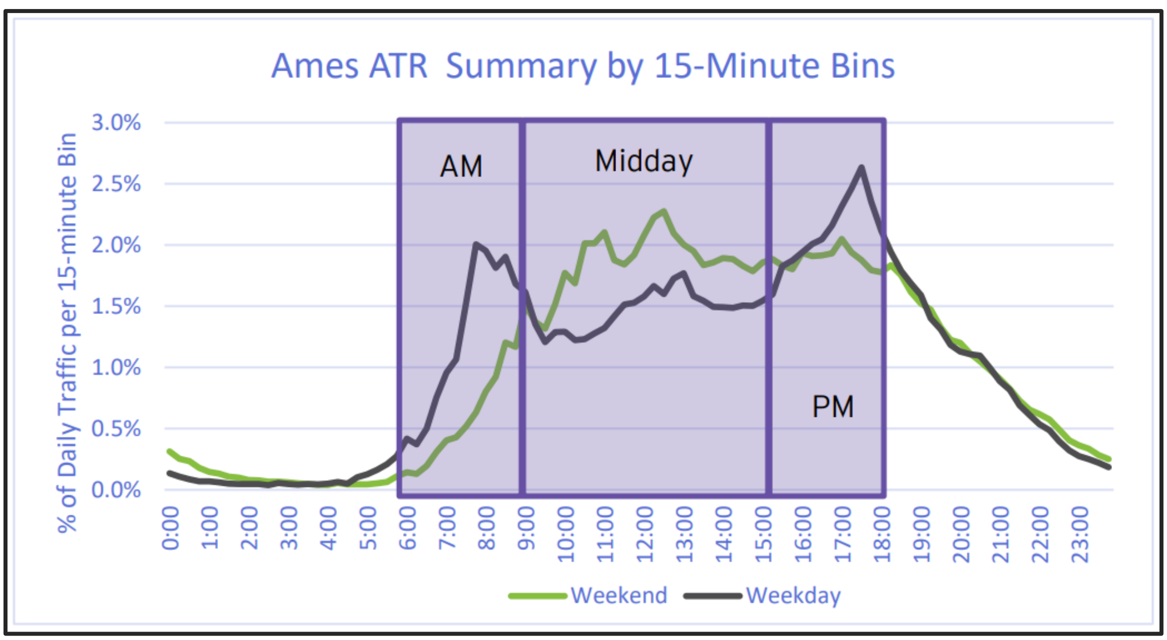


Figure 4-2: Peak Periods Defined by ATR Data



Survey data was also used to develop default ISMS time of day parameters for various elements of the ISMS process including trip production and attraction rates, which are described in Sections 4.12 and 4.13 respectively. These default values should provide a reasonable starting point for model development. Adjustments to default values should be made if validation results identify discrepancies between observed and estimated travel.

While re-estimating model time of day parameters from a household survey is best practice, that may be difficult because there are often too few survey observations to fill in all the cells by purpose and land use. Adjustments to default values rather than complete re-estimation may yield more direct usable rates. Hourly traffic count data may be sufficient for getting time period factors.

Traffic generator counts are useful in developing land use specific adjustments to be made to time of day trip rates. With a large number of link counts, patterns of repeated over or under assignment may become evident by particular nearby land uses.

VALIDATION DATA

ITE trip generation manual provides valuable data on peak hour-specific trip rates along with daily trip rates for select land uses, including some weekend-specific data. Work shift schedules for major employers provides insight into time of day patterns. Other data sources available from vendors include AirSage and StreetLight data. Some of this data is available from the Iowa DOT such as the StreetLight Origin-Destination data.

Directional traffic counts by 15-minute bins provide a validation data set for traffic assignments by time of day, as shown in Figure 4-3. Hourly count data typically shows similar trends and may be used if 15-minute data is not available, even if they are short-term counts. Note the marked difference in traffic patterns between weekday and weekend. A summation of weekday and weekend patterns for 13th Street in Ames is shown in Figure 4-4.

Figure 4-3 Hourly Traffic Flows, 13th Street in Ames

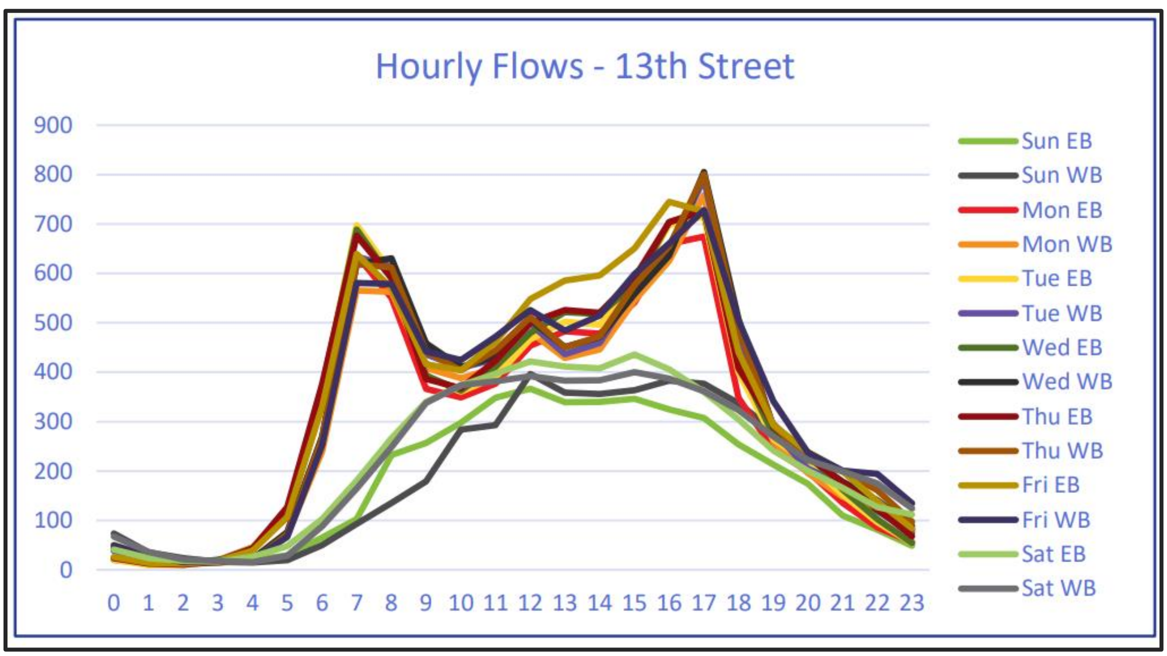
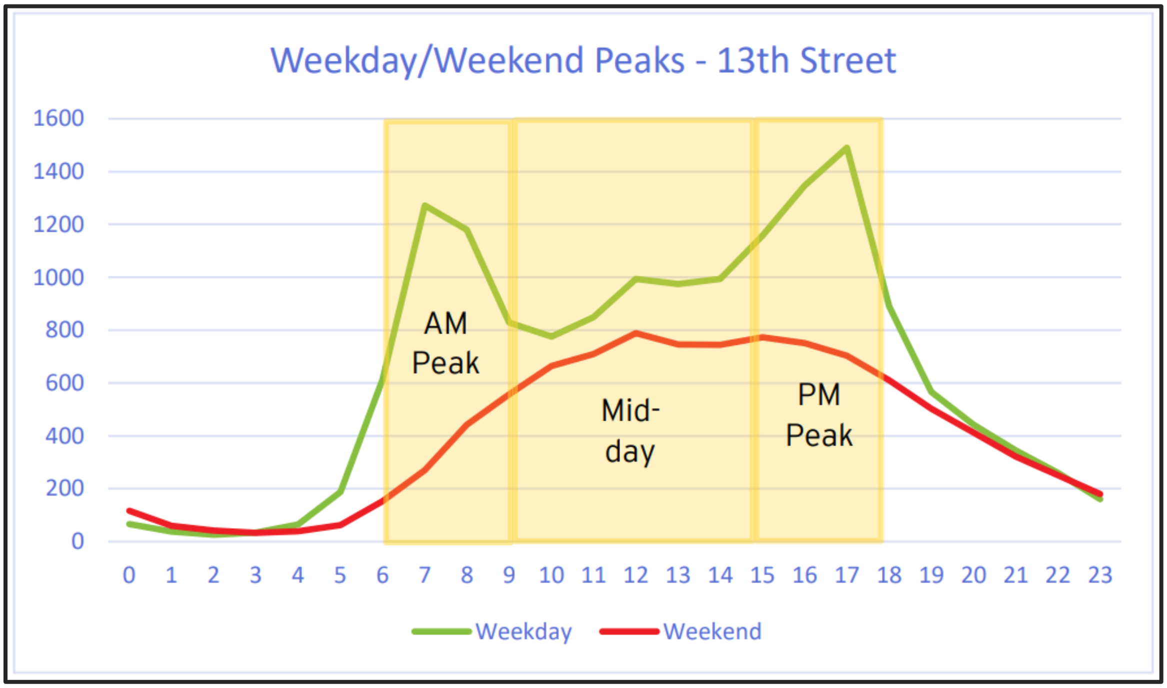


Figure 4-4: Figure 4 4: Peak Periods Defined by Traffic Counts



The MPT should also inventory traffic generators that display unique time of day characteristics, such as multi-shift manufacturing, night schools and other special purpose facilities (airports, hospitals, regional recreation, universities). Changes to the time of day factors for these generators should be incorporated through modifications of the existing land use code specific factors as shown in **Error! Reference source not found.** and **Error! Reference source not found.**. Alternatively, additional land use codes may be developed to facilitate inputting time-of day factors specific to the unique generator.

OUTPUT DATA

If modifications to time of day definitions are made, various ISMS model elements will require modification, such as hour to period capacity adjustments, transit route attributes, external data time periods, etc. Maintaining the defined time of day definitions is encouraged due to the ISMS architecture including three time-of-day periods as a recommended default, thus, deviations must be discussed with MPT prior to implementation.

If sufficient TOD count data exists to support changing or development of new TOD periods, this can be done. It is recommended that the MPO discusses if changes to ISMS time periods are needed for their specific context. Also, the MPT can make the determination about whether the count data is available to support such a change to the TOD periods.

Site specific time of day data including traffic counts, speeds and trip generation data may be used in subsequent tasks to modify specific model parameters. For example, hourly traffic count data on a road that serves as the only access to and from a school provides a reasonable benchmark for modifying the time of day factors for the specific school land use code.

4.3.4 ISMS Application

Default time of day constants for each land use code, time period and weekday/weekend combination are available, as shown in **Error! Reference source not found.**. These constants may be modified to improve the model's representation of the land use, consistent with the inventory of unique generators and DOT guidance. An optional fourth time period may be utilized within the ISMS prototype. The off-peak values shall be proportioned to represent midday (maintained as OP) and night (NT). Changes in time of day constants should be conducted in increments (roughly 10-20% per model run) to verify the change in input resulted in the intended change in output.

4.3.5 Calibration, Validation and Reasonableness Checking

Unique traffic generators shall be reviewed against available local data, and the constants used in the ISMS model modified as best replicate the observed condition.

Ensure total activity across the three or four time periods summarizes to the total daily activity (AM period plus PM period plus Off-peak period equals 1.0).

Available hourly traffic count data shall be used as a validation check for the land use specific time of day constants. Initial traffic assignments from the ISMS process will generate link-specific model assignments which are compared to period-specific traffic count data. While many links will have traffic generator from a multitude of land use codes, patterns may emerge to indicate that zones with specific land use codes are typically associated with links that are consistently over or under assigning traffic compared to observed counts.

4.3.6 Future Year Considerations

No changes in time of day elements are anticipated with future year analysis. Consult the MPT if conditions change that may warrant a change in constants.

4.3.7 Documentation Standards

An inventory of specific traffic generators that display unique time of day characteristics shall be included in the model documentation, including distinguishing features of the generator, the change in model constants used in ISMS and a narrative of the results of the ISMS application.

During subsequent steps in the ISMS process, additional modifications to time of day constants may become apparent. Any changes in constants shall be documented including rationale for the modifications.

4.3.8 Quality Assurance and Control

MPO staff are responsible for obtaining data to justify modifications to the ISMS default time of day constants. The MPT shall review the resulting constants for reasonableness.

4.4 Parcel Data and Land Use Codes

4.4.1 Overview

Travel demand models rely on data about economic activity to predict transportation decisions and trip generation. In residential areas the number of housing units determines trip-making potential. In non-residential areas economic activity can be represented by a number of possible indicators including employment, building area, and land use area. A small number of specialized activities can be more accurately measured by more specific indicators such as student enrollment, hospital beds, or air passenger enplanements.

Employment-based models usually obtain base year employment data from private vendors who provide databases listing each employer with a number of attributes including:

- Employer name
- Employer address
- NAICS code which describes the type of economic activity of the employer
- Geographic coordinates of the employer location derived from the employer address and a geographic reference file

NAICS codes are often grouped into a small number of categories such as retail, service and industrial for use in travel demand models. Employment is used to determine both the number of commute trips and the number of other trips generated by the employer. For example, at shopping centers employment is used to determine shopping trips in addition to work trips by employees.

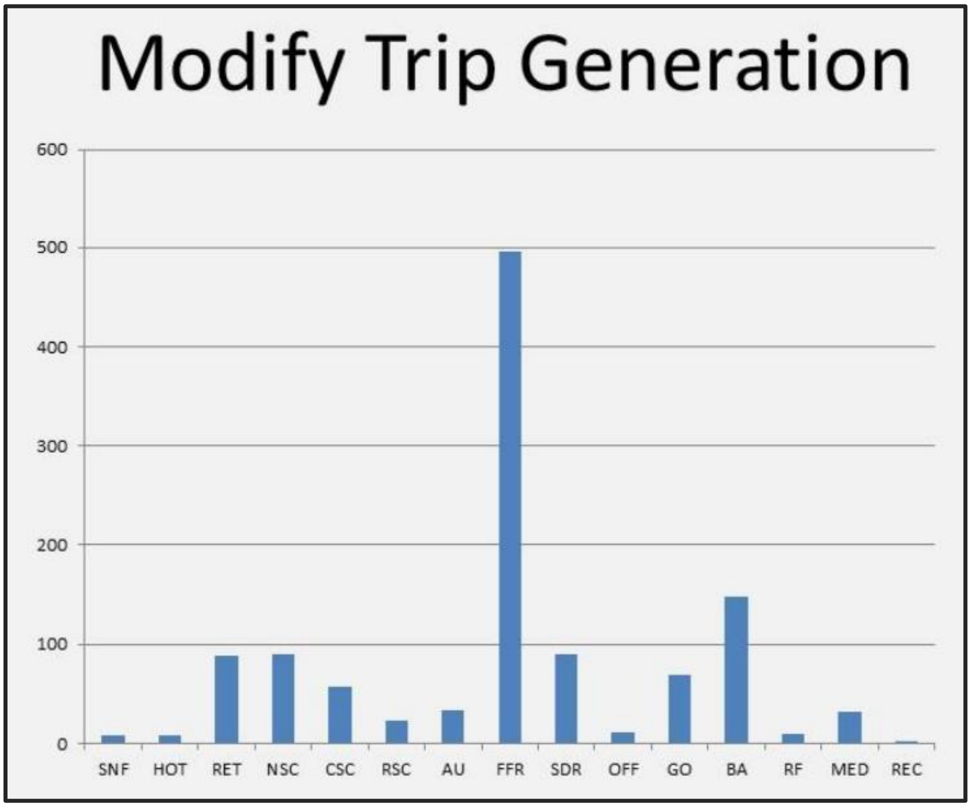
Building area can be obtained from parcel data maintained by local governments for tax assessment purposes. Parcel files often have a large number of attributes, the fields that are required for use in the model are:

- Parcel address
- Building use
- Building area (commercial parcels)
- Residential units (residential parcels)
- Geographic coordinates of the parcel based on a parcel GIS file

Building area can be used directly to determine non-residential trip generation. Alternatively parcel employment can be estimated by applying employment density assumptions and then trip generation can be determined using employee-based trip rates.

The ISMS team used the AAMPO (Ames, IA) model as a test case to evaluate the strengths and weaknesses of the employment and parcel file as inputs to trip generation. The test developed trip attraction rates using parcel data by land use type, as shown in Figure 4-5. These rates were subsequently used to develop trip tables and traffic assignments. Network links that were primarily serving one land use type where then reviewed for reasonableness against traffic counts to further refine and validate the trip rates. This flexibility in adjusting trip rates to observable data is a major benefit to the parcel approach. Additional details of the assessment are available in Section 5.2.1.

Figure 4-5: Trip Attraction Rates by Select Land Use Code



Based on the results of that comparison it is recommended that the standard model architecture make use of parcel data for the following reasons:

- Parcel data is generally very accurate since it is used to collect property taxes
- Building use codes are very detailed and can be aggregated to land uses that better reflect trip generation potential as opposed to a small number of employment categories
- Locational accuracy is very high since coordinates are obtained directly from a GIS file rather than through an address matching process
- Parcel data is readily available, often without charge, from tax assessment agencies/local County GIS departments and can reduce data collection costs

In lieu of available parcel data, the model development team may opt to utilize traditional housing and employment data for the purpose of generating trips. The ISMS script does not include a process of estimating trips outside of the parcel process, however, trip productions and attractions estimated outside of ISMS but formatted consistent with ISMS trip generation outputs may be used as input to subsequent steps in the ISMS process.

4.4.2 Recommended Architecture

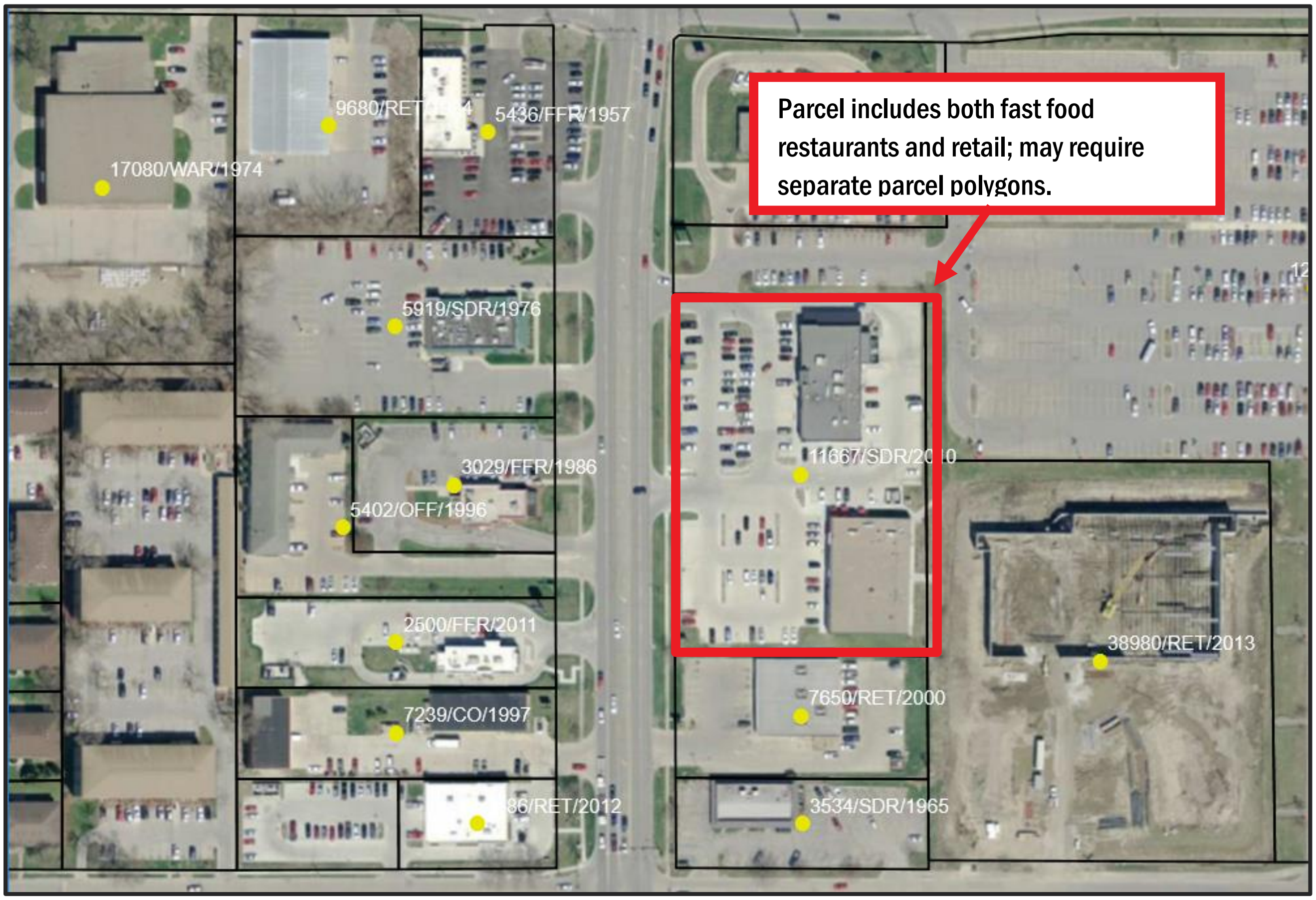
After identifying parcel data as the recommended source for estimating trip generation potential, the ISMS project team investigated alternative methods for assembling, storing, and making use of parcel data as a part of the travel demand modeling process. The following approach is recommended.

A single GIS Model Parcel File should be developed for each MPO which would be derived from various parcel files maintained by property tax agencies/local Counties within the MPO. Many MPOs are made up of more than one county which would be separate tax assessment agencies. Major cities may also maintain parcel files separate from the county in which they are located. For any MPO that has jurisdiction outside of Iowa, please note that extra time may be needed to obtain data and clean it up so that the merger can take place.

The ISMS model uses the TAZ attribute entered into each individual parcel record to perform an aggregation of data from the parcels to the TAZ's during run time. Edits to the parcel data are therefore done once during model development, and data is subsequently pulled and joined to the TAZ layer at run time.

In addition to merging multiple files, a number of parcel edits will facilitate the use of parcel data within the modeling process. Condominium developments often have "stacked" polygons for each condominium unit. Duplicate polygons can be deleted leaving only one base polygon for each location or maintained as separate polygon records. The critical issue is to ensure this land use isn't double counted (in the AMT field) and only one record is summarized for each condominium unit. Some large sites will be made up of multiple parcel polygons. These parcels should be merged into one polygon for each site. As far as possible, efforts should be made to ensure that the individual parcel address information is retained and is left unchanged. Additional fields in the parcel data may be maintained to aid in linking the ISMS parcel input data with the original parcel data file. Finally, some large parcels should be split into multiple parcels. For example, parcels in rural areas slated for development may need to be subdivided to reflect future trip generation potential. In addition, some existing parcels may be made of more than one land use which would be better represented by splitting parcels, as shown in Figure 4-6

Figure 4-6: Parcel Edit Example



Error! Reference source not found. of Appendix I lists the standard land use codes (LUC) recommended as part of the standard architecture, including a description of each in **Error! Reference source not found.** of Appendix I. More than 70 land use codes have been identified which can be grouped into the following nine broad categories:

- 10-12, Single family residential
- 20 -28, Multifamily and special residential
- 30-39, Industrial
- 40-45, Transportation
- 50-59, Commercial
- 60-69, Office, service
- 70-79, Institutional
- 80-89, Educational
- 90-99, Low intensity

Additional land use codes 303, 304, 305, 306, and 308 have been identified to code future year land uses where detailed land use codes may not be available.

During the process of assigning LUC's to parcels, development of a crosswalk table relating local coding convention to the recommended ISMS LUC is highly recommended. This table will streamline future data updates and provide a documentation source for the development of the parcel data.

Appendix I details the land use codes and the predictive variables to be assigned to each parcel. For most cases build area is measured by thousands of square feet (KSF), with the results entered in the amount (AMT) field. School enrollment is a more accurate measure of school trip generation and enrollment and should be coded in the "AMT" fields for school land uses. The trip generation potential of a number of low-generating uses such as parks, golf courses, and extractive industries use acres as the predictive variable. Residential uses can be grouped into a single residential use (LUC=10) or identified with more detailed residential uses (LUC=10-24).

Parcel attributes also need to be standardized into the recommended fields as shown in Table 4-2. Note that most parcels will either have housing units or the amount of non-residential activity. Housing includes all housing unit, not only occupied units. Mixed-use residential/non-residential parcels would be coded with the non-residential use, amount of non-residential activity, and number of housing units. Mixed-use non-residential parcels would either be coded with the predominate non-residential use or split into multiple parcels where necessary.

The Model Parcel File will be used to specify base year land use as well as future year land use changes. Fields are repeated to enable future year land use coding.

Planned land uses can be coded with as much detail as is available. It may be appropriate to code site plans and approved subdivisions with the detailed land use codes 10-99, as is done in Appendix I. Longer range plans may be coded with more generalized codes 303, 304, 305, 306, and 308.

4.4.3 Data Sets

INPUT DATA

The type and structure of parcel data can vary by MPO and property tax agency, however, there are usually two components: 1) a GIS file of parcel boundaries with summary parcel data, and 2) residential and commercial property tax records linked to the GIS file though the parcel identification number (PIN). There are various GIS repositories with parcel files but it is best to work directly with local agencies. Parcel data is continually being updated so it important that the GIS layer is consistent with property tax records. The MPO shall work with local agencies to obtain the data needed to populate the attributes of each parcel as defined in Table 4-2.

School enrollment by school site and grade level is available from the Iowa Department of Education. [6] A geocoding process will be necessary to assign coordinate locations to schools based on the school building address.

[6] Iowa Department of Education - https://www.educateiowa.gov/education-statistics

Future year data is input within the parcel data file, which allows up to 2 changes in the land use within the parcel. The future data is denoted by the year of change, new land use code, amount of new development and number of housing units. Future year land use codes are provided that are more generic in nature, allowing for flexibility in application to loosely defined development plans. In the event a land use forecasting model is being utilized, additional steps may be needed to first aggregate developable space to the TAZ level, then disaggregate forecasted growth at the TAZ level back to the developable parcels within each TAZ.

Table 4-2: Parcel.Bin Parcel File Attributes

ATTRIBUTE NAME	FORMAT	RESPONSIBLE PARTY	DESCRIPTION
SEQID	Integer	MPO	Sequential identification number, user assigned sequential identification number for each parcel
PFILE	Integer	MPO	Parcel file identification number, unique number of the parcel file source for MPOs with multiple tax assessment agencies
PID	Integer	MPO	Parcel identification number, unique number to assign each parcel by the tax assessment agency
PIN	Integer	MPO	Parcel identification number, often a fifteen-digit parcel id number used by tax assessment agencies
ADDNUM	Integer	MPO	Parcel address number of the address (maybe included in the "ADDNAME" field)
ADDNAME	Character	MPO	Street name of the parcel address
ADDCITY	Character	MPO	City of the parcel address
ADDZIP	Character	MPO	Zip code of the parcel address
DEEDHOLDER	Character	MPO	Optional: Parcel owner
CLASSCODE	Integer	MPO	Broad parcel type used to identify agricultural, residential, commercial and exempt parcels in the original parcel file
OCCODE	Integer	MPO	Occupancy or building use code for the parcel from the original parcel file
ACRES	Real	MPO	Acres of the parcel
YEAR	Integer	MPO	Year parcel structures were built based on fields in the original parcel files

ATTRIBUTE NAME	FORMAT	RESPONSIBLE PARTY	DESCRIPTION
LUC	Integer	MPO	Generalized land use code (see **Error! Reference source not found.**) assigned to a parcel based on fields in the original parcel files
LUNAME	Character	MPO	Name of land use code
HU	Integer	MPO	Not Used Currently
AMT	Real	MPO	Number of existing housing units on the parcel
OCC	Real	MPO	Existing occupancy factor for the parcel (default assumption is that parcels are fully occupied but users can modify this assumption based on local knowledge)
YEAR1 (-) YEAR2 (-)	Integer	MPO	Year parcel structures are anticipated. Two fields provide for up to two future modifications to parcel's structure.
LUC1 (-) LUC2 (-)	Integer	MPO	Generalized land use code (see **Error! Reference source not found.**) for up to two future parcel structure modifications.
HU1 (-) HU2 (-)	Integer	MPO	Number of future housing units on the parcel for up to two future parcel structure modifications.
AMT1 (-) AMT2 (-)	Real	MPO	Amount of future non-residential activity on the site (see **Error! Reference source not found.**) for up to two future parcel structure modifications
OCC1 (-) OCC2 (-)	Real	MPO	Future occupancy factor for the parcel for up to two future parcel structure modifications.
X	Real	MPO	X coordinate of parcel centroid
Y	Real	MPO	Y coordinate of parcel centroid
TAZ	Integer	MPO	TAZ the parcel lies within

NOTE: (-) indicates attribute has entries for future year-specific updates. Only non-zero values in these columns will be used directly in future year analysis.

ESTIMATION DATA

No estimation data is applicable.

VALIDATION DATA

No data source is 100% accurate. It is recommended that as many different data sources as possible be used to cross-check data, identify inconsistencies, and make corrections where errors are found. These data sources could include:

- Digital aerial photography
- Internet searches
- US Decennial Census block level housing unit counts
- Iowa Workforce Development (IWD) data, ES202 employment files
- Private vendor employment files (Infogroup, Woods and Poole)
- Building footprint GIS files
- Household travel survey files
- Site inspections and contacts with building owners/occupants

OUTPUT DATA

Once the parcel data has been corrected, the TAZ boundaries are established and numbered, as described in Section 4.4.1. Most parcels are small in size and would correspond closely to TAZ boundaries but can be subdivided where necessary. The ISMS prototype produces a summary of activity for each land use code located within the TAZ. A portion of an example output file is provided in Table 4-3. Here TAZ 1 has 94 KSF of hotel use (LUC = 26), 4 KSF of warehousing use (LUC= 32), and so on. **Error! Reference source not found.** and **Error! Reference source not found.** describe the land use codes (LUC) and predictive variable units in more detail.

Table 4-3: Portion of Example Parcel to TAZ Summary Output File (WDAMTEMPLU.BIN)

TAZ	LU	AMOUNT
1	26	94
1	32	4
1	34	8
1	50	48
1	56	6
1	59	12
1	60	5
1	93	28
2	63	25

Developing TAZ land use data sets for each model scenario should be discussed as a major work task during the model kick-off meeting, as it will involve the following major functions:

1. Develop an initial MPO Model Parcel File with the structure and codes described above.

2. Conduct a detailed base year parcel file validation exercise using the validation data sources described above, including comparing the percent of the regional total square footage from each of the various land use codes, comparing the largest parcels by developed space against aerial photography and local knowledge, and comparing employment and work force development data to parcel data.
3. During the model execution, the base year land use data gets aggregated at the TAZ level for input to the trip generation model.
4. Execute the base year travel demand model. Examine land use coding adjacent to roads with large discrepancies between traffic counts and model-estimated counts. Correct base year land use coding where errors are identified.
5. Identify parcels available for new development, redevelopment or in-fill and assign planned land use codes. Develop future year TAZ level land use files by determining the developable spaces within each TAZ, then allocating growth by forecast year to the developable parcels based on land use plans, development density assumption, phasing assumptions and local knowledge. This data is input within the parcel data file, which allows up to 2 changes in the land use within the parcel, denoted by the year of change, new land use code, amount of new development and number of housing units. Future year land use codes are provided that are more generic in nature, allowing for flexibility in application to loosely defined development plans.
6. Conduct periodic updates to the model parcel file to reflect on-going development and plan revisions. These updates could be made on an annual basis as a routine MPO task. At a minimum, the file would need to be updated before an update of the Long-Range Transportation Plan.

Developing and validating an initial Model Parcel File is the most resource intensive part of the process. As described above, Property Tax Assessor/local County offices maintain files with information about parcels used to calculate the assessed valuation of the parcel. These files are linked to the GIS parcel files through the PIN field. There are usually two property tax files, one for commercial parcels and the other for residential parcels.

Commercial parcels include non-residential uses and apartment buildings. Records contain fields describing the building occupancy use, building area, and number of units in apartment buildings. While the purpose of building occupancy codes is to calculate assessed valuation, these codes also provide detailed information useful for calculating trip generation. Occupancy use coding schemes differ between assessor offices and it is necessary to develop cross reference tables to convert occupancy codes into trip generation land uses shown the Table 4-3.

Some parcels will have more than one building which may have different uses. For example, a manufacturing site might have an office building, a manufacturing plant and a warehouse building. Coding multiple parcel land uses adds complexity and it is recommended that a single parcel land use be determined based on the use with the most building area. Parcels can be subdivided to delineate individual uses if necessary. Alternatively, additional mixed-use land use codes can be added.

After processing commercial property tax records, parcel GIS files can be updated with the parcel land use codes, such as building area, number of units, and year built. In some cases, a property tax record may identify a commercial building without a corresponding commercial parcel in the GIS file, or conversely a commercial use in the GIS file without a commercial building record in the property tax file. These mismatches between tax records and parcel files will need to be identified and resolved. It is also important to correctly process building area fields. There may be fields identifying parking levels which should not be included in trip generation building use calculations. Mixed use parcels with ground floor commercial uses and upper level residential uses should not include residential building area since residential uses will be accounted for by housing unit counts.

Most travel demand models obtain housing unit counts from decennial US Census block counts, however, parcel level housing units provide greater geographic detail, enable updates to housing unit estimates on an annual basis, and provide additional housing unit information such as building area, number of bedrooms and assessed valuation. It is therefore recommended that residential property tax records be used to obtain parcel level housing unit counts. It should be noted that property tax records usually do not include housing unit counts for mobile home parks. It is recommended to create a GIS point file for each mobile home to include these units in parcel level housing unit counts. While population data is not a direct input into the ISMS process, it does form a logical reasonableness check. It is suggested to apply household occupancy rates to the parcel developed housing data to validate the regional population estimate from the model data against known regional totals.

Some parcels are exempt from paying property taxes such as government owned parcels and parcels owned by religious organizations. These parcels have an "exempt" classification code. A manual editing process will be necessary to code land uses on exempt parcels which can include transitional housing (27), government office buildings (61), libraries (64), post offices (65), police/fire stations (66), religious uses (68), other public uses (69), schools (80-84), parks (93-94), and vacant uses (99) such as utility easements, parcels adjacent to road rights-of way and designed open space.

Once an initial Model Parcel File has been developed for an area it is recommended that the file be periodically updated, perhaps semi-annually. Potential updates can be identified by changes to parcel GIS files and/or property tax records. After verifying potential changes with digital photography, the Model Parcel File can be updated to reflect changes, and then implemented into the model to test the results, after coordination with the Iowa DOT. While every change in parcel data does not warrant a revalidation of the official model and a new model version release, the impacts of the new data should be understood and shared with model users for consideration in their modeling efforts.

Parcel file updates and planned land use assumptions can be facilitated by monitoring local government development approval process which can identify areas of expected development.

Obtaining, cleaning and validating the parcel data will require substantial effort, which should be closely reviewed by MPO staff.

4.4.4 ISMS Application

The ISMS model specifies the parcel file as an input to the model process. The summary file including activity by land use code per parcel is produced for subsequent use.

4.4.5 Calibration, Validation and Reasonableness Checking

A relatively low resource validation effort would use a GIS application to pan through parcels labeled with land use showing digital aerial photography in the background. Parcels where photography appears to be inconsistent with land use coding can be checked with internet maps to correct land use codes.

A more detailed base year parcel file validation exercise includes comparing the percent of the regional total square footage from each of the various land use codes, comparing the largest parcels by developed space against aerial photography and local knowledge.

More rigorous and focused validation efforts are possible by comparing parcel data with secondary sources. At a minimum 2010 parcel housing units should be aggregated to Census blocks and compared with 2010 Decennial Census housing units. Blocks with large discrepancies should be identified and corrected as necessary.

A limited number of MPOs will have building footprint files and/or household travel survey files that can be used to verify parcel data.

Reasonableness checking of parcel data includes the following checklist:

- Verify that parcel GIS data is in a usable projection to match with Census tract data and Iowa DOT RAMS data. This may require additional GIS tools such as ESRI's Arc products.
- Verify that building square footage is reasonable by comparing data with other MPOs in terms of non-residential building area to total area of the MPO and non-residential building area to housing units in the MPO.
- Review the distribution of building area by land use code for reasonableness with other MPOs.

4.4.6 Future Year Considerations

The parcel database is designed to accommodate two changes in land use, type and magnitude. Scenario analysis that includes changes in land use type or magnitude should be conducted through the use of a scenario parcel file and stored in the /Outputs/1 TripGeneration folder of the model directory.

4.4.7 Documentation Standards

Parcel data shall be documented by summarizing the regional square footage of each land use code across the MPO region, and by additional geographic extents as deemed necessary, such as by city, county or state.

A crosswalk table between local land use codes and the ISMS LUC shall be developed.

A summary of quality control steps taken to verify accuracy in the parcel data.

4.4.8 Quality Assurance and Control

A thorough review of the parcel data is recommended as part of the ISMS recommended architecture. It is also acceptable to have an independent local agency that is familiar with the parcel data review the file. This is not a common practice, however there could be some benefit if time allows.

4.5 Transportation Analysis Zone Development

4.5.1 Overview

A transportation analysis zone (TAZ) represents the geography within which economic activity occurs that results in the movement of people and freight. The ISMS model uses a standard TransCAD Version 7 area geographic file to represent the TAZ structure. The TAZ geographic structure is developed during the model development phase, and is subsequently used with no modification in model application unless in special circumstances. Attributes of the TAZ may be modified as part of model application.

4.5.2 Recommended Architecture

TAZ development should incorporate the following guidance and standard practices as applicable:

- Utilize Census and parcel geography to facilitate exchange of data
- In cases of conflict between Census and parcel geography, review for mapping errors. Parcel data is a direct input while Census data is used to apply demographics, therefore use parcel boundaries if geographic differences persist.
- Size zones to result in similar levels of activity across most zones; consider future land use projections which may require zones with low levels of existing activity
- Separate housing and non-housing activity if feasible
- Consider zones specific to special generators
- Avoid including barriers (rivers, rail lines, major roadways, etc.) within the TAZ
- Consider proximity to transit stops; consider developing zones within walking distance to transit
- Consider joining areas on either side of minor roadways into one zone if land uses are similar
- Maintain continuity of a TAZ border with various administrative boundaries including but not limited to county and city areas as well as CTPP TAZ boundaries
- Eliminate gaps and overlaps in the TAZ boundaries
- External TAZs should be located at every single-entry point into the model planning boundary (even on roads that are not modeled such as gravel/B-roads)
- TAZ numbering begins with the External TAZs with a value of 1 and continuing until all externals are accounted for. If the amount of External TAZs exceeds 100, the VB Macro used for the external analysis process will need to be modified. Further numbering can follow any scheme that is desired by the MPO, but an easily distinguishable method should be devised. Allow separation between Externals and Internals. i.e. Bi-State Regional Commission method: Externals numbered 1-86, Iowa Internal TAZs numbered 1000-1994, and Illinois TAZs numbered 2000-2800.
- Order zones by ascending order of area and review reasonableness of smallest and largest zones
- Test for unanticipated geography by creating a centroid for each TAZ, then tag the centroids with TAZ number to verify consistency (avoid 2-part areas, highly concave TAZ, etc.)

The TAZ.DBD's attribute table file's attributes are outlined in Table 4-4.

Table 4-4: TAZ.Bin File Attributes

ATTRIBUTE NAME	FORMAT	RESPONSIBLE PARTY	DESCRIPTION
ID	Integer	Auto-generated	Unique identification value for each TAZ in the database
Area	Real	Auto-generated	Area of TAZ in square miles
TAZ	Integer	TBD	Unique identification value for the Transportation Analysis Zone
HH	Real	Model-generated	Summation of the total number of housing units (occupied and unoccupied) in the TAZ
KSF	Real	Model-generated	Summation of the square footage of non-residential buildings with the TAZ (in thousands)
Density	Real	Model-generated	Unit of economic activity within the TAZ – (HH+KSF)/Area: 0-500 = Low density 501-2000 = Medium density 2001 or more = High density
CTPP	Real	TBD	Used to store the CTPP TAZ GEOID10 identification number for transfer of cross-classification data. If a TAZ falls within more than one CTPP TAZ, use the CTPP TAZ that mostly closely matches the characteristics of the MPO TAZ
Prod_Hold	Integer	TBD (See Section 4.16)	Flag to hold the productions calculated at the TAZ constant through the trip balancing process 0=Balance 1=Hold Constant
Attr_Hold	Integer	TBD (See Section 4.16)	Flag to hold the attractions calculated at the TAZ constant through the trip balancing process 0=Balance 1=Hold Constant
EXTERNAL	Integer	TBD (See Section 4.16)	Indicates whether a TAZ is an external TAZ or not. 0 or Null = Internal TAZ 1 = External TAZ
District	Integer	TBD (See Section 4.19)	The K factor district of the TAZ, value of 1 to 50.
Park_cap (-)	Integer	TBD (See Section 4.20)	Public parking availability and capacity: -1 = No parking 0 = No restrictions (unlimited parking) >0 = Capacity of parking within the zone

ATTRIBUTE NAME	FORMAT	RESPONSIBLE PARTY	DESCRIPTION
Park_Cost (-)	Real	TBD	Cost in dollars to park for general public. See Section 4.20 for details.
UPark_Staff_Cap (-)	Integer	TBD (See Section 4.20)	University Staff parking availability and capacity: -1 = No parking 0 = No restrictions (unlimited parking) >0 = Capacity of parking within the zone
UPark_Staff_C	Real	TBD	Cost in dollars to park for University staff. See Section 4.20 for details.
UPark_Stud_Cap	Integer	TBD (See Section 4.20)	University student parking availability and capacity: -1 = No parking 0 = No restrictions (unlimited parking) >0 = Capacity of parking within the zone
UPark_Stud_C	Real	TBD	Cost in dollars to park for University students. See Section 4.20 for details.
Offcampus_20xx	Integer	TBD	Number of off-campus university students that live outside of the model area and would be anticipated to enter the model area from the respective external station
TRANSIT	Integer	TBD	Transit availability for zone: 0 = No transit 1 = Limited transit 2 = Dense transit (Typically CBD and Campus areas) See Section 4.23 for details.
PROJNO1	Integer	TBD	Project number for the first implemented parking modification in the TAZ; used to join to the project master list. See Section 4.10 for details.
PROJNO2	Integer	TBD	Project number for the second implemented parking modification in the TAZ; used to join to the project master list.
PROJNO3	Integer	TBD	Project number for the third implemented parking modification in the TAZ; used to join to the project master list.

NOTE: (-) indicates attribute has 3 subsequent entries for project-specific updates. Only non-zero values in these columns will be used directly in project analysis.

Verification of a TAZ data set is the responsibility of the project development team. The development of the data may be conducted by DOT or other, and includes a TransCAD geodatabase containing all internal and external TAZs for the model area as defined in Table 4-4. The MPO boards may be the final approver of the TAZ structure.

TAZ's representing the external stations should be developed, providing a graphical reference for mapping of activities associated with the externals. Additionally, the number of off-campus students entering the model area at each external is included in the data as described above.

The household classification data processing effort shall be reviewed by the model development team. The process is outlined below.

Include field metadata information within the TAZ file.

4.5.3 Data Sets

INPUT DATA

The ISMS recommended input data sets for TAZ development are Census Block geography and parcel data (which is subsequently used for trip generation.) Parcel data and parking capacity attributes described in Table 4-4 are outputs of the Parcel development process described in Section 4.3 and the parking capacity process described in Section 4.20.

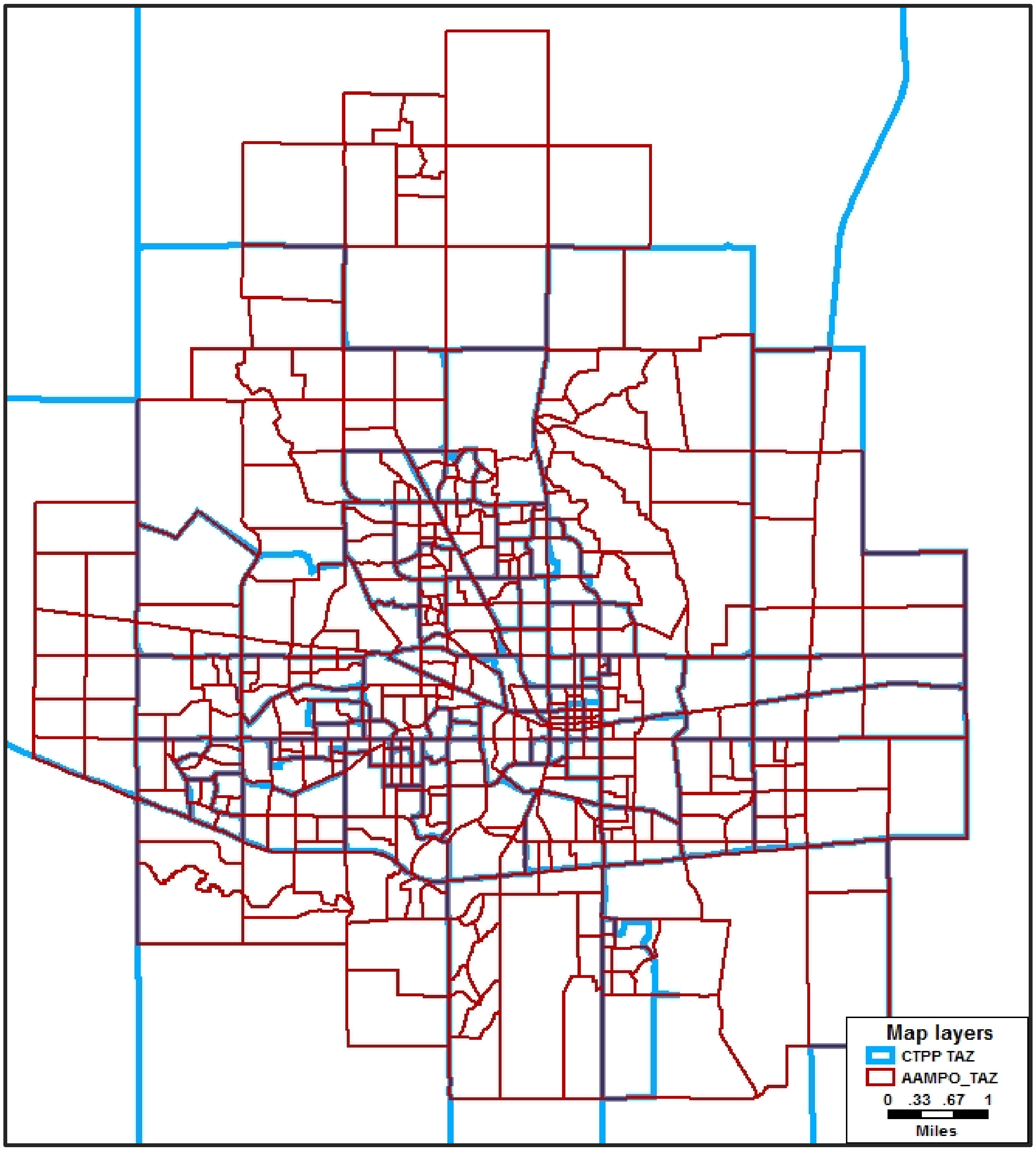
Household cross-classification data is available from the Census Transportation Planning Package (CTPP) website. The ISMS model assigns trip making characteristics of households based on the classification by the income and the number of occupants in the household. ISMS quantifies low income households as having less than $35,000 of income in the last 12 months, middle income households between $35,000 and $100,000 of income in the last 12 months, and high-income households as having more than $100,000 of income in the last 12 months. Household size is quantified into one, two, three, and four or more occupants. This data is available from the CTPP A112208C file (https://www.fhwa.dot.gov/planning/census_issues/ctpp/data_products/2006-2010_table_list/sheet02.cfm), which provides the number of households classified by the income and number of occupants at CTPP TAZ level.

Processing the A112208C file may be completed using Microsoft Excel, and should only need to be completed once for the base year model set. The income levels of the CTPP data must be consolidated to match the ISMS income categories. Add a new field within the Excel file titled *Income*. Using the Filter function, select *Household Income in the Past 12 Months* fields with a value of less than $35,000, then populate the *Income* field with a value of 1. Repeat process for $35,000 to $100,000 with a value of 2, and finally a value of 3 for more than $100,000. Select all records, then unselect the records with "Total Households" as the value of the *Household Size 5* field and the records with "Total, household income" as the value of the *Household Income in the Past 12 Months* field. Copy the remaining records to a new sheet in the spreadsheet, then Insert<Pivot Table to add a Pivot Table to a new sheet. Select the *Residence* field, *Household Size 5* field, *Income* field, and the *Households* field. Calculate the percent of the total CTPP TAZ households that are within each Household-Income bin. Check for CTPP TAZ with zero households and less than fifty households to ensure reasonable percentages across the bins. CTPP TAZ with zero households may borrow the splits from neighboring zones, or use a default of 0.0833 for each bin (represents the hypothetical of even distribution across all 12 bins). Save this file for import into TransCAD. An Excel spreadsheet is available on the Iowa DOT's ProjectWise site as a reference for calculating the CTPP TAZ household characteristics data:

A statewide CTPP TAZ shapefile for assigning the household cross-classification data to the ISMS MPO TAZ's is also available at the locations above.

The CTPP TAZ shapefile's *GEOID10* field equates to the A112208C records. Typically, multiple ISMS MPO TAZ's will nest within one CTPP TAZ, as shown in Figure 4-7. While nesting is recommended, it is not required, the CTPP TAZ that best represents the characteristics of an MPO TAZ shall be selected. Tag the *CTPP* field within the TAZ table with the GEOID10 field.

Figure 4-7: CTPP and ISMS TAZ Nesting



ISMS recommends saving a copy of the TAZ table as a TransCAD binary file, named CTPP_percents.bin. Open CTPP_percents.bin within TransCAD, then modify fields as shown in Table 4-5. Open within TransCAD the file that was created previously in Excel that contains the percent of households in each CTPP TAZ. Join with CTPP_percents.bin using the CTPP ID, then populate each column in CTPP_percents.bin with the corresponding percentages.

Table 4-5: CTPP_percents.bin Household Classification Table Description

ATTRIBUTE NAME	FORMAT	RESPONSIBLE PARTY	DESCRIPTION
TAZ	Integer	TBD	Unique identification value for the Transportation Analysis Zone
CTPP	Character (length=18)	TBD	Used to store the CTPP TAZ GEOID10 identification number for transfer of cross-classification data.
SZ1_I1	Real	TBD	Percent of the total households within the CTPP TAZ that have 1 household occupant and are low income.
SZ1_I2	Real	TBD	Percent of the total households within the CTPP TAZ that have 1 household occupant and are medium income.
SZ1_I3	Real	TBD	Percent of the total households within the CTPP TAZ that have 1 household occupant and are high income.
SZ2_I1	Real	TBD	Percent of the total households within the CTPP TAZ that have 2 household occupants and are low income.
Pattern continues....			
SZ4_I3	Real	TBD	Percent of the total households within the CTPP TAZ that have 4 or more household occupants and are high income.

A portion of the household classification input file is shown in Table 4-6.

Table 4-6: Example CTPP_percents.bin ISMS TAZ Household Classification Table

TAZ	CTPP	SZ1_I1	SZ1_I2	SZ1_I3	SZ2_I1	SZ2_I2	SZ2_I3	SZ3_I1	SZ3_I2	SZ3_I3	SZ4_I1	SZ4_I2	SZ4_I3
1	1916900000001	0.4167	0.1667	0	0	0.4167	0	0	0	0	0	0	0
2	1916900000001	0.4167	0.1667	0	0	0.4167	0	0	0	0	0	0	0
3	1916900000001	0.4167	0.1667	0	0	0.4167	0	0	0	0	0	0	0
4	1916900000001	0.4167	0.1667	0	0	0.4167	0	0	0	0	0	0	0
5	1916900000003	0.25	0.5	0	0	0	0	0.25	0	0	0	0	0

Subsequent model years may warrant modifications to the household classification data. A separate file for future conditions may be developed, and formatted as shown in Table 4-6. Examples in which modification of the household classification data may be warranted include:

- Zones that are undeveloped in the base year that significant housing growth in future years.
- Zones that experience redevelopment, converting to housing or mixed uses.

- Forecasted changes in regional or local demographics, including scenario analysis of potential changes.

ESTIMATION DATA

A household survey may be used as estimation data for the household classification data.

VALIDATION DATA

Validation data includes transportation features such as roadways, railroads, natural features such as rivers and environmental corridors, and future conditions such as proposed land developments. These datasets will aid in determining zonal boundaries.

American Community Survey (ACS) data at the Census block group level may be used as validation of the household classification data. As described in Appendix G, there are 21 ACS tables of data which includes the total population and household size classification data.

4.5.4 ISMS Application

The user provides the ISMS Model with a TAZ geographic file. The TAZ file contains attributes used in the ISMS script for trip productions (Section 4.12), trip attractions (Section 4.12.4), trip balancing (4.17) and parking capacity (Section 4.20).

The CTPP_percents.bin file is created through the use of TransCAD and Excel, utilizing CTPP data and the MPO TAZs. The CTPP_percents.bin file is applied to each TAZ's total housing units to determine the number of households in each size and income bin. Future years may be alternative classification files that are included in the Inputs folder of the specific scenario folder.

4.5.5 Calibration, Validation and Reasonableness Checking

Calibration is conducted by summarizing the areas of the internal TAZ's and checking against the area of the MPO planning area.

Sort TAZ's by area, looking for zones with null and extremely small, or very large, areas for mapping issues.

Reasonableness of the TAZ size is best accomplished after trip generation data is associated with the TAZ's, and assessing the TAZ's for zones with extremely high and low total trip ends.

Join the CTPP_percents.bin file to the TAZ file and sort for mismatches in the join, such as TAZ with no CTPP data, or CTPP data not joined to a TAZ (while technically possible, it is unexpected that a CTPP area would be smaller than a TAZ).

Calculate the number of housing units within each of the cross-classification bins and compare the sum against the total sum of housing units from the parcel file.

Household characteristics should be validated regionally against American Community Survey (ACS) data.

https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=CF

Longitudinal Employer-Housing Dynamics (LEHD) data may be used to validate income-specific employment by geographic region, as discussed in Section 0.

4.5.6 Future Year Considerations

The TAZ structure should be maintained through all analysis years. In areas where future/planned development is anticipated, it is recommended that additional TAZs (with zero trip making activity for base year) be added with some dummy links to represent future networks and centroid connectors.

While the CTPP_percents.bin file is assumed to be static across analysis years, it may be modified to vary by analysis year, or by scenario by placing a modified version of the file in the Inputs folder of the scenario.

4.5.7 Documentation Standards

Mapping of the TAZ structure including the TAZ number is recommended.

Provide a table of each household characteristics data as an appendix in the model documentation, including the total percentage across the 12 bins. Describe in general terms the rationale for changes in the data over time.

4.5.8 Quality Assurance and Control

The model project team is responsible for reviewing and approving the TAZ structure as well as the household characteristics file with assistance from DOT staff.

4.6 Transportation Network Development - Links

4.6.1 Overview

The transportation network used for travel demand modeling is a simplified representation of the physical transportation network. Typically, this is represented within a computer model and includes roadways, transit routes, walking and bicycle facilities of some importance to the regional transportation system. The ISM model uses a standardized TransCAD Version 7 geographic file to store data about the transportation roadway network. The master geographic file contains geographic coordinates for both the nodes and links of the network, along with attribute tables for each. Network data for all scenarios, including base and future years, are stored in a single geographic file. Typically, all functionally classified roadways are included in demand model networks, along with roadways that provide local circulation to major traffic generators or could be used as cut-through routes around functionally classified roadways.

4.6.2 Recommended Architecture

The roadway links represent several different features including:

- Roadway driving lanes (including mixed use and off-peak parking facilities)
- Transit only lanes
- Pedestrian/bike only lanes

- Centroid connectors that roughly represent the local street network, providing access between centroids and the rest of the roadway network
- Transit walk links that represent walking routes between transit stops (transfers) or between centroids and transit stops (access/egress).

The master geographic network file (Master.dbd) contains both the links and nodes for the ISMS model. The geographic file may be developed from scratch within TransCAD, or imported into TransCAD from an existing geographic source such as TransCAD's street database or Iowa DOT's RAMS. The use of RAMS as a starting geography is recommended. Coordinate with Iowa DOT staff to acquire a geographic file containing RAMS datasets at outlined in Table 4-7. The extraction of RAMS data for developing the geographic file is described in Section 4.6.3.

Table 4-7: Master.dbd Roadway link attributes

ATTRIBUTE NAME	FORMAT	RULE	RESPONSIBLE PARTY	DESCRIPTION
ID	Integer	N/A	Auto-generated	Unique identification value for each link in the database assigned by TransCAD
Dir (-0	Integer	Copy	MPO verified	Directionality of the link: -1 = One-way link in the BA direction 0 = Two-way link 1 = One-way link in the AB direction
DIR1	Integer	Copy	MPO	First Year - Change in Direction
DIR2	Integer	Copy	MPO	Second Year - Change in Direction
DIR3	Integer	Copy	MPO	Third Year – Change in Direction
Length	Real	N/A	Auto-generated	Length of the link in miles (verify TransCAD is set up to calculate in miles, as subsequent values assume length is in miles)
NAME	Character	Copy	DOT provided from RAMS; MPO verified	Name of facility
SEC Name	Character	Copy	DOT provided; MPO verified	Secondary name of facility, such as state or county highway number
COUNTY	Integer	Copy	MPO	Number representing the county
JURIS	Character	Copy	MPO	Jurisdiction the facility is in (city name)
SYSTEM	Character	Copy	MPO	Jurisdiction controlling the facility (DOT, DNR, etc.)
Base_Construction	Integer	Copy	MPO/DOT	Optional: Determines if a link was under construction during base year. Consideration for model flows/counts. 0 or null = Normal operation 1= Under construction, flows/counts potentially impacted

ATTRIBUTE NAME	FORMAT	RULE	RESPONSIBLE PARTY	DESCRIPTION
AREATYPE (-)	Integer	Copy	DOT provided; MPO verified	Optional: User defined area type of link, used for reporting purposes only: 1 = Central business district 2 = Fringe business district 3 = Outlying business 4 = Residential 5 = Rural
FEDFUNC	Integer	Copy	DOT provided; MPO verified	Federal functional classification of facility, used for reporting purposes only: 1 = Interstate 2 = Other Freeway/Expressway 3 = Other Principal Arterial 4 = Minor Arterial 5 = Major Collector 6 = Minor Collector 7 = Local Note ramps coded consistent with connecting facility with highest functionality classification
FACTYPE (-)	Integer	Copy	DOT provides FEDFUNC; MPO to reclassify to more detailed FACTYPE	ISMS Functional classification of facility 0 = Not in existing model 1 = Interstate 2 = Freeway 3 = Expressway 4 = System ramp 5 = Service ramp 6 = Principal arterial 7 = Minor arterial 8 = Collector 9 = Minor collector 10 = Local 11 = Unpaved 12 = Centroid Connectors 13 = Bus only 14 = Walk link
MEDIAN (-)	Integer	Copy	DOT provided; MPO verified	Median type: 1 = Wide divided median (>20 feet) 2 = Narrow divided median (<20 feet) 3 = Center turn lane 4 = Undivided (all ramps assumed undivided)
ACCESS (-)	Integer	Copy	DOT provided; MPO verified	Level of access along link, measured in number of mid-block access points per mile: 1 = No access 2 = Low access (<5 per mile, per direction) 3 = Medium access (5-20 per mile, per direction) 4 = High access (>10 per mile, per direction)

ATTRIBUTE NAME	FORMAT	RULE	RESPONSIBLE PARTY	DESCRIPTION
				Data available from RAMS. Assume no mid-link access on Interstate and Freeway facilities
HPMSACCESS	Integer	Copy	DOT provided; MPO verified	HPMS-defined access level 1 = No access 2 = Partial access 3 = Full access See the info in the following link for more details: https://www.fhwa.dot.gov/policyinformation/hpms/fieldmanual/chapter4b.cfm#chapt4_4_3
FACILITY_CODE	Integer	Copy	Model-generated	Identifier based on the various link attributes: FACTYPE*100 + MEDIAN*10 + ACCESS
RSTRCT (-)	Integer	Copy	DOT provided from RAMS; MPO verified	Restrictions on link: 1 = No restrictions 2 = No trucks 3 = Trucks only
PSPEED (-)	Real	Copy	DOT provided from RAMS; MPO verified	Posted speed of facility in miles per hour
*_TMC_Code/ INRIXD Code	Character	Copy	DOT provided from RAMS or CTRE	Traffic Message Channel or INRIX XD code to join link to observed travel speed from INRIX data by time and day of week, either provided as a RAMS attribute or through data conversion process as described in Section 4.11.
*_SPEED_ADJ	Real	Copy	MPO/DOT	Modification of speed for calibration purposes. Value represents change from posted speed entered manually on a per link basis.
*_CNT	Integer	Blank	MPO†	Intersection control at end of link (directional attributes) 0 = No control 1 = Yield 2 = Stop control/roundabout 3 = Signalized control (sequential) 4 = Signalized control (actuated)
*_BLanes (-)	Real	Copy	DOT provided from RAMS; MPO verified	Number of lanes open throughout the day, by direction
*_AM_XL (-) *_PM_XL (-) *_OP_XL (-)	Integer	Copy	DOT provided from RAMS; MPO verified	Number of additional lanes open during the time period (such as prohibited parking in peak periods)
*_TH (-)	Real	Blank	MPO†	Optional: Number of through lanes at the intersection (directional attributes); used for intersection-specific penalty calculations
*_LF (-)	Real	Blank	MPO†	Optional: Number of left-turn lanes at the intersection (directional attributes); used for intersection-specific penalty calculations

ATTRIBUTE NAME	FORMAT	RULE	RESPONSIBLE PARTY	DESCRIPTION
*_LeftLength (-)	Real	Blank	MPO[†]	Optional: Distance (in feet) of left-turn lane(s); used for intersection-specific penalty calculations
*_RT (-)	Real	Blank	MPO[†]	Optional: Number of right-turn lanes at the intersection (directional attributes); used for intersection-specific penalty calculations
*_RightLength (-)	Real	Blank	MPO[†]	Optional: Distance (in feet) of right-turn lane(s); used for intersection-specific penalty calculations
PROJNO1	Integer	Copy	MPO	Project number for first implemented project on the link; used to join to the project master list. See Section 4.10 for details.
YRPROJ1	Integer	Copy	MPO	(Optional) Project year for the first implemented project on the link
PROJNO2	Integer	Copy	MPO	Project number for second implemented project on the link; used to join to the project master list.
YRPROJ2	Integer	Copy	MPO	(Optional) Project year for the second implemented project on the link
PROJNO3	Integer	Copy	MPO	Project number for third implemented project on the link; used to join to the project master list.
YRPROJ3	Integer	Copy	MPO	(Optional) Project year for the third implemented project on the link
AADT	Integer	Copy	DOT provided from RAMS; MPO Verified	Counted Average Annual Daily Traffic if available. If not available, synthetic counts can be utilized.
Weekday	Integer	Copy	NA	Field for Performance Report – Leave Empty
Weekend	Integer	Copy	NA	Field for Performance Report – Leave Empty
SU	Integer	Copy	DOT provided from RAMS; MPO Verified	Counted Single Unit truck traffic if available. If not available, synthetic counts can be utilized.
CU	Integer	Copy	DOT provided from RAMS; MPO verified	Counted Combo Unit truck traffic if available. If not available, synthetic counts can be utilized.
YEAR	Integer	Copy	DOT/MPO	Year of AADT/SU/CU Count

** Indicates unique fields for AB and BA directions, such as AB_BLanes and BA_BLanes.*

[†] Recommend use of the Intersection Control Editor, see Appendix F: Intersection Control Editor Notes.

NOTE: (-) indicates attribute has 3 subsequent entries for project-specific updates. Only non-zero values in these columns will be used directly in project analysis.

Optional fields still need to be included in the master network file even if all values would be null or zero.

The model development team shall conduct network cleaning and validation exercises as described in Section 4.6.5. Network link development and editing should be done in conjunction with network node tasks as described in Section 4.6.1.

4.6.3 Data Sets

INPUT DATA

Many of the link attribute datasets, including the geographic data, are available from Iowa DOT's RAMS system, as outlined in Table 4-7. If RAMS data are utilized, consult DOT staff regarding extraction of a geographic file. The extraction from the RAMS linear referencing system should be conducted such that a change in any attribute included in the ISMS recommended network creates a break in the link structure and a corresponding network node.

The PROJNO attributes will be used in scenario modeling, as described in more detail in Section 4.10.

The ISMS model uses a lookup function to populate key attributes of roadway links that are used in the traffic assignment step in the modeling process. The LINKATT table stores coefficient values for link attributes including per lane hourly capacity, time of day capacity factors, and alpha and beta assignment factors. These parameters are described accordingly in Section 4.26.

ESTIMATION DATA

Google Maps or other aerial photography may be used if RAMS or other Iowa DOT data sets are not available.

VALIDATION DATA

Link attributes should be validated through the use of aerial photography or field observations. Additionally, as-built plans may provide data for use in network link validation.

OUTPUT DATA

The ISMS script creates Highway.dbd, a working network geographic file that includes the links and nodes that are to be included within the model scenario being executed.

ISMS also generates additional attributes for each link based upon the input attributes of the link. These additional attributes are used later in the ISMS modeling process and are described in Table 4-8.

Table 4-8: Highway.bin Output Link Attributes

ATTRIBUTE NAME	FORMAT	DESCRIPTION
*_AM_LKCAP *_PM_LKCAP *_OP_LKCAP	Real	Total directional link capacity by time period, calculated as the total number of directional lanes multiplied by the per lane capacity from the LINKATT lookup file.
*_LKTM	Real	Directional travel time along the link, calculated using the link length in miles and the posted speed. Assume constant speed limit throughout the day.
Alpha	Real	Alpha and beta factors used in traffic assignment; read from the LINKATT lookup file. See Section 4.26 for details.

ATTRIBUTE NAME	FORMAT	DESCRIPTION
Beta	Real	Alpha and beta factors used in traffic assignment; read from the LINKATT lookup file. See Section 4.26 for details.
ANODE	Integer	Node number of A node of link
BNODE	Integer	Node number of B node of link
AB_TURNTYPE	Integer	Link description based on intersection control and functional classification of approach; see Section 4.7.1
BA_TURNTYPE	Integer	Link description based on intersection control and functional classification of approach; see Section 4.7.1

** Indicates unique fields for AB and BA directions, such as AB_BLanes and BA_BLanes.*

4.6.4 ISMS Application

ISMS uses a master geographic file (Master.dbd) as input to the network modeling components. Committed, Planned, and Illustrative network edits are input into the Master.dbd file, and controlled through the use of the Project Master List as described in Section 4.10.

4.6.5 Calibration, Validation and Reasonableness Checking

MPO staff and/or the model development team should conduct the following tests on the network link and node system:

Query for links with distance less than 0.01 miles. Determine if link is required based on differences in link attributes from upstream and downstream links, or if it can be joined with an upstream or downstream link. Document link edits to facilitate recreation of network from RAMS in future if necessary.

Map each input link attribute outlined in Table 4-7 starting with AREATYPE. Include a prominent color and line thickness for null values, zero values and values outside the range of inputs.

Map each output link attribute outlined in Table 4-8, excluding ANODE and BNODE. Include a prominent color and line thickness for null values, zero values and values outside the range of outputs.

Review locations with grade separations to ensure accurate connectivity exists.

Review locations with significant curvature, such as loop ramps. Verify link distance is accurate when compared to aerial photography.

Map one-way links (DIR<>0) and verify correct directionality.

Utilize TransCAD's network connectivity tool to test for unconnected links.

Create a network file using TransCAD's Network pull-down menu, including the link travel time fields. Use the SKIM function to develop a shortest path output matrix. Export the row totals and column totals, then join the two tables and compare. Review links near zones that show significant difference for network connectivity issues.

Develop a dummy trip table using the centroids selection set from the node's attributes, and populate the table with a value of 1 for every cell. Conduct a traffic assignment using TransCAD's Planning pull-down menu (all or nothing is sufficient for this exercise). Review the assignment output for zero volume links and determine if connectivity issues exist.

The modeling team should review the travel times of the ISMS network links against the observed data. This process is conducted through review and modification of both travel speed and turn penalty input constants, and is described in more detail in Section 4.8.5. The link attribute SPEED_ADJ is used to modify the speed used in ISMS.

4.6.6 Future Year Considerations

The master geographic file maintains both base and up to three future year sets of attributes. New future roadway facilities are also stored within the master geographic file. For more details on the coding of future projects, see Section 4.10.

4.6.7 Documentation Standards

Document the sources of data used to populate Table 4-7. Generate mapping of facility type, number of lanes, and posted speeds for inclusion in model documentation.

4.6.8 Quality Assurance and Control

Review interchange locations for correct attributes on each roadway segment (Interstate/Freeway, ramp and cross-street), and correct connectivity (no direct connection between limited access road and cross-street).

4.7 Transportation Network Development - Nodes

4.7.1 Overview

The transportation network used for travel demand modeling is a simplification of the physical transportation network. Typically, it is represented within a computer model and including roadways, transit routes, walking and bicycle facilities of some importance to the regional transportation system. The ISMS model uses a standardized TransCAD Version 7 geographic file to store data about the transportation roadway network. The master geographic file contains geographic coordinates for both the nodes and links of the network, along with attribute tables for each. Network data for all scenarios, including base and future years, are stored in a single geographic file. Typically, nodes include centroids, intersections, or nodes that simply represent changes in link attributes.

4.7.2 Recommended Architecture

The roadway nodes represent several different features including:

- Centroids representing trip origins and destinations,
- Intersections of two or more roadways,

- External stations representing the point where trips enter/leave the model area,
- Shape point to better represent the geography of the roadway network.

The model project team is responsible for verifying the transportation network attributes, however, the Iowa DOT staff have direct access to the RAMS database, which includes many of the attributes used by the ISMS model. Therefore, it is of value for Iowa DOT to provide the MPO with an initial transportation network database from which the master geographic network file is created.

Roadway node attributes are outlined in Table 4-9 below.

Table 4-9: Master.dbd Roadway Node Attributes

ATTRIBUTE NAME	FORMAT	RESPONSIBLE PARTY	DESCRIPTION
ID	Integer	Auto-generated	Unique identification value for each node in the database assigned by TransCAD
Longitude	Integer	Auto-generated	Geographic coordinate
Latitude	Integer	Auto-generated	Geographic coordinate
Elevation	Integer	Auto-generated	Geographic coordinate
Node_type	Integer	MPO	Identification for type of node: 0 = standard node 1 = intersection node 2 = internal centroid 3 = external centroid
TAZ	Integer	MPO	Unique identification value corresponding with the Transportation Analysis Zone
iTRAM	Integer	MPO	Value representing the iTRAM TAZ the centroid nests within; not applicable to non-centroid nodes.

ATTRIBUTE NAME	FORMAT	RESPONSIBLE PARTY	DESCRIPTION
CONTROL (-)	Integer	MPO*	Represents the intersection control type: 0 = No control/shape point 1 = Yield 2 = Stop control/roundabout 3 = Signalized control (sequential) 4 = Signalized control (actuated) 5 = Other delay (RR crossing, school crossing, etc.) 6 = Centroid loader 7 = Transit stop 8 = Internal centroid 9 = External centroid
AM_cycle (-)	Integer	MPO	Value representing the cycle length of the intersection's traffic signal
PM_cycle (-)	Integer	MPO	Value representing the cycle length of the intersection's traffic signal
OP_cycleX (-)	Integer	MPO	Value representing the cycle length of the intersection's traffic signal
PROJNO1	Character	MPO	Project number for the first implemented project on the node; used to join to the project master list. See Section 4.10 for details.
PROJNO2	Character	MPO	Project number for the first implemented project on the node; used to join to the project master list.
PROJNO3	Character	MPO	Project number for the first implemented project on the node; used to join to the project master list.

** Recommend use of the Intersection Control Editor, see Appendix F: Intersection Control Editor Notes.*

NOTE: (-) indicates attribute has 3 subsequent entries for project-specific updates. Only non-zero values in these columns will be used directly in project analysis.

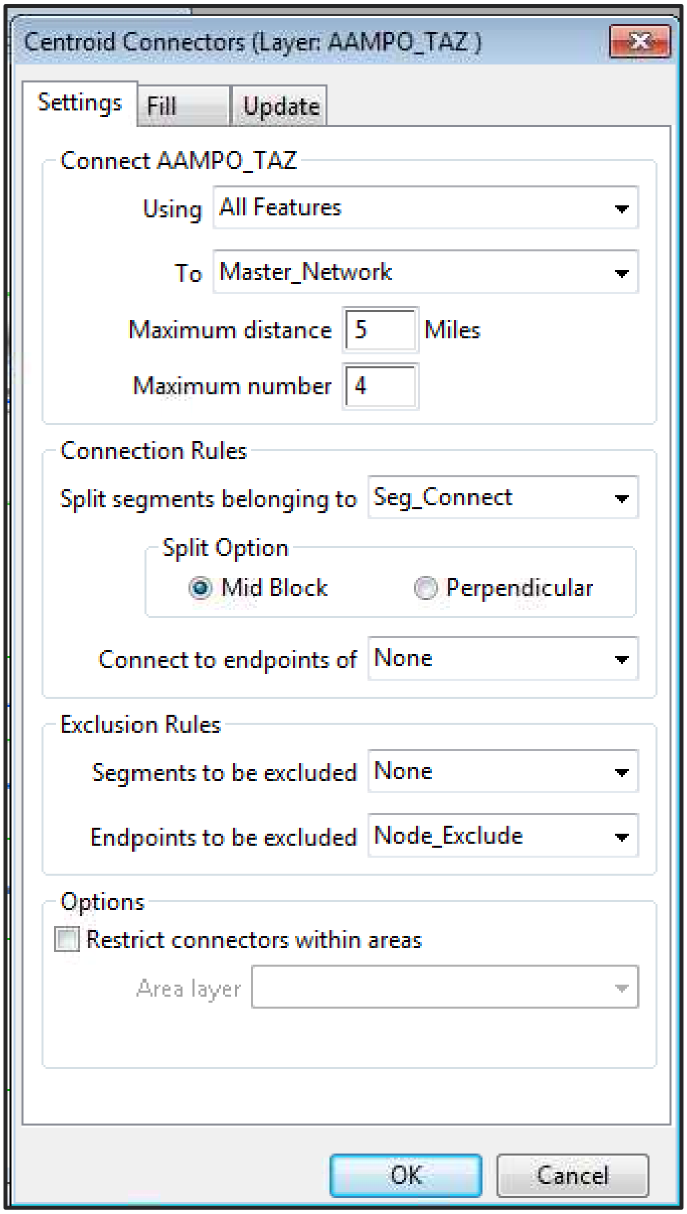
TAZ centroids can be added to the Master.dbd master geographic network through the use of TransCAD's Centroid Connectors tool. Prior to using the Centroid Connectors tool, the following selection sets must be developed.

- Create a link selection named Seg_Connect to include links that are allowed to have centroid connectors connecting to them. This set should include FACTYPE values of 1 through 11, 13 and 14. FACTYPE = 12 is the field value for a centroid connector and why it is omitted from the list.
- Create a node selection name Node_Excluded to include nodes that are to "not" have centroid connectors connection to them. This set should include CONTROL values of 1 through 4.

Access the TransCAD Centroid Connector tool by making the TAZ.dbd TAZ file the active layer in the map, then selecting the Planning>Planning Utilities>Centroid Connectors pull down menu. Populate the input window as shown in Figure 4-8 below.

It's recommended to set the maximum distance to 5 miles and the maximum number of connections to 4. After completing the selection sets as shown below, select the Fill tab. Select the Endpoint Field pull-down menu and select TAZ. Fill with IDs from TAZ layer. Select the Update tab and review settings, making note of any fields based on the distance or travel time of the link to ensure proper modification of attributes if the link is split. Archiving of the geographic file as suggested by TransCAD is recommended.

Figure 4-8: TransCAD Centroid Connector Function



Iowa DOT recommendations on the development of project identification numbers is available in Iowa DOT Policies and Procedures Manual, policy number 130.01. It's recommended to consider aligning project numbers with adjoining state projects and/or local project numbering systems.

Note the trip generation output in the form of productions and attractions are stored in scenario-specific tables which are joined to the node tables for subsequent demand modeling applications.

4.7.3 Data Sets

INPUT DATA

TransCAD develops and maintains the network nodes as part of the master geographic file. TAZ numbering is tied to the Transportation Analysis Zone development as described in Section 4.4.1. The iTRAM zone number is available via a geographic file of the iTRAM TAZ structure. Control data should be collected through coordination with Iowa DOT and local municipalities.

DOT staff have access to RAMS data, which will likely form the basis for the geographic data of the network nodes.

ESTIMATION DATA

No applicable data.

VALIDATION DATA

Nodes should exist at locations within the model network that represent physical locations where a person traveling through the transportation system encounters a change in the transportation environment (link attributes change) or an opportunity to make a transportation decision (turn left or go straight). Data such as aerial photography and Iowa DOT's RAMS database can be used to validate these conditions.

Control data should be validated using aerial photography, Google Street View, or Iowa DOT's highway log.

OUTPUT DATA

ISMS creates the Highway.dbd working network geographic file that includes the links and nodes that are to be included within the model scenario being executed. More information regarding selecting the model scenario is available in Section 4.10.

4.7.4 ISMS Application

ISMS uses the master geographic file as input to the network modeling components and creates the Highway.dbd geographic file specific to the model scenario.

4.7.5 Calibration, Validation and Reasonableness Checking

Follow the guidance listed in Section 4.6.5. Also develop mapping of intersection control and validate using aerial photography, Google Street View, or Iowa DOT's highway log.

The model project team will also provide guidance and quality review of network nodal data, in conjunction with link geography and data.

4.7.6 Future Year Considerations

The master geographic file maintains both base and up to three changes in link attributes, including the year of the proposed change. New future roadway facilities are also stored within the master geographic file. For more details on the coding of future projects, see Section 4.10.

4.7.7 Documentation Standards

Incorporate mapping of intersection control into the model documentation. Additional information, such as traffic length cycle lengths, can be summarized in a table if this information is utilized in the model.

4.7.8 Quality Assurance and Control

Join the link database using the ANODE attribute to the node database and confirm each non-centroid node has more than one link associated with the number. Nodes with only one associated link should be reviewed as dangling links. Repeat with the BNODE attribute.

4.8 Transportation Network Development - Turn Penalties

4.8.1 Overview

The ISMS model utilizes both link delay and intersection delay to approximate the time required to travel between points within the transportation network. The intersection delay accounts for time spent decelerating towards, stopped at, and accelerating from intersection control devices such as stop signs and traffic signals.

4.8.2 Recommended Architecture

The ISMS modeling process relies on the use of turn penalties to represent the delay that occurs at intersections and is not adequately accommodated through the use of the link-based congestion equations. ISMS uses a two-tiered turn penalty system. Turn penalties are first applied based on the functional classification and intersection control, using the linktype definitions shown in Table 4-10.

Table 4-10: Linktype definitions

FUNCTIONAL CLASS	LINKTYPE	INTERSECTION CONTROL
Limited access (interstate, freeway and system ramps)	1	n/a
Principal arterials and minor arterials	11	Signalized
	12	All Way Stop Controlled (AWSC)

FUNCTIONAL CLASS	LINKTYPE	INTERSECTION CONTROL
	13	Side-street stop/roundabout
	14	No control
Major and minor collectors	21	Signalized
	22	AWSC
	23	Side-street stop/roundabout
	24	No control
Local roads, gravel roads and centroid connectors	31	Signalized
	32	AWSC
	33	Side-street stop/roundabout
	34	No control
Service ramps	41	Signalized
	42	AWSC
	43	Side-street stop/roundabout
	44	No control

Turn penalties are then applied based on the From and To link combination of each respective movement. The default turn penalties are shown in Table 4-11. Generally, left turn penalties are higher than through movements. Peak period penalties are approximately level of service (LOS) C, with signalized through movements slightly lower to account for signal progressions, and right turn movements lower at unsignalized locations. Off-peak values generally follow the pattern of peak period delays, but start at LOS B. These values may be modified during calibration to better represent observed travel times throughout the network.

Table 4-11: Default linktype-specific turn delays

FROM LINKTYPE	TO LINKTYPE	MINUTES OF DELAY PER TURN (PEAK)				MINUTES OF DELAY PER TURN (OFF-PEAK)			
		LEFT	RIGHT	THRU	UTURN	LEFT	RIGHT	THRU	UTURN
Limited access	Ramps	0.15	0.15	0.15	99	0.15	0.15	0.15	99
	All others	0.15	0.15	0.00	99	0.15	0.15	0.00	99
	Arterial/ramp	0.50	0.15	0.25	0.50	0.38	0.11	0.19	0.38

FROM LINKTYPE	TO LINKTYPE	MINUTES OF DELAY PER TURN (PEAK)				MINUTES OF DELAY PER TURN (OFF-PEAK)			
		LEFT	RIGHT	THRU	UTURN	LEFT	RIGHT	THRU	UTURN
Signalized arterial/ramp	Collector	0.50	0.15	0.25	0.50	0.38	0.11	0.19	0.38
	Local/CC	0.35	0.10	0.15	0.40	0.26	0.08	0.11	0.30
AWSC	Arterial/ramp	0.30	0.10	0.30	0.30	0.23	0.08	0.23	0.23
Arterial/ramp	Collector	0.25	0.10	0.25	0.25	0.19	0.08	0.19	0.19
	Local/CC	0.20	0.07	0.20	0.20	0.15	0.05	0.15	0.15
Two Way Stop Controlled (TWSC) arterial/ramp	Arterial/ramp	0.45	0.15	0.35	0.45	0.34	0.11	0.26	0.34
	Collector	0.30	0.10	0.25	0.30	0.23	0.08	0.19	0.23
	Local/CC	0.25	0.10	0.20	0.25	0.19	0.08	0.15	0.19
Uncontrolled arterial/ramp	All types	0.25	.05	0	0.25	0.19	0.04	0	0.19
Signalized collector	Arterial/ramp	0.55	0.20	0.40	0.60	0.41	0.15	0.30	0.45
	Collector	0.40	0.15	0.30	0.40	0.30	0.11	0.23	0.30
	Local/CC	0.35	0.10	0.25	0.35	0.26	0.08	0.19	0.26
AWSC collector	Arterial/ramp	0.25	0.10	0.25	0.25	0.19	0.08	0.19	0.19
	Collector	0.25	0.10	0.25	0.25	0.19	0.08	0.19	0.19
	Local/CC	0.20	0.07	0.20	0.20	0.15	0.05	0.15	0.15
TWSC collector	Arterial/ramp	0.40	0.15	0.35	0.40	0.30	0.11	0.26	0.30
	Collector	0.30	0.10	0.25	0.30	0.23	0.08	0.19	0.23
	Local/CC	0.25	0.10	0.20	0.25	0.19	0.08	0.15	0.19
Uncontrolled collector	Arterial/ramp	0.20	0.05	0	0.20	0.15	0.04	0	0.15
	Collector	0.17	0.05	0	0.17	0.13	0.04	0	0.13
	Local/CC	0.15	0.05	0	0.15	0.11	0.04	0	0.11
Signalized local/CC	Arterial/ramp	0.60	0.25	0.50	0.60	0.45	0.19	0.38	0.45
	Collector	0.40	0.15	0.30	0.40	0.30	0.11	0.23	0.30
	Local/CC	0.35	0.10	0.25	0.35	0.26	0.08	0.19	0.26

FROM LINKTYPE	TO LINKTYPE	MINUTES OF DELAY PER TURN (PEAK)				MINUTES OF DELAY PER TURN (OFF-PEAK)			
		LEFT	RIGHT	THRU	UTURN	LEFT	RIGHT	THRU	UTURN
AWSC local/CC	Arterial/ramp	0.25	0.10	0.25	0.25	0.19	0.08	0.19	0.19
	Collector	0.20	0.10	0.20	0.20	0.15	0.08	0.15	0.15
	Local/CC	0.20	0.10	0.20	0.20	0.15	0.08	0.15	0.15
TWSC local/CC	Arterial/ramp	0.40	0.15	0.35	0.40	0.30	0.11	0.26	0.30
	Collector	0.30	0.10	0.25	0.30	0.23	0.08	0.19	0.23
	Local/CC	0.20	0.10	0.17	0.20	0.15	0.08	0.13	0.15
Uncontrolled local/CC	Arterial/ramp	1.00	0.20	0	1.00	0.75	0.15	0	0.75
	Collector	0.35	0.15	0	0.35	0.26	0.11	0	0.26
	Local/CC	0.15	0.05	0	0.35	0.11	0.04	0	0.11

NOTE: AWSC = All way stop control; TWSC = Two way stop control; CC = Centroid connector

Intersection turn movement delays that vary from the linktype-provided penalties can be updated using movement-specific penalties. The format of the turn penalty file is shown in Table 4-12. There are several methods available for developing movement-specific turn penalties. These methods are described in Section 5.2.4 and **Error! Reference source not found.**.

The project team will determine locations where movement-specific turn penalties are required. MPO staff are responsible for obtaining input data at these locations. The project team will determine who will conduct analysis to estimate movement-specific turn penalties. No movement-specific turn penalties are required to run ISMS, and it is anticipated that most MPO's will determine less than 50 intersections have unique conditions that warrant movement-specific turn penalties.

Table 4-12: Movement-specific turn penalty file

ATTRIBUTE NAME	FORMAT	RESPONSIBLE PARTY	DESCRIPTION
FROM_ID	Integer	MPO	From link
TO_ID	Integer	MPO	To link
PENALTY	Real	MPO	Penalty in minutes

4.8.3 Data Sets

INPUT DATA

No input data is required to implement the default linktype turn penalties within ISMS.

ESTIMATION DATA

No estimation data is required to utilize the default linktype turn penalties within ISMS.

Use of movement-specific turn penalties within ISMS requires data based on the methodology used to develop the penalties. Tools to conduct traffic signal operational analysis tools such as Synchro, microsimulation, Highway Capacity Software or TransCAD's volume-dependent delay function require temporal turning movement volumes by movement, roadway geometry by approach lane and intersection control information (traffic signal timing and phasing). The availability and format of these datasets depends upon the jurisdiction that maintains the intersection.

Direct field observation of intersection control delay may be conducted to provide a direct input into the movement-specific turn penalty file. The process is outlined in the Iowa DOT's traffic manual: [http://www.Iowa DOT.gov/traffic/manuals/pdf/07h-01.pdf](http://www.IowaDOT.gov/traffic/manuals/pdf/07h-01.pdf)

VALIDATION DATA

INRIX travel time data for major roadway corridors is available through the Iowa DOT's contract with Center for Transportation Research (CTRE). This travel time data provides a validation target for the combined value of link travel time and the turn penalties. Off-peak travel time values are recommended as validation data for the uncongested travel time. The process for obtaining, processing and utilizing the INRIX travel time data is outlined in Section 4.11.

OUTPUT DATA

The linktype value is added to the link attribute table for each link in the network.

Turn penalties by movement are used in the reporting of congested travel times. A portion of an example turn penalty output file is shown in Table 4-13.

Table 4-13: Portion of Example Turn Penalty Output File

FROM LINK	TO LINK	AM DELAY	PM DELAY	OFF PEAK DELAY
1234	1254	0.25	0.25	0.25
1234	1335	0.10	0.10	0.10
1234	1875	0.25	0.25	0.25
1254	1234	0.25	0.25	0.25

4.8.4 ISMS Application

The default linktype turn delay file is an input to the ISMS prototype. ISMS uses this table in conjunction with the linktype attribute of each link to assign a turn delay to every movement within the model network.

The movement-specific turn penalty file is also an input, but may be omitted or blank if no penalties apply.

4.8.5 Calibration, Validation and Reasonableness Checking

Observed travel speed data is imported into the ISMS prototype as described in Section 4.11.

The model development team should validate the travel speeds of the ISMS network links compared to observed travel speed data as discussed in Section 4.11. This process is conducted through review and modification of both travel speed and turn penalty input constants. This process is iterative for the free-flow condition, and for the period-specific congested condition.

Free flow travel speed validation is completed by comparing observed travel speeds with the modeled travel speeds of the same roadway segment. Free flow travel time within the ISMS prototype is composed of two elements, link travel time and turn delays. The link travel time is calculated by ISMS based on the link distance and the posted speed of the facility.

The default linktype turn delays should be calibrated based on network-wide summaries of modeled versus observed travel speed by facility type. The off-peak delay values should be adjusted first to represent the free-flow conditions of the system. Corridor-specific travel speeds may be adjusted using the link SPEED_ADJ attribute.

Peak delay should be equal to or greater than the off-peak delays. Calibration of the peak travel speeds requires potential modification to the volume-delay function's constants associated with the traffic assignment process. This process is described in more detail in Section 4.23.

4.8.6 Future Year Considerations

Default turn penalties are assumed to be constant over time. However, alternative turn penalty files may be used for scenario analysis.

4.8.7 Documentation Standards

The linktype turn penalties shall be included as an appendix to the travel demand model documentation.

4.8.8 Quality Assurance and Control

MPO staff and/or DOT staff are responsible for the values of the turn penalty files. DOT staff should review these values for reasonableness.

4.9 Transportation Network Development - Transit Route System

4.9.1 Overview

Explicitly modeling transit is not required. Transit trips can be removed from the overall person trip pool via a more simplified mode split approach. However, in order to conduct mode choice and a transit assignment within ISMS, a TransCAD route system and network are required.

TransCAD stores routes in a route system, which is tied to the roadway geographic file. A route system is a map layer that contains a collection of routes. The routes system consists of routes, route stops, and physical stops. A route is defined as a series of one or more line features. Each line feature that is part of a route is referred to as a segment. Every route is made up of a series of segments. Several routes in a route system may overlap and operate on the same segment. A route stop is a location where riders can board and alight from a transit vehicle. Physical stops are the locations along a route where route stops occur. Each physical stop corresponds with one side of a segment, based on the directionality of the segment.

4.9.2 Recommended Architecture

Many transit agencies across the country now provide a General Transit Feed Specification (GTFS) dataset of their transit systems to help support the development of third-party applications such as trip planning. The GTFS is a text-based representation of a transit system and consists of several individual files. The most relevant files include a transit system's routes, stops, route trips and stop times. TransCAD can import GTFS files and create a line geographic file/route system. Because the manual coding of a transit route system can be a labor-intensive task, the creation of a route system from pre-existing GTFS files offers the potential of significant time savings and automation when creating a transit system representation from scratch or updating existing transit system attributes to reflect any recent route and service modifications.

The ISMS project team obtained a GTFS dataset from the Ames CyRide transit system for the purpose of evaluating the level of effort required to import GTFS files and create a usable TransCAD route system for the purposes of transit path building, skimming, and assignment. During the evaluation period, the project team determined that a significant amount of data cleansing and manipulation could be required in order to create usable TransCAD route system and transit network. Given this finding, the project team felt that most of the value of GTFS data within the context of ISMS lies with its ability to serve as a reference layer for a manual coding approach to transit routes and stops. Compared to the traditional coding approach where transit routes are typically translated from route map information, using GTFS as a reference layer within TransCAD should afford some time savings and improved initial accuracy of the transit system network representation. **Error! Reference source not found.** provides some guidance on the importing of GTFS and use in coding a TransCAD transit network.

Following the development of the route system, the transit network is created. Similar to a roadway network, a transit network consists of links and nodes, as well as the attributes of each link (e.g., transit time). The links in the transit network represent actual transit segments (segments between two consecutive transit stops), and segments from the underlying geographic line layer that provide connectivity to the network in the form of zone-to-stop access links, walking links, driving links, and transfer links.

Transit networks provide the foundation for finding the optimal route or combination of routes between a trip origin and destination, skimming the attributes of the optimal paths, creating level-of-service matrices for mode choice models, and assigning trips to routes.

The TransCAD Help and User Guide features detailed documentation and step-by-step instructions for creating route systems and transit networks.

A transit route system and corresponding transit network are required to generate the level-of-service skims necessary to support mode choice model utility expressions, estimate on and offs at each stop, and estimate ridership for each route.

Detailed descriptions of the attributes required for the ISMS transit route, transit stop and physical stop files are shown in Table 4-14 through Table 4-16, respectively.

The MPT shall collectively determine the appropriateness of undertaking a full mode choice analysis, including the responsibility of developing a transit route system.

Table 4-14: Required Attributes of Transit route file (Routes.rts)

ATTRIBUTE NAME	FORMAT	RESPONSIBLE PARTY	DESCRIPTION
Route_ID	Integer	Auto-generated	Unique ID for each transit route assigned by TransCAD
Route_Name	Character	MPO	User-defined description (name and/or number) of the transit route
Route	Integer	MPO	Route Number used to define the transit route
Short Name	Character	MPO	Optional – 28-character limit for name of transit route
Description	Character	MPO	Optional – Additional description of transit route
Agency	Character	MPO	Optional – Name of agency operating transit route
Mode	Integer	MPO	Mode of transportation represented by the transit route – not used in analysis; each unique mode represented by unique value, such as local transit as 1 and BRT as 2.
AMHDWY	Real	MPO	Route service frequency for AM transit service
OPHDWY	Real	MPO	Route service frequency for off-peak (or midday) transit service
PMHDWY	Real	MPO	Route service frequency for PM transit service
NTHDWY	Real	MPO	Route service frequency for night transit service
Length	Real	MPO	Optional – Total length of transit route; not used in analysis
Direction	Character	MPO	Optional – Flag for considering the directionality of the transit route; not used in analysis
Fare	Real	MPO	Cost in dollars for riding the transit route

Table 4-15: Transit stops file (RoutesS.bin)

ATTRIBUTE NAME	FORMAT	RESPONSIBLE PARTY	DESCRIPTION
ID	Integer	Auto-generated	Unique ID for each transit stop assigned by TransCAD
Longitude	Integer	Auto-generated	Longitude coordinate of stop location
Latitude	Integer	Auto-generated	Latitude coordinate of stop location
Route_ID	Integer	Auto-generated	Transit route ID associated with stop
Pass_Count	Integer	Auto-generated	For transit vehicles that pass by a location multiple times, this field is used to tell the model whether the stop should be associated with the first pass or second (or third, etc.).
Milepost	Real	Auto-generated	Route-specific milepost location of stop
Physical_Stop_ID	Integer	Auto-generated	ID of the Physical Stop
STOP_ID	Integer	Auto-generated	Unique TransCAD ID for stop

Table 4-16: Physical stop file (RoutesP.bin)

ATTRIBUTE NAME	FORMAT	RESPONSIBLE PARTY	DESCRIPTION
ID	Integer	Auto-generated	Unique ID for each physical stop assigned by TransCAD
Longitude	Integer	Auto-generated	Longitude coordinate of stop location
Latitude	Integer	Auto-generated	Latitude coordinate of stop location
Direction	Character	Auto-generated	+/-
Name	Character	Auto-generated	Name of physical stop
Stop_ID	Integer	Auto-generated	Numerical value of stop name

4.9.3 Data Sets

INPUT DATA

System or route-level mapping identifying route/stop locations and service type/frequency by time period (e.g., peak vs off-peak headways, express vs local service). This data can be obtained directly from the transit operator/provider. If available, a

GTFS or GIS-based representation of the transit system will serve as a useful reference guide for manual coding. See appendix H for details.

ESTIMATION DATA

No estimation data is required to develop transit route systems and networks with ISMS.

VALIDATION DATA

Route-level schedule and/or runtime information obtained from the transportation operator/provider that can be directly compared to model-estimated route-level runtimes.

OUTPUT DATA

A transit network that can be used to find the optimal route or combination of routes between a trip origin and destination, skim the attributes of the optimal paths and creating level-of-service matrices for mode choice models, and assign trips to routes. Section 4.21 describes the development of the transit skim files which rely on the transit network files.

4.9.4 ISMS Application

Explicitly modeling transit is optional. Transit trips can be removed from the overall person trip pool via a more simplified mode split approach as described in Section 4.23. In order to conduct mode choice and a transit assignment within ISMS, a TransCAD route system and network are required.

4.9.5 Calibration, Validation and Reasonableness Checking

Model estimated route-level runtimes compared against route-level schedule and/or runtime information obtained from the transportation operator/provider.

Review the skim matrices that are developed through the process described in Section 4.21.

4.9.6 Future Year Considerations

Transit files for future years and scenario analysis shall be created as needed. In the event that the transit routes for a model application are consistent with the base condition, the base file may be used. In other conditions, create scenario-specific files tied to a future year roadway network developed from the master geographic file, containing the same attributes as defined in Table 4-14 and Table 4-15.

4.9.7 Documentation Standards

The input data (i.e., route mapping, GTFS, GIS, etc.) used by to develop and code the route system should be kept on file by the MPO for future reference until the route system is updated or replaced with new or more recent information. The source, date, and other key bibliographical information related to the input data should be noted in travel model documentation.

4.9.8 Quality Assurance and Control

TransCAD includes built-in features and utilities to check for any inconsistencies in the routes system and report errors. These features should be utilized any time the route system is modified or updated.

4.10 Transportation Network Development - Project Master List

4.10.1 Overview

Transportation improvements not included in the base condition model are also stored in the master geographic file. The attributes of these improvements are coded in the node and link attribute tables as described above.

4.10.2 Recommended Architecture

MPO staff shall coordinate with participating agencies to develop the list of projects to be tested as part of the long-range transportation planning effort. Additional projects may be included in the listing for scenario testing purposes. The improvement can be new roadways, additional or reduced capacity, change in access, transit route changes, etc.

The projects are implemented with the ISMS process through the use of the Project Master List file PROJLUT.BIN, described in Table 4-17.

Table 4-17: Project master list (PROJLUT.BIN)

ATTRIBUTE NAME	FORMAT	RESPONSIBLE PARTY	DESCRIPTION
PROJNO	Real	MPO	Unique identification number to join project to the impacted elements in the roadway network file
Description	Character	MPO	Text description of the project
Committed	Integer	MPO	Year that the project has committed funding, or 9999 if no funding is currently committed
Planned	Integer	MPO	Year project is implemented within the constrained long-range transportation plan, or 9999 if not within the constrained LRTP
Illustrative	Integer	MPO	Year project is implemented within an unconstrained LRTP, or 9999 if not within the unconstrained LRTP
Model impact	Character	MPO	Text description of how model network is impacted with project implementation

The ISMS model incorporates the above datasets to develop a TransCAD network file for use in developing skims. Selection sets are developed for links with auto restrictions (RSTRCT=1 or 3) and truck restrictions (RSTRCT = 2 or 3) for use in traffic assignment. The network file also includes a selection set of the centroids in the network and the turn penalties. U-turns are prohibited.

The model development team shall conduct model testing to verify projects have been incorporated appropriately.

4.10.3 Data Sets

INPUT DATA
MPO and DOT project list should be used to generate the PROJLUT.BIN project master list.

ESTIMATION DATA
Some project details may not be well defined during the conceptual testing phase. Discussions with project sponsors may be required to estimate the details needed for ISMS modeling.

VALIDATION DATA
Not applicable.

OUTPUT DATA
The ISMS Master.dbd network file will include the links and nodes corresponding to the projects included within the PROJLUT.BIN project list. Subsequent modeling steps will utilize this network for skimming and assignment purposes.

MPO staff should test each project independently to verify the coding of attributes is correct prior to implementation. Testing includes running the model with a project included, then review the outputs to determine if reasonable changes in output occurred due to the change from the project.

4.10.4 ISMS Application
Network links and nodes may be coded with the PROJNO and corresponding attributes relating to a specific project as outlined above. The PROJLUT.BIN project list is stored within the Network folder.

4.10.5 Calibration, Validation and Reasonableness Checking
MPO staff shall quality check the coding of the projects in the list by running the model to ensure there are no errors in the network coding with each project included independently. MPO shall review reasonableness of outputs based on the project, and share with the MPT for concurrent review.

4.10.6 Future Year Considerations
Future year roadway projects are included within ISMS through the use of the PROJLUT.BIN project list file.

4.10.7 Documentation Standards
The projects included in the PROJLUT.BIN project list file shall be included in the model documentation, along with a brief narrative of testing conducted on each project.

4.10.8 Quality Assurance and Control
MPO staff shall review ISMS outputs related to projects from the PROJLUT.BIN project list file. MPT shall check model outputs and coordinate with MPO as needed.

4.11 Travel Time and Speed Data

4.11.1 Overview

Travel demand models use impedance values such as travel time to estimate the likelihood of selecting one option compared to other available options. Modelers should strive to develop models that estimate travel times which reasonably represent the observed conditions within the modeled area. MPO models within Iowa have INRIX travel time data as a viable resource to quantify existing travel times for major roadway corridors. The INRIX data is available through the Iowa DOT.

4.11.2 Recommended Architecture

Travel speed is available on many high volume and functional class facilities across the State of Iowa from INRIX travel time data. The travel time data is collected along segments of roadways defined as Traffic Message Channels (TMC). Alternatively, INRIX has developed a proprietary network layer known as INRIX XD.

Iowa DOT has integrated INRIX data with the RAMS system. This integration allows for the use of INRIX travel time data in the ISMS system by bringing the data into the master network as link attributes. The travel time data is processed to generate average travel speed by time period, and stored with the ISMS files as a separate line geographic file. During model execution, a TMC ID is assigned to model network links to facilitate the exchange of travel speed data.

The INRIX travel time data is available to MPO's through Iowa DOT's contract with INRIX. The MPO is responsible for review of the travel time data and the accuracy of the data translation to the ISMS network. The travel time data should represent the average condition during the analysis period. The travel time data includes both observed and estimated speeds, however only actual observed data records (record type 30) should be included in the data used to calculate average travel speeds for ISMS. Data should be processed by month to facilitate review of each months' results for consistency. Winter and summer data may not be consistent with the rest of the year and may be excluded if appropriate.

PROCESSING RAW INRIX DATA:

The following steps describe the steps to process the raw INRIX data.

Open the INRIX CSV file within TransCAD.

Convert the data file to BIN format and open the new BIN file.

Create a selection set of records where Confidence_score equals 30 or more.

Save the resulting file as new BIN file. This reduces the magnitude of data to only actual observed records.

Open the new BIN file and modify the dataview using the Dataview>Modify Table pull-down menu to include the following new fields:

Hour	Real	8 characters
Peak	Real	8 characters

Day	Real	5 characters
WD-WE	Real	8 characters

Fill the Hour field using Equation 4-1:

Equation 4-1: Calculation of Hour Field

S2r(left(right(measurement_tstamp,8),2))

Fill the Peak field with a value of 0 to represent the off peak, then conduct the following queries and fill the Peak field with the corresponding value:

Hour>5 and Hour<9	Peak=1
Hour>14 and Hour<18	Peak=2
Hour<6 or Hour>17	Peak=3 (only use Night if explicitly modeling Night period within ISMS, otherwise, maintain the coding of these hours as Peak=0 for off-peak)

Fill the Day field with a four-digit number representing the month and day using Equation 4-2:

Equation 4-2: Calculation of Day Field

S2r(left(right(measurement_tstamp,14),2))*100+S2r(left(right(measurement_tstamp,11),2))

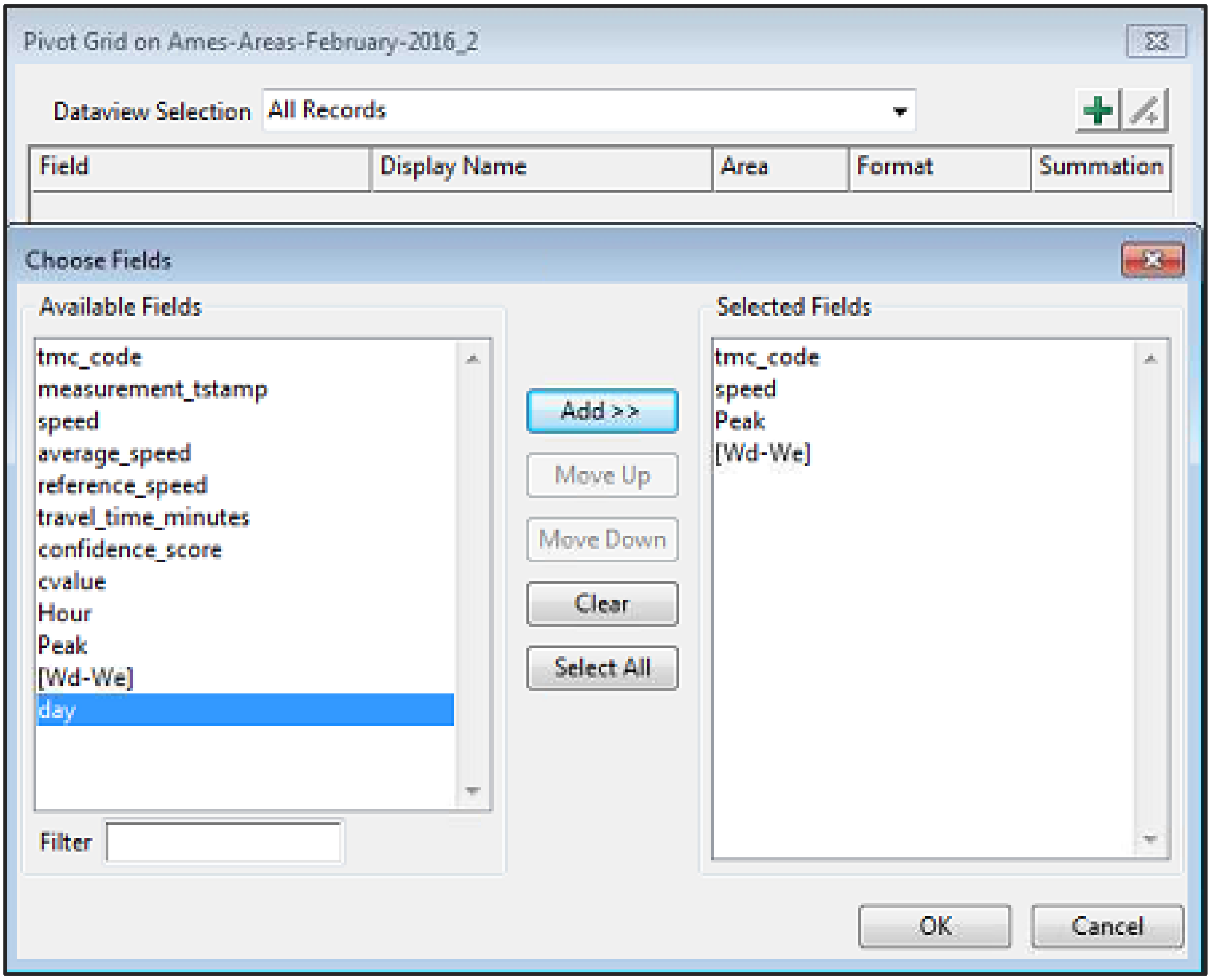
Fill the WD-WE field with a value of 0, then review the calendar and select records with weekend days and fill the WD-WE field with a value of 1. An example is shown below:

Day=0206 or Day=0207 or Day=0213 or Day=0214 or Day=0220 or Day=0221 or Day=0227 or Day=0228

Select the Statistics>Pivot Table option from the TransCAD pull-down menu (activate the Statistics pull-down menu by selecting the Procedures pull-down menu if Statistics is not visible). Set Dataview Selection to All Records. Add the following 4 fields within the Choose Fields window as shown in Figure 4-9:

- TMC_Code
- Speed
- Peak
- WD-WE

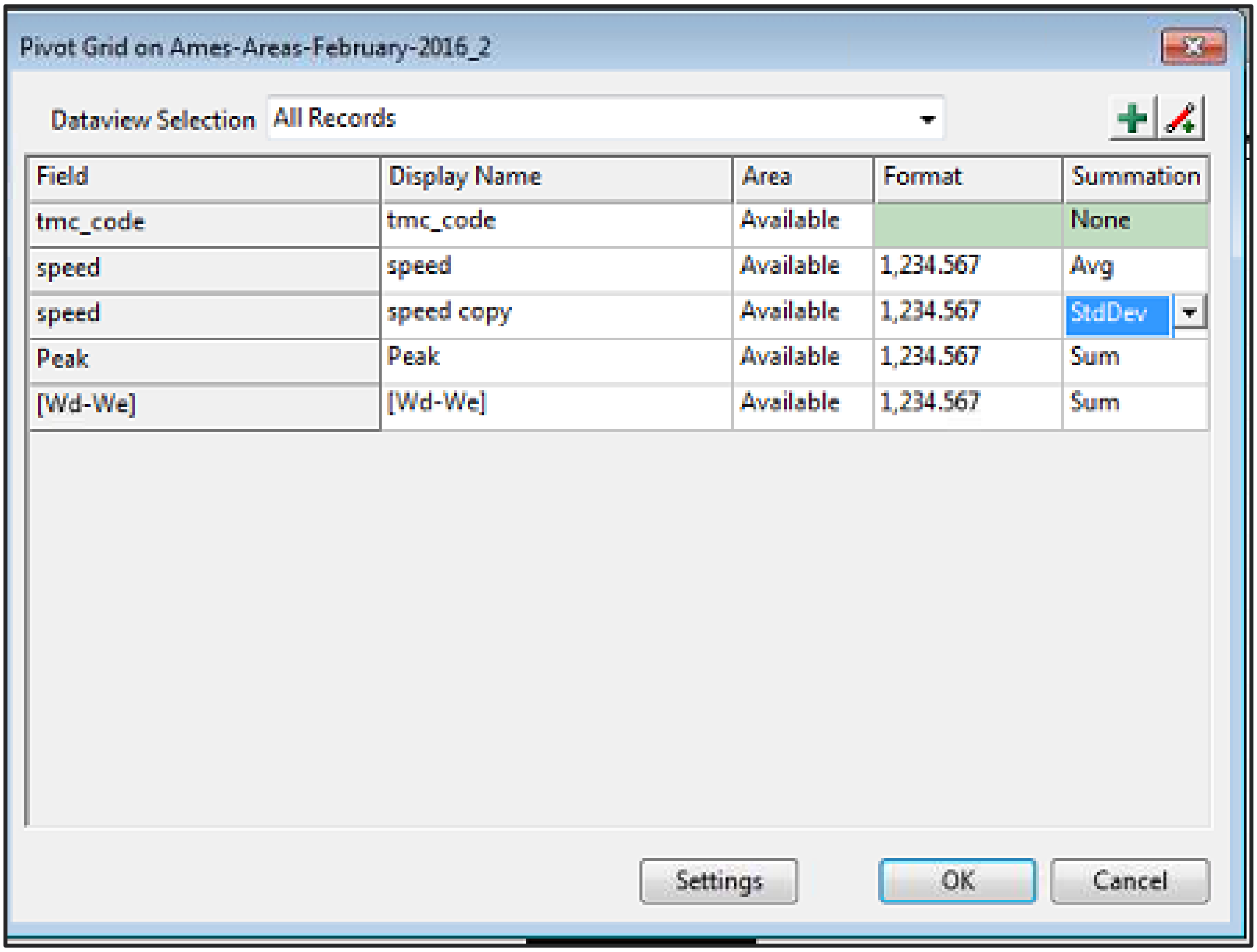
Figure 4-9: Selecting INRIX Attributes for Developing Speed Data



Click OK.

The next screen identifies how to handle the data. Select the Speed row, and change the value of the Summation field from Sum to Avg. While the Speed row is selected, press the Duplicate button in the upper right corner to add a row named Speed Copy. Change the Summation field value to StdDev. Keep the Summation setting as Sum for Peak and WD-WE fields, as shown in Figure 4-10. Click OK. The processing of data may take several minutes.

Figure 4-10: Selecting Summation Field Values for Speed Pivot Table



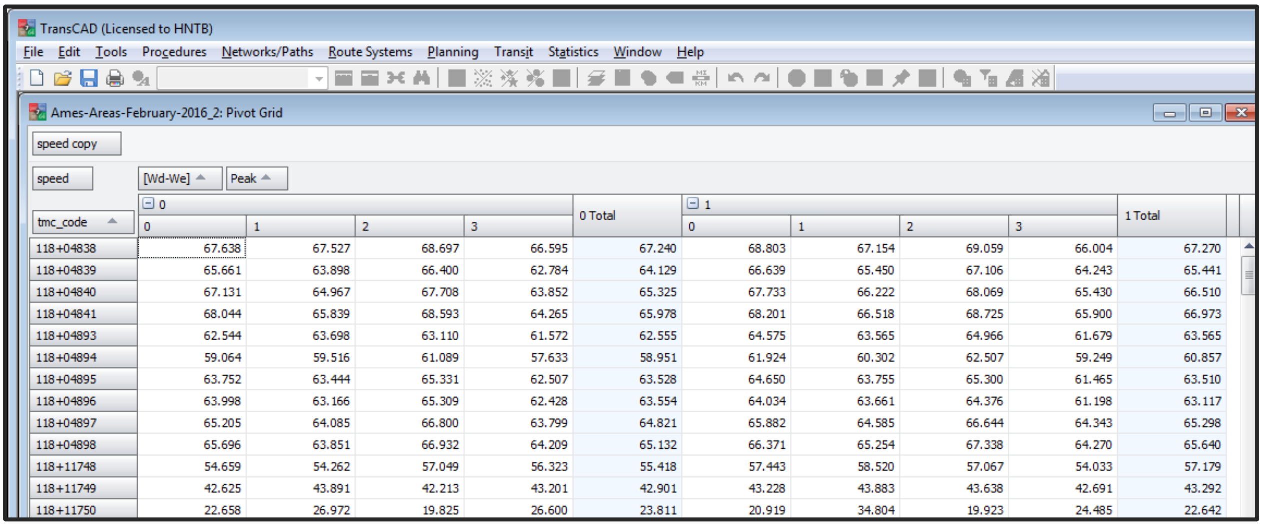
Drag the TMC_Code tile and drop on the "Drop Row Fields Here" area of the Pivot Grid.

Drag the WD-WE tile and drop on the "Drop Column Fields Here" area of the Pivot Grid.

Drag the Peak tile and drop on the "Drop Column Fields Here" area of the Pivot Grid, to the right of the WE-WE tile.

Drag the Speed tile and drop on the "Drop Data Items" area of the Pivot Grid. Results should be similar to Figure 4-11. The Speed Copy tile may be used to generate a report of the standard deviation in travel speeds. The standard deviation output provides a reasonable range within which the travel demand model's congested output speeds should fall within. If only 3 time periods are being used, then the table will not have the same number of columns as shown in Figure 4-11.

Figure 4-11: Speed Pivot Table Results Example



tmc_code	0 / 0	0 / 1	0 / 2	0 / 3	0 Total	1 / 0	1 / 1	1 / 2	1 / 3	1 Total
118+04838	67.638	67.527	68.697	66.595	67.240	68.803	67.154	69.059	66.004	67.270
118+04839	65.661	63.898	66.400	62.784	64.129	66.639	65.450	67.106	64.243	65.441
118+04840	67.131	64.967	67.708	63.852	65.325	67.733	66.222	68.069	65.430	66.510
118+04841	68.044	65.839	68.593	64.265	65.978	68.201	66.518	68.725	65.900	66.973
118+04893	62.544	63.698	63.110	61.572	62.555	64.575	63.565	64.966	61.679	63.565
118+04894	59.064	59.516	61.089	57.633	58.951	61.924	60.302	62.507	59.249	60.857
118+04895	63.752	63.444	65.331	62.507	63.528	64.650	63.755	65.300	61.465	63.510
118+04896	63.998	63.166	65.309	62.428	63.554	64.034	63.661	64.376	61.198	63.117
118+04897	65.205	64.085	66.800	63.799	64.821	65.882	64.585	66.644	64.343	65.298
118+04898	65.696	63.851	66.932	64.209	65.132	66.371	65.254	67.338	64.270	65.640
118+11748	54.659	54.262	57.049	56.323	55.418	57.443	58.520	57.067	54.033	57.179
118+11749	42.625	43.891	42.213	43.201	42.901	43.228	43.883	43.638	42.691	43.292
118+11750	22.658	26.972	19.825	26.600	23.811	20.919	34.804	19.923	24.485	22.642

Save the Pivot Grid table to an Excel file using the File>Save As function. Open the Excel file and delete the first two rows. Add a line back into the top of the file with the column headers shown in Table 4-18. Columns B1 and B2 will be blank columns.

Table 4-18: Example of Speed_output.csv Observed Speed Data Table

TMC_CODE	B1	WDOP	WDAM	WDPM	WDNT	WDT	B2	WEOP	WEAM	WEPM	WENT	WET
118+04838		67.6	67.5	68.7	66.6	67.2		68.8	67.2	69.1	66.0	67.3
118+04839		65.7	63.9	66.4	62.8	64.1		66.6	65.5	67.1	64.2	65.4
118+04840		67.1	65.0	67.7	63.9	65.3		67.7	66.2	68.1	65.4	66.5
118N04838		68.0	65.8	68.6	64.3	66.0		68.2	66.5	68.7	65.9	67.0
118N04839		62.5	63.7	63.1	61.6	62.6		64.6	63.6	65.0	61.7	63.6

Select all data in the Excel spreadsheet, then Save As a CSV file, named Speed_output.csv, then close the file.

Open the Speed_output.csv file in TransCAD and join to the TMC geographic file.

The speed data is stored for positive and negative directions separately. To attach the data to the ISMS network link attribute table, the directionality of the ISMS links must be established. Open the ISMS roadway network links from the master geographic file. Right-click on the map, select Layers and press the Style button. Under Arrows, press the Topology button, then press OK and Close.

Create two selection sets within the TMC geographic file, one with segments that have a P or + within the TMC code, and one with N or – within the TMC code. Then manually create two selections within the ISMS network links, one with links that have a topology arrow indicating northbound or eastbound topology, and one with southbound or westbound topology. Use the Tag function to populate the selected north and eastbound ISMS link's AB_TMC_Code attribute with the positive TMC segments' TMC_Code. Populate the BA_TMC_Code attribute with the negative TMC segments' TMC_Code. Repeat the process for segments and links using the southbound or westbound topology and a N or – value within the TMC code for the AB_TMC_Code, then the positive TMC segment's TMC_Code for the BA_TMC_Code.

Ultimately all that is needed is to get the average speed values from INRIX into these fields.

4.11.3 Data Sets

INPUT DATA

INRIX data is provided in a text format, typically CSV, with attributes as shown in Table 4-19. A geographic file or ESRI shapefile representing the geography of the TMC may be requested from the Iowa DOT to join the INRIX travel time data. Alternatively, a shapefile may be created using the TMC start and end coordinates using ArcMap's XY to Line function. Data may be hosted on Iowa DOT's ProjectWise site as well.

Table 4-19: INRIX Travel Time Data Format

ATTRIBUTE NAME	FORMAT	DESCRIPTION
TMC_Code	Character	Traffic Message Channel Identification Value Three-part code: Route: 3-digit route number Direction: (+) or P for positive cardinal direction (NB or EB) (-) or N for negative cardinal direction (SB or WB) Segment: 5-digit segment number
Measurement_tstamp	Character	Identifies date and military time of data point
Speed	Real	
Average_speed	Real	
Reference_speed	Real	
Travel_time_minutes	Real	Travel time along segment in minutes during identified time
Confidence_score	Real	Score corresponding to the confidence in the reported data 10- 20- 30-actual observed data
Cvalue	Real	Confidence value

DOT staff may facilitate the acquisition of INRIX tabular and geographic data for MPO use. DOT may provide guidance to MPO staff in the analysis and formatting of data. MPO staff should conduct a quality check on the travel speed maps for reasonableness.

A data processing effort is required to convert the INRIX travel time data into files for use in the ISMS process. The process is conducted once during model development and is described in Section 4.11.2.

ESTIMATION DATA

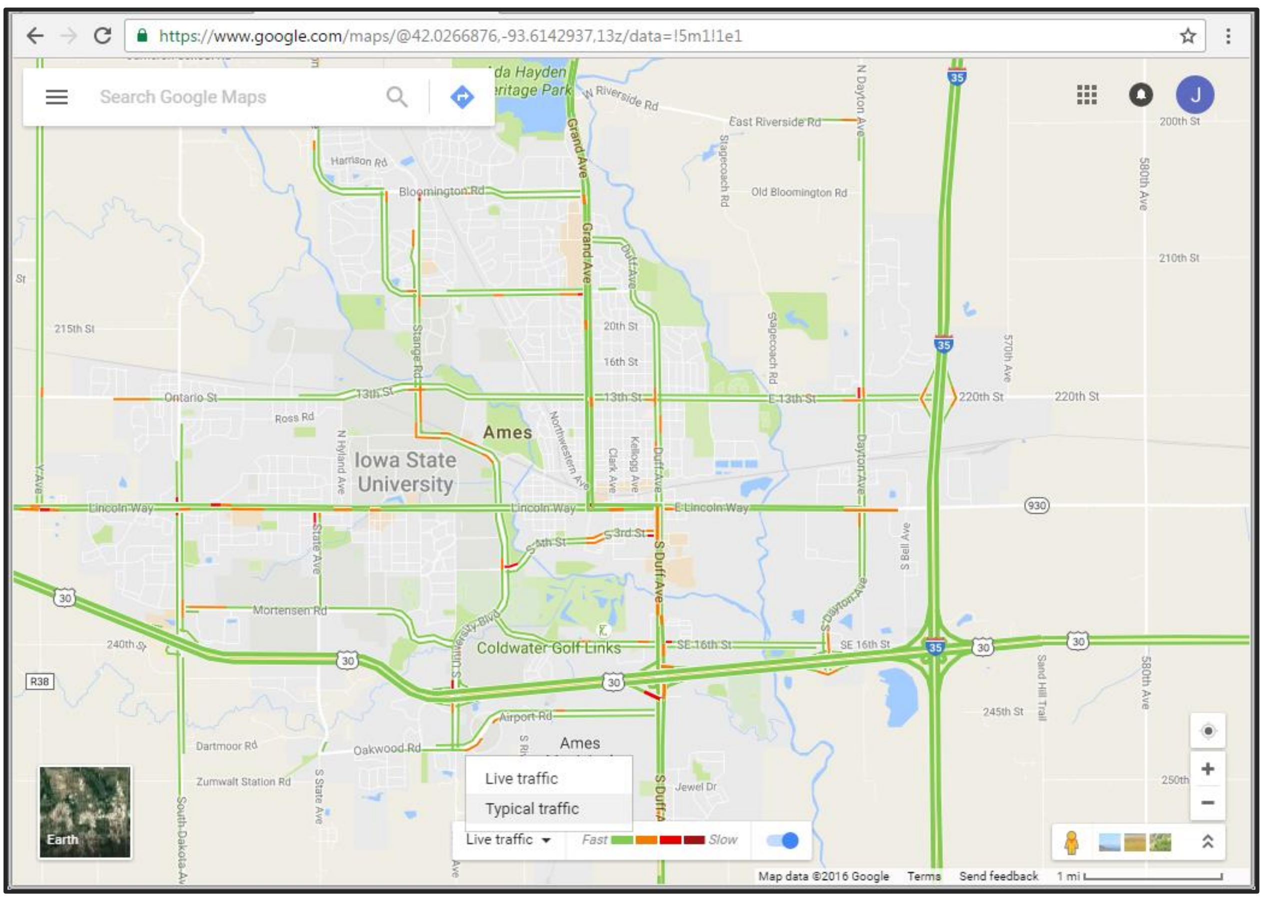
Not applicable.

VALIDATION DATA

Google Maps provides speed estimates for Typical traffic, as shown Figure 4-12. While specific speed data is not provided, the data provides a reasonableness check to determine recurring congestion locations within the MPO model network.

Floating car surveys may also be conducted for specific corridors. The survey should be conducted in such a way as to determine time spent waiting at intersections. More details about floating car surveys is available in Section 5.1.3.

Figure 4-12: Google Maps Typical Traffic Speeds



OUTPUT DATA

Attributes from the ISMS travel speed data process are shown in Table 4-20. This data is then joined to the ISMS network links during model execution to generate link-specific, time and day of week specific observed speeds for validation reporting as described later.

Table 4-20: Travel speed date file format

ATTRIBUTE NAME	FORMAT	DESCRIPTION
TMC_Code/INRIX_XD_Code	Character	Unique identification value for each TMC/INRIX XD segment
FAC_TYPE	Integer	Facility type of majority of TMC segment, see Table 4-7 for details.
FACILITY_CODE	Integer	Facility code of majority of TMC segment, see Table 4-7 for details.
*_AMWD_INRIX	Real	Observed travel speed from INRIX data by time and day of week, either provided as a RAMS attribute or through data conversion process.
*_PMWD_INRIX		
*_OPWD_INRIX		
*_NTWD_INRIX		
*_AMWE_INRIX		
*_PMWE_INRIX		
*_OPWE_INRIX		
*_NTWE_INRIX		
*_AMWD_Link	Real	Vehicle hours of travel on links within the TMC
*_PMWD_Link		
*_OPWD_Link		
*_NTWD_Link		
*_AMWE_Link		
*_PMWE_Link		
*_OPWE_Link		
*_NTWE_Link		
*_AMWD_Turn	Real	

ATTRIBUTE NAME	FORMAT	DESCRIPTION
*_PMWD_Turn		Vehicle hours of travel within intersections within the TMC
*_OPWD_Turn		
*_NTWD_Turn		
*_AMWE_Turn		
*_PMWE_Turn		
*_OPWE_Turn		
*_NTWE_Turn		
*_AMWD_VMT	Real	Vehicle miles of travel within intersections within the TMC
*_PMWD_VMT		
*_OPWD_VMT		
*_AMWE_VMT		
*_PMWE_VMT		
*_OPWE_VMT		
*_NTWE_VMT		
*_AMWD_Speed	Real	ISMS generated travel speed for the TMC segment
*_PMWD_Speed		
*_OPWD_Speed		
*_NTWD_Speed		
*_AMWE_Speed		
*_PMWE_Speed		
*_OPWE_Speed		
*_NTWE_Speed		

** Indicates unique fields for AB and BA directions.*

4.11.4 ISMS Application

The travel speed data shown in Table 4-18 is developed outside of the ISMS application. During ISMS model execution, the travel speed data is joined to the link attributes table using the TMC_Code/INRIX_XD_Code attribute. Subsequent analysis of observed speeds and model speeds is then conducted.

4.11.5 Calibration, Validation and Reasonableness Checking

Create maps displaying the directional observed speeds from the INRIX travel time data. Search for segments that appear to have data for the opposing direction, or for a parallel segment.

Verify if any ramps should have travel speed data provided.

Query for locations with observed speeds greater than the posted speed, and the 10 mph greater or less than the posted speed.

Query all roads with a FACTYPE of 1-3 and 6-7 to verify high proportion of the links have data.

Query all roads with a FACTYPE of 8 or greater to verify if the data is intended for the facility, or misplaced.

Compare the off-peak travel speeds to the model free-flow speeds that include both the link posted speed and the intersection delay.

4.11.6 Future Year Considerations

INRIX travel time data is available for a limited number of historic years, such that predicting future conditions is not currently recommended. Future model outputs should be expected to indicate slower travel speeds than the existing condition.

4.11.7 Documentation Standards

Provide mapping of observed speeds by time period and weekday/weekend for priority corridors or sections of the metropolitan area.

Provide mapping of the standard deviation of the observed speeds to illustrate the typical range in observed speeds within the analysis period.

4.11.8 Quality Assurance and Control

MPO shall review the travel time data used for ISMS application for reasonableness. MPT shall may independently review the travel time data.

4.12 Person Trip Generation - Productions

4.12.1 Overview

Each trip has two trip ends. The trip generation model calculates trip ends separately: one end is classified as a trip production and the other end as a trip attraction. When trips start or end at home, the home end is defined as the production end and the other end is defined as the attraction end. Some trips are classified as non-home-based trips when neither end is a home location such as a trip from a work location to a shopping center. Non-home based trip ends are split evenly into trip productions and trip attractions.

Trip generation is the process of estimating the number of trip productions and attractions at each transportation analysis zone (TAZ) based on the socio-economic activity within the zone. This process is conducted independently by trip purpose and typically done for each discrete time period. The ISMS prototype conducts trip generation separately for weekday and weekend travel.

4.12.2 Recommended Architecture

Trip productions by purpose are calculated at the daily level for each zone using household size and personal income levels using the constants shown in Table 4-21. The production rates are stored in the P_Rates.bin file. These constants may be adjusted during model calibration, or for scenario-specific applications as scenario input files. Additionally, the university trip rates would only be applicable for urban areas without a major university. Otherwise the university sub-model that uses student and employment data may be used to generate university trips.

According to the Corridor MPO documentation, only 8 percent of households have 5 or more residents, resulting in the recommendation to classify household size as 4+. Unless a household travel survey is available, this must be conducted or the default ISMS trip rates can't be used. Trip productions for each trip purpose are calculated independently, but utilize the same predictive variables.

Parcel data indicates the number of housing units per parcel. Additionally, Census data provides the number of households within geographic areas. These two datasets should be used jointly to provide a quality check for housing data by TAZ as described in Section 4.3. The number of occupants per household and the income per household are available from Census data.

Table 4-21: Household trip production rates by purpose, household size, income and weekday/weekend

PURPOSE	HHSIZE	MONDAY-FRIDAY			SATURDAY-SUNDAY		
		LOW	MEDIUM	HIGH	LOW	MEDIUM	HIGH
Home-Based Work	1	0.86	1.46	1.50	0.18	0.30	0.31
	2	1.26	1.86	1.90	0.26	0.39	0.39
	3	1.62	2.22	2.26	0.34	0.46	0.47
	4	1.69	2.29	2.33	0.35	0.47	0.48
Home-Based School	1		0.03			0.00	
	2		0.09			0.01	
	3		0.70			0.08	
	4		1.76			0.21	
Home-Based Shop	1	1.96	2.60	2.75	3.04	4.03	4.26
	2	2.87	3.51	3.66	4.46	5.45	5.69
	3	3.33	3.97	4.12	5.18	6.17	6.40
	4	3.68	4.32	4.47	5.71	6.70	6.94
Home-based Other	1	1.98	2.60	3.19	2.82	3.71	4.54
	2	2.62	3.25	3.83	3.73	4.62	5.45
	3	3.53	4.15	4.74	5.02	5.91	6.74
	4	5.32	5.94	6.53	7.57	8.45	9.29
	1	2.77	4.27	4.54	3.07	4.73	5.03

PURPOSE	HHSIZE	MONDAY-FRIDAY			SATURDAY-SUNDAY		
		LOW	MEDIUM	HIGH	LOW	MEDIUM	HIGH
Non-Home Based	2	3.86	5.36	5.63	4.27	5.93	6.24
	3	4.75	6.25	6.52	5.25	6.91	7.22
	4	5.97	7.47	7.75	6.61	8.27	8.58
University	1		0.08			0.07	
	2		0.22			0.20	
	3		0.07			0.06	
	4		0.35			0.31	
Hospital	1		0.14			0.04	
	2		0.29			0.08	
	3		0.38			0.10	
	4		0.39			0.11	
Airport	1	0.00	0.00	0.14	0.00	0.01	0.30
	2	0.01	0.02	0.16	0.03	0.04	0.33
	3	0.08	0.08	0.22	0.16	0.17	0.46
	4	0.10	0.10	0.24	0.20	0.21	0.50
Regional Recreation	1	0.01	0.01	0.01	0.02	0.02	0.02
	2	0.02	0.03	0.02	0.04	0.04	0.03
	3	0.02	0.02	0.02	0.03	0.04	0.03
	4	0.02	0.02	0.02	0.03	0.03	0.03

Hotel purpose productions are estimated based on hotel building area and not per household. Local households are not generating hotel trips.

The home-based work trip purpose is further disaggregated to distinguish low, medium and high-income trips. Both work tour productions and attractions are disaggregated, allowing the distribution model and subsequent modeling steps to process work tours that are income stratified. This stratification aids the distribution model in matching low-income workers with low income jobs, and the mode choice model in identifying transit dependent workers. A high-income household may have low income workers; therefore, personal income is used to stratify trips into the income bins.

The ISMS prototype trip production rates were developed using the reported incomes from the 2001 Des Moines household travel survey to estimate the income splits by land use code to stratify work trips.

If local travel survey data is available, the production rates by land use code as shown in Table 4-21 may be re-estimated, with guidance and support from MPT.

In the absence of a statistically significant travel survey, the production rates shall be reviewed for reasonableness by the MPT. Checks should include the total production rates for households compared with rates used in previous model versions and against published rates as noted in the Validation section.

The trip productions by trip purpose as calculated by the ISMS prototype shall be reviewed both region-wide and by TAZ by mapping productions by purpose. Anomalies in trip productions by TAZ shall be investigated by reviewing parcel data and hand-calculating resulting trip productions.

The modeling team shall obtain and process validation data, including Journey to Work and PUMS data, to provide regional control totals for comparison against work trip production outputs.

The daily productions are then disaggregated to the time periods using the factors developed in Section 4.3.

4.12.3 Data Sets

INPUT DATA

Required input to the ISMS prototype is the parcel data for the model scenario from Section 4.5.1, the TransCAD TAZ layer including CTPP income stratification data from Section 4.3, and trip generation model constants as shown in Table 4-21 and **Error! Reference source not found.**.

ESTIMATION DATA

Travel survey data is highly valuable and should be collected approximately every 10 years to estimate or modify trip production rates. Consult with DOT staff and Section 5.1 prior to implementing a travel survey.

VALIDATION DATA

Model Validation and Reasonableness Checking Manual, Version 2 provides trip rates by urban area population using 2001 NHTS data.

Validation of trip production output can be accomplished at the regional level by reviewing PUMS, Journey to Work and LODES data. These datasets are described in more detail in **Error! Reference source not found.**. Site-specific reasonableness checks can be accomplished by comparing estimated productions to trip ends provided in the ITE Trip Generation Manual[7]. Note that published ITE rates are typically higher than those observed in Iowa. Comparing relative differences between two similar land uses and applying those differences to existing trip rates may provide more reasonable results than using ITE rates directly.

Trip production rates in **Error! Reference source not found.** are provided by land use code, across three time periods for each trip purpose. NCHRP 716 Tables C.5 through C.9 provide trip production rates by various cross-classification rates. NCHRP 716 Table C.11 provides time of day distributions by trip purpose and direction to aid in validating the relative difference in generated productions by time period across all land use codes. For example, Table C.11 indicates approximately 34 percent of all home-based work trip productions should be anticipated in the 6:00 to 9:00 AM time period.

The Longitudinal Employer Household Dynamics (LEHD) data classifies work trips using personal income. The LEHD data is a useful validation set, but may likely have noise within it due to privacy considerations and in how data is reported to Census by Iowa Workforce Development (IWD). More information on the use of LEHD is available in Section 5.2.3. Errors in the LEHD

[7] Institute of Transportation Engineers, Trip Generation Manual Version 9, 2012, Washington, D.C.

data or the IWD data should be reported to IWD to aid in improving accuracy of future LEHD datasets, however, existing LEHD datasets will not be re-estimated based on changes in IWD data.

OUTPUT DATA

The ISMS model outputs trip productions by trip purpose for each TAZ. A portion of an example output file is shown in Table 4-22.

Table 4-22: Portion of Example Trip Production Output Data (WDOPUNBAL.BIN)

TAZ	PHBWL	AHBWL	PHBWM	AHBWM		PCOMBO	ACOMBO
1	1.51	1.80	2.53	0.00	Pattern continues	0.02	0.02
2	23.44	21.57	18.15	40.56		0.31	0.31
3	6.1	27.1	16.3	225.00		0.00	0.00

4.12.4 ISMS Application

The ISMS model user is not required to specify inputs or outputs to this process. The WEAMTEMPLU.BIN file containing the total activity by land use code by TAZ is used. The trip production constants in Table 4-21 may be modified as a scenario-specific input file.

4.12.5 Calibration, Validation and Reasonableness Checking

In the absence of a local travel survey, direct calibration of production rates by land use code, time-period and trip purpose cannot be completed directly. Surveys from comparable urban areas may only be used to estimate rates.

Validation of work trip production output can be accomplished at the region-wide level by reviewing PUMS, Journey to Work and LODES data. These datasets are described in more detail in **Error! Reference source not found.**.

NCHRP 716[8] and 365[9] provide regional reasonableness checks for trip productions as shown in Table 4-23. C.5 through C.11 of NCHRP 716 provide example rates by generic trip purposes. Table 5 of NCHRP 365 provides more detailed breakdown by household size and income. While each metropolitan area has different trip making characteristics, region-wide totals should be expected to be with 10-15% of the values noted below. Exceptions require additional review of inputs into the trip production calculation process with the MPT.

Table 4-23: NCHRP Trip Production Validation

URBANIZED AREA POPULATION	PERSON TRIPS/ HOUSEHOLD (716)	PERSON TRIPS/ HOUSEHOLD (365)	PERSON TRIPS/ HOUSEHOLD (187)
50,000 to 200,000	9.5	9.2	14.1
200,000 to 500,000		9.0	11.8

[8] National Cooperative Highway Research Program, Report 716: Travel Demand Forecasting: Parameters and Techniques, National Academy Press, Washington D.C., 2012, page C-13-19.
[9] National Cooperative Highway Research Program, Report 365: Travel Estimation Techniques for Urban Planning, National Academy Press, Washington D.C., 1999, page 24.

URBANIZED AREA POPULATION	PERSON TRIPS/ HOUSEHOLD (716)	PERSON TRIPS/ HOUSEHOLD (365)	PERSON TRIPS/ HOUSEHOLD (187)
500,000 to 1,000,000	10.0	8.6	7.6

The Model Validation and Reasonableness Checking Manual Table 5.7 also provides tips related to validation checks.

Site-specific reasonableness checks can be accomplished by comparing estimated productions to trip ends provided in the ITE Trip Generation Manual.

Trip production for special purposes such as airports, hospitals, and regional recreation are validated by comparing modeled trips to observed trips at the specific locations.

Revalidation of time of day constants is recommended to verify trip productions by time period are reasonable. Modifications to time of day constants resulting from this process should be documented.

4.12.6 Future Year Considerations

Trip production rates are assumed to be held constant over time. Scenario-specific rates may be used for future condition analysis by placing a copy of the P_Rates.bin file in the Scenarios folder, then editing as desired.

4.12.7 Documentation Standards

Develop a table showing raw internal trip productions by purpose, household size, income and weekday/weekend. Document changes to trip production and time of day constants as deemed appropriate during the model validation exercise, including rationale for modification.

Table 4-24: Example Trip Production Summary Report Table

PURPOSE	WEEKDAY				WEEKEND			
	AM PERIOD	PM PERIOD	OFF-PEAK	DAILY	AM PERIOD	PM PERIOD	OFF-PEAK	DAILY
HBWLI								
HBWMI								
HBWHI								
HBSC								
HBSH								
HBO								
NHB								
UNIV								
HOSP								
APRT								
RREC								
SU								
COMBO								

4.12.8 Quality Assurance and Control

MPO staff or their technical assistance team are responsible for assuring quality of inputs into and the outputs of the trip production process. This requires review of model data, typically accomplished by mapping production output data to the parcel or zone level and inspecting the magnitude of trip ends relative to the activities located within the space. The MPT is available to provide a review of inputs and outputs, and to assist in addressing issues with data integrity and outliers.

4.13 Person Trip Generation - Attractions

4.13.1 Overview

Each trip has two trip ends. The trip generation model calculates trip ends separately: one end is classified as a trip production and the other end as a trip attraction. When trips start or end at home the home end is defined as the production end and the other end is defined as the attraction end. Some trips are classified as non-home-based trips when neither end is a home location such as a trip from a work location to a shopping center. Non-home based trip ends are split evenly into trip productions and trip attractions.

Trip generation is the process of estimating the number of trip productions and attractions at each transportation analysis zone (TAZ) based on the socio-economic activity within the zone. This process is conducted independently by trip purpose and typically done for each discrete time period. The ISMS model conducts trip generation separately for weekday and weekend travel.

Person trip attractions are calculated based trip rates by land use codes for each parcel, aggregated to the TAZ level. Trip attraction rates are based on commercial building area, school enrollment, site acres, or number of households depending land use.

4.13.2 Recommended Architecture

Error! Reference source not found. (**Error! Reference source not found.** and **Error! Reference source not found.**) show the default weekday and weekend trip attraction rates respectively per unit for each land use code by trip purpose. Trip attractions are further subdivided into income bins using the percentages shown in **Error! Reference source not found.**. These constants may be adjusted during model calibration, or for scenario-specific applications as scenario input files.

The default constants were derived from 2001 Des Moines NHTS data and ITE trip generation rates. Constants were modified to match traffic counts in the Ames test case. This includes the income-specific attraction rates for the home-based work purpose.

If local travel survey data is available, the attraction rates by land use code as shown in APPENDIX K, **Error! Reference source not found.** and **Error! Reference source not found.** may be re-estimated with guidance from the MPT.

In the absence of a statistically significant travel survey, the attraction rates shall be reviewed by the MPT for reasonableness. Site-specific rates may be modified if traffic count information for a significant portion of the parcels within a land use code can be processed to justify a change in the default rate. Consult with the MPT prior to undertaking the process to modify attraction rates.

The trip attractions by trip purpose as calculated by the ISMS prototype shall be reviewed by region-wide totals, land use code specific totals and by TAZ by mapping attractions by purpose. Anomalies in trip attractions by TAZ or land use code shall be investigated by reviewing parcel data and hand-calculating resulting trip attractions.

The MPT shall obtain and process validation data, including Journey to Work and PUMS data to provide regional control totals to compare against work trip attraction outputs.

4.13.3 Data Sets

INPUT DATA

Required input to the ISMS model are parcel data for the model scenario from Section 4.3, the TransCAD TAZ layer from Section 4.4.1, and trip generation model constants, as shown in the tables above.

ESTIMATION DATA

Travel survey data may be collected to estimate or modify trip attraction rates. Consult with the MPT and Section 5.1 prior to implementing a travel survey.

Trip attractions for special purposes such as airports, hospitals, and regional recreation should be estimated by comparing modeled trips to observed trips at the specific locations.

VALIDATION DATA

Site-specific validation checks can be accomplished by comparing estimated attractions to trip ends provided in the ITE Trip Generation Manual[10]. Validation of trip attraction output can be accomplished at the regional level by reviewing PUMS, Journey to Work, and LODES data. These datasets are described in more detail in **Error! Reference source not found.**.

OUTPUT DATA

The ISMS model outputs trip attractions by trip purpose for each TAZ, along with the trip productions. A portion of an example output file is shown in Table 4-25.

Table 4-25: Portion of Example Trip Attractions Output Data (WDOPUNBAL.BIN)

TAZ	PHBWL	AHBWL	PHBWM	AHBWM		PCOMBO	ACOMBO
1	1.51	1.80	2.53	0.00	Pattern continues	0.02	0.02
2	23.44	21.57	18.15	40.56		0.31	0.05
3	6.1	27.1	16.3	225.00		0.00	0.00

4.13.4 ISMS Application

The ISMS model user is not required to use specific inputs or outputs to this process. The trip attraction constants in **Error! Reference source not found.**, **Error! Reference source not found.** and **Error! Reference source not found.** may be modified as a scenario-specific input files.

4.13.5 Calibration, Validation and Reasonableness Checking

Trip attraction rates for special purposes such as airports, hospitals, and regional recreation are calibrated by comparing modeled trips to observed trips at the specific locations.

In the absence of a local travel survey, direct calibration of attraction rates by land use code and time-period for more common land uses may be difficult. Surveys from comparable urban areas may be used to estimate rates. Site-specific validation checks can be accomplished by comparing estimated attractions to trip ends provided in the ITE Trip Generation Manual.

Validation of work trip attraction output can be accomplished at the region-wide level by reviewing PUMS, Journey to Work and LODES data. These datasets are described in more detail in **Error! Reference source not found.**.

NCHRP 716[11] and 365[12] provide regional reasonableness checks for trip attractions as shown in Table 4-23. While each metropolitan area has different trip making characteristics, region-wide totals should be expected to be within 10-15% of the values noted. Exceptions require additional review of inputs into the trip attraction calculation process with the MPT.

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[10] Institute of Transportation Engineers, Trip Generation Manual 9th Edition, 2012, Washington, D.C.
[11] National Cooperative Highway Research Program, Report 716: Travel Demand Forecasting: Parameters and Techniques, National Academy Press, Washington D.C., 2012, page C-13-19.
[12] National Cooperative Highway Research Program, Report 365: Travel Estimation Techniques for Urban Planning, National Academy Press, Washington D.C., 1999, page 24.

Revalidation of time of day constants is recommended to verify trip attractions by time period are reasonable. Modifications to time of day constants resulting from this process shall be documented.

4.13.6 Future Year Considerations

Trip attraction rates are assumed to be held constant over time. Scenario-specific rates may be used for future condition analysis by placing a copy of the A_Rates.bin file in the Scenarios folder, then editing as desired.

4.13.7 Documentation Standards

Develop a table showing raw trip attractions by purpose, income and weekday/weekend. Document changes to trip attraction and time of day constants as deemed appropriate during the model validation exercise, including rationale for modification.

4.13.8 Quality Assurance and Control

MPO staff or their technical assistance team are responsible for assuring quality of inputs into and the outputs of the trip attraction process. This requires review of model data, typically accomplished by mapping attraction output data to the parcel or zone level and inspecting the magnitude of trip ends relative to the activities located within the space. Iowa DOT staff are available to provide a review of inputs and outputs, and to assist in addressing issues with data integrity and outliers.

4.14 Truck Trip Ends

4.14.1 Overview

Truck trips are primarily a factor of non-residential land uses. The ISMS recommended architecture builds upon the Quick Response Freight Manual's (QRFM) recommendations on trip generation rates for truck trips. The Quick Response Freight Manual uses background data, simple techniques and transferrable parameters to develop freight trip tables for conventional four-step travel demand models.

4.14.2 Recommended Architecture

Truck trip tours are calculated using a combination of sources including the QRFM (Table 4.1) and ITE trip generation manual. The resulting values, shown in **Error! Reference source not found.**, **Error! Reference source not found.** are consistent with rates used in several MPO's across Iowa. The tours are not production or attraction specific, therefore, the total trip ends are divided equally by zone and passed on to distribution. These constants may be adjusted during model calibration, or for scenario-specific applications as scenario input files. The A_Rates.bin files contain the trip rates for SU and COMBO truck trips.

4.14.3 Data Sets

INPUT DATA

The truck trips are calculated using the square footage by land use type at the TAZ level.

ESTIMATION DATA

Truck trip tables may also be estimated from truck surveys or through a matrix estimation process if sufficient truck counts are available.

VALIDATION DATA

Local truck data is recommended to validate the ISMS truck movements. Major truck generators and shippers should be contacted to determine the magnitude, distribution and time characteristics of truck movements in and out of their facilities. Truck movements are also available from the American Transportation Research Institute (ATRI) data (which is available to Iowa DOT), and this provides an independent data set for truck movements. iTRAM may also provide a resource for checking the reasonableness of truck trip ends. Truck classification count data may be used to validate truck trip generation rates in cases with a specific generator loading to a specific location.

OUTPUT DATA

The ISMS prototype outputs internal truck trip ends by trip purpose for each TAZ. A portion of an example output file is shown in Table 4-26.

Table 4-26: Portion of Example Truck Trip Output Data (WDOPUNBAL.BIN)

TAZ	PHBWL	AHBWL	PHBWM	AHBWM		PSU	ASU	PCOMBO	ACOMBO
1	1.51	1.80	2.53	0.00	Pattern continues	0.12	0.12	0.02	0.02
2	23.44	21.57	18.15	40.56		0.51	0.51	0.31	0.31
3	6.1	27.1	16.3	225.00		0.00	0.00	0.00	0.00

4.14.4 ISMS Application

There are no specific inputs or outputs to this process. The trip generation constants in **Error! Reference source not found.** may be modified as a scenario-specific input file.

4.14.5 Calibration, Validation and Reasonableness Checking

Review the truck trip generation rates against QRFM Table 4.1. These rates are this is the default, but the constants can be modified during the model calibration piece and again later during validation. Alternatively, this can be a scenario specific input file.

Review the Quick Response Freight Manual for more details on application and validation of truck movements within an urban travel demand model.

4.14.6 Future Year Considerations

Truck trip rates are assumed to be held constant over time. Scenario-specific rates may be used for future condition analysis by placing a copy of the A_Rates.bin file in the Inputs folder of the scenario, then editing as desired.

4.14.7 Documentation Standards

Develop a table showing raw truck trips ends by purpose, land use code and weekday/weekend. Document changes to truck trip generation and time of day constants as deemed appropriate during the model validation exercise, including rationale for modification.

4.14.8 Quality Assurance and Control

MPO staff are responsible for assuring quality of inputs into and the outputs of the truck trip generation process. DOT staff are available to provide a review of inputs and outputs, and to assist in addressing issues with data integrity and outliers.

4.15 University Sub-Model

4.15.1 Overview

The household and parcel-based approach to generating person-trip ends is supplemented with specific data for university-related activities. Parcel data does not typically include attributes that quantify the activities on major campuses, such as the number of on-campus or off-campus students at major housing centers, or the type of activities conducted within the various buildings on campus. Therefore, the ISMS prototype includes a sub-model related specifically to the generation of person trips for activities related to Universities. This process generates trips both for the university trip purpose and non-university purposes such as Home-Based Work and Non-Home Based.

The decision about whether a university sub-model will be developed is a model definition decision to be made early in the model development/refinement process. The existence of a larger university and large student population within the model limits is a good reason to have a university sub-model. However, if the MPO is interested in looking at impacts of university trips or if the regional transportation plan incorporates changes to the university area, a university sub-model can be utilized.

4.15.2 Recommended Architecture

The architecture of the ISMS university sub-model is adapted from the Ames Area MPO's University sub-model. This process uses zonal data summarizing the University Full-Time Equivalent (FTE) employment, on-campus students and off-campus students within each zone, stored in the UNIV_SE.bin file. The process also provides three sets of trip rates, stored in the U_Rates.bin file. The user may select one of the three rate sets during model calibration. These two datasets are used to calculate productions and attractions for each trip purpose.

Home-based work trips generated by the university sub-model are divided across the three income levels. Student employment is considered to be low-income, while staff employment is assumed to be equally spread across the three income brackets.

The university sub-model accounts for University students residing outside the model limits by summarizing the number of students outside the model area that would enter the model area at each respective external station. This data is used by the university sub-model to calculate trip ends that would occur at the external station. This data is then entered into the external production/attraction spreadsheet as described in Section 4.16.

4.15.3 Data Sets

INPUT DATA

The input data for the University sub-model includes both employment and housing data, as described in Table 4-27. Note university students living outside the model area are included in this data as OFFCAMPUS data entered within the TAZ representing the external zone.

Table 4-27: File Format for UNIV_SE.BIN File

ATTRIBUTE NAME	FORMAT	RESPONSIBLE PARTY	DESCRIPTION
ID	Integer	Auto-generated	Unique identification value for each TAZ in the database
TAZ	Integer	MPO	Unique identification value for the Transportation Analysis Zone
FTE_EMP_	Integer	MPO	Sum of Full-Time Equivalent (FTE) employment within the zone. This data should be available from university administration or use best approximation based on review of staff directories or info from university brochures.
UNIV_EMP_	Integer	MPO	Sum of the university staff employees within the zone. This total excludes students employed within the zone. This data should be available from University administration.
ONCAMPUS_	Integer	MPO	Number of students living in traditional on-campus housing within the zone.
OFFCAMPUS_	Integer	MPO	Number of students living in off-campus housing within the zone. Students living outside the model area and entering the model at a specific external zone are entered into the corresponding TAZ in this field also. Recommended approach is to obtain zip codes of students place of residence and allocated market sheds to determine the external zone to which the externals should be allocated.

The data is summarized within each zone for each analysis year and is stored in the UNIV_SE.bin file, as shown in Table 4-28. This data should be gathered through discussions with the University administration.

Table 4-28: UNIV_SE.bin file Containing Input Data for University Sub-Model

TAZ	FTE_EMP_2010	UNIV_EMP_2010	ONCAMPU_2010	OFFCAMPUS_2010	FTE_EMP_2015	UNIV_EMP_2015	ONCAMPUS_2015	OFFCAMPUS_2015
86	819	369	0	0	852	384	0	0
87	1759	835	0	0	1830	868	0	0

TAZ	FTE_EMP_2010	UNIV_EMP_2010	ONCAMPU_2010	OFFCAMPUS_2010	FTE_EMP_2015	UNIV_EMP_2015	ONCAMPUS_2015	OFFCAMPUS_2015
88	1664	738	0	0	1731	768	0	0
92	28	14	1058	1919	29	15	1110	1919

The trip rates for the university sub-model are stored in U_Rates.bin, and shown in **Error! Reference source not found.**. Model 1 represents rates from the Colorado North Front Range MPO. Model 2 represents rates from the Virginia DOT[13] and Model 3 represents a hybrid of the two sets. The ISMS default is to use Model 2. The Virginia DOT data is based on surveys from four public universities and was therefore considered more reliable.

The MPT shall collect university housing and employment data at the zonal level. This data should be available directly from the university administration. Data related to parking cost, capacity and accessibility (public, staff or student only) shall also be gathered from university administration

Students living outside the model area are designated to the external station most likely to serve the movement between the student's residence and the campus.

Upon running the university sub-model process and determining the results are acceptable, the number of university trips assigned to each external station is then provided to DOT staff for input into the external production/attraction spreadsheet. Establishing the university trips to/from the external stations is required for any model scenarios in which the number of university students outside the model area changes, which will occur for each model scenario year at a minimum.

The model development team will review the university housing and employment data entered into ISMS, including the external stations. DOT shall review resulting university sub-model generated trips, including the external stations, then input external data into the external spreadsheet as special generators, see Section 4.16 for details.

ESTIMATION DATA

Campus surveys, pedestrian counts and traffic counts at major generators and attractions on campus will aid in estimating trip generation parameters that are applicable to a specific university sub-model land use type (FTE, On and Off Campus housing).

VALIDATION DATA

A North Carolina DOT report provides approximate trip rates by mode and distance from campus.[14]

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[13] Virginia Department of Transportation. (2012). *Comparative Analysis of Virginia University Student Travel Surveys*, Richmond, VA

[14] https://connect.ncdot.gov/projects/planning/RNAProjDocs/NC-Student-Trip-Study-Final-Report.pdf

University-focused data was collected at three major universities across the country (Texas A&M, Arizona State and Utah State) by RSG, with the materials available at the ISMS Sharepoint site entitled TRB Planning Applications 3 Colleges Case Study.pdf.

OUTPUT DATA

Trip productions and attractions attributable to university activities, across all trip purposes, are calculated and output as shown in Table 4-29.

Table 4-29: Portion of Example University Sub-Model Trip Output Data (WDAMUNIV.BIN)

TAZ	PHBWL	AHBWL	PHBWM	AHBWM		PCOMBO	ACOMBO
1	0	0	0	0	Pattern continues	0	0
2	0	0	0	0		0	0
3	0	0	0	0		0	0

Note that trip ends are estimated at the external zones for the university sub-model. The number of university productions and attractions at each external shall be entered into the External Processing spreadsheet as described in Section 4.16. This need only be done once for each model scenario.

4.15.4 ISMS Application

ISMS inputs are developed by MPO staff using the Univ_SE.bin file. Upon running the university sub-model, the resulting trips at external stations resulting from university students living outside of the model area are entered into the external trip production/attraction spreadsheet discussed in Section 4.16. This data transfer is required once for each time the number of students outside the model area changes, including each model analysis year and for any scenarios in which the number of students outside the model area is changed.

4.15.5 Calibration, Validation and Reasonableness Checking

The University sub-model generates trips for several trip purposes, including home-based university. A review of the total number of productions and attractions generated by the university sub-model should be completed as part of the calibration exercise.

Depending on the configuration of the university circulation system, specific roadway segments may be counted to provide a validation target for total vehicle traffic entering and exiting the University area, or a select university residential area.

Total trips per student is a metric to review for confirming the reasonableness of the university sub-model outputs.

4.15.6 Future Year Considerations

Estimates of future year housing and employment data are entered into the Univ_SE.bin by year. Changes in the number of students from external zones requires rerunning the university sub-model to calculate university sub-model generated trip ends at the external stations, then updating the corresponding data in the external calculations spreadsheet as described in Section 4.16.

4.15.7 Documentation Standards

The housing and employment data used by the university sub-model shall be documented, along with notes concerning the process to acquire and process the data for use within ISMS. The number of students from outside the model area and the process to assign them to external stations shall be documented, along with the number of university sub-model generated trip ends at the external stations.

4.15.8 Quality Assurance and Control

MPO staff shall collect data regarding university housing and employment, with DOT staff providing a quality review. MPO shall document inputs and results of the process, with DOT staff review.

4.16 External Trips

4.16.1 Overview

Vehicle trips that have one or both ends outside the area covered by the demand model are generally referred to as external trips.

These external trips are further subdivided into three categories:

- External-external (E-E) trips that have both ends of the trip outside the model area
- External-internal (E-I) trips originate outside the model area and terminate inside the model area
- Internal-external (I-E) trips originate inside the model area and terminate outside the model area

The development of the external trip data is completed once as a cooperative effort between MPO and DOT modeling staff for each model scenario. Subsequent execution of the ISMS prototype utilizes this data for inclusion in the travel demand modeling stream.

4.16.2 Recommended Architecture

The methods to estimate travel behavior for external trips differs from the methods used for trips with both ends inside the model area. In the case of E-E trips, no information is readily available about the household or employment characteristics on either end of the trip. For E-I and I-E trips, those characteristics are known only for one end of the trip.

The ISMS recommended process for E-E trips is to establish a set of trip tables for autos, single unit and combination trucks. The use of the iTRAM model as a seed for the E-E trip table development is recommended at a minimum, but additional data collection is suggested. Selecting the location of external stations should consider traffic count data to aid in subsequent data analysis, preferably hourly classification count data. The external locations are then entered into the iTRAM model by Iowa DOT staff, and a subarea extraction process is conducted to output subarea trip tables by seven trip purposes. The iTRAM output tables are then fratared to better match observed traffic counts at or near the external stations. Fratar is an iterative process of factoring inputs (e.g., iTRAM output tables) to match the desired output (e.g., observed traffic counts at or near the external station)

The fratared iTRAM tables provides an estimate of the portion of the total traffic flow that is E-E at the external station, truck percentages, and estimates the change in traffic volume over time per external station. A second trip table source based on local data like StreetLight O-D data (or other big data sources) is strongly recommended to provide more refinement than is anticipated to come from the statewide travel demand model. Note the Iowa DOT is analyzing the first year of StreetLight O-D data on primary routes for usability and reasonableness in estimating external travel. This may be available for MPOs to use in the near future. NCHRP Report 365 could also be used as an additional reasonableness check.

E-I and I-E trips collectively comprise the remaining trips observed at the external stations. The survey methods shown below provide different data elements to aid in categorizing these trips for further incorporation into the demand model.

E-I and I-E trips are subdivided into the internal trip purposes and the resulting trip origins and destinations converted to productions and attraction for inclusion in subsequent trip balancing by purpose. iTRAM provides an estimate of E-I and I-E trips by purpose, while roadside and cellular surveys provide sampled data on the subject. Trip lengths for the E-I/I-E trips should be documented for later use in trip distribution, as described in Section 4.19.

Tables 26 and 27 of NCHRP 365 show that the split of E-I and I-E trips between trip purposes is a function of what lies outside the modeled area. Two urbanized areas in close proximity, such as Cedar Rapids and Iowa City, would be expected to impact each other, with more equal production and attraction flows between the urban areas. In contrast, isolated urban areas such as Sioux City would be expected to have a more one-way relationship, with trips produces outside the urban area and attracted into the urban area.

Hourly classification count data provides Iowa DOT with data to estimate the portion of the external travel that occurs in each time period. ATR's are preferable, but will likely not be available at all sites. Short term counts may be requested to provide local data, or approximate hourly splits from similar facilities may be applied.

The MPO staff shall coordinate development of the external trip tables with DOT staff. If a travel survey is deemed appropriate for the MPO model, a methodology to acquire and process the data must be developed.

In the absence of a travel survey, the Iowa DOT will use the mapping provided by the MPO to establish a subarea to use with the iTRAM statewide model to extract vehicle trip tables corresponding to the external points of the MPO model.

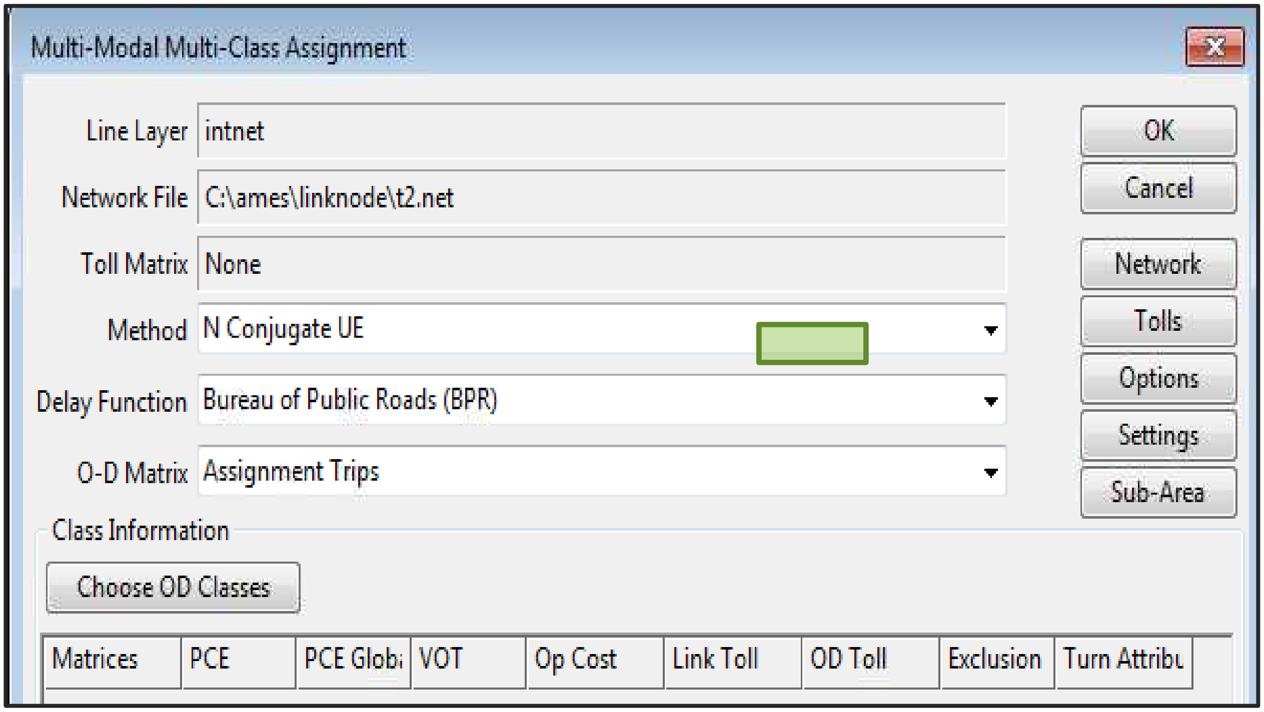
Development of the E-E trip tables and the E-I/I-E production and attraction data is conducted for each model year, and is completed outside of ISMS. Iowa DOT staff execute the iTRAM model using TransCAD's multi-modal, multi-class subarea assignment process, and input trip table files that include 8 sets of production/attraction data as shown in Table 4-30.

Table 4-30: Allocation of External Trips to Internal Purposes

ITRAM TRIP TABLE FILE	ITRAM TRIP TABLE	ISMS PURPOSES	DISAGGREGATION PROCESS
\\3 Trip Distribution\\ PA_HH_Trips.mtx	HBW	HBWLI HBWMI HBWHI	Subdivide into income bins based on ratio of internally generated work attractions by income
	HBO	HBSC HBSH HBO Hospital Regional Recreation Hotel	Determine if any school attractions are generated external to model area Divide remaining trips into remaining purposes based on ratio of internally generated attractions by purpose or by travel survey
	NHB	NHB	Direct input
\\3 Trip Distribution\\ PA_Long_DW.mtx	Long Distance Work	HBWLI HBWMI HBWHI	Subdivide into income bins based on ratio of internally generated work attractions by income
\\3 Trip Distribution\\ PA_Long_DNW.mtx	Long Distance Non-Work	Hospital University Regional Recreation Hotel	Outreach to specific generators to determine reasonable patterns to external stations.
\\3 Trip Distribution\\ Airport_OD.mtx	Airport	Airport	Direct input
\\3 Trip Distribution\\ OD-Truck_PreDelta.mtx	Med_Tk(0-24)	Single-Unit	Direct input
	Heavy_Tk(0-24)	Combination	Direct input

Prior to executing iTRAM assignment, the subarea needs to be defined within the network. Open a map containing the iTRAM model network geographic file and the subarea geographic file, along with a trip table (the specific table is not critical, no assignment will be done initially). If "Sub_Centroid" and "Sub_External" fields do not already exist within the iTRAM nodes layer, add them. Similarly, if "Sub_Crossing" field does not exist in the iTRAM link layer, add it. Next, manually initiate a TransCAD multi-class subarea assignment, then select the Sub-Area button to define the subarea network as shown in Figure 4-13. Select the type of data file the subarea is defined with, then press "Create Subarea". Selection sets of links and nodes will be created that represent the Sub_Crossing, Sub_Centroid and Sub_External elements for the subarea assignment process. Populate the attribute fields of the selected links and nodes across the three respective selection sets with a value of 1.

Figure 4-13: Subarea Network Definition



A GISDK script (itramext.rsc) for executing the subarea assignment process within iTRAM is available at the ISMS Sharepoint site: PWMain\Documents\Planning\Systems Planning\TrafficModeling\+ISMS\Data\External_Travel\

Check the file names within the script, then execute it. Upon completion, export the eight purpose-specific subarea trip tables to CSV format.

An Excel spreadsheet is also available on ProjectWise site. The spreadsheet contains a Visual Basic macro that reads the subarea trip tables and generates both EI/IE and EE trip information for use within ISMS. The spreadsheet also reads a time of day CSV file, an iTRAM link correspondence CSV file, and an iTRAM node correspondence spreadsheet file. Upon updating file contents and names to correspond with the specific MPO model and version of the iTRAM model used to develop the subarea trip tables, two sheets require user input. The first sheet (0-Param) includes parameters for converting daily iTRAM vehicle trips into weekday/weekend, time of day, income-segregated trip ends. The second sheet (1-TAZDATA) in the spreadsheet contains the following:

Column 1: MPO external zone number

Column 2: Corresponding ITRAM link id

Column 3: Corresponding 2nd ITRAM link id if the external has directional links (freeways)

Column 4: Nearby ITRAM link if the external zone is on a lower functional class road

Column 5: Traffic count at external

Columns 6-13: Hard-coded special purpose productions and attractions including University trips as calculated in Section 4.15.

Column 14: Adjusted traffic count to balance non-special purpose trip to adjust model output

Once the parameters in the first tab have been updated or verified and the correspondence and special purpose data in the second sheet has been entered, the VB macro is executed by the user. The spreadsheet outputs draft E-E trip tables and E-I production and attraction data by the ISMS trip purposes for input into the ISMS prototype. The project management team shall review draft materials and finalize, which requires the filename to be modified to exclude 'draft'.

Iowa DOT will input the appropriate traffic count data at each external station location for frataring the iTRAM output tables. Note that hourly directional classification counts at the external stations are recommended to aid in model development. Additional coordination time and effort to acquire these traffic counts are required.

Note the E-I production and attraction data is at the vehicle trip level. Using the iTRAM auto occupancy factors entered in the first tab of the Excel spreadsheet, ISMS converts these trips to person trips for trip balancing and distribution purposes using auto occupancy rates, then back to person trips for traffic assignment.

DOT staff will provide the MPO with the portion of the travel that occurs in each time period. This is covered in more detail in Section 4.3.

DOT shall provide the project team with final E-E and E-I/I-E tables. MPO staff will review the resulting draft E- E trip tables provided by DOT staff. The MPO staff will create final E-E tables based on the draft materials provided by DOT. The MPO staff will also review draft external productions and attractions for E-I/I-E movements by purpose. MPO staff will create final E-I/I-E tables based on the draft materials provided by Iowa DOT.

Each MPO model scenario (either an interim year or an alternative test scenario) requires additional coordination time with Iowa DOT.

4.16.3 Data Sets

INPUT DATA

The MPO provides mapping showing the location and zone numbering of external stations.

Traffic count (hourly classification) data is required to fratar iTRAM output tables to better reflect observed conditions. The MPO shall consider conducting or requesting special counts at locations representing external stations to provide detailed data for model development.

The Iowa DOT executes the iTRAM statewide model to estimate external movements.

ESTIMATION DATA

There are several alternative sources available to develop the base year external trip tables including:

Cellular phone data – 3rd party vendors can provide O-D for E-E trips along with E-I/I-E and I-I trips by sub-regional geography, time period and trip purpose; however limited vehicle class data and some sampling bias may occur. StreetLight data also provides similar functionality.

Roadside Origin-Destination survey - provides data on O-D for both E-E and E-I/I-E trips, along with trip purpose, frequency, time of day, occupancy by location; however, has safety concerns for high speed, high volume facilities.

Video License Plate survey – provides O-D for E-E trips by collecting license plate data at entry and exit points by vehicle class and time of day, then post-processing to match the license plate values between locations; however, has perceived privacy concerns. Some examples include a study done by MAPA[15]. Another available resource from FHWA provide guidance on conducting license plate surveys[16].

NCHRP Report 365 – Chapter 5 provides a methodology to estimate E-E movements by functional class for smaller urbanized area; provides a reasonableness check to methods above or a last resort in lieu of local data collected through the methods above. NCHRP Report 716 also provides some guidance on external surveys.

OnTheMap (OTM) data can be used to compare and assess the reasonableness of external work trips into and out of an MPO model study area.

Major employer and major destination surveys to collect trip origin and purpose can also produce data related to the E-I/I-E movements within the model area.

VALIDATION DATA

The estimation data sets shown above could also be used to validate the external trips tables.

OUTPUT DATA

Iowa DOT staff will produce E-E trips tables for auto, single-unit and combination trucks.

Iowa DOT staff will produce draft E-I/I-E trip productions and attractions for the internal trip purposes and truck purposes for each external station. A portion of an example table is shown in Table 4-31. Both productions and attractions are calculated for each purpose, and each time period for both weekday and weekend.

Table 4-31: Portion of External-Internal Production-Attraction Table (paei_wdam.bin)

TAZ	PHBWL	AHBWL	PHBWM	AHBWM	(CONTINUED)		AHOT	PSU	ASU	PCOMBO	ACOMBO
1000	84.58	22.4	357.85	94.76			0	6.93	6.93	22.64	22.64
1001	0.36	0.17	1.5	0.72			0	0.04	0.04	0.13	0.13

[15] Details of MAPACOG external surveys study are available in http://mapacog.org/wp-content/uploads/2015/11/MAPA-External-Travel-Survey-Summary-Report-Final-low-res.pdf

[16] Guidance on external surveys via video license plate surveys from FHWA https://www.fhwa.dot.gov/environment/air_quality/conformity/research/improving_data/taqs08.cfm

TAZ	PHBWL	AHBWL	PHBWM	AHBWM	(CONTINUED)		AHOT	PSU	ASU	PCOMBO	ACOMBO
1002	0.79	0.38	3.34	1.59			0	0.1	0.1	0.29	0.29

4.16.4 ISMS Application

ISMS model inputs are developed by Iowa DOT staff for MPO use from the iTRAM model and post-processing spreadsheets. No user input is required at ISMS run time for execution of the external portion of the ISMS prototype.

Note that the MPO's auto occupancies are incorporated to convert vehicle trips to person trips, consistent with the definition of trips from trip generation.

4.16.5 Calibration, Validation and Reasonableness Checking

Anecdotal or qualitative information or feedback based on related freight, traffic, and travel surveys, data, or studies that help to assess the credibility of the estimated external travel analysis.

NCHRP 365 provides Equation 4-3 for estimating the potential E-E percentage of roads based on volume and functional classification:

Equation 4-3: NCHRP 365 E-E Estimation

$$Y=76.76 + 11.22*I - 25.74*PA-42.18*MA+0.00012*ADT+0.59-PTKS-0.48*PPS-0.000417*POP$$

Where:

Y=percentage of the ADT at the external station that are through trips

I=Interstate (0 or 1)

PA=Principal arterial (0 or 1)

MA=Minor arterial (0 or 1)

ADT=average daily traffic at external station

PTKS=percentage of trucks excluding vans and pickups at external station

PPS=percentage of vans and pickups at external station

POP=population inside the cordon area

Iowa DOT staff have utilized this equation as a reasonableness check for E-E percentages. This equation can provide unrealistic output, such as negative E-E percentages, especially in larger urban areas.

Generally, higher functional class roadways have higher E-E percentages.

4.16.6 Future Year Considerations

The future year traffic volume estimates need to be developed for each external station independent of the ISMS process. Discussion on development of future year traffic volumes between Iowa DOT and MPO staff is highly encouraged to develop these values based on both historical traffic counts and iTRAM model outputs. More than one future year may be required depending upon the desired functionality of the MPO's model.

A second Excel template is then used to aid in developing future year external trip data. This spreadsheet reads the base and future year iTRAM subarea extractions, conducts a balancing exercise for the future condition based on the future traffic volume estimates, then applies the iTRAM predicted growth per purpose to the final base year data sets.

Similar to the base year Excel spreadsheet, the user may include special purpose totals by station. The forecasting process checks for and eliminates negative production and attraction values. The process also caps future year values to be 5 times the base year. This check was inserted to avoid iTRAM assignment fluctuations on small volume facilities from producing artificially high future trip ends. This cap should be checked by MPO staff prior to finalizing the future year trip data.

Different ISMS model year data sets may be estimated by altering the future traffic volume estimates by external station on the 1-TAZDATA tab.

The MPO shall review the draft outputs of the external forecasting effort for reasonableness. Modifications to the data should be documented including rationale for the modification.

4.16.7 Documentation Standards

A table documenting the total volume at each external station shall be developed, along with the percent of E-E by vehicle type, and E-I/I-E by trip purpose. The table shall be repeated for each scenario (both base and future years(s)) used by the MPO in the planning process. A regional map showing the locations of the externals shall accompany the tables. Modifications to the draft values should be documented including rationale for the modification.

4.16.8 Quality Assurance and Control

The development of the external data is a collaborative effort by the MPT and ensuring the values are consistent with the local understanding of the external stations. Draft external data must be finalized by the MPT, then used as input for the future year(s).

4.17 Trip Balancing

4.17.1 Overview

Productions and attractions for each trip purpose, including university sub-model and external trips, are calculated independently as previous described. While these independent processes are likely to estimate different values for productions and attractions, the trip-based modeling process requires productions and attractions to be equal. Trip balancing systematically modifies either trip productions or attractions throughout the model area to result in an equal number of each. The balancing process varies by trip purpose depending on the confidences of the data used to estimate productions and attractions.

4.17.2 Recommended Architecture

Output of the independent trip production and trip attraction processes should be compared prior to trip balancing. The respective sum of productions and attractions (including applicable external trip ends) for each trip purpose should be within 10% of each other[17]. If the sums differ by more than 10%, a review of the trip production and attraction estimation processes should be conducted after consultation with Iowa DOT staff.

Certain trip productions and attractions are typically kept constant during the balancing process. E-I and I-E trip productions and attractions should be held constant so as to maintain the known quantity of trips at the external station. Additionally, trip productions and attractions from special generators may be held constant if a high degree of confidence in the data exists.

Home based trip purposes (work, shop, other) typically have a higher degree of confidence in trip productions calculated from household attributes than the attractions calculated from land use or economic variables. For these trip purposes, unlocked attractions (non-external and non-special generator estimated) are modified based on the ratio of total unlocked productions to total unlocked attractions at the zonal level.

Specialized trip purposes (school, university, hospital, airport, recreational) are better controlled at the attraction end, where the number of attendees at the specialized locations is known. In these cases, the unlocked productions should be modified based on the ratio of total unlocked attractions to total unlocked productions at the zonal level.

Non-home-based trips not related to the work tour, known as Other based non-home-based trips, are balanced to the global total of productions as estimated by equations based on household characteristics. This process adjusts the attractions at the non-household end. These non-household related trip ends (or attractions) form one end of the actual non-home-based trip. The productions at each zone are set to equal the attractions, consistent with accepted practice.[18] Table 4-32 below outlines the balancing process for each trip purposes within the ISMS model.

Table 4-32: Trip Balancing Process

GENERIC PURPOSE	SPECIFIC PURPOSE	BALANCING PROCESS
Home-based work	Home-based work low income (HBWL)	Balance trip attractions to trip productions. Consider independent datasets to verify regional total across all income groups is accurate. Examples of independent datasets include using national datasets including journey to wok (JTW) and explain ways in which local travel characteristics differ from national.
	Home-based work medium income (HBWM)	
	Home-based work high income (HBWH)	
Home-based non-work	Home-based K-12 school	Balance productions to known entity of school attendees, tied directly to attractions.

[17] NCHRP Report 716. Travel Demand Forecasting: Parameters and Techniques. P 38. While most literature on best practices recommends that the difference between unbalanced regional attractions and productions be kept to ☐/☐10 percent for each purpose, a review of model validation reports shows that this standard is often exceeded.
[18] National Cooperative Highway Research Program Report 365, Travel Estimation Techniques for Urban Planning, pages 32-33.

GENERIC PURPOSE	SPECIFIC PURPOSE	BALANCING PROCESS
	Home-based shopping	Balance attractions to productions.
	Home-based other	Balance attractions to productions.
Non-home based	Both ends not at home	Set regional target to match sum of productions, scale attractions such that sum of attractions equals target, then set zonal productions equal to zonal attractions.
Special purposes	University	Balance productions equal to attractions.
	Hospital	Balance productions equal to attractions.
	Airport	Balance productions equal to attractions.
	Regional recreation	Balance productions equal to attractions.
	Hotel	Balance attractions equal to productions. (trips produced at hotel rooms)
Trucks	Single-unit truck	Balanced during trip generation.
	Combination truck	Balanced during trip generation.

The MPT shall fill the TAZ attribute table to hold the production and/or attraction values at selected TAZs such as special generators. The holding of production and/or attraction values will be conducted at all external stations. Other selected TAZs would require justification based on consultation with MPT. This process will likely be reviewed iteratively during model calibration/validation exercises.

The MPT shall collectively review and provide input for maintaining the raw production or attraction values at specific non-external TAZs.

4.17.3 Data Sets

INPUT DATA

The ISMS prototype produces trip production and attraction data by TAZ. These datasets are inputs of the trip balancing process. Table 4-33 shows the TAZ attributes used to hold productions or attractions constant through the trip balancing process.

Table 4-33: Production and Attraction Hold as Entered in TAZ Attributes

ATTRIBUTE NAME	FORMAT	RESPONSIBLE PARTY	DESCRIPTION
Prod_Hold	Integer	MPO (See Section 4.16)	Flag to hold the productions calculated at the TAZ constant through the trip balancing process 0=Balance 1=Hold Constant
Attr_Hold	Integer	MPO (See Section 4.16)	Flag to hold the attractions calculated at the TAZ constant through the trip balancing process 0=Balance 1=Hold Constant

ESTIMATION DATA

No applicable data.

VALIDATION DATA

Data regarding the justification of holding a TAZ's trip ends constant is required. This data includes traffic count data, parking data or related site-specific data.

OUTPUT DATA

Table of balanced productions and attractions by trip purpose, time of day and weekday/weekend combination. A portion of an example table is shown in Table 4-34.

Table 4-34: Portion of Example Trip Balancing Output Data (PAWDAM.BIN)

TAZ	PHBWL	AHBWL	PHBWM	AHBWM	COLUMNS CONTINUE	PCOMBO	ACOMBO
1	2.31	1.51	2.15	1.80		0.08	0.08
2	28.53	23.44	33.50	21.57		0.63	0.63
3	0.00	6.1	0.00	27.1		5.78	5.78

4.17.4 ISMS Application

As discussed above, the ISMS model user specifies TAZs that will retain the raw production or attraction values from trip generation through the trip balancing process. This applies to all external stations at a minimum. Other TAZ's may also have their production or attraction values held constant if justifiable, based on consultation with the MPT.

4.17.5 Calibration, Validation and Reasonableness Checking

Validation of trip balancing begins with reviewing the sum of raw productions and attractions by trip purpose. If the two values differ by more than 10 percent, a review of the trip production and attraction estimation processes shall be conducted.

The ISMS model checks the sum of productions and attractions that are held constant, along with the sum of 'free' productions and attractions that may be balanced. Due to both production and attraction values being held constant at all external zones, a situation may occur where there are not enough internal trip ends to accommodate the opposing external trip end. For example, a trip purpose that has the attractions held due to higher confidence in those values, such as airport, has 500 internal trip attractions calculated during the trip generation process. A sum of external trip productions for the purpose of 600 trips would cause an error, as the 500 internal productions are held constant but do not satisfy the 600 external productions that are also held constant. The ISMS model will provide the user with an error message. The user then must review the process of calculating both the internal and external trip ends and make modifications in one or both in order to bring the two values in line.

The total balanced trips per household should be in the ranges outlined in Table 4-23C.5 as defined by NCHRP 716.

TAZs where the raw productions and/or attractions are not included in the balancing shall be reviewed for reasonableness.

4.17.6 Future Year Considerations

ISMS assumes TAZs that production and/or attraction holds are applied to all analysis years.

4.17.7 Documentation Standards

The raw productions and attractions, including the external trip ends, shall be documented prior to trip balancing, along with the ratio of the two independently calculated trip ends prior to trip balancing, including reference to the external and internal productions separately and in total. The difference between the productions and attractions by purpose shall be documented. If trip productions or attractions at non-external and specific TAZs are to be held constant through the trip balancing process, these locations should be documented including rationale for their exclusion from the trip balancing process.

4.17.8 Quality Assurance and Control

The MPT is responsible for reviewing the impacts of trip balancing and determining if production or attraction estimates for specific TAZ should be excluded from the trip balancing process. The specific roles and responsibilities of these tasks will be identified in the workplan.

4.18 Network Skimming

4.18.1 Overview

The ISMS model develops two sets of network skims, the first representing vehicle travel times and the second representing walk travel times. A third optional skim is also developed for transit and is described in Section 4.21.

The ISMS prototype develops the auto skim matrix representing the travel time between all zones within the model network using the roadway network. This auto skim is used by ISMS prototype for distributing person trips, as discussed in Section 4.19. The auto skim includes time traveling the roadway network, terminal times and intrazonal times, as described in more detail below.

A separate walk network skim is also developed by ISMS. The walk network excludes limited access facilities (interstates, freeways and ramps) and includes roadways with walk access and walk-only links.

4.18.2 Recommended Architecture

AUTO TRAVEL TIME SKIM

The ISMS model develops an auto skim matrix representing the travel time between all zones within the model network. This auto travel time skim is used for distributing trips between zones, and includes both link travel time and intersection turning delays, along with any turn prohibitions.

ISMS uses free flow link travel times for auto skims. Intersection turning delays are estimated using the process described in Section 4.7.1. Manually developed turn penalties may also be included in the auto network and included in the corresponding skims.

AUTO INTRAZONAL TIME

The ISMS model calculates the disutility of travel within a specific zone, known as the intrazonal skim. The auto skimming process does not capture this time directly. The intrazonal travel time may be calculated in various ways.

The recommended approach uses non-network road segments within a TAZ to calculate the average intrazonal length, speed and travel time for each TAZ. The theory behind this calculation rests on the propensity for longer trip times to correlate with the availability of longer, uninterrupted road segments within a TAZ. Simultaneously, the opposite is true for the availability of shorter, more interrupted road segments.

Recommended Workflow:

Average Segment Speed and Length

1. Utilize RAMS road segments to represent local roads not included in the model network.
2. Use the model network to select and remove segments that form TAZ boundaries.
3. Tag TAZ ID to segments within each respective zone.
4. Aggregate the average segment length and average speed for each TAZ based on road segment TAZ IDs.

Average Travel Time

1. Convert road segment speed for each TAZ's local roads from Miles/Hour to Miles/Minute by dividing the segment value by 60.
2. Multiply each segments' length by its corresponding new segment speed to calculate travel time in minutes.
3. Aggregate average travel time for each TAZ based on road segment TAZ IDs

Table 4-35: Attributes for Intrazonal Travel Time Calculation

FIELD	TYPE	DESCRIPTION
ROAD_LENGTH	Integer	Total length of roadway segments within a TAZ
ROAD_DENSITY	Integer	Ratio of total length of roadway segments over TAZ area. Density listed in Miles/Square Mile.
AVG_LENGTH	Integer	Average length of roadway segments within a TAZ
AVG_SPEED	Integer	Average speed of roadway segments within a TAZ
AVG_TRAVEL	Integer	Average travel time within a TAZ. Time listed in Minutes.

Alternative approaches to calculating intrazonal travel times may also be considered. TransCAD's nearest neighbor approach is used by the ISMS prototype to develop a default value. The nearest neighbor takes half of the average travel time between any zone and the three closest zones as determined by travel time. An approach that uses a function of the area of the zone may also be used. Manual estimation may also be used.

The selected value for intrazonal time is determined, then entered into the Terminal File (Termfile.bin) as shown in

Table 4-36. If a null value is maintained in the Terminal File, the prototype will use the default value as calculated by the nearest neighbor approach. Note that external zones do not require intrazonal travel times, as no trips at the external zones are allowed to be intrazonal. External zones utilize K-factors to preclude two external zones from matching up during trip distribution, also preventing intrazonal trips at the externals.

Table 4-36: TERMFILE.BIN Input file for Intrazonal and Terminal Times by Zone

TAZ	IZTIME	TERMTIME
1	-	10
2	-	3
3	-	3
Pattern continues		
101	0.2	2
102	0.2	1
103	0.2	3

AUTO TERMINAL TIME

Terminal times are also incorporated into the roadway skim value. The izterm.BIN file contains the values used by the ISMS model. A default set of terminal time values are calculated by ISMS for both internal and external zones, and may be used to develop the values placed in izterm.BIN. Manually developed values may also be used to account for specific conditions.

Internal zone terminal times represent the time spent accessing a vehicle at the origin end, and parking and walking to the destination of the trip. The ISMS default value for internal terminal time is calculated during model execution using the Density attribute of each TAZ, as calculated by Equation 4-4.

Equation 4-4: TAZ Density Equation

$$Density = \left(KSF + \frac{HH}{2} + \frac{SCH}{10} + OTH\right)/\text{Area}$$

Where:

KSF = Sum of non-residential land use that is quantified in units of 1000 square feet (see **Error! Reference source not found.** for listing of land use codes with KSF as units)

HH = Number of housing units (land use codes 10-21, 24 & 25)

SCH = School enrollment (land use codes 81 through 84)

OTH = Other activities not defined above (in acres) plus University employment and one-fourth of housing from the UNIV_SE.BIN file.

Area = Square miles within TAZ

The terminal time values by TAZ density value are shown in Table 4-37. Figure 4-14 shows the density by TAZ for the Ames area, while Figure 4-15 shows the density by TAZ for the Des Moines area. Both show the central business district as having density above 10,000 units per square mile. The ISU campus and Campustown areas of Ames also show a density above 10,000.

Table 4-37: Terminal Time Values by Density for Internal Zones

DENSITY	TERMINAL TIME	DESCRIPTION
<500	0 minute	Rural-type activity pattern
501-1,999	1 minutes	Low density activity pattern
2,000-9,999	2 minutes	Medium density activity pattern

Figure 4-14: TAZ Density Map of Ames

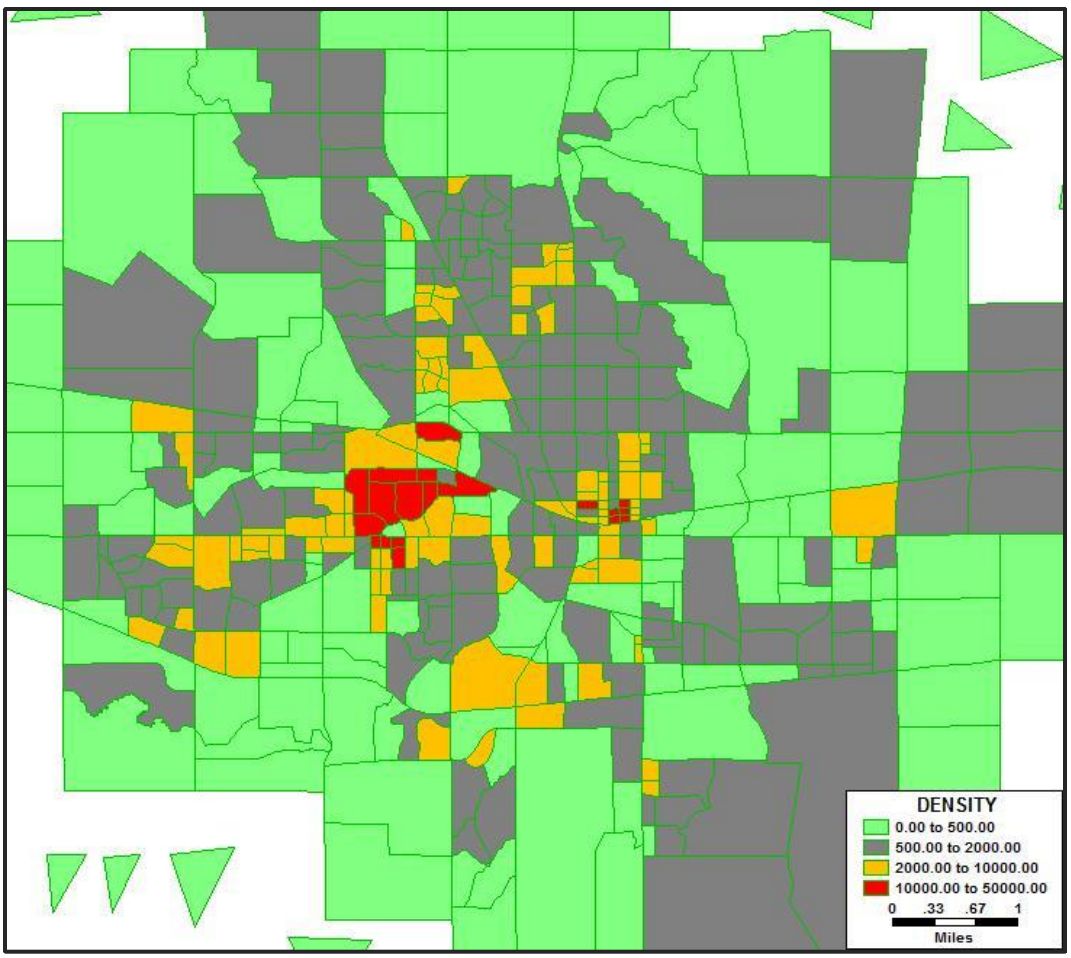
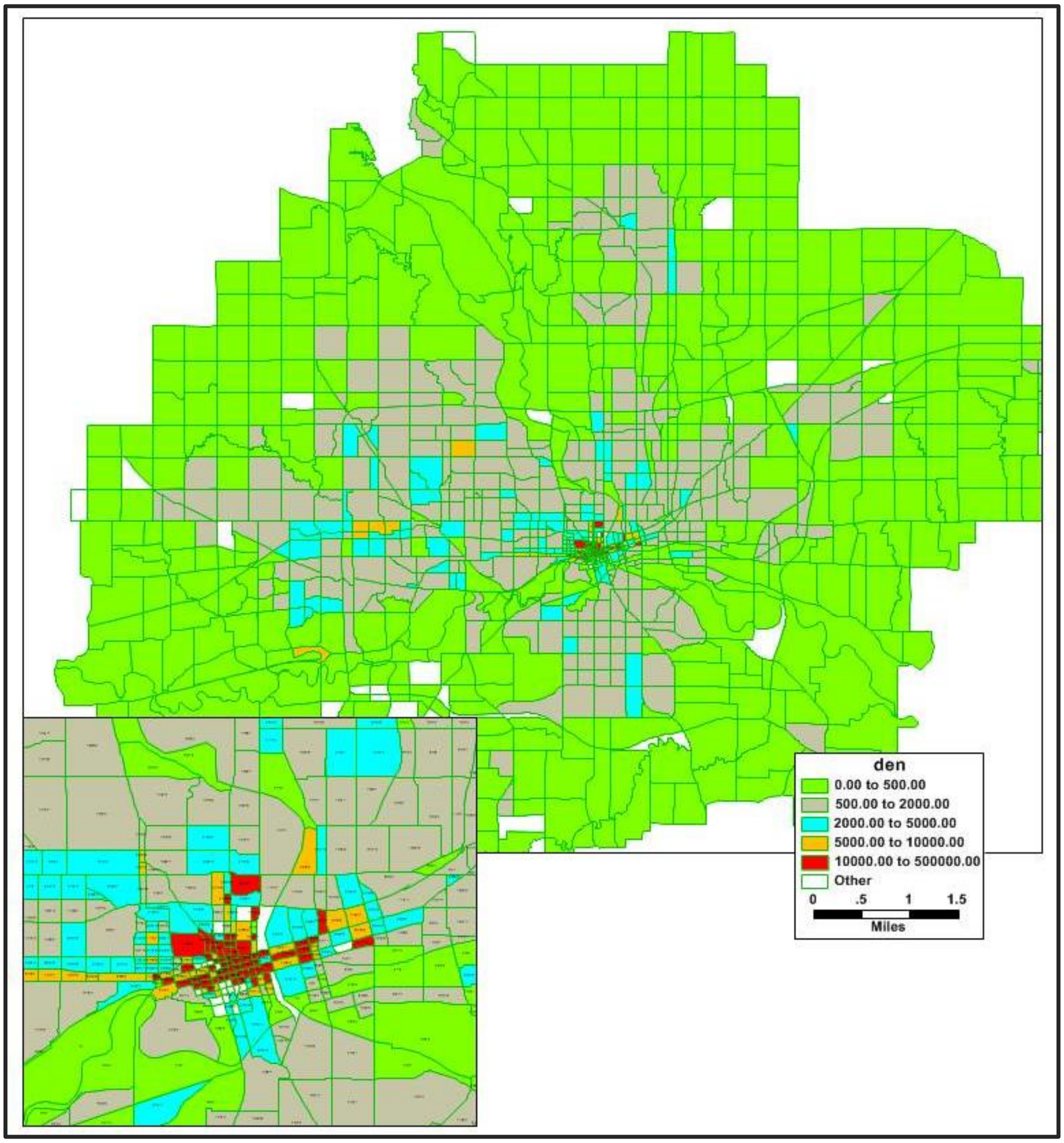


Figure 4-15: TAZ Density Map of Des Moines



External zone terminal time represents the time spent outside the model network traveling to the metropolitan area. This value is not explicitly calculated, but rather estimated based on the general size of the travel shed for the external zone, with high functional class facilities such as interstates and freeways having larger travel sheds than collectors, as shown in Table 4-38. Without a substantial terminal time at external zones, distribution models will see productions and attractions at external zones as having a high likelihood of matching with nearby internal zones. While this may be true for service trips at interchanges, other trip purposes should be expected to have trips distributed more evenly throughout the model area from the external zones. A travel survey is useful in calibrating the external terminal time values. The additional time added to the externals helps to make it more attractive to go to the attractive inner zones from these externals.

Table 4-38: Terminal Time Values by Functional Class for External Zones

FUNCTIONAL CLASS	TERMINAL TIME	DESCRIPTION
1 = Interstate 2 = Freeway	15 minutes	Large travel shed covering counties of states
3 = Expressway 6 = Principal Arterial	10 minutes	Mid-sized travel shed covering portions of adjacent county
7 = Minor Arterial	5 minutes	Modest travel shed covering narrow area along facility
8 = Collector or Other	3 minutes	Very focused travel shed

WALK DISTANCE SKIM

The ISMS model includes a mode split component that incorporates the presence of walkable facilities and bus stops. The walk skim is developed from a selection of links that traditionally allow for pedestrians, and excludes limited access facilities including interstates, freeways and ramps. Walk only links are also included in the walk network. The walk distance skim does not include turn penalties, intrazonal or terminal times, and is used only to estimate the portion of trips between two zones that would be expected to walk to complete the trip. The mode split process is described in more detail in Section 4.23. The primary function of the walk network is to add the ability to exclude these links from the auto mode, and it also helps to build the potential framework that might allow full mode choice in the future.

4.18.3 Data Sets

INPUT DATA

Roadway and walk only link distances and travel times are available in the link network data, as shown in Table 4-7.

Intersection delays incorporated into the auto skims are available as described in Section 4.7.1.

TAZ area is available as described in Section 4.3. Density data is calculated within ISMS at run time.

Terminal times for both internal and external zones are manually developed and entered into izterm.bin, with default values available as described above. The project team shall develop the terminal time values for each zone in the network and populate the izterm.bin file accordingly. Staff may choose to use the ISMS model's default value as described above. The MPO shall coordinate with DOT staff on the method for developing intrazonal times, then calculate values or review DOT provided values.

ESTIMATION DATA

External terminal times may be estimated by determining the center of activity for trips coming to/from the model area via each external zone. For example, the terminal time for the I-35 zone south of Ames should consider the time to travel to the Des Moines metropolitan area.

VALIDATION DATA

Aerial photography to aid in review of the physical environment, including proximity of parking, pedestrian paths, local road network and other factors influencing total travel time between zones. This can be supplemented by MPO's local knowledge of pedestrian paths and walkable neighborhoods.

Travel survey data; specifically for estimating terminal times for external stations through review of observed movements and post-trip distribution trip table interactions at external zones.

Google Maps or other on-line programs to estimate travel time and distance between locations.

OUTPUT DATA

The auto travel time skims are output by the ISMS prototype within the scenario's Outputs\2 HighwaySkim folder. One skim is created for each peak period, named Spmat[tod].mtx.

The walk distance skim is output by the ISMS model within the scenario's Outputs\4 Mode folder and is named Walkskim.mtx.

4.18.4 ISMS Application

Default values for both intrazonal and terminal time data are produced by the prototype, however the user must develop the final values for both attributes and place in the izterm.bin file. The ISMS model then reads intrazonal and terminal time information from the izterm.bin file for model execution. Auto travel time and walk distance data are processed by ISMS from the Highway.dbd file.

4.18.5 Calibration, Validation and Reasonableness Checking

The project team shall review the auto travel time skims between zonal pairs to verify reasonable differences between points in the network. Hand validation of select zone pairs shall be conducted by using Google Maps to identify both travel distance and travel time. This review shall also be conducted within a set of zones to validate the intrazonal travel times. Network connectivity errors may result in unrealistic travel time skims, and should be considered while reviewing travel times. Use of TransCAD's Network/Paths>Shortest Path tool will aid in visualizing the path selected by TransCAD between zonal pairs. One method of doing this is to select key origins and destinations (downtown CDB or major employers) that might use major highways when the shortest paths are built. If the paths or travel times look unreasonable, it might indicate that some functional classes (and related link capacities or speeds) have been coded incorrectly.

Terminal times shall be validated through review of the physical environment via aerial photography or on-site inspection. For example, a zone with a centralized parking lot that requires a considerable walk to complete the trip should have a larger terminal time than a zone with ample parking in front of each store.

External zone terminal times influence the trip lengths for internal-external and external-internal trips. The MPO shall review the travel patterns at external stations compared to observed data and modify external travel times accordingly, with higher travel times tending to length average trip lengths to/from the external zone.

4.18.6 Future Year Considerations

Intrazonal and terminal time values may change over time as development may alter the local road network and density of economic activity. MPO staff shall review the intrazonal and terminal time inputs considering future year roadway and parcel data. ISMS prototype may be used to estimate future year terminal time values at internal zones. Auto travel time and walk distance are recomputed at model run time, including any roadway projects included as documented in Section 4.10. ISMS assumes all parameters related to highway network skimming apply to all analysis years.

4.18.7 Documentation Standards

A map of TAZ densities shall be included in the documentation. The izterm.bin file shall be included in the model documentation, including the methodology used to calculate the data.

4.18.8 Quality Assurance and Control

MPO staff shall review default values for calculating the intrazonal time and terminal times, along with intrazonal travel time values provided by Iowa DOT staff. MPO staff then populate the izterm.bin file as appropriate. Modification of these values shall be coordinated with Iowa DOT staff. Iowa DOT staff then conduct a review of final inputs and outputs of the network skimming process.

4.19 Trip Distribution

4.19.1 Overview

The ISMS prototype model provides users with two options for completing trip distribution.

The first option is the standard gravity model process. The likelihood of a production from zone A matching with an attraction at zone B is a factor of the magnitude of attractions at zone B and the disutility between zones A and B relative to the sum of the attractions and the disutility's between A and the universe of zones within the model.

The second option is a destination choice model process. More details on this process will be included in this manual at a later date after a working version of the destination choice modeling process is implemented. Please contact the Systems Planning Bureau Modeling Coordinator with any questions.

4.19.2 Recommended Architecture

The ISMS model gravity distribution model uses the balanced trip productions and attractions calculated in Section 4.17 and the skim disutility as calculated in Section 4.18. The ISMS prototype also uses friction factors by trip purpose to represent the decreasing likelihood of a trip interaction as the skim between the subject zones increases. This relationship is dependent upon the purpose of the trip, where work-based trips are less sensitive to longer time and distance while non-home based are much more sensitive.

The gravity model (adapted from Newton's Law of Gravitation) assumes that the amount of travel between TAZs is based on the relative attractiveness between the origin and the destination.

The ISMS prototype provides the user with the ability to utilize district to district K-factors to improve the performance of the gravity model. The district K factors are applied by specifying the district number as an attribute of each TAZ, as shown in Table 4-39.

Table 4-39: K Factor Districts as Entered in TAZ Attributes

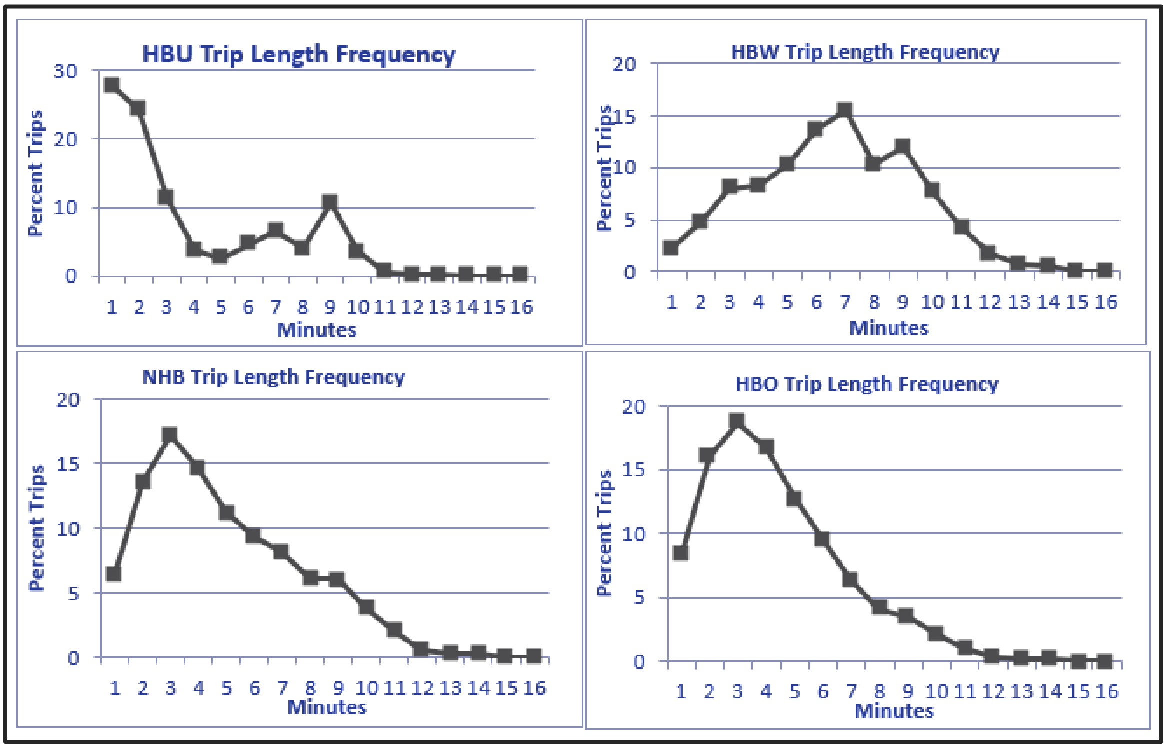
ATTRIBUTE NAME	FORMAT	RESPONSIBLE PARTY	DESCRIPTION
District	Integer	MPO	The K factor district of the TAZ, value of 1 to 50.

The district to district provides the following applications:

- Eliminate E-I/I-E trip ends from matching with another external trip end (which would be an E-E trip by definition)
- Influence distribution to better reflect Journey to Work data
- Influence distribution to better align with regional cut and screenlines

K Factors are used to model individual variations by origin-destination pair that are not otherwise accounted for in the trip distribution model. An example of the trip length distribution by purpose is depicted in Figure 4-16. K factors help to account for socioeconomic linkages that are not being fully captured by the gravity model. The use of K factors should be done judiciously and only in areas where there is some individual pattern variation that cannot otherwise be captured by the trip distribution (gravity) model.

Figure 4-16: Trip Length Distributions Example (from Household Survey)



4.19.3 Data Sets

INPUT DATA

A friction factor table is required for each trip purpose and may be developed for each time period and weekday/weekend uniquely. The default setting for ISMS is to utilize one friction factor table per trip purpose for all time periods. The default values are shown in **Error! Reference source not found.**.

The K factors are entered into a matrix, with one table for each trip purpose. It is assumed that one set of K factors are appropriate for each time period and weekday/weekend. An example of a K factor matrix is shown in **Error! Reference source not found.**.

ESTIMATION DATA

Household travel surveys provide data for estimating friction factors and K factors. Other specialized surveys targeted at specific purposes or locations can also be used to augment distribution parameters.

VALIDATION DATA

Journey to Work data provides a commonly accepted observed target value for trips associated with getting to work and the return trip. Note that journey to work may include trips other than home-based work trips in the ISMS model, as a trip going from home to the coffee shop and on to work would be classified as one home-based other and one non-home-based trips.

OUTPUT DATA

Person trip tables by trip purpose, time period and day of week are output by the distribution model.

4.19.4 ISMS Application

The ISMS prototype will need the user to supply district to district K-factors to improve the performance of the gravity model. The district-district trips and/or travel patterns for the HBW trips can be compared to district-district trips from the origin-destination districts from Journey to Work data.

4.19.5 Calibration, Validation and Reasonableness Checking

During calibration, k factors may be adjusted to achieve better linkage between origins and destination. If an origin-destination pair has too many trips, the k factor is typically adjusted to be less than 1.0. If an origin-destination pair has too few trips, the k factor is typically adjusted to be greater than 1.0. If k factors greater than 3 or 4 are needed for multiple district to district pairs to adequately mimic observed trip patterns, a review of the friction factors, skims and input production-attraction values should be conducted before continuing through distribution model calibration.

Desire lines showing the magnitude of trips from a specific zone or district to all other zones or districts provide a visual reasonableness check.

4.19.6 Future Year Considerations

Once calibrated for the base year, most trip distribution parameters (including k-factors) are held constant for future years.

4.19.7 Documentation Standards

Trip length distribution curves shall be provided for each trip purpose. Friction factor variables and k-factor tables shall also be included in the documentation.

4.19.8 Quality Assurance and Control

The travel demand model development team shall review values developed for use in the trip distribution model.

4.20 Parking Allocation (Optional Analysis)

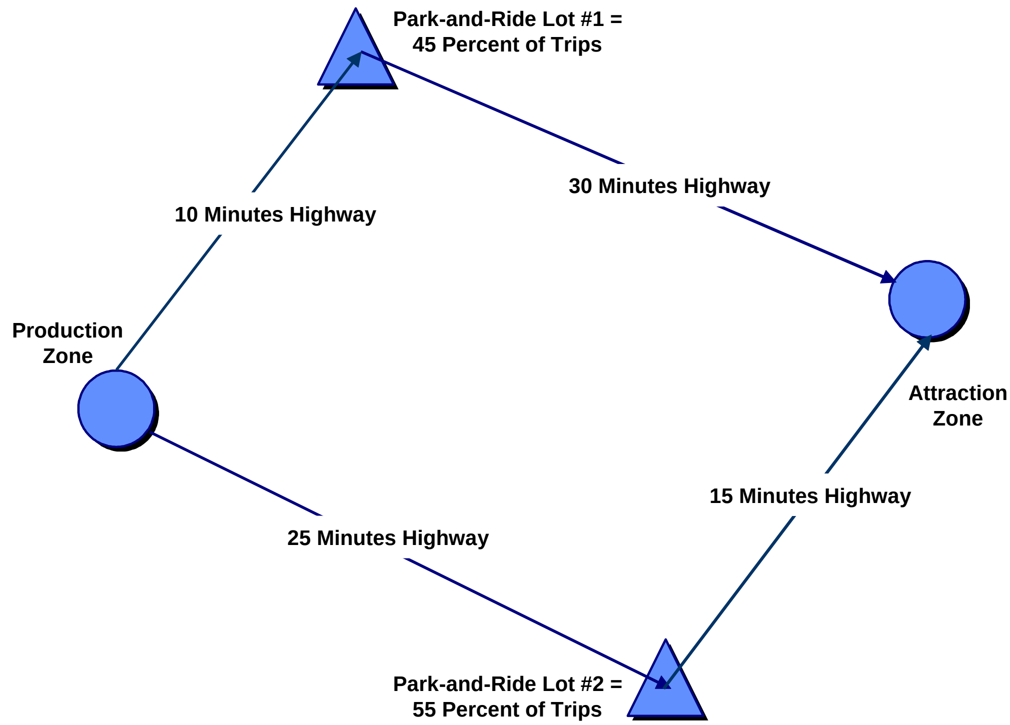
4.20.1 Overview

Due to restrictions or limited availability of parking, not all vehicle trips end at the same location as the person-trips destination. The ISMS model uses TransCAD's transit network building functionality. The approach is applied to trips where travelers drive to a park-and-ride lot and then use transit to access the final destination, but it could be applied to trips where walking is the mode used to reach the final destination. However, this will require manually reallocating the parking destination trips so they are associated with the TAZ employment, school enrollment (K-12 and University), or other possible descriptive variables where the parking location is different from the final destination.

4.20.2 Recommended Architecture

Within the ISMS recommended architecture, auto-access-to-transit trips are distributed to various parking lots based on combined auto and transit travel times. Figure 4-18 presents an example of auto access transit trips distributed to different parking lot options based on auto and transit utilities.

Figure 4-18: Parking allocation model



Example of Park-and-Ride Lot Shares:

	Auto Access Trip #1	Auto Access Trip #2
Highway	10	25
Transit	30	15
Total Time	40	40
Auto Utility	0.137	0.007
Transit Utility	0.361	0.600
Composite Utility	0.497	0.607
Share of Trips	45%	55%

The auto access utilities are determined using a function of the highway travel time, as shown in Equation 4-5:

Equation 4-5: Auto Access Utility

Auto Access Utility = exp (-0.199*Highway Time)

Transit in-vehicle utilities for drive-to-transit trips are determined using a similar function, as shown in Equation 4-6:

Equation 4-6: Transit In-Vehicle Utility

Transit In-Vehicle Utility = exp (-0.034*Total Transit Time)

In this example, travelers are encouraged to choose parking lots closer to the origin of the trip with good transit service rather than choosing parking lots closer to the destination of the trip. The coefficients in the utility equations shown above were calibrated to conditions observed for the Puget Sound, WA region.

Total travel time for these drive-to-transit trips is then determined by the sum of the auto access time to a particular park-and-ride lot and the transit in-vehicle time to the destination. With this method it is necessary to identify the locations of park-and-ride lots prior to skimming and calculation of utilities, but the list of pre-identified park-and-ride lots can include both formal and informal locations. The path is determined by isolating the first part of the trip from the origin to the parking lot, and the second part of the trip from the park-and-ride lot to the destination, and then merging these into a single trip record.

If the mode of access to the final destination was walking, instead of transit, then the coefficients on highway time and walk time could be calibrated to encourage travelers to choose parking lots closer to the destination of the trip where walking is more feasible. In this case, the coefficient with the walk leg utility would be calibrated to locally observed conditions. In the event that observed local data doesn't exist, survey data from communities of similar size and with similar attributes could be used to estimate the coefficient. Because it uses origin-destination travel time data (i.e., skims) as the basis for calculating utilities, it should be noted that this methodology is best suited for model structures that include a mode choice models. For models that include less robust mode "split" models, more investigation will be needed to determine the transferability of this methodology to those model structures.

Table 4-40 outlines the format of parking capacity data to be entered into the TAZ attributes table.

Table 4-40: Parking Capacity as Entered in TAZ Attributes

ATTRIBUTE NAME	FORMAT	RESPONSIBLE PARTY	DESCRIPTION
Park_cap (-)	Integer	MPO	Public parking availability and capacity: -1 = No parking 0 = No restrictions (unlimited parking) >0 = Capacity of parking within the zone
Park_Cost (-)	Real	MPO	Cost in dollars to park for general public.
UPark_Staff_Cap (-)	Integer	MPO	University Staff parking availability and capacity: -1 = No parking 0 = No restrictions (unlimited parking) >0 = Capacity of parking within the zone
UPark_Staff_C	Real	MPO	Cost in dollars to park for University staff.

ATTRIBUTE NAME	FORMAT	RESPONSIBLE PARTY	DESCRIPTION
UPark_Stud_Cap	Integer	MPO (See Section 4.20)	University student parking availability and capacity: -1 = No parking 0 = No restrictions (unlimited parking) >0 = Capacity of parking within the zone
UPark_Stud_C	Real	MPO	Cost in dollars to park for University students.

NOTE: (-) indicates attribute has 3 subsequent entries for project-specific updates. Only non-zero values in these columns will be used directly in project analysis.

4.20.3 Data Sets

INPUT DATA

Parking capacity data is required for use of the parking allocation model. The source of the number of parking spaces at a given location is MPO-specific, typically available from other local agencies or public sources.

ESTIMATION DATA

Not applicable.

VALIDATION DATA

Aerial data provides an independent source to counting or estimating the quantity of parking at specific locations.

OUTPUT DATA

Trip tables that are mode-specific and incorporate the end of the auto trip at the parking location and the beginning of the transit trip at the parking location.

4.20.4 ISMS Application

Parking capacity is input in the ISMS prototype as a TAZ attribute.

4.20.5 Calibration, Validation and Reasonableness Checking

Reasonableness checking for parking allocation should be conducted with mapping showing TAZ with parking restrictions and with the number of available parking spaces by time of day.

4.20.6 Future Year Considerations

Up to three parking capacities and corresponding parking costs may be included in the TAZ attributes.

4.20.7 Documentation Standards

Mapping of TAZ with parking restrictions and with the number of available parking spaces by time of day.

4.20.8 Quality Assurance and Control

4.21 Transit Skims (Optional Analysis)

4.21.1 Overview

The ISMS model provides the option to incorporate a mode choice model into the model process. Mode choice is not required, as some MPO's do not require explicit analysis or forecasting of transit ridership and operations. The mode choice model replaces the simpler mode split process. Mode choice includes specific transit route details, including each transit route, route stops, route headways and access modes to and from transit. The process of coding transit routes is described in more detail in Section 4.9.

4.21.2 Recommended Architecture

Transit skims include several variables that collectively influence the likelihood of using one mode of transportation over another mode. While travel time is a key variable, other factors also are included into the skims. Each set of skim attributes is collected for each access mode, time period, and both weekday and weekend. Table 4-41 below outlines the various transit skim attributes collected during the transit skim development process. Note that an initial traffic assignment is completed prior to transit skims to generate approximate congested travel speeds along the roadway network. These congested values are subsequently used to develop the various in-vehicle travel times for the transit skimming process. No feedback loops are currently conducted within the ISMS model to verify congested speeds during the initial traffic assignment are consistent with the final assignment speeds.

Table 4-41: Transit Attributes Used in Transit Skim

ATTRIBUTE NAME	FORMAT	DESCRIPTION
Fare	Real (dollars)	The initial fare in dollars required to ride the transit mode – a function of the transit route file
In-Vehicle Time	Real (minutes)	Number of minutes required to complete the portion of the trip while in the transit vehicle
Initial Wait Time	Real (minutes)	Number of minutes required to wait for the initial bus needed to complete the trip to arrive at the stop – a function of the headway of routes that serve the OD pair – minimum =2 minutes, maximum = 99999
Transfer Wait Time	Real (minutes)	Number of minutes required to wait for the transfer bus(es) needed to complete the trip to arrive at the transfer stop – minimum = 2 minutes, maximum = 99999, zero if no transfer required

ATTRIBUTE NAME	FORMAT	DESCRIPTION
Transfer Walk Time	Real (minutes)	Number of minutes required to walk between the egress point of the first bus and the access point of the second bus within a transfer – a function of the available road/walk links between the bus stops
Access Walk Time	Real (minutes)	Number of minutes required to walk between the trip origin and the first bus stop on the trip – a function of the available road/walk links in the roadway network
Egress Walk Time	Real (minutes)	Number of minutes required to walk between the last bus stop in the trip and the destination of the trip – a function of the available road/walk links in the roadway network
Access Drive Time	Real (minutes)	Number of minutes required to drive between the trip origin and the park and ride stop on the trip – a function of the available road links in the road network
Number of Transfers	Integer	Number of transferred between transit routes required to complete the trip
Access Drive Distance	Real (miles)	Number of miles required to drive between the trip origin and the park and ride stop on the trip – a function of the available road links in the road network
OVTT	Real (minutes)	Out of Vehicle Travel Time – Total time spent outside of a vehicle in completing the trip, including access, egress, wait and transfer times.

4.21.3 Data Sets

INPUT DATA

Transit fares are input into the skim process via the transit route file. The remaining input data is calculated based on the transit and roadway networks directly, with minimum and maximum values as outlined in Table 4-. These minimum and maximum values are typical to the industry, and may be modified during the transit mode choice calibration effort.

Walk speed is input into the ISMS prototype directly, with a default value of 3 miles per hour. This variable is modified by highlighting the scenario, pressing Setup Scenarios, highlighting the Mode Split step in the upper right corner, then pressing the Parameters tab.

ESTIMATION DATA

Due to the limited number of transfers in a typical transit system, calculating transfer times may be difficult. Estimating these times to be consistent with other walk times is reasonable.

VALIDATION DATA

Transit schedules are typically used to validate the in-vehicle time. Walk travel times may be validated through observing transit users near major bus stop locations. Auto travel times may be validated using observed travel time data, as described in Section 4.11.

OUTPUT DATA

Matrix files containing the various skim values outlined in this section are output for each time period, and both weekday and weekend. These skim values are then used in mode choice as described in Section 4.22.

4.21.4 ISMS Application

The mode choice sub-model can be turned on or off within the ISMS model. The user toggles by highlighting the scenario, pressing Setup Scenarios, highlighting the Mode Split step in the upper right corner, then pressing the Parameters tab. Enter a value of 0 in Mode Split Option to run the full mode choice sub-model, or a value of 1 to run the mode split sub-model.

4.21.5 Calibration, Validation and Reasonableness Checking

A key to transit modeling is to first carefully review the various skim values between reasonably spaced zones that are well served by transit. Manually view the links traversed for the access walk to the most likely transit stop and compare to the model skim. Determine the number and headways of transit routes that serve both the initial stop and the final stop along the trip; these are used to calculate the initial wait period. Review the bus schedule between the two stops for run time and compare to the in-vehicle travel time. View the egress walk links and compare to the model skim. Supplement with reviews of aerial photography for additional obstacles at either the access or egress ends of the trip. Repeat the above process, but using the drive access mode, which includes driving to a park and ride facility, then using the bus system. Repeat this process for a 5-10 additional random zone to zone pairs, ideally with different transit, walk and park and ride characteristics.

Identify zones with the highest values within each skim matrix and determine if the value is reasonable.

4.21.6 Future Year Considerations

Future transit network route and stops files shall be created prior to running future year ISMS models as discussed in Section 4.9.

4.21.7 Documentation Standards

Document the transit route file used for the analysis. Note the walk speed used. Provide a brief synopsis of the reasonableness checks conducted, supplemented with any additional modifications made during Mode Choice calibration, see Section 4.22

4.21.8 Quality Assurance and Control

A thorough review of transit skims is required prior to modifying mode choice parameters. An initial overall review for reasonableness should be conducted cooperatively between Iowa DOT and MPO staff, with more detailed testing and evaluation to completed upon determination of overall reasonableness.

4.22 Mode Choice (Optional Analysis)

4.22.1 Overview

The ISMS model provides the option to incorporate a mode choice model into the process. Mode choice is not required, as some MPO's do not require explicit analysis or forecasting of transit ridership and operations. The mode choice model replaces the simpler mode split process. Mode choice includes specific transit route details, including each transit route, route stops, route headways and access modes to and from transit. The process of coding transit routes is described in more detail in Section 4.9. The mode choice model converts person trips from the trip distribution model into the following categories:

- Non-motorized person trips (including walk and bicycle modes)
- Auto person trips (to be converted to vehicle trips)
- Transit-walk person trips with walk access to and from bus stops
- Transit-drive person trips with park-and-ride access at one end of bus trips

It should be noted that the auto mode is a generic term which includes autos, light and medium duty trucks, and motorcycles. The transit mode accounts for trips on scheduled public transit vehicles. Other "transit" trips on school buses and paratransit vehicles are not accounted for.

Mode shares are relatively stable across many of the detailed trip purposes used in the trip generation and distribution models. The 12 non-truck purposes are aggregated into the six mode choice purposes shown in Table 4-42. Single-unit and combination truck trips as well as external-external trips are generated as vehicle trips so they are not included in mode choice procedures.

Table 4-42: Mode choice purposes

MODE CHOICE PURPOSE	SPECIFIC PURPOSE
Home-based work low income	Home-based work low income
Home-based work medium income	Home-based work medium income
Home-based work high income	Home-based work high income
Home-based other	Home-based K-12 school
Home-based other	Home-based shopping
Home-based other	Home-based other
Home-based other	Hospital
Home-based other	Airport

MODE CHOICE PURPOSE	SPECIFIC PURPOSE
Home-based other	Regional recreation
Home-based other	Hotel
Non-home based	Non-home based
University	University

4.22.2 Recommended Architecture

Non-motorized trips by bicycling and walking are first subtracted from total person trips using procedures described in Section 4.23). The remaining person trips are then allocated to auto and transit modes based on the relative times and costs of each mode.

Roadway networks are coded to obtain zone-to-zone auto in-vehicle travel time and distance matrices, as described in Section 4.20. A $0.13 per mile auto operating cost is used to obtain auto operating costs from auto distance matrices. Zone-level average parking costs are coded on TAZ geographic files and added to auto operating costs to obtain total auto costs. Auto terminal (out-of-vehicle) times represent the time spent walking from parking locations to final destinations. Similarly transit route systems are coded on roadway networks to represent the path, service frequency and fare for each scheduled transit route. TransCAD transit path finding procedures are then used to obtain zone-to-zone transit in-vehicle travel time, initial wait time, walk access/egress time, drive access time, and fare matrices, as described in Section 4.20.

The file mcparm.bin, as described in Table 4-43, contains the time and cost parameters listed below which are multiplied by times and costs between each zone pair and then added to mode constants listed in Table 4-44 to calculate utility measures for each mode (borrowed from the AAMPO model). Finally, TransCAD's "Logit Model Application" function is used to compute mode shares between zones by time period and trip purpose based on mode utilities. Trips by mode are then obtained by applying mode shares to total person trips after subtracting out non-motorized trips. Resulting trips are accumulated and output in summary reports and as trip tables for the highway and transit assignment process. Note mode choice constants were not estimated for income-specific purposes.

Table 4-43: Mode Choice Time and Cost Parameters

TIME AND COST COMPONENT	PARAMETER
Auto In-Vehicle Time	-0.03
Auto Cost	-0.13
Transit In-Vehicle Time	-0.03
Transit Initial Wait Time	-0.05
Transit Transfer Wait Time	-0.05
Transit Walk Access/Egress Time	-0.05
Transit Drive Access Time	-0.03
Transit Fare	-0.13

Table 4-44: Sample Mode Choice Mode Constants

PURPOSE	TRANSIT-WALK CONSTANT	TRANSIT-AUTO CONSTANT
HBWL	....	....
HBWM	-0.13	-1.85
HBWH	....	....
HBO	-2.80	-5.25
NHB	....	....
HBU	1.50	0.68

4.22.3 Data Sets

INPUT DATA

Model inputs include person trips from the trip distribution step, times and costs by mode from the network skimming process, parking costs from field surveys or other sources, and estimated model parameters. MPO staff typically obtain parking cost and work with transit agencies to conduct transit on-board surveys and transit passenger counts.

ESTIMATION DATA

Ideally MPOs making use of a mode choice model should have both a household travel survey and an on-board transit passenger survey so that mode constants can be estimated. Household travel surveys are used to provide the of base year calibration targets by purpose for auto and non-motorized modes. Household travel survey transit sample sizes are usually too small for logit model estimation. As a result, household surveys are augmented with on-board transit passenger surveys to provide base year calibration targets by purpose for transit-walk and transit-drive modes.

It may be possible to apply a mode choice model in MPOs lacking survey data by applying generic mode constants. Transit mode constants can then be adjusted during the model validation process to match transit passenger counts for the MPO.

Household travel surveys are discussed in more detail in Section 5.1.1. On-board transit surveys are discussed in Section 5.1.2.

VALIDATION DATA

A transit passenger count database is the primary source for validating a mode choice model. Ideally transit boarding and alighting counts would be collected by stop, route and time-of-day. At a high level, Census Journey-to-work data for trips by mode is a good data source for overall auto versus transit trips validation. Additionally, the National Transit Database (NTD)[19] data can be useful for transit ridership and trends

[19] National Transit Database data is available at https://www.transit.dot.gov/ntd/ntd-data

OUTPUT DATA

The mode choice sub-model produces auto person trip tables by purpose and time-of-day that are subsequently used with auto occupancy factors in Section 4.24 to generate vehicle trips for highway assignment. Transit trips tables are also produced for transit assignment.

The MPT shall review the non-motorized model inputs developed by the MPO, along with the non-motorized trip table output by the ISMS model for reasonableness.

The MPT shall review the transit estimation and validation data summary developed by the MPO, along with other model inputs. The MPT shall also review the reasonableness of the transit trips output by the ISMS model.

4.22.4 ISMS Application

The ISMS model user may elect to use the default non-motorized and transit mode split sub-models to separate person trips into auto-oriented, transit-oriented and non-motorized trips. Alternatively, the user may select the detailed transit mode choice option described in Section 4.22.

The mode choice submodel can be turned on or off within the ISMS model. The user toggles by highlighting the scenario, pressing Setup Scenarios, highlighting the Mode Split step in the upper right corner, then pressing the Parameters tab. Enter a value of 0 in Mode Split Option to run the full mode choice submodel, or a value of 1 to run the mode split submodel.

The ISMS model uses TransCAD's standard transit route system process. See Section 4.9 for details on the transit route files and Section 4.21 on developing transit skims.

4.22.5 Calibration, Validation and Reasonableness Checking

Non-motorized trips should occur only between zones a distance of 1 mile or less. The total non-motorized trip table should total less than 2 percent of the total person trip table. The exception is when a major university exists within the model area, in which case the total non-motorized percentage may be higher. The MPT shall review the non-motorized model inputs developed by the MPO, along with the non-motorized trip table output by the ISMS model for reasonableness.

System-wide model-estimated boardings should be compared observed counts to determine if the overall number of transit trips is correct. Adjustments to mode constants and transfer wait time penalties can be made to bring observed and estimated boardings into agreement. Route-level comparisons should be used to determine if there are biases by service frequency and type of service. Stop-level comparisons should be used to identify outliers and systematic errors such as density, area type or parking cost biases.

Maps of the transit network and transit mode shares by TAZ should be evaluated for reasonableness.

Model-estimated trip frequencies by trip length, number of transfers, walk time, and initial wait time should be compared with on-board survey data. Adjustments to time and cost parameters to bring observed and estimated results into agreement.

The MPT shall review the transit estimation and validation data summary developed by the model development team, along with other model inputs. The MPT shall also review the reasonableness of the transit trips output by the ISMS model.

4.22.6 Future Year Considerations

Mode choice parameters are assumed to be constant across analysis years, although person trip and highway and transit networks would vary by forecast year.

4.22.7 Documentation Standards

The model development team shall document the total number and percentage of model-estimated and observed person trips by mode and purpose.

The model development team shall document the existing transit ridership in terms of total riders in the system, and create a map showing the TAZ's transit mode shares estimated by ISMS.

4.22.8 Quality Assurance and Control

The development of the mode split data is a collaborative effort among the model project team. An MPT member shall conduct a cursory review of the model.

4.23 Mode Split

4.23.1 Overview

The ISMS model provides the option to incorporate a mode choice model into the model process. If mode choice is not performed, a mode split calculation is conducted. The mode split converts person trips into the following categories:

- Non-motorized person trips (including walk and bicycle modes)
- Auto-oriented person trips (to be converted to vehicle trips)
- Bus-oriented person trips

4.23.2 Recommended Architecture

The ISMS model determines the anticipated mode split for each OD pair based on the distance between the zones and the availability of transit at each zone. This procedure is used in lieu of a more detailed and network-based mode choice analysis. The process allows for calculation of auto-oriented person trips by stratifying person trips into auto, transit and non-motorized tables.

The approach taken to account for non-motorized within the ISMS model involves applying factors to separate motorized from non-motorized trips(NCHRP 716[20]). For such models, the assignment of the non-motorized and transit trips is not conducted with this procedure. However, sensitivities related to the effects of increased transit and non-motorized modes on the roadway network is facilitated through this procedure. By modifying the transit availability for a few model zones, for example, it is possible to see the effects of this change on overall motorized travel and VMT in the region.

[20] National Cooperative Highway Research Program, Report 716, page 9.

NON-MOTORIZED

For aggregate models like regional travel demand models, non-motorized trip making is viewed from an areawide perspective. These models attempt to relate the various demographic or trip-making inputs with the travel characteristics like the number of percentage of trips made by non-motorized modes (FHWA's Guidebook on Methods to Estimate Non-Motorized Travel: Overview of Methods). Non-motorized trips within the ISMS prototype are calculated using the distance in miles between the origin and destination zones, as derived by a skim matrix that includes walk only links and excludes access-limited roadway facilities, as described in Section 4.18. The default percentage of trips allocated by the ISMS model to the non-motorized mode by distance is stored in the **non-motorized.bin** file as shown in Table 4-45. According to NCHRP 716[21], the average non-motorized trip takes about 15 minutes to complete with most trips consistently in the mid-teens. This equates to about 0.75 miles. Therefore, trips greater than one mile in length are assumed to have no non-motorized share.

Table 4-45: Non-Motorized.bin File, Trip Percentages Allocated to the Mode by Purpose and Distance

	WEEKDAY		WEEKEND	
PURPOSE	0-0.5 MILES	0.5-1 MILES	0-0.5 MILES	0.5-1 MILES
HBWL	5%	1%	5%	1%
HBWM	5%	1%	5%	1%
HBWH	5%	1%	5%	1%
HBSC	5%	1%	5%	1%
HBSH	5%	1%	5%	1%
HBO	5%	1%	5%	1%
NHB	5%	1%	5%	1%
UNIV	50%	15%	50%	15%
HOSP	5%	1%	5%	1%
APRT	0%	0%	0%	0%
RREC	5%	1%	5%	1%
HOT	5%	1%	5%	1%
SU	0%	0%	0%	0%
COMBO	0%	0%	0%	0%

[21] National Cooperative Highway Research Program, Report 716, page 48.

DEFAULT TRANSIT

A simplified default transit sub-model is available in the ISMS model. This simplified process does not require development of a transit network, but rather uses transit availability at the TAZ level as the indicator of transit use. A value of 0, 1 or 2 is entered into each TAZ by the model user as described in Table 4-46. If either trip end is associated with a zone with no transit (value of zero), no trips will be allocated to transit. If both zones are served by transit, the portion of the person trips allocated is the average of the origin and destination zone's transit portions as read from the **default_transit.bin** file, shown in Table 4-47. Zone pairs with a distance skim of 0.5 miles or less are given a zero percent transit skim, assuming trips would be non-motorized instead.

Table 4-46: Default Transit Values as Entered in TAZ Attributes

ATTRIBUTE NAME	FORMAT	RESPONSIBLE PARTY	DESCRIPTION
ID	Integer	Auto-generated	Unique identification value for each TAZ in the database
Area	Real	Auto-generated	Area of TAZ in square miles
TAZ	Integer	MPO	Unique identification value for the Transportation Analysis Zone
TRANSIT	Integer	MPO	Transit availability for zone: 0 = No transit 1 = Limited transit 2 = Dense transit (Typically CBD and Campus areas)

Table 4-47: Default_transit.bin File Containing Trip Percentages Allocated to Transit by Purpose and Distance

	TRANSIT VALUE		
PURPOSE	0	1	2
HBWL	0%	1%	5%
HBWM	0%	1%	5%
HBWH	0%	1%	5%
HBSC	0%	1%	5%
HBSH	0%	1%	5%
HBO	0%	1%	5%
NHB	0%	1%	5%
UNIV	0%	1%	5%
HOSP	0%	1%	5%

	TRANSIT VALUE		
PURPOSE	0	1	2
APRT	0%	1%	5%
RREC	0%	1%	5%
HOT	0%	0%	0%
SU	0%	0%	0%
COMBO	0%	0%	0%

4.23.3 Data Sets

INPUT DATA

The non-motorized sub-model uses the network distance between zones as the predictive variable. This is generated during the model execution process.

The default transit sub-model estimates transit usage based on applied transit frequency. A transit route map including stop locations is useful in determining the zones that are served by transit. Due to the simplicity of the process, some judgement may be required to determine zones that are served, and which zones are heavily served, such as CBD and campus areas. As noted previously, some judgment will need to be applied to assign a 0, 1 or 2 for the TRANSIT availability variable. Once TRANSIT is defined, the model will estimate the transit share based on the look-up (as explained in the Transit.bin file in Table 4-).

MPO staff are responsible for determining the zones that are served by transit at both low and high levels. MPO staff are responsible for obtaining ridership data for validation of the transit sub-model. The observed transit ridership shall be summarized to identify the total system trips, boardings, transfers and the ten zones or bus stops with the largest number of transit boardings. Based on this summary, the modeling team shall verify the reasonableness of the total transit trips and the zones with the largest number of transit trips.

ESTIMATION DATA

Household travel surveys may provide an estimate of the total trip making that occurs by non-motorized means and by transit. Due to the low number of trips that are typically made by non-automobile modes, care should be taken to determine transit and non-motorized percentages from household surveys.

VALIDATION DATA

System-wide transit ridership numbers should be used to validate the region-wide transit sub-model output. If route and stop level boarding and alighting data is available, additional refinement to the Transit attribute on the TAZ layer may be conducted. The TAZs that have the largest number of transit trips should be reviewed for reasonableness.

MPO staff are responsible for reviewing the non-motorized percentages by trip purpose used in their model development. They are also responsible for verifying the reasonableness of the total non-motorized share of trips estimated by the ISMS model.

The MPT shall review the transit validation data summary developed by the MPO, along with the coding of TAZ's served by transit. The MPT shall also review the reasonableness of the total transit trips output by the ISMS prototype.

OUTPUT DATA

The mode split sub-model produces auto-oriented person trip tables by purpose that are subsequently used with auto occupancy factors in Section 4.24 to generate auto trips.

4.23.4 ISMS Application

The ISMS prototype user may elect to use the default non-motorized and transit mode split sub-models to separate person trips into auto-oriented, transit-oriented and non-motorized trips. Alternatively, the user may select the detailed transit mode choice option described in Section 4.22.

The mode split sub-model can be turned on or off within the ISMS model. The user toggles by highlighting the scenario, pressing Setup Scenarios, highlighting the Mode Split step in the upper right corner, then pressing the Parameters tab. Enter a value of 0 in Mode Split Option to run the full mode choice sub-model, or a value of 1 to run the mode split sub-model.

The ISMS model's default transit mode split and non-motorized sub-models use skim matrices developed in Section 4.18 to determine distances between zones, the TAZ Transit attribute and the lookup tables described above.

4.23.5 Calibration, Validation and Reasonableness Checking

Non-motorized trips should occur only between zones a distance of 1 mile or less. The total non-motorized trip table should total less than 2 percent of the total person trip table. The exception is when a major university exists within the model area, in which case the total non-motorized percentage may be higher.

Transit trips should occur only between zones that have been designated as being served by transit, and should not occur at external zones or between zones less than 0.5 miles apart. The total transit trip table should total less than 2 percent of the total person trip table, since the share of transit trips is typically small. The exception is when a major university exists within the model area, in which case the total transit percentage may be higher. Coordination with transit provider staff is recommended to ensure reasonable results are being obtained from the modeling process.

4.23.6 Future Year Considerations

Mode split percentages are assumed to be constant across analysis years.

4.23.7 Documentation Standards

MPO shall document the non-motorized percentages by distance and trip purpose used for model development, along with the total number and percentage of person trips in the non-motorized mode.

MPO shall document the existing transit ridership in terms of total riders in the system and the locations of the higher bus boardings. MPO shall create a map showing the TAZ's that are served by transit, document the transit percentages by purpose and intensity, and documents the total system transit trips estimated by ISMS.

4.23.8 Quality Assurance and Control

The development of the mode split data is a collaborative effort between the MPO and Iowa DOT staff. An MPT member shall conduct a cursory review of the model .

4.24 Auto Occupancy

4.24.1 Overview

Person trips that will travel within an automobile are developed during either the detailed transit mode choice sub-model (Section 4.22) or the default mode split sub-model (Section 4.23). The auto-oriented person trips are then converted to auto trips using an auto occupancy factor. This factor is purpose-specific and is assumed constant over time, but may be edited within ISMS.

RECOMMENDED ARCHITECTURE

Auto occupancy is typically a function of the type of trip occurring, with work trips often made by single occupants, while other trip types such as shopping are more likely to have multiple occupants. The time of day has some impact on auto occupancy, with AM having slightly lower rates as predicted by NCHRP 716 Table 4.16.

Auto occupancy may also be impacted by transportation policies, such as high-occupancy only lanes. The ISMS model does not incorporate within the mode choice element a specific estimate of auto occupancy dependent upon differing levels of service between single occupant and high occupant lanes. Therefore, ISMS does not estimate changes in auto occupancies but rather assumes occupancy factors to be constant across all model scenarios. A scenario-specific auto occupancy file may be used to test the impacts of an independently estimated set of auto occupancies by placing the Auto_occupancy.bin file within the Inputs folder of the scenario directory.

The modeling team shall process household travel survey data or other applicable survey data to estimate auto occupancy rates by purpose. If no survey exists for estimation of occupancy rates, the team shall review rates used by other Iowa MPO's and NCHRP 716 rates for applicability to their respective MPO. Iowa DOT staff shall compare calculated occupancy rates to published average national rates from NCHRP 716 and available Census data to determine appropriateness of auto occupancy rates. If no survey is available, Iowa DOT staff shall provide the MPO with rates from other MPO's as a starting point.

The auto occupancy factor (MD is shown last since it is an optional time period) is read into the ISMS model during model execution using the auto_occupancy.bin file, as shown by the example rates borrowed from the Ames model in Table 4-48.

Table 4-48: Auto_occupancy.bin File Showing Occupancy Factors by Purpose

PURPOSE	WDWE	AM	PM	OP	MD
HBWL	wd	1.06	1.07	1.07	1.07
HBWL	we	1.06	1.07	1.07	1.07
HBWM	wd	1.06	1.07	1.07	1.07
HBWM	we	1.06	1.07	1.07	1.07
HBWH	wd	1.06	1.07	1.07	1.07
HBWH	we	1.06	1.07	1.07	1.07
HBSC	wd	1.42	1.42	1.42	1.42
HBSC	we	1.42	1.42	1.42	1.42
HBSH	wd	1.27	1.42	1.42	1.42
HBSH	we	1.27	1.42	1.42	1.42
HBO	wd	1.27	1.42	1.42	1.42
HBO	we	1.27	1.42	1.42	1.42
NHB	wd	1.35	1.57	1.57	1.57
NHB	we	1.35	1.57	1.57	1.57
UNIV	wd	1.06	1.07	1.07	1.07
UNIV	we	1.06	1.07	1.07	1.07
HOSP	wd	2	2	2	2
HOSP	we	2	2	2	2
APRT	wd	2	2	2	2
APRT	we	2	2	2	2
RREC	wd	2	2	2	2
RREC	we	2	2	2	2
HOT	wd	2	2	2	2
HOT	we	2	2	2	2
SU	wd	1	1	1	1

PURPOSE	WDWE	AM	PM	OP	MD
SU	we	1	1	1	1
COMBO	wd	1	1	1	1
COMBO	we	1	1	1	1

4.24.2 Data Sets

INPUT DATA

Auto-oriented person trip tables by purpose from the mode choice or mode split sub-models.

ESTIMATION DATA

Household travel surveys or road-side travel surveys provide estimates of auto occupancy by purpose. Care should be taken if using survey methods that do not incorporate the purpose of the trip, such as remote visual inspection of vehicles.

Public Use Microdata Sample (PUMS), American Community Survey (ACS) and journey to Work (JTW) data records provide estimates of parameters but lack detailed purposes.

In the absence of a local travel survey, rates may be borrowed from another similar MPO, or estimated using the validation data sets below.

VALIDATION DATA

NCHRP 716, table 4.16 provides a set of auto occupancy factors for comparison purposes as shown below inTable 4-49. Note the low rate published for Home-based school, which indicates the majority of trips are made by single occupant vehicles. This rate may be more applicable to the University purpose, rather than a K-12 school purpose with many students dropped off and picked up by parents. Peak period specific values are also available for select purposes.

Table 4-49: Auto Occupancy Factors as Provided by NCHRP 716

PURPOSE	OCCUPANCY FACTOR
HBWork	1.10
HBNonWork	1.72
HBSchool	1.14
HBOther	1.75
NHB	1.66

OUTPUT DATA

Automobile trip tables by weekday/weekend, time period and trip purpose, are summarized into a single auto trip table for traffic assignment in Section 4.26.

4.24.3 ISMS Application

The ISMS model applies the auto occupancy rates in Auto_occupancy.bin to the auto-based person trip tables by trip purpose to calculate auto trip tables. A scenario-specific auto occupancy file may be used to test the impacts of an independently estimated set of auto occupancies by placing a copy of the Auto_occupancy.bin file within the Inputs folder of the scenario directory.

External vehicle trips are converted to purpose trips using the auto occupancy factors. The resulting external person trip ends are included with internal person trip ends for the distribution model. The auto occupancy factors are then reapplied to convert the person trips back to vehicle trips. This process facilitates the external trip ends to be distributed with the internal trip ends throughout the MPO model area.

4.24.4 Calibration, Validation and Reasonableness Checking

Calibration of auto occupancy rates is conducted when a travel survey covering the model area is available to compare model estimated total person trips to estimated total auto trips by trip purpose. Care must be taken to appropriately consider external travel when comparing survey results to model results, as external vehicle trips are converted to person trips using the auto occupancy rates from within the model area, then converted back to vehicle trips after distribution using the same rates.

Validation of auto occupancy rates is influenced by the confidence in person trip tables (number of trips and trip length distribution), modal shares (either from mode split or mode choice), traffic assignment and the target validation data. For example, a person trip table with too few trips that has too many non-auto trips removed could be modified by using a lower auto occupancy rate to produce the expected number of auto trips. Furthermore, if the person trip table's trip lengths were generally too short, the resulting traffic assignment's link volumes and vehicle miles traveled would be lower than observed values, which could be addressed by adjusting auto occupancy factors to effectively produce more auto trips. Therefore, while auto occupancy is a simple parameter to modify during model validation to bring model-wide assignment results in line with observed values, it must be done in conjunction with a similar level of review on other parts of the modeling process. Changing the auto occupancy factors should not be used as a 'catch-all' calibration factor to adjust trip tables to improve traffic assignment results compared to observed count data.

Reasonableness checking of auto occupancy rates is conducted by comparing occupancy rates used within the model against occupancy rates from other similar MPO's Additionally, 2009 NHTS survey data is available for the state of Iowa using the online table builder (http://nhts.ornl.gov/tables09/ae/TableDesigner.aspx) as shown in Table 4-50 Variations are expected, with similar trends between work and non-work purposes across MPO's.

Table 4-50: 2009 NHTS Auto Occupancy Rates for Iowa

GENERAL TRIP PURPOSE (HOME-BASED PURPOSE TYPES)		NOT ASCERTAINED	OTHER HOME-BASED	HOME-BASED SHOPPING	HOME-BASED SOCIAL/RECREATIONAL	HOME-BASE WORK	NOT HOME-BASED	ALL
Derived total HH income TD Vehicle Occupancy (Mean)	Refused	1	1.22	1.47	1.84	1.21	1.6	1.34
	Don't know	.	1.27	1.82	1.94	1.02	1.83	1.62
	Not ascertained	.	.	1	.	.	.	1
	< $5,000	.	1.79	2.46	1	1.32	1.03	1.12
	$5,000 - $9,999	.	1.24	1.21	1.36	1	1.89	1.53
	$10,000 - $14,999	.	1.78	2.03	1.64	1	1.87	1.74
	$15,000 - $19,999	1	1.82	1.3	1.34	1.08	1.44	1.47
	$20,000 - $24,999	.	1.73	1.36	1.96	1.1	1.39	1.56
	$25,000 - $29,999	1	1.35	1.67	2.37	1.04	1.92	1.73
	$30,000 - $34,999	2	1.95	1.59	2.7	3.32	2.01	2.46
	$35,000 - $39,999	1	1.91	1.48	1.7	1.04	1.33	1.36
	$40,000 - $44,999	.	1.91	1.37	2.25	1.03	1.72	1.59
	$45,000 - $49,999	.	1.91	1.84	1.9	1.02	2.47	1.85
	$50,000 - $54,999	1	1.53	1.5	2.23	1.03	1.45	1.45
	$55,000 - $59,999	.	1.78	1.55	1.57	1.07	1.19	1.32
	$60,000 - $64,999	.	2.27	1.8	3.11	1.04	1.75	1.9
	$65,000 - $69,999	.	1.45	1.67	1.84	1.18	1.31	1.4
	$70,000 - $74,999	.	1.87	1.95	1.74	1.06	1.55	1.54
	$75,000 - $79,999	.	1.47	1.32	2.4	1.11	1.48	1.56
	$80,000 - $99,999	.	1.65	1.38	1.93	1.01	1.73	1.45
	> = $100,000	.	1.7	1.65	2.29	1.03	2.41	1.93
		1.22	1.64	1.6	2.06	1.15	1.75	1.6

4.24.5 Future Year Considerations

Auto occupancy factors are assumed to be constant across analysis years. This assumption may be modified within ISMS for testing scenarios such as autonomous vehicles. A scenario-specific auto occupancy file may be used to test the impacts of an independently estimated set of auto occupancies by placing a copy of the Auto_occupancy.bin file within the Inputs folder of the scenario directory.

4.24.6 Documentation Standards

Auto occupancy factors shall be documented, including sources used to develop the initial rates and modifications made to those rates during model validation.

4.24.7 Quality Assurance and Control

The development of the auto occupancy rates is a collaborative effort between the MPO and DOT staff. If a travel survey is used to estimate rates, the MPO shall estimate rates by purpose, then the Iowa DOT will review. In the absence of a travel survey, Iowa DOT shall provide MPO with initial occupancy rates from similar MPO's, the MPO will adjust rates as needed during model validation, then the Iowa DOT will review.

4.25 Traffic Counts

4.25.1 Overview

Traffic count data is used for validating the base year model and for forecasting future year volumes.

4.25.2 Recommended Architecture

The ISMS model conducts detailed analysis by time of day, day of week and vehicle type. Aside from establishing the magnitude of travel at external stations, traffic counts are used in the demand model process directly. Count fields for Average Annual Daily Traffic (AADT), Single Unit Trucks (SU), and Combination Unit Trucks (COMBO) are maintained in the master network.

Traffic counts may be collected as mid-block volumes or intersection turning movements. The ISMS model uses mid-block volumes, with intersection turning movements aggregated to total approach volumes.

Raw traffic counts should be factored as directed by Iowa DOT process to establish the AADT value for any count location.

4.25.3 Data Sets

INPUT DATA

Traffic count data is readily available from Iowa DOT staff. A detailed set of the steps needed to process observed traffic count information stored in the Iowa DOT traffic count inventory system known as TRADAS (TRAffic DAta System) is provided in a technical memorandum entitled "Traffic count data processing for use in Iowa Travel Demand Models". TRADAS stores short-term and continuous traffic count information in an Oracle database and contains traffic data based on FHWA 13 vehicle classification, vehicle length classification, and speed data.

As part ISMS input data, a point-based GIS file will be provided by Iowa DOT that will include various traffic count information (i.e. AADT, AAWDT, AM peak hour, PM peak hour) by location. This information can be used in concert with an ISMS model network to establish traffic count information that is used to assess the validation and reasonableness of a model.

MPO staff shall coordinate with Iowa DOT staff in collecting existing traffic count data from across the MPO region. Local governments may also have traffic count data that may be included in the ISMS traffic count data set, all of which should be included in the point-based GIS file.

Raw traffic counts should be factored to establish the AADT value. Other values may be factored depending upon Iowa DOT process. Data from the point-based GIS file will need to be spatially joined to specific links in the master ISMS model network database.

ESTIMATION DATA

Estimated traffic counts should be avoided for use in model validation and forecasting.

VALIDATION DATA

Historic traffic counts from the same location are useful in validating current traffic count data.

4.25.4 ISMS Application

The ISMS model applies the auto occupancy rates in Auto_occupancy.bin to the auto-based person trip tables by trip purpose to calculate auto trip tables. A scenario-specific auto occupancy file may be used to test the impacts of an independently estimated set of auto occupancies by placing a copy of the Auto_occupancy.bin file within the Inputs folder of the scenario directory.

External vehicle trips are converted to purpose trips using the auto occupancy factors. The resulting external person trip ends are included with internal person trip ends for the distribution model. The auto occupancy factors are then reapplied to convert the person trips back to vehicle trips. This process facilitates the external trip ends to be distributed with the internal trip ends throughout the MPO model area.

4.25.5 Calibration, Validation and Reasonableness Checking

MPO staff shall review the counts for reasonableness, including checking the latest count against historical counts for decreases or significant variation and update the point-based GIS file accordingly.

4.25.6 Future Year Considerations

Traffic counts are used primarily for base year analysis. Traffic forecasting using base and future year traffic assignments and base year counts is described in more detail in Section 6.1.

4.25.7 Documentation Standards

Map showing count locations and general magnitudes of the counts.

4.25.8 Quality Assurance and Control

Much of the count data will be provided by DOT. MPO staff shall review the counts for reasonableness, including checking the latest count against historical counts for decreases or significant variation.

4.26 Roadway Capacity

4.26.1 Overview

Roadway capacity is a link attribute used by travel demand models to assess the level of congestion on each link segment and accordingly adjust the time required to traverse the link. This process is conducted within the traffic assignment process, as described in Section 4.27. This section discusses the process of estimating the capacity of the various link types within the ISMS model.

4.26.2 Recommended Architecture

The ISMS model uses roadway (or link) capacity within the link delay function of the traffic assignment, as described in Section 4.27. The definition of capacity within the contexts of a travel demand model requires some clarification. In reality, a transportation facility can only accommodate a finite number of units within a specific timeframe, such as vehicles per hour per lane. However, travel demand models may predict a number of units within the specified timeframe that exceed the stated capacity. This indicates a demand for the transportation resource that exceeds the supply. To address this, some travel demand models have set roadway capacity to represent values below the actual capacity of the roadway; more consistent with the volume of traffic that would initiate speed reductions on the facility (LOS C capacity). Other travel demand models have maintained capacities that represent the actual capacity of the roadways (LOS E capacity). Either approach can be useful in applying a travel demand model, as long as the definition of capacity is understood by the user. ISMS uses capacities close to actual operating capacities, however, the definition of capacity is further complicated by the presence of intersection control. Capacity of a segment of road that is not affected by intersection control is much higher than a segment that approaches a signalized intersection. The ISMS model accounts for this by explicitly modeling intersection delay in addition to link-specific delay.

Link capacities are read into the ISMS model using a lookup table, as shown in Appendix P. These values may be modified during the model calibration process, with documentation provided on the rationale for the modification.

The process for estimating the default link capacity values varies by the type of facility. The link capacities used as the starting point for the ISMS model are estimated using the process developed for the Corridor MPO travel demand model developed by LSA and Associates. his process has subsequently been adopted by other MPO's across Iowa.

The ideal capacities for uninterrupted, or limited access facilities including Interstates (FACTYPE 1), freeways (FACTYPE 2) and system ramps (FACTYPE 4) are based on the Highway Capacity Manual Version 6.0, exhibit 12-4. These ideal capacities are then adjusted based on the factors outlined in Equation 4-7.

Equation 4-7: Capacity Adjustment Equation for Uninterrupted Facilities

$$C = C_1 * PHF * f_{HV} * f_p - f_s$$

Where:

C = Adjusted per lane capacity (passenger cars per hour per lane or pc/hr/ln)

C_1 = Ideal per lane capacity (pc/hr/ln)

PHF = peak hour factor; typically 0.88 to 0.92, calculated as the total hourly count divided by four times the highest 15-minute count with the hour; assumed at 0.92 for urban conditions

f_{HV} = heavy vehicle adjustment factor; equals one, as ISMS assigns a passenger car equivalent to heavy vehicles

f_P = driver population factor; equals one, as ISMS assumes drivers are familiar with the area

f_s = speed adjustment factor; lowers capacity based on lower speeds (70 minus posted speed limit)*10

The ISMS model does not explicitly use area type as a link attribute. The capacity calculation instead reduces the per lane capacity for links with posted speed limits lower than 70 miles per hour, as illustrated in Table 4-52. The capacity lookup table does not have a record for each speed bin, rather, the capacity reduction is calculated by the ISMS model at run time based on the PSPEED attribute of the link.

Table 4-51: Capacity Calculations for Uninterrupted Facilities

FACTYPE	POSTED SPEED	INITIAL CAPACITY	PHF	FHV	FP	FS	ADJUSTED CAPACITY
1, 2 & 4	70	2400	0.92	1	1	0	2210
1, 2 & 4	65	2400	0.92	1	1	-50	2160
1, 2 & 4	60	2400	0.92	1	1	-100	2110
1, 2 & 4	55	2400	0.92	1	1	-150	2060
1, 2 & 4	50	2400	0.92	1	1	-200	2010

The ISMS model assignment process calculates travel delay along links representing facilities with controlled intersections based on both link and node attributes. Specifically, the intersection delay is explicitly calculated, and is therefore not required to be incorporated into the delay calculated on the link as is typically done within traditional travel demand models. Therefore, link capacities are influenced by turbulence along the link, such as driveway density and median treatments, as shown in Equation 4-8. Initial capacities measured in passenger cars per hour per lane (pc/hr/ln) by facility type are shown in Table 4-. The capacity reduction factors for median and driveway access are shown in Table 4-. An example of resulting capacity calculations for Principal Arterials is shown in Table 4-. The full table of capacities is available in Appendix P.

Equation 4-8: Capacity Adjustment Equation for Interrupted Facilities

$$C = C_1 * PHF - f_m - f_a$$

Where:

C = Adjusted per lane capacity (passenger cars per hour per lane or pc/hr/ln)

C_1 = Ideal per lane capacity (pc/hr/ln), see Table 4-53

PHF = peak hour factor; typically 0.88 to 0.92, calculated as the total hourly count divided by four times the highest 15-minute count with the hour; assumed at 0.92 for urban conditions

F_m = median adjustment factor; which reduces the per lane capacity based on the center median treatment; see Table 4-54 (Note a center turn lane imparts turbulence on the actual through lane, reducing its capacity from an uninterrupted lane)

f_a = driveway access factor, which reduces the per lane capacity based on the density of driveways along the link; see Table 4-54

Table 4-52: Initial Capacities for Links Along Interrupted Facilities

FACTYPE	INITIAL CAPACITY (PC/HR/LN)
3-Expressway	1900
5-Service Ramp	1500
6-Principal Arterial	1900
7-Minor Arterial	1800
8-Collector	1600
9-Minor Collector	1200
10-Local	900
11-Unpaved	700
12-Centroid Connector	10,000

Table 4-53: Capacity Reduction Factors for Links Along Interrupted Facilities

MEDIAN TYPE	CAPACITY REDUCTION (PC/HR/LN)		ACCESS LEVEL	CAPACITY REDUCTION (PC/HR/LN)
1-Wide divided	0		1-No access	0

MEDIAN TYPE	CAPACITY REDUCTION (PC/HR/LN)		ACCESS LEVEL	CAPACITY REDUCTION (PC/HR/LN)
2-Narrow divided	0		2-Low (<5/mile)	-50
3-Center turn lane	-100		3-Medium (5-10/mile)	-100
4-Undivided	-200		4-High (>10/mile)	-200

Table 4-54: Example Capacity Calculations for Interrupted Facilities

FACTYPE	INITIAL CAPACITY	MEDIAN	ACCESS	PHF	FM	FA	ADJUSTED CAPACITY
6	1900	1	1	0.92	0	0	1750
6	1900	1	2	0.92	0	-50	1700
6	1900	1	3	0.92	0	-100	1650
6	1900	1	4	0.92	0	-200	1550
6	1900	2	1	0.92	0	0	1750
6	1900	2	2	0.92	0	-50	1700
6	1900	2	3	0.92	0	-100	1650
6	1900	2	4	0.92	0	-200	1550
6	1900	3	1	0.92	-100	0	1650
6	1900	3	2	0.92	-100	-50	1600
6	1900	3	3	0.92	-100	-100	1550
6	1900	3	4	0.92	-100	-200	1450

4.26.3 Data Sets

INPUT DATA

The link capacities are calculated primarily using inputs as described in Table 4-7. The capacities on limited access facilities (Interstate, Freeways and System Ramps) are also impacted by the caplookup.bin input file, as shown in Table 4-. The user may opt to set these variables to zero to eliminate their impact.

Table 4-55: Attributes of Capfactors.BIN File

VARIABLE	VALUE
Speed Reduction Factor (Decrease in PCPHPL per 1 MPH under 70)	10
Outside Lane Factor (Decrease in PCPHPL for outside lane of limited access facilities)	100

ESTIMATION DATA

Roadway capacities may be validated through the combined use of detailed traffic volumes (15 minute or finer) and congested speed data (15 minute or finer).

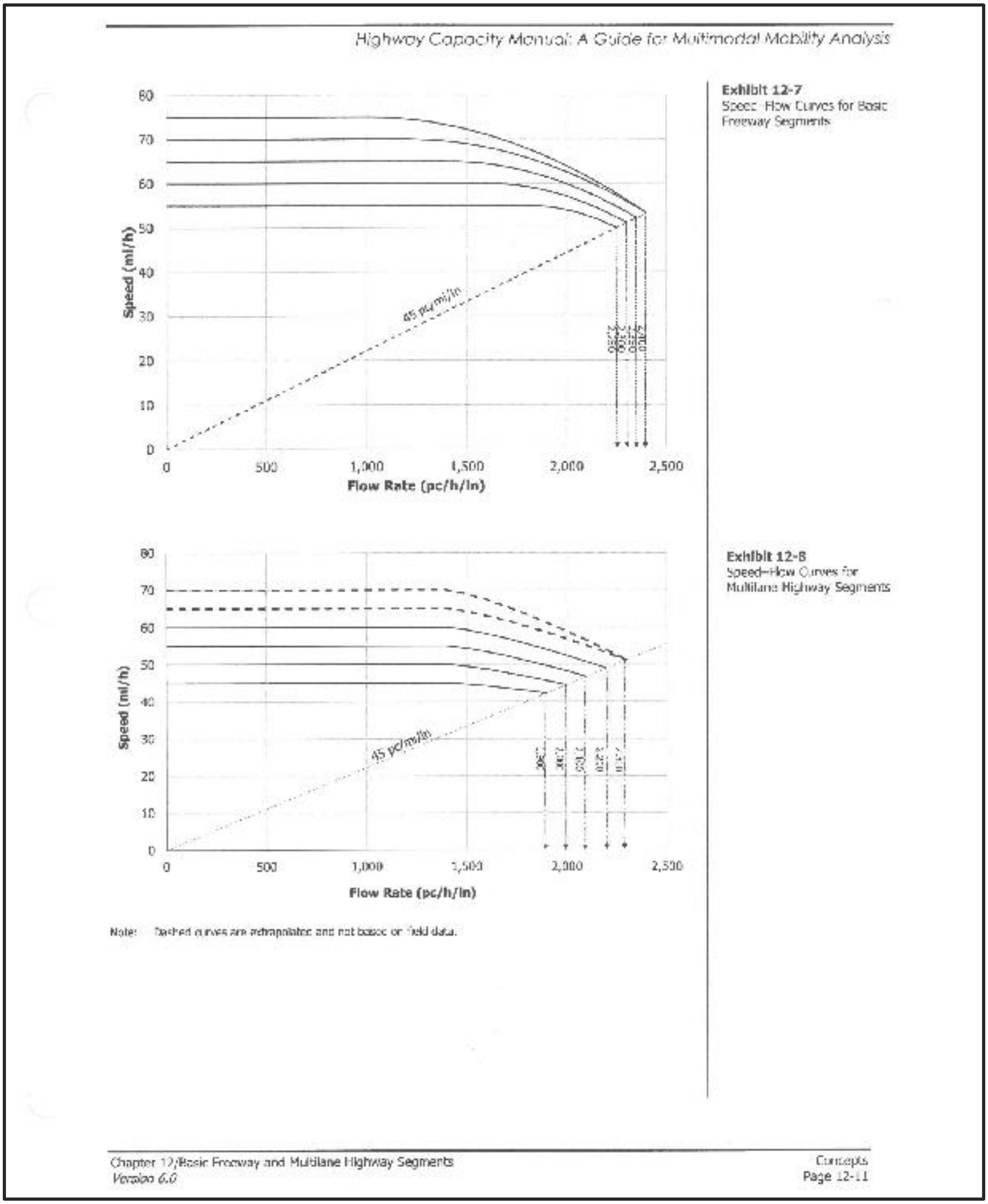
OUTPUT DATA

Link capacities are calculated and loaded into a lookup file, then the GISDK scripts update each link in Highway.dbd based on the look up file. These capacities are subsequently used in traffic assignment, as outlined in Section 4.27.

VALIDATION DATA

Roadway capacities may be validated through the combined use of detailed traffic volumes (15 minute or finer) and congested speed data (15 minute or finer). Evaluate roadway segments that show recurring travel speed reductions. True capacity would be identified as the volume of traffic at which speeds rapidly decrease, as shown in Exhibit 12-7 and 12-8 of the Highway Capacity Manual.

Figure 4-19: HCM Speed Flow Curves



4.26.4 ISMS Application

Roadway capacities are automatically calculated for each roadway link included in the scenario network.

4.26.5 Calibration, Validation and Reasonableness

Validation of roadway capacities may be conducted through review of detailed travel speed and traffic volume data, as outlined in Section 4.26.3.

Various other travel demand modeling references provide recommendations on link capacities; however, care should be taken to verify consistent definition of capacity (LOS C or LOS E capacity) and the components of the capacity (link only versus link and node delay).

4.26.6 Future Year Considerations

Traditionally, roadway capacities have been assumed to be relatively constant over time. However, the impending implementation of connected and autonomous vehicles (CAV) may require scenario testing of increased roadway capacities. This may be accomplished by developing a scenario-specific capacity lookup table (Caplookup.bin).

4.26.7 Documentation Standards

Changes in capacity assumptions, including the use of CAV's should be noted in the documentation. The capacity lookup table should be included in the appendix of the model documentation.

4.26.8 Quality Assurance and Control

Review locations for correct attributes on each roadway segment (Interstate/Freeway, ramp and cross-street), and correct connectivity (no direct connection between limited access road and cross-street).

Upon initial traffic assignment, conduct a review of the volume to capacity ratios for abnormalities.

4.27 Traffic Assignment

4.27.1 Overview

Traffic or route assignment is the process of estimating the traffic flows on a network. The process evaluates the impedance along the possible combination of links to connect each trip's origin and destination, then assigns the trips to those links. The process then recalculates the impedance on each link based on the number of trips assigned the link and the relationship to the availability capacity of each link. With updated impedances, the assignment process reassigns trips, continuing in an iterative process until an acceptable tolerance has been achieved between impedances and trips on the network.

4.27.2 Recommended Architecture

Various traffic assignment processes are available within TransCAD Version 7 and were evaluated against the mission, goals and objectives of the ISMS process. Highly detailed assignment processes such as Dynamic Traffic Assignment (DTA) were determined to require more data and effort than is needed to answer the questions asked of travel demand models. Simpler assignment processes such as Single Class, User Equilibrium, do no offer the ability to route trucks separately from autos without a preloading function.

The ISMS model uses the Multi-Modal, Multi-Class Assignment (MMA) for traffic assignment. This process allows for unique trip tables to be assigned to unique sets of links within the network, such as truck trip tables assigned to links that do not restrict truck movements. Similarly, the assigned volume for any specific trip purpose can be identified within the network, allowing for more detailed analysis of specific travel markets. More information about the MMA process can be found in the TransCAD User's Manual or Online Help Menu.

ISMS uses TransCAD's combined link and node delay function. This process assigns delay based on attributes of both the link and the node at the departure end of the link. The link delay component is calculated using the traditional Bureau of Public Roads (BPR) function, as shown in Equation 4-9.

Equation 4-9: Link Delay Function

$$T_c = T_f[1 + \alpha(\frac{v}{c})^{\beta}]$$

T_c=Congested travel time on link

T_f=Free flow travel time on link, as calculated by ISMS (see Section 4.6)

α = alpha constant, read from a lookup file (see Section 4.27.3)

v=volume assigned to link, output from previous assignment iteration

c=capacity of link, read from a lookup file (see Section 4.27.3)

β = beta constant, read from a lookup file (see Section 4.27.3)

The traffic assignment process uses several network attributes read into the network through the use of a look-up table. Attributes include capacity, peak period factors, and the alpha/beta assignment factors. The default values for these coefficients are shown in **Error! Reference source not found.**.

Capacity is defined as the Level of Service E capacity, or ultimate capacity, consistent with guidance from NCHRP 716. Note that Interstate and Freeway directional capacity assumes one lane to be at 90% of the per lane capacity due to turbulence from merge, diverge and weaving activity. See **Error! Reference source not found.** for specific values recommended for ISMS.

The volume-delay function incorporates Alpha and Beta factors during the traffic assignment stage to calculate the congested link travel time based on the volume and capacity of the link as shown in Equation 4-10.

Equation 4-10: Volume-Delay Function

$$TT_C = TT_f * (1 + \alpha * (\frac{vol}{cap})^{\beta})$$

TT_C = congested travel time and TT_f = free flow travel time.

NCHRP 716 suggests the general values as shown in Table 4-. See **Error! Reference source not found.** for specific values recommended for ISMS.

Table 4-56: Reference Values for Alpha and Beta

	WISCONSIN[22]		AMES AREA MPO		NCHRP 716	
FACILITY TYPE	**ALPHA**	**BETA**	**ALPHA**	**BETA**	**ALPHA**	**BETA**
Interstate/ Freeways	0.88	9.8	0.9	6	0.43	8.82
Expressway	0.56	3.6	0.9	3	0.42	5.20
Ramps	0.83	5.5	0.55	5		
Principal Arterials	1.00	5.4	0.9	3		
Minor Arterials	0.83	2.7				
Collectors	0.71	2.1	0.45	2		
Local	0.25	1.5				
Centroid Connector	0.15	1.5	0.15	5		

Node delay is calculated based on the type of control of the intersection the node represents. Signalized intersection delay and unsignalized delay are calculated independently using Equation 4-11 and Equation 4-12 respectively.

[22] Table 4.8, Wisconsin Statewide Model, Passenger and Freight Models, Final Report, Cambridge Systematics

Equation 4-11: Signalized Delay Equation

$$d_1(v) = \frac{(C-g)^2}{2C\left(1-\frac{v}{s}\right)} + k_1\left(\frac{v}{\frac{g}{C}s}\right)^{k_2} + k_3$$

Where:

$d_1(v)$	Average delay at intersection, in seconds.
v	Traffic volume on entering link, in vehicles (passenger car equivalents) per hour.
s	Exiting rate of traffic volume at saturation flow stage, in vehicles (passenger car equivalents) per hour.
g	Total green time of the approach phase, in seconds.
C	Cycle length of the traffic signal, in seconds.
k_1, k_2, k_3	Parameters, defaulting to 43, 4, and 5, respectively.

The magnitude of s is usually estimated by multiplying the exiting rate of traffic volume per lane by the number of lanes. This value varies by travel behavior and roadway geometry and can be calculated using the Highway Capacity Manual procedures for saturation flow rate. Note that $(1 - v/s)$ may be replaced by $\max \ (1 - {}^{v}/_{s}, 100)$ to ensure mathematical validity.

Source: TransCAD Travel Demand Modeling User's Guide, page 191

Equation 4-12: Unsignalized Delay Equation

$$d_2(v) = d_0\left(k_{1\,\text{unsig}} + k_{2\,\text{unsig}}\left(\frac{v}{c}\right)^2\right)$$

Where:

$d_2(v)$ Average delay at intersection, in seconds.

d Number of possible turns at intersection multiplied by factor , computed as follows:

$\delta(nz - w - p)$, where:

n Number of links entering the intersection.

z Number of links exiting the intersection.

p Number of turns prohibited at each intersection.

w Number of two way links entering the intersection.

$$\delta = \begin{cases} 0.5 & \text{if the link has no priority} \\ 0.25 & \text{if the link has priority and classified less than minor arterial} \\ 0.17 & \text{if the link has priority and classified as major arterial or higher} \end{cases}$$

$k_{1\,\text{unsig}}, k_{2\,\text{unsig}}$ Parameters, defaulting to 2.5 and 2, respectively.

c Link capacity, in vehicle (passenger car equivalent) per hour.

Source: TransCAD Travel Demand Modeling User's Guide, page 191

Operating cost may be utilized within the ISMS models to discourage trucks from using lower functionally classified roads. This is done in lieu of pre-loading which does not provide trucks with options to modify their route based on congestion, or truck restrictions which may preclude trucks from accessing destination zones. The operating cost inflates the travel time for trucks on the lower class roadways making the high class facilities more attractive while allowing the lower class facilities to be used to complete the trip and to be a viable option in the case of severe congestion or closure of a high class facility. The Operating Cost attribute works in conjunction with the Value of Time attribute, therefore any deviation of the Value of Time attribute from 1.0 requires a corresponding change in the Operating Cost.

Value of Time should be kept at 1.0 as mentioned above assuming no tolls are included in the analysis. If tolling is to be included, an additional network attribute is required to incorporate the toll cost, the network file must be manually updated and the Operating Cost updated.

Default parameters included in the ISMS prototype's traffic assignment process include:

Passenger-Car Equivalent Factors for Single Unit Trucks = 1.5 from QRFM[23]

Passenger-Car Equivalent Factor for Combination Trucks = 2.0 from QRFM

[23] Quick Response Freight Manual, Version 2, Publication No., FHWA-HOP-08-0102007.

Iterations = 500

Relative Gap = 0.0001

Select zone and link query file can be updated using TransCAD's query builder.

Turning movements are saved for all intersections by default.

Note that it is recommended to set the assignment iterations when attempting to calculate the difference in traffic assignments between scenarios on a link by link basis. The number of iterations of the base condition should be utilized for subsequent scenarios. This results in differences in assignment being directly related to the differences in input data and not the mathematical condition of assignment closure. For example, if the base scenario closes in 35 iterations, the iterations for subsequent analysis should be set to 35 and the relative gap set extremely low, such as 0.00001. This should ensure that the scenario's assignment will have exactly 35 iterations. If scenarios and the base have a different number of iterations, small differences in assignments will appear on links across the network, including places that should not be impacted by the scenario's change.

4.27.3 Data Sets

INPUT DATA

Roadway travel time is generated during model network development as described in Section 4.5.1. Roadway capacity, alpha and beta values are input via a look-up table as shown in **Error! Reference source not found.**.

Intersection turn penalties are developed as described in Section 4.7.1.

Vehicle trip tables are generated during the mode split or mode choice process as described in Sections 4.21.4.23 and 4.22 respectively.

ESTIMATION DATA

Roadway capacity, alpha and beta factors work in concert to influence travel time. Temporally detailed volume and travel speed data may be used to modify the values of these three parameters. INTRIX data and ATR data are both available from Iowa DOT.

VALIDATION DATA

Traffic count information is the primary validation data set for traffic assignment. The format of the traffic count data is described in Section 4.23 and Section 4.25. ISMS compares assigned traffic volumes to observed traffic counts on links where both exist, then compiles various comparisons.

Travel speed should also be validated using INRIX travel time data by segment. The format of the travel speed data is described in Section 4.11.

See Section 4.27.4 and Section 4.27.5 for more discussion on standards for count and speed validation.

4.27.4 ISMS Application

Note that it is recommended to set the assignment iterations when attempting to calculate the difference in traffic assignments between scenarios on a link by link basis. The number of iterations of the base condition should be utilized for subsequent scenarios. This results in differences in assignment being directly related to the differences in input data and not the mathematical condition of assignment closure. For example, if the base scenario closes in 35 iterations, the iterations for subsequent analysis should be set to 35 and the relative gap set extremely low, such as 0.00001. This should ensure that the scenario's assignment will have exactly 35 iterations. If scenarios and the base have a different number of iterations, small differences in assignments will appear on links across the network, including places that should not be impacted by the scenario's change.

4.27.5 Calibration, Validation and Reasonableness Checking

Traffic volume validation compares observed traffic counts to model assigned volumes on a link by link basis. The locations that have both data sets are aggregated by various classifications including facility type, area type and volume bin. Each metric has an acceptable error range based on national best practices[24] as shown in Table 4-.

Table 4-49: Assignment Validation Standards by Facility Type

FACILITY TYPE (FACTYPE)	AADT VOLUME/ COUNT RATIO	DAILY TRUCK VOLUME/ COUNT RATIO	AM/PM PERIOD VOLUME/ COUNT RATIOS	TOTAL RMSE
Total System	+/- 5%	+/- 10%	+/- 10%	40%
1 = Interstate	+/- 7%	+/- 10%	+/- 10%	30%
2 = Freeway	+/- 7%	+/- 10%	+/- 15%	30%
3 = Expressway	+/- 10%	+/- 15%	+/- 15%	35%
4 = System ramp	+/- 25%	+/- 40%	+/- 35%	x
5 – Service ramp	+/- 25%	+/- 40%	+/- 35%	x
6 = Principal arterial	+/- 10%	+/- 15%	+/- 15%	40%
7 = Minor arterial	+/- 10%	+/- 20%	+/- 20%	40%
8 = Collector	+/- 15%	+/- 30%	+/- 25%	x
9 = Minor collector	+/- 25%	+/- 40%	+/- 35%	x
10 = Local	N/A	N/A	N/A	N/A
11 = Gravel	N/A	N/A	N/A	N/A

[24] Travel Model Improvement Program, Model Validation and Reasonableness Checking Manual, Second Edition, Table 9.2

FACILITY TYPE (FACTYPE)	AADT VOLUME/ COUNT RATIO	DAILY TRUCK VOLUME/ COUNT RATIO	AM/PM PERIOD VOLUME/ COUNT RATIOS	TOTAL RMSE
12 = Centroid connectors	N/A	N/A	N/A	N/A

Traffic speed validation compares observed travel speeds to model assigned speeds by roadway segments.

4.27.6 Future Year Considerations

If the future year network links change compared to the base year, the links corresponding to the future links must follow the same coding rules as defined previously in this section.

4.27.7 Documentation Standards

Any major changes to key parameters should be documented. Overall validation to counts by functional classification should be documented for future reference and potential future improvements to model performance.

4.27.8 Quality Assurance and Control

Review major roadways and roadways by functional classification for correct attributes, V/C ratios and congested speeds on each roadway segment (Interstate/Freeway, ramp and cross-street). At this stage, additional efforts can be undertaken to verify correct connectivity and add / remove / move centroid connectors to improve traffic loadings and overall assignments compared to observed counts and speeds.

5: GENERAL MODELING PROTOCOLS AND PROCEDURES

5.1 Surveys

5.1.1 Household travel surveys

Travel demand models estimate travel behavior within a region. In order to have confidence in the model to replicate travel behavior, that behavior needs to be observed and quantified. This is done through the use of travel surveys. Household travel surveys target transportation system users at the household level, obtaining data about all members of the household and how they utilize the transportation system. The National Household Travel Survey (NHTS) and the American Community Survey (ACS) are household travel surveys that are done across the country. These surveys are conducted in a standardized manner and provide the model development team with data pertaining to trip generation, trip distribution and modal decisions.

5.1.2 Transit on-board travel surveys

Transit on-board surveys are used to collect information about transit riders, and data about the rider's trip. Data about the rider is generally demographic data, such as age, gender, race, student enrollment status (i.e., full or part time), and employment status. It is also important to collect demographic data about the rider's household, such as household location, household size, the number of workers in the household, household income, and the number of vehicles available to household members with a valid driver's license.

Transit on-board surveys are generally timed to capture rider behavior occurring under "typical or normal" conditions. For most communities, these conditions generally occur in the fall or spring when school is in session (K-12, colleges, and universities) and on an "average" weekday, typically Tuesdays, Wednesdays, and Thursdays. Transit on-board surveys are usually administered throughout the day during the hours that transit service is provided, but in cases where planning questions or mode choice model data needs are limited to peak hours or periods, the survey effort could be scaled back to coincide with similar time periods.

5.1.3 Floating car travel time surveys

Travel time data is a useful dataset to validate the congested travel time elements of the travel demand models, both the assignment generated outputs and the assumed inputs to trip distribution. The floating car survey provides data on the total travel time (and subsequent travel speed) along a corridor of interest, but can also be conducted in such a way as to determine the portion of the travel time resulting from intersection control delay versus mid-block delay. This detailed data about the elements of travel time is difficult to obtain through less intrusive data collection means, such as INRIX or HERE travel time data.

The floating car survey requires the use of a time keeping device, and either a GPS enabled device or detailed data collection sheet to identify the time the vehicle passes key points along the corridor. To execute the floating car survey, the driver should attempt to be at the median speed of traffic, passing only as many cars as are passing the survey vehicle. More information on conducting floating car travel surveys can be found in Chapter 3 of FHWA's Travel Time Data Collection Handbook.[25]

5.1.4 External travel surveys

Trips that have one or both trip ends outside the geographic limits of the model area are labeled as external trips. Obtaining information about these trips requires conducting surveys that cover the model boundary area, or extend beyond it. Several methods for obtaining data about these trips existing including:

- Roadside Origin-Destination survey - provides data on origin and destination (OD)for both External-External(EE) and External/Internal(EI) or Internal/External(IE) trips, along with trip purpose, frequency, time of day, occupancy by location; however this method has safety concerns for high speed, high volume facilities
- Video License Plate survey – provides O-D for E-E trips by collecting license plate data at entry and exit points by vehicle class and time of day; however this method has perceived privacy concerns
- Cellular phone data – 3rd party vendors can provide O-D for E-E trips along with E-I/I-E and I-I trips by subregional geography, time period and trip purpose; however limited vehicle class data and some sampling bias may occur

5.2 Methods/Scenario Testing

5.2.1 Employment and land use code assessment

The ISMS development team assessed the use of various datasets for the purposes of generating trip attractions at non-residential locations within the model. This assessment compared the use of parcel data, Iowa Workforce Development employment data and Infogroup employment data. The findings of the assessment were presented at the March 2016 MTMUG meeting in Ames, Iowa. The team determined there to be benefits to the use of parcel data, particularly when modeling sub-daily activities that may vary for specific land use types. This section provides some guidelines on the structure and processing steps for the components like parcel data, IWD Data and InfoGroup Data. **Please note:** Infogroup and IWD data are no longer utilized in the ISMS process. The following pages are being included for reference only and are to not be used with any ISMS model.

[25] https://www.fhwa.dot.gov/ohim/tvtw/natmec/00020.pdf

Parcel Data Structure

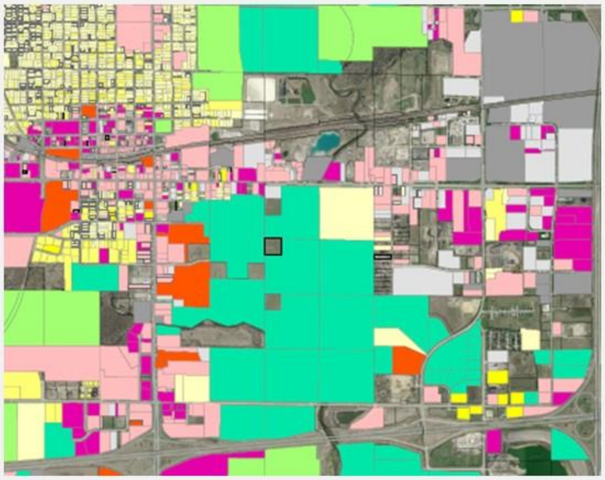
- Parcel shape files have polygons for each parcel
  - Multiple stacked polygons for condominiums
  - Each parcel may have 70+ data fields
  - Key fields:
    - Parcel ID number
    - Property Class (A, C, E, I, R)
    - Owner Name
    - Site address
    - Dwelling unit count
    - Latitude/longitude
- Commercial building files have records for each building
  - May have 30+ fields
  - Key fields
    - Parcel ID number
    - Building address
    - Year built
    - Use (occupancy) code
    - Building area
    - Number of apartment and hotel/motel units
  - Linked to polygon file though Parcel ID Number

.

Parcel Description

- Annual updates to parcel shape files and related property tax files
- Building area can be aggregated to obtain total parcel area
- Detailed building use codes can be summarized to obtain generalized parcel land use code
- Ratios of employees per square foot by land use code can be applied to obtain parcel level employment estimates
- Year built codes can be used to track changes over time

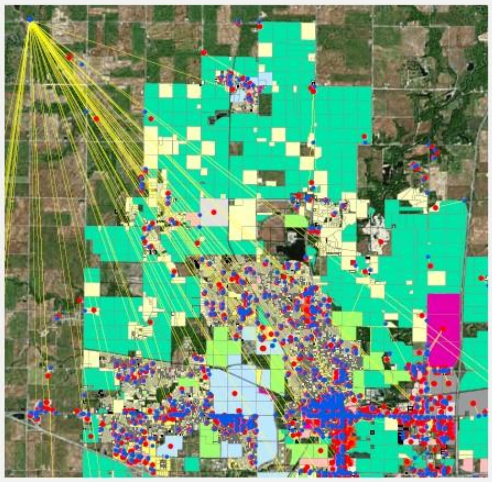
Parcel File



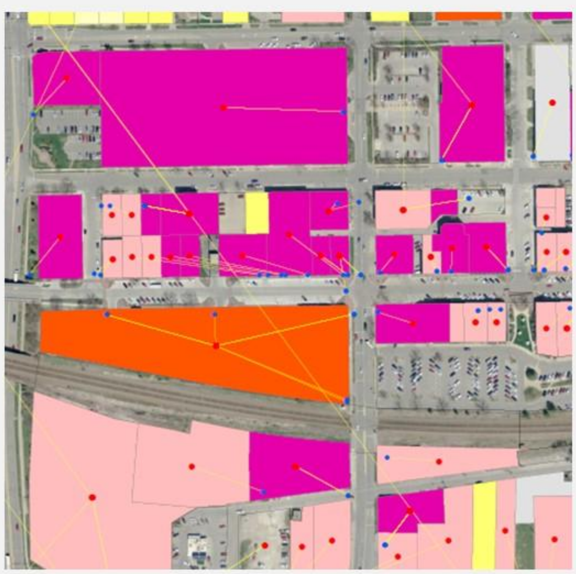
IWD Description

- Employers required to submit monthly employment estimates
- Almost all public/private employers covered
- Key fields
  - Employer name
  - Address
  - Latitude/longitude
  - NAICS code
  - Monthly employment
  - UI/Key ID
- Geocoding done at the federal level
- Employment collected by sites for chains and multi-site employers with more than 9 employees
- Strict confidentiality issues

IWD Geocoding



IWD Geocoding

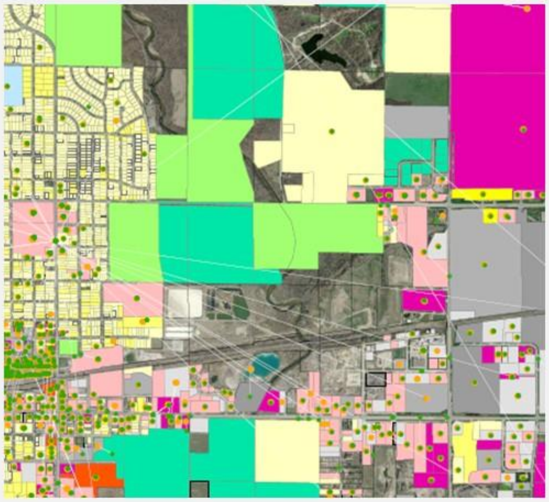


Infogroup Description

- Each employer record has 150+ fields of data
- Key fields
  - Employer name
  - Primary/secondary address
  - Latitude/longitude
  - Match level
  - NAICS code
  - Actual location
  - Infousa ID
- All employers included
- Employment allocated to sites for chains and multi-site emloyers

Infogroup Geocoding

Infogroup Geocoding



Summary of Parcel Findings

- Most buildings on "Exempt" parcels are missing
- Very accurate building data on non-exempt parcels
- New buildings are well tracked
- Vacant or low occupancy buildings not identified
- Data processing is somewhat messy because methodologies differ by agency
- Parcel data appears to be available throughout Iowa but unclear for adjacent states

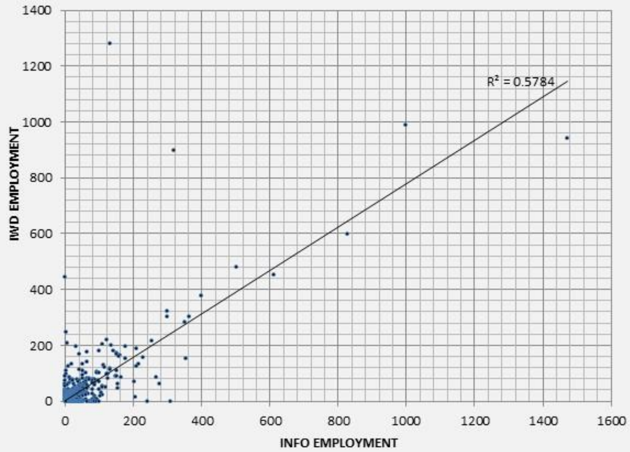
Summary of IWD Findings

- Very good enumeration of employers
- Very good NAICS code assignment
- New/closed firms well tracked
- Monthly site level employment variations appear to be accurate
- Employment at residential locations can be overstated
- Employment overstated at employers without a fixed place of work
- Significant geocoding errors
- Availability for other states may be an issue

Summary of Infogroup Findings

- Some missing employers
- Many duplicate employers
- Info/IWD site level employment estimates vary widely
- Some incorrect NAICS codes
- New/closed firms not well tracked
- Most site level employment estimates remain constant over time
- Employment at residential locations can be overstated
- Employment overstated at employers without a fixed place of work
- Some geocoding errors

IWD/Infogroup Comparison



Recommended Approach

- Initial process
- Update process
- Modify trip generation process

Initial Process

- One time reconciliation of data sources
- Produce parcel GIS file with:
  - Land use code
  - Year Built
  - Residential units
  - Commercial building area
  - Occupancy factor
- Compute employment densities by land use from aggregated employment and building area
- Estimate parcel employment by applying employment densities
- Feedback with IWD and assessor's offices

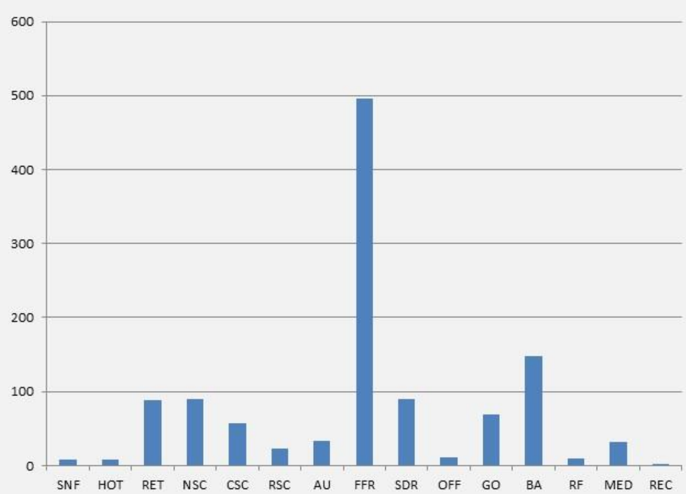
Employment Densities

Code	Name	SQFT	Employment	Employment Density
60	General Office	1,735,585	5,491	316
50	Street Front Commercial	652,446	1,696	385
30	Manufacturing	907,463	1,689	537
58	Restaurant	218,274	1,589	137
51	Neighborhood Shopping Center	438,182	1,402	313
31	Industrial Park/Light Industry	877,772	1,369	641
59	Other Commercial	832,306	1,235	674
71	Other Health Care	307,713	1,196	257
61	Government Office	115,430	1,155	100
52	Community Shopping Center/Big Box	697,508	947	737
57	Fast Food	87,330	849	103
32	Warehousing	982,038	786	1,249
53	Regional Shopping Center	376,325	678	555
25	Assisted Living/Hospice/SNF	156,960	581	270
26	Hotel/Motel	656,409	560	1,172
65	Bank	154,428	390	396
55	Auto Dealership	151,617	317	478

Update Process

- Identify new IWD records and records with address changes(25%?)
- Geocode new/change IWD records
- Identify new parcel commercial building records
- Reconcile IWD/parcel changes
- Edit parcel file to incorporate updates
- Estimate updated parcel employment
  - Apply employment densities to new sites
  - Adjust to IWD regional totals
- Annual process?

Modify Trip Generation



5.2.2 Hybrid non-home based/work tour assessment

The figures below highlight a case study done with the Ames model. Figure 5-1 shows the magnitude of intermediate stops at each zone (using Non-Home Based trip ends as a surrogate for this example). Figure 5-2 shows the number of intermediate stops that occur at each zone for the work trips that are traveling from zone 285 to zone 168, using a power function of 3. Note that zones with a high number of intermediate trip ends, such as those in the southwest portion of Ames, do not attract a high percent of the intermediate trips due to their relative distance from the subject origin and destination zones. Figure 5-3 shows the same outputs using a power function of 8. This higher power function increases the impact the additional distance has on the probability of stopping at a specific location, which is illustrated through the tighter grouping of trip ends along the shortest path between zones 285 and 168.

Figure 5-1: Intermediate Stops Available by TAZ

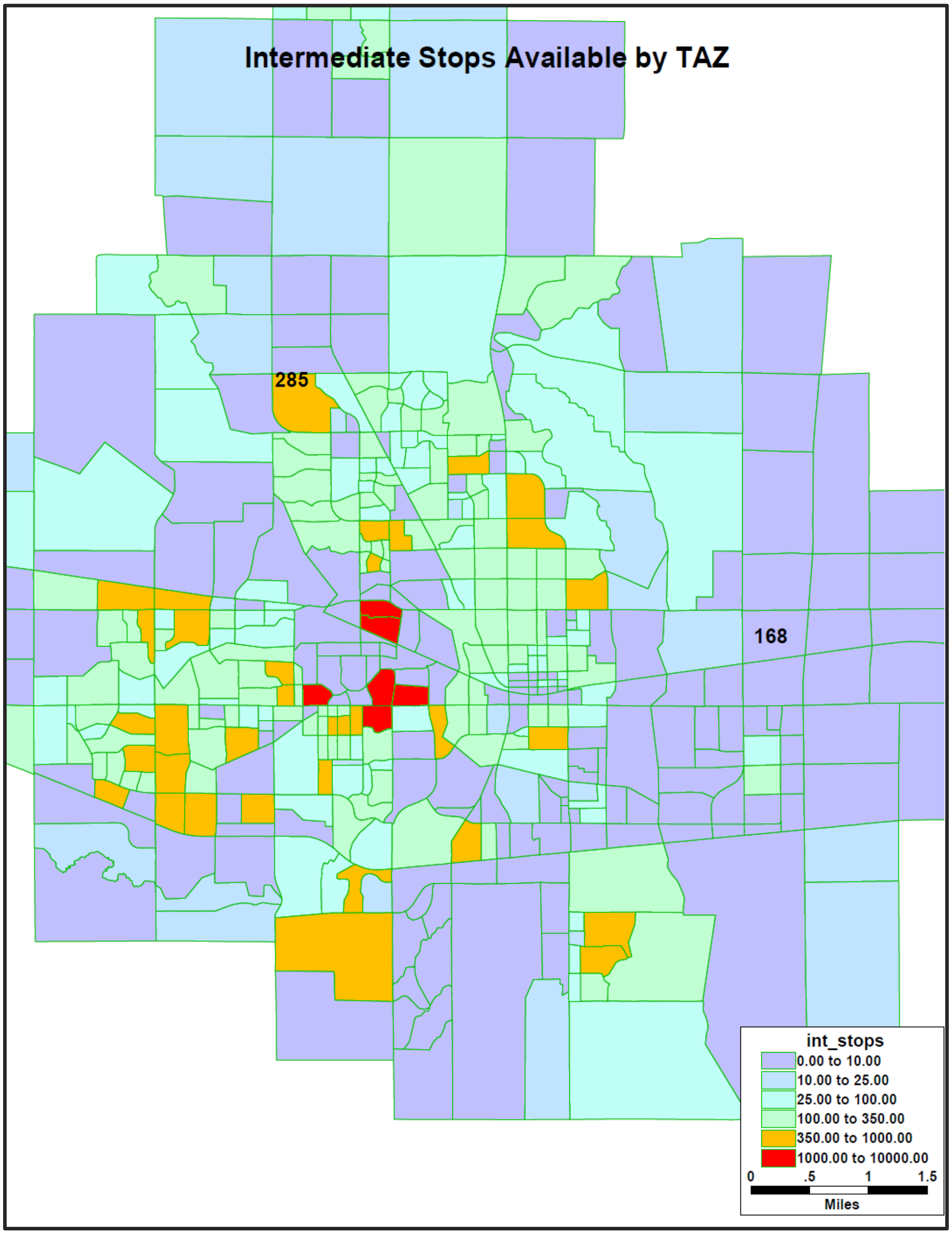


Figure 5-2: Intermediate Stops – P=3

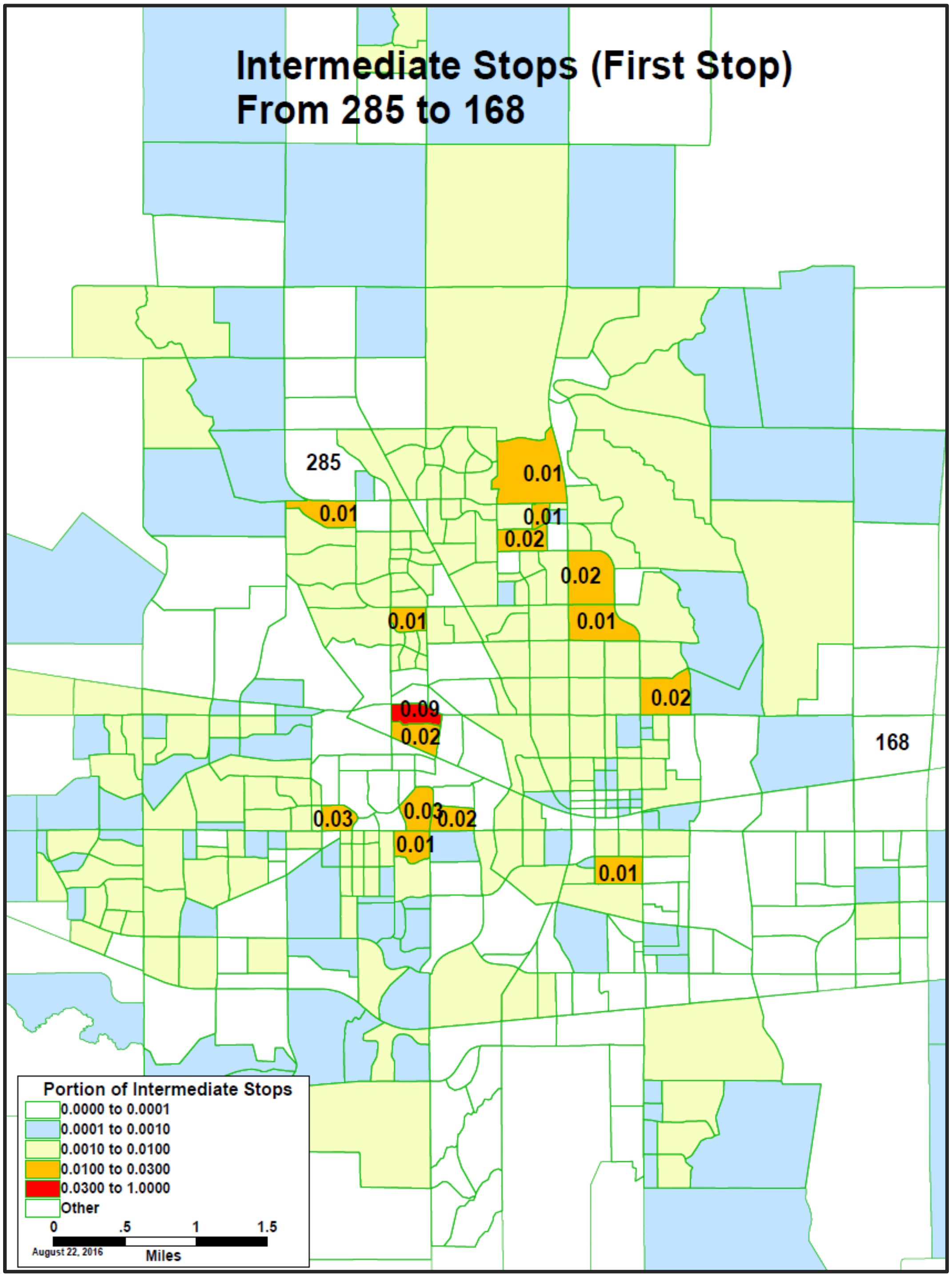
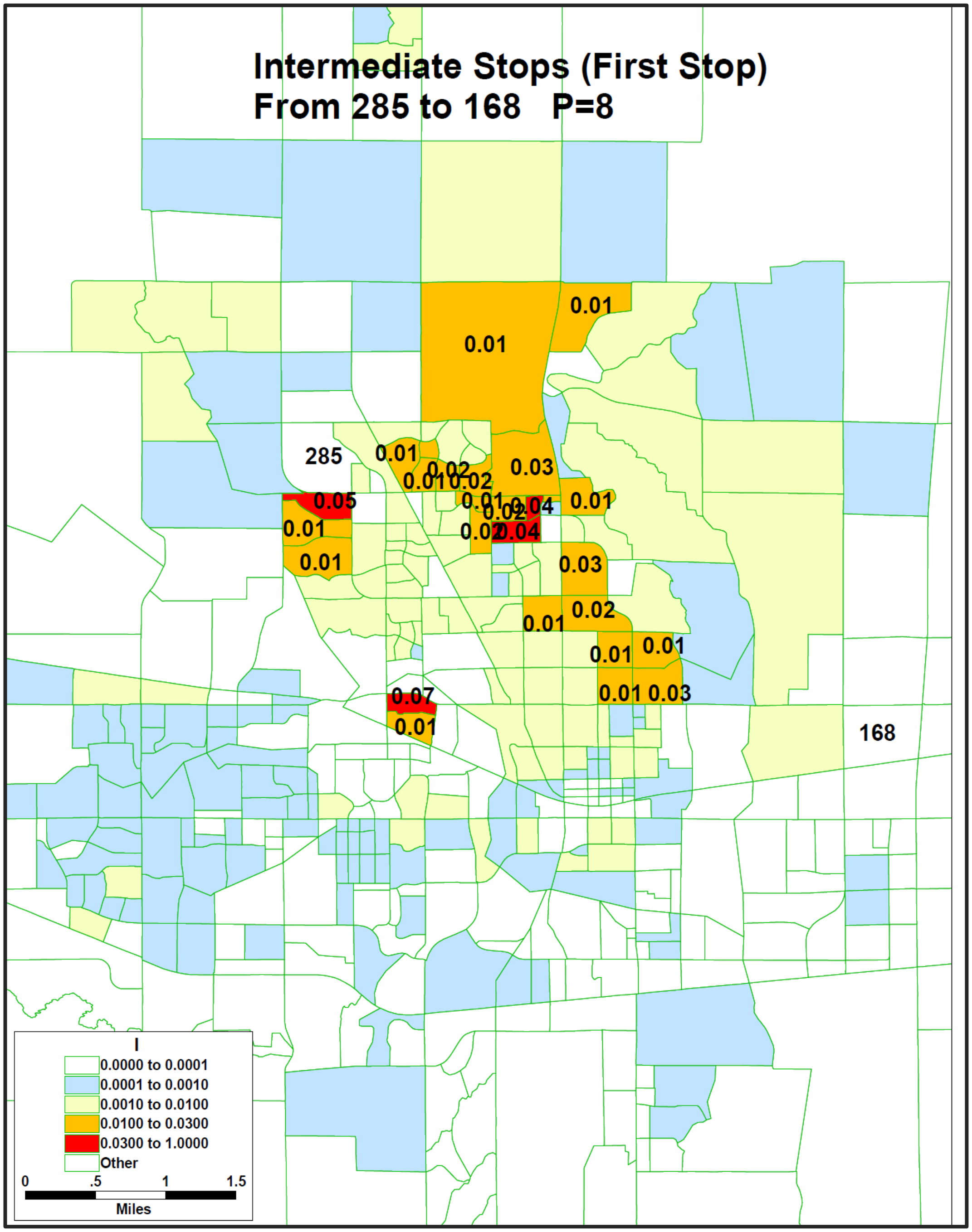


Figure 5-3: Intermediate Stops – P=8

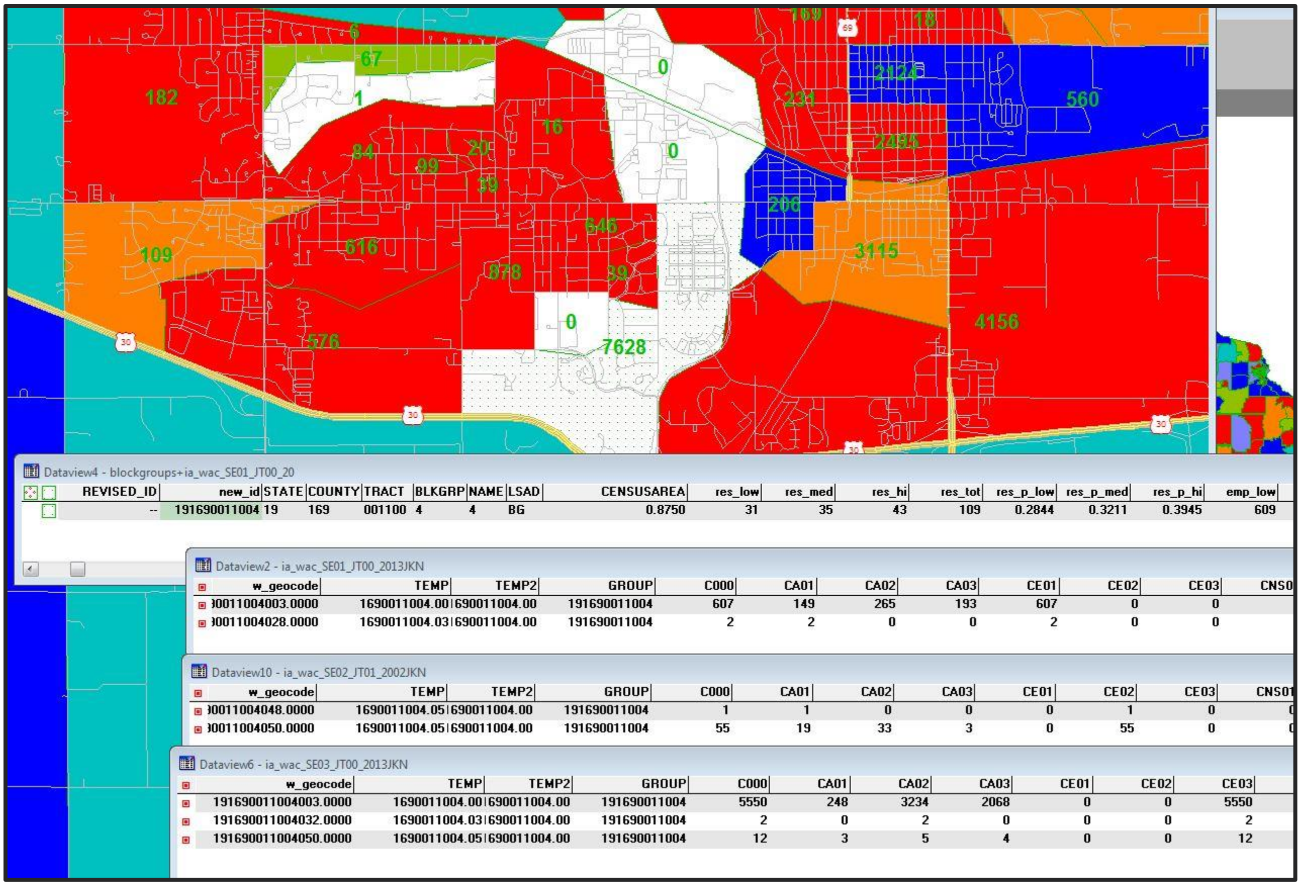


5.2.3 Longitudinal employer-household dynamics assessment

The Longitudinal Employer-Household Dynamics (LEHD) data is provided by the Center for Economic Studies at the US Census Bureau. There are several data products available for use in travel demand modeling.

The LEHD Residence and Workplace Characteristics data for the Ames area was processed to utilize in disaggregating the population into low, medium and high-income residents and employees. A check on the employee data was conducted for the Iowa State University area. Note in Figure 5-4 below the zone with 7,628 employees. The three bottom tables depict the original data provided for this block group. As shown, there is more detailed data provided across the three income groups (SE01 represents low income, SE02 is medium and SE03 is high income), however the geography is not consistent among the three income groups as noted by the differences in w_geocode attributes. This is why the data was aggregated to block groups.

Figure 5-4: LEHD Data Assessment near Iowa State University



Dataview4 - blockgroups+ia_wac_SE01_JT00_20

REVISED_ID	new_id	STATE	COUNTY	TRACT	BLKGRP	NAME	LSAD	CENSUSAREA	res_low	res_med	res_hi	res_tot	res_p_low	res_p_med	res_p_hi	emp_low
--	191690011004	19	169	001100	4	4	BG	0.8750	31	35	43	109	0.2844	0.3211	0.3945	609

Dataview2 - ia_wac_SE01_JT00_2013JKN

w_geocode	TEMP	TEMP2	GROUP	C000	CA01	CA02	CA03	CE01	CE02	CE03	CNS0
)0011004003.0000	1690011004.00	l690011004.00	191690011004	607	149	265	193	607	0	0	
)0011004028.0000	1690011004.03	l690011004.00	191690011004	2	2	0	0	2	0	0	

Dataview10 - ia_wac_SE02_JT01_2002JKN

w_geocode	TEMP	TEMP2	GROUP	C000	CA01	CA02	CA03	CE01	CE02	CE03	CNS01
)0011004048.0000	1690011004.05	l690011004.00	191690011004	1	1	0	0	0	1	0	0
)0011004050.0000	1690011004.05	l690011004.00	191690011004	55	19	33	3	0	55	0	0

Dataview6 - ia_wac_SE03_JT00_2013JKN

w_geocode	TEMP	TEMP2	GROUP	C000	CA01	CA02	CA03	CE01	CE02	CE03
191690011004003.0000	1690011004.00	l690011004.00	191690011004	5550	248	3234	2068	0	0	5550
191690011004032.0000	1690011004.03	l690011004.00	191690011004	2	0	2	0	0	0	2
191690011004050.0000	1690011004.05	l690011004.00	191690011004	12	3	5	4	0	0	12

Also note several block groups in the area around the subject block group that have zero total employees. This is inconsistent with actual data and is likely caused by ISU employees being reported as having a common work address and not the actual physical location. This error in location leads to a determination to not use the LEHD data as a direct input into the modeling process.

Also noteworthy is the relatively high percent of employees in the ISU area that are high income. Student workers appear to not be included in the employment numbers here.Table 5-1 shows the unbalanced productions and attractions for the Ames model's home-based work trip purpose when the LEHD data is applied after trip generation. Note the large number of external trip ends, particularly for the production end. Note the analysis uses LEHD data from the block group within which the external zone is physically located in the model.

Table 5-1: Production/Attraction Disaggregated by LEHD Income Data

	TOTAL		INTERNALS		EXTERNALS	
	HBWP	HBWA	HBWP	HBWA	HBWP	HBWA
LOW	11,659	17,535	5,898	15,731	5,761	1,805
MED	12,990	12,961	6,464	10,276	6,526	2,685
HIGH	21,868	17,416	10,075	13,407	11,793	4,009
TOTAL	46,518	47,913	22,437	39,414	24,080	8,499
ORIGINAL	46,518	47,913	22,437	39,414	24,080	8,499

Also note the relatively low number of low-income work trip productions compared to attractions. This would indicate many low-income jobs are being filled by workers who live outside the model area. Currently, block groups with no LEHD data assume all employees and their associated attractions are low income. This process should be revisited to utilize region-wide averages, but is not highly influencing the totals in the table above.

The original data row shows the productions and attractions from the model prior to applying the LEHD data; this provides a check on the arithmetic.

Other trip purposes will not use the income data for employment as direct inputs into segregating attractions. For example, a home-based other attraction is not dependent on the income of the employee at the attraction end as both low- and high-income people will shop at the same store regardless of the income of the clerk.

LEHD data is based on employment data provided by Iowa Workforce Development. Errors in IWD will impact usefulness of LEHD data. During review of IWD data, corrections should be provided to IWD to improve accuracy of future LEHD products, however, previous LEHD datasets will not be updated. Therefore, it is recommended to utilize the LEHD Residence and Workplace Characteristics files as validation data rather than direct model inputs.

5.2.4 Intersection delay development

The process of incorporating delay into the travel demand model's traffic assignment process was investigated using a combination of both link and node (or intersection) delays. Traditionally, traffic assignment calculates travel time delay based on link values of capacity, volume and delay parameters, but does not consider intersection control. Intersection delay is often less straightforward to estimate as more elements contribute to the delay calculation.

To quantify the effects of including intersection delay into the calculation of travel time in the traffic assignment process, a case study along the US 69 (Duff Avenue) corridor in Ames was conducted. The Duff Avenue corridor was selected due to the presence of signalized intersection control, relatively high peak volumes, and availability of data including turning movement counts, traffic signal timings/phasing data, INRIX travel time data and DOT-collected travel time data.

Figure 5-5, Figure 5-6 and Table 5-2 show the free flow speed along the corridor, the INRIX reported congested speed, the congested speed as observed by a floating car travel time survey and the Synchro/SimTraffic estimated congested speed along the corridor. he speed limit varies along the corridor, resulting in a 36 MPH average free flow speed. INRIX data indicates average congested speed along the corridor to be between 17 and 19 MPH during the PM peak (3 – 6 pm). INRIX data for Des Moines was also provided, in a higher resolution format, but was found to have similar geographic resolution for arterial segments. The GPS survey collected by Iowa DOT included both total travel time and intersection delay, and resulted in congested speeds of 22 MPH in each direction (note travel time not collected from 5-6 PM, the most congested hour in the PM peak). SimTraffic is a traffic simulation software that use traffic signal timing data, intersection geometry, vehicle and driver behavior estimates and intersection counts along the corridor. Simtraffic estimated congested speeds of 18 to 20 MPH in the corridor.

A roadway network of the entire Ames model area and a static PM period trip table (comprised of auto and two truck tables for the multi-modal assignment process) were used for all traffic assignments. The resulting traffic assignments produced volume to capacity ratios of 0.45 to 0.64, indicating the roadway links were not near capacity. Volume to capacity ratios from Synchro were approximately 0.5. The link delay equations using the Bureau of Public Roads (BPR) functions do not generate sufficient delay at these mid-level volume to capacity ratios to account for the delays along the Duff Avenue corridor. Therefore, a process to incorporate delay at the intersections was evaluated.

Figure 5-5: Congested speeds using various levels of intersection delay

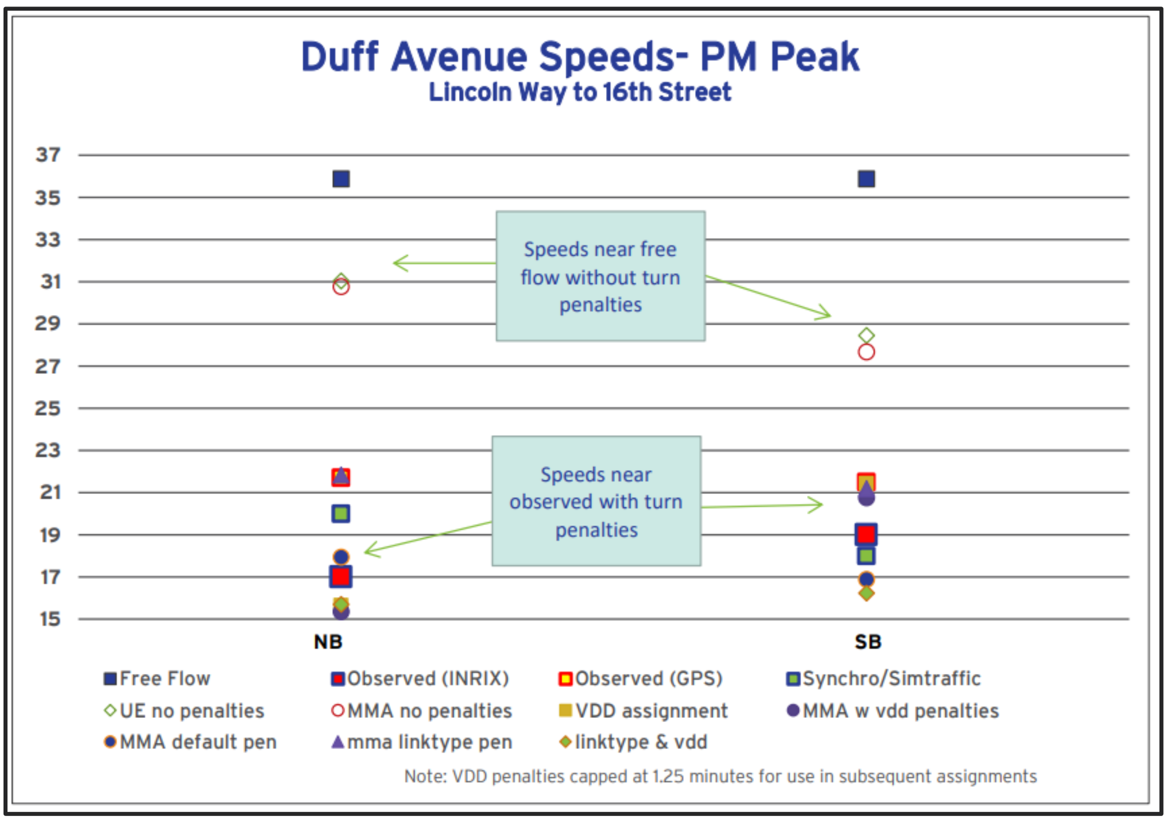


Figure 5-6: Close-up of congested speeds near observed speeds

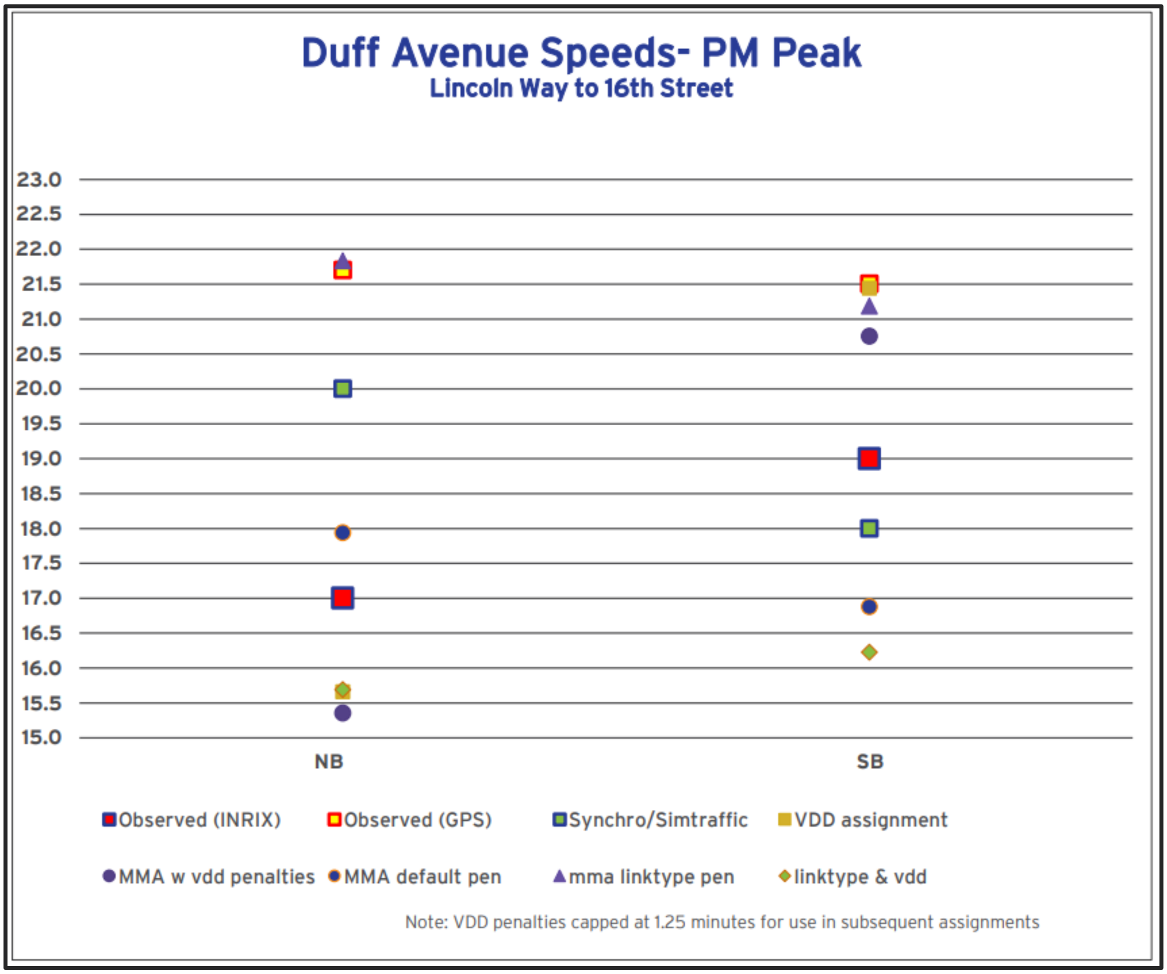


Table 5-2: Congested speeds using various levels of intersection delay

ASSIGNMENT TYPE	NORTHBOUND				SOUTHBOUND			
	CONGESTED LINK TIME	INTERSECTION DELAY	TOTAL TRAVEL TIME (MIN)	SPEED (MPH)	CONGESTED LINK TIME	INTERSECTION DELAY	TOTAL TRAVEL TIME (MIN)	SPEED (MPH)
Free flow	1.99		1.99	35.9	1.99	0.00	1.99	35.9
UE no penalties	2.30	0.00	2.30	31.0	2.51	0.00	2.51	28.4

ASSIGNMENT TYPE	NORTHBOUND				SOUTHBOUND			
	CONGESTED LINK TIME	INTERSECTION DELAY	TOTAL TRAVEL TIME (MIN)	SPEED (MPH)	CONGESTED LINK TIME	INTERSECTION DELAY	TOTAL TRAVEL TIME (MIN)	SPEED (MPH)
MMA no penalties	2.32	0.00	2.32	30.8	2.58	0.00	2.58	27.7
UE w vdd penalties	2.13	2.50	4.63	15.4	2.18	1.24	3.42	20.9
VDD assignment	2.06	2.50	4.56	15.7	2.09	1.24	3.33	21.4
MMA w vdd penalties	2.15	2.50	4.65	15.4	2.2	1.24	3.44	20.8
UE default pen	3.10	0.85	3.95	18.1	3.36	0.85	4.21	17.0
MMA default pen	3.13	0.85	3.98	17.9	3.38	0.85	4.23	16.9
MMA linktype pen	2.02	1.25	3.27	21.8	2.12	1.25	3.37	21.2
Linktype & vdd	2.00	2.55	4.55	15.7	2.07	2.33	4.4	16.2
Observed (INRIX)				17.0				19.0
Observed (GPS)	1.53	1.76	3.29	21.7	2.51	0.81	3.32	21.5
Synchro/ Simtraffic				20.0				18.0

Traffic assignment was first conducted using both a User-Equilibrium (UE) method and the Multi-Modal Assignment (MMA) with autos and two classes of trucks. The resulting congested speeds were between 27.5 and 31 MPH, much higher than the observed speeds.

TransCAD's Volume-Dependent Delay (VDD) assignment function was then utilized to produce volumes and congested speeds as a typical assignment, along with producing an estimate of delays for each signalized movement. The VDD function calculates delay using Highway Capacity Manual (HCM) equations. VDD requires explicit coding of many features of the signalized intersection such as number and length of turn bays, and signal control parameters, requiring the use of the Intersection Control Editor, see **Error! Reference source not found.**.

More details of the VDD function are available in the TransCAD User's Manual. The VDD assignment estimated congested speeds along Duff at 16 to 21 MPH. The VDD function appeared to have difficulty in generating stable assignment outputs, with traffic assignments that did not reach equilibrium after 500 iterations in the relatively uncongested Ames example. The VDD function also produced estimated delays at specific locations that did not always appear logical, such as an estimate of 15 minutes of delay for right turn movements at a relatively low volume intersection. The VDD function also did not easily address delay at stop-controlled intersections. Generally, the resulting movement-specific delays for signalized intersections in the Ames example were reasonable.

Movement-specific turn delays from the VDD assignment were then reformatted to TransCAD's turn penalty format and fed into the traditional traffic assignment methodologies. Both the UE and MMA assignments using VDD delays resulted in congested speeds of 15 to 21 MPH. Note that movement-specific penalties greater than 75 seconds were capped at 75 seconds. This upper limit of signalized delay was utilized as no signals in the Ames example regularly experience cycle failure as defined as vehicles unable to pass through a signalized intersection within one signal cycle. If signalized intersections exist within the model area that regularly experience cycle failure, the maximum penalty for the associated movements should be adjusted accordingly.

A default set of turn delays was then developed that was control specific, but not volume or facility type specific. Turn movements were auto generated and the default delays were applied to each movement, then the tables were reformatted into TransCAD's turn penalty format. Default values were derived from previous modeling efforts, but generally assume delays of approximate level of service (LOS) C. One exception is two-way stop control, which has delays in the LOS D range to minimize the local rerouting from signalized intersections. Both the UE and MMA assignments using the default delays resulted in congested speeds of 17 to 18 MPH.

TransCAD's linktype turn penalty process similarly assigns turn penalties, but can be facility-type specific. The values in Table 5-3 show the values input into the Duff Avenue corridor case study, and are generally LOS C values. These values are intended to represent the delay at a typical intersection. This process requires the highway network to include the A-node and B-node of the link, which are used to obtain the intersection control for each direction of the link. The linktype value is then assigned for each direction of each link, and the corresponding penalty is assigned using the From and To Linktype lookup. This process utilizes TransCAD's network features to identify the directionality of each turn automatically, and the values that constitute a left or right turn from a through movement are editable globally within TransCAD. Using the Linktype turn penalties resulted in congested speeds of 21 to 22 MPH.

TransCAD allows for global, linktype and location specific penalties to all be utilized simultaneously. Linktype penalties override global penalties, and location specific penalties override linktype penalties. For example, a global penalty of 0.05 minutes for all right turns could be input, with a linktype penalty of 0.15 at signalized arterials, and a location specific penalty of 0.25 for a specific intersection with a shared right turn lane.

A model assignment was then conducted using the linktype penalties and the volume-dependent delay turn penalties developed at signalized intersections. As the linktype delays were developed to represent typical intersections, the higher delays at specific intersections can be used to override the linktype defaults. Similarly, specific penalties could be included during the calibration process to override the default when actual delays are lower than the default.

Table 5-3: Default linktype-specific turn delays

FROM LINKTYPE	TO LINKTYPE	MINUTES OF DELAY PER TURN (PEAK)				MINUTES OF DELAY PER TURN (OFF-PEAK)			
		LEFT	RIGHT	THRU	UTURN	LEFT	RIGHT	THRU	UTURN
Limited access	Ramps	0.15	0.15	0.15	99	0.15	0.15	0.15	99
	All others	0.15	0.15	0.00	99	0.15	0.15	0.00	99
Signalized arterial/ramp	Arterial/ramp	0.50	0.15	0.25	0.50	0.38	0.11	0.19	0.38
	Collector	0.50	0.15	0.25	0.50	0.38	0.11	0.19	0.38
	Local/CC	0.35	0.10	0.15	0.40	0.26	0.08	0.11	0.30
AWSC	Arterial/ramp	0.30	0.10	0.30	0.30	0.23	0.08	0.23	0.23
Arterial/ramp	Collector	0.25	0.10	0.25	0.25	0.19	0.08	0.19	0.19
	Local/CC	0.20	0.07	0.20	0.20	0.15	0.05	0.15	0.15
TWSC arterial/ramp	Arterial/ramp	0.45	0.15	0.35	0.45	0.34	0.11	0.26	0.34
	Collector	0.30	0.10	0.25	0.30	0.23	0.08	0.19	0.23
	Local/CC	0.25	0.10	0.20	0.25	0.19	0.08	0.15	0.19
Uncontrolled arterial/ramp	All types	0.25	-.05	0	0.25	0.19	0.04	0	0.19
Signalized collector	Arterial/ramp	0.55	0.20	0.40	0.60	0.41	0.15	0.30	0.45
	Collector	0.40	0.15	0.30	0.40	0.30	0.11	0.23	0.30
	Local/CC	0.35	0.10	0.25	0.35	0.26	0.08	0.19	0.26
AWSC collector	Arterial/ramp	0.25	0.10	0.25	0.25	0.19	0.08	0.19	0.19
	Collector	0.25	0.10	0.25	0.25	0.19	0.08	0.19	0.19
	Local/CC	0.20	0.07	0.20	0.20	0.15	0.05	0.15	0.15
TWSC collector	Arterial/ramp	0.40	0.15	0.35	0.40	0.30	0.11	0.26	0.30
	Collector	0.30	0.10	0.25	0.30	0.23	0.08	0.19	0.23
	Local/CC	0.25	0.10	0.20	0.25	0.19	0.08	0.15	0.19
Uncontrolled collector	Arterial/ramp	0.20	0.05	0	0.20	0.15	0.04	0	0.15
	Collector	0.17	0.05	0	0.17	0.13	0.04	0	0.13

FROM LINKTYPE	TO LINKTYPE	MINUTES OF DELAY PER TURN (PEAK)				MINUTES OF DELAY PER TURN (OFF-PEAK)			
		LEFT	RIGHT	THRU	UTURN	LEFT	RIGHT	THRU	UTURN
	Local/CC	0.15	0.05	0	0.15	0.11	0.04	0	0.11
Signalized local/CC	Arterial/ramp	0.60	0.25	0.50	0.60	0.45	0.19	0.38	0.45
	Collector	0.40	0.15	0.30	0.40	0.30	0.11	0.23	0.30
	Local/CC	0.35	0.10	0.25	0.35	0.26	0.08	0.19	0.26
AWSC local/CC	Arterial/ramp	0.25	0.10	0.25	0.25	0.19	0.08	0.19	0.19
	Collector	0.20	0.10	0.20	0.20	0.15	0.08	0.15	0.15
	Local/CC	0.20	0.10	0.20	0.20	0.15	0.08	0.15	0.15
TWSC local/CC	Arterial/ramp	0.40	0.15	0.35	0.40	0.30	0.11	0.26	0.30
	Collector	0.30	0.10	0.25	0.30	0.23	0.08	0.19	0.23
	Local/CC	0.20	0.10	0.17	0.20	0.15	0.08	0.13	0.15
Uncontrolled local/CC	Arterial/ramp	1.00	0.20	0	1.00	0.75	0.15	0	0.75
	Collector	0.35	0.15	0	0.35	0.26	0.11	0	0.26
	Local/CC	0.15	0.05	0	0.35	0.11	0.04	0	0.11

NOTE: AWSC = All way stop control; TWSC = Two way stop control; CC = Centroid connector

The Duff Avenue corridor case-study indicates that TransCAD assignments that include a delay for appropriate movements increases the accuracy of the resulting congested travel speeds. Default turning movement specific delay values shown produce reasonable estimates of congested speeds along a signalized arterial, while not impacting speeds along controlled access facilities. The VDD process produces detailed estimates of delay at signalized intersections, but the delays from the process must be reviewed for reasonableness before implementing.

Recommended practice is to utilize the linktype turn penalties shown in Section 4.8 as a starting point in network development. More detailed delay data should be used where available, especially for routes with higher volumes and delays as part of movement-specific turn penalties. Floating car travel time surveys, TransCAD's VDD function, traffic microsimulation, or HCS-type intersection analysis can be used to adjust movement-specific delay values to more accurately incorporate specific intersections. Within Iowa, these higher-class facilities may have INRIX data available to aid in validating the input delays for both peak and off-peak conditions.

6: GUIDANCE ON MODEL APPLICATION

6.1 Traffic Forecasting

6.1.1 Various national resources exist defining and providing guidance on the process of forecasting traffic. NCHRP Report 765

NCHRP Report 765 – Analytical Travel Forecasting Approached for Project-Level Planning and Design

Published in 2014, this document is an update to NCHRP *Report 255 – Highway Traffic Data for Urbanized Area Project Planning and Design*. In addition to topics addressed by NCHRP 255, this update features a focus on travel demand management and operational efficiency strategies; spatial and temporal aspects of congestion at the project-level; and for heavily congested urban study areas and corridors - the effects of residual demand and peak spreading at a project level. Special topic areas include methods for toll/revenue forecasts, work zone diversion and delay forecasts, as well as environmental justice.

6.1.2 Travel Model Validation and Reasonableness Checking Manual, Second Edition

Travel Model Validation and Reasonableness Checking Manual, Second Edition

The *Travel Model Validation and Reasonableness Checking Manual, Second Edition*, published in September 2010, for the Federal Highway Administration provides guidance on four aspects of implementing state-of-the-art modeling methods including: the development of model validation plans, including collection of proper validation data; the role and specification of validation and reasonableness checks and criteria; the role of model sensitivity testing in model validation; and the development of validation documentation. The manual provides information pertaining to both existing trip-based and emerging activity and tour-based modeling processes.

6.1.3 NCHRP Report 716

NCHRP Report 716 - Travel Demand Forecasting: Parameters and Techniques

NCHRP Report 716 was published in 2012 to revise and update NCHRP Report 365 to reflect current travel characteristics and to provide guidance on travel demand forecasting procedures and their application for solving common transportation problems. The report covers a range of topics encompassing the planning applications context; data needed for modeling; model components: (vehicle availability, trip generation, trip distribution, external travel, mode choice, automobile occupancy, time-of-day, freight/truck modeling, highway assignment, and transit assignment); model validation and reasonableness checking; emerging modeling practices; and case studies.

6.1.4 FTA Travel Forecasting for New Starts Workshop

FTA Travel Forecasting for New Starts Workshop

This workshop was held in St. Louis, Mo in September 2007 and outlines FTA requirements for New Starts, SAFETEA-LU provisions for forecasting, and policy guidance for project sponsors and travel forecasters. Travel model topics include recommended architecture, data collection methods, calibration/validation of models, CTPP-based forecasting, application of alternative-specific effects, and forecast uncertainty. The workshop also addressed closure of topics introduced at the 2006 workshop: allowance of variable trip tables and trip ends in the calculation of project benefits and use of a CTPP-based aggregate model for quality control of mode choice results.

6.2 Use of Models in Traffic Forecasting

It is important to remember that the output obtained from a travel demand model does not represent the traffic forecast necessary to complete an operational analysis of an existing or future facility. Rather, the output from the travel demand model is one piece of information used to develop the traffic forecast. The following sections will provide guidance on the preparation and use of model output data.

6.2.1 Resources

There are many resources that provide guidance on the development of traffic forecasts. The "National Cooperative Highway Research Program (NCHRP) Report 255: Highway Traffic Data for Urbanized Area Project Planning and Design", published in 1982, has long been used as the primary resource for developing traffic forecasts. This publication was recently reviewed and updated by "NCHRP Report 765: Analytical Travel Forecasting Approaches for Project-Level Planning and Design". NCHRP Report 765 also lays out what is considered "the essential bookshelf", which is a list of documents supporting the fundamentals of project level forecasting. These documents include:

- NCHRP Report 716: Travel Demand Forecasting: Parameters and Techniques
- NCHRP Report 365: Travel Estimation Techniques for Urban Planning
- Highway Capacity Manual 2010 (HCM2010) (now updated by HCM 6th Edition)
- Travel Model Validation and Reasonableness Checking Manual, Second Edition
- Quick Response Freight Manual II (QRFM II)
- Institute of Transportation Engineers Trip Generation Manual and Trip Generation Handbook
- NCHRP Synthesis 406: Advanced Practices in Travel Forecasting
- Dynamic Traffic Assignment – Dynamic Traffic Assignment: A Primer
- Dynamic Traffic Assignment – Utilization of Dynamic Traffic Assignment in Modeling
- FHWA's Traffic Analysis Toolbox

While the essential bookshelf provides a valuable list of resources that practitioners should be familiar with, the general process for development of traffic forecasts is described in Chapter 4 of NCHRP 765. A compatible process was also presented to MTMUG in November 2015 by the Iowa DOT.

The following subsections provide a list of "Things to Consider" topics when preparing traffic forecasts.

6.2.2 Things to Consider

NATURE AND REQUIREMENTS OF THE PROJECT

The data requirements to complete an Interchange Justification Report (IJR) for a systems interchange are different from those of a Traffic Impact Study (TIS) for a proposed development. For a TIS for a proposed development, data requirements tend to be focused more on the attributes of the proposed development as well as roadway and intersection improvements in the immediate area for the future year. Different considerations need to be taken into account for IJRs. The process used to develop IJR traffic forecasts should take this difference into consideration. For example, if a system interchange study is proposed to include VISSIM traffic modeling, current requirements of FHWA dictate that significant amounts of existing data must be collected to calibrate the existing conditions traffic microsimulation model. This data includes existing traffic counts, average speeds, and queue observations at adjacent service interchanges. This data, once collected, provides a recent snapshot of the existing conditions along the study area roadways and should be used as the basis for project-level traffic forecasts.

RELEVANCE OF BASE (SOURCE) DATA

The Iowa DOT's traffic counting program provides a good source of turning movement traffic counts at various locations around the state. This program may not have count data on local roadways within the specific project area; however, you can contact the Iowa DOT to conduct special counts to cover those areas. A basic understanding of activities in and surrounding the study area is also helpful. For instance, was there construction occurring at the time that turning movement traffic counts were collected which may have diverted or changed traffic patterns? The available historic count data in the area should be thoroughly scrutinized and new data collected if it is determined that the historic data is compromised in some manner or the data is too old to be useful to the project.

TAZ REVIEW

The TAZ structure within and surrounding the study area should be reviewed prior to efforts to develop traffic forecasts. This review should evaluate the socioeconomic data assigned to the TAZ(s). Questions to evaluate include:

- Does the socioeconomic data align with the details of the study being completed? (i.e., are there developments being proposed as part of the study and do these align with the growth already shown in the model?)
- Are the TAZs in the study area appropriately sized to distribute trips within the study area?
- Are the TAZ connectors sufficient to distribute trips to the study area network for both the existing and future year conditions?
- Is the study area ill-suited within the model to have realistic gravity model performance? (i.e., is the study area on the periphery of the model?)

STUDY AREA MODEL ROADWAY AND OUTPUT REVIEW

The assigned flows within the study area should be reviewed for reasonableness. Questions to evaluate include:

- Have the study area roadways received adequate calibration to existing traffic count data?
- Do parallel roadway flows make sense? (i.e., are higher capacity roadways getting assigned more traffic than expected when compared to parallel routes?)
- Is the directionality of the flows reasonable?
- Do the time period-specific assignments seem reasonable?

Additionally, the analyst is cautioned to only use like models when determining annual growth of study area roadways. In other words, comparisons between the adjusted base model and adjusted forecast model should be used. However, comparisons between the unadjusted base model and the adjusted forecast model should be avoided.

On new links where no adjusted flow is available, the analyst should review the unadjusted flows assigned to the new links to determine reasonableness within the context of the surrounding roadways. Some things to consider in this review include:

- Did surrounding and/or parallel existing links incur significant adjustment which could lead the analyst to question the unadjusted flow of the new link?
- Did the capacity of the new link get coded correctly? (Is the unadjusted flow significantly higher or lower than expected?)

If the capacity of the new link is found to be incorrectly coded, the coding should be corrected and the model should be rerun. Should the analyst find significant adjustments to parallel roadways, it may be necessary to incorporate a screenline analysis of parallel links to make manual adjustments to the unadjusted flow being reported on the new link before moving forward with the develop of traffic forecasts.

CONTINUITY WITH PREVIOUS FORECASTS FOR THE AREA

Traffic forecasts are often created for adjacent, overlapping, and sometimes the same project study area over the course of several years. These forecasts may be based on differing travel demand model versions if completed years apart. Care should be taken to review traffic forecasts with previous forecasts completed in and around the study area. Differences in traffic volumes should be justifiably explained. For instance, traffic forecasts for a specific project study area are being compared to forecasts previously completed prior to an update of the region's travel demand model. During the travel demand model update process, changes in the socioeconomic data due to a newly planned large development in the area resulted in higher annual growth rates for the study area roadways. In these situations, the forecaster and/or the DOT should identify a pre-defined methodology for reconciling forecasts (e.g., rely on the most recent travel patterns and underlying socioeconomic data since these reflect the most updated network and demographic assumptions.

Traffic forecasts for most projects should be based on the adopted travel demand model. This adopted model includes the socioeconomic data on which the model is based. While it is expected that scenarios may be tested between official model adoption where socioeconomic data may be changed, care should be taken to determine that the traffic forecasts being developed are based on the adopted model and the associated socioeconomic dataset.

COMPARISON WITH HISTORICAL TRAFFIC GROWTH

When historical traffic volume data is available, a comparison of historical growth rates to growth rates determined from the travel demand modeling process is appropriate and encouraged. Care should be taken to understand the historical development trends within and surrounding the area which may affect the comparison of the two growth rates. For instance, if the study area was considered rural in nature 20 years ago, the historical growth rate may show a high annual growth rate as the area developed and became more urban in nature. This high growth rate would not likely continue as the area reaches a full-build state.

VOLUME BALANCING (SMOOTHING)

Once traffic forecasts have been created for each of the study area intersections, the links within the study area should be reviewed to determine if access is provided along the link. Areas with no access, like within interchanges, should have the forecast volumes balanced such that the departing volume from one intersection equals the approaching volume at the adjacent intersection. Traffic forecasts for most projects should be based on the adopted travel demand model. This adopted model includes the socioeconomic data on which the model is based. While it is expected that scenarios may be tested between official model adoption where socioeconomic data may be changed, care should be taken to determine that the traffic forecasts being developed are based on the adopted model and the associated socioeconomic dataset.

HEAVY VEHICLE ESTIMATION

The heavy vehicle percentage along a corridor plays an important role in traffic operations analysis. Traffic forecasts should provide an estimate for heavy vehicle percentage at the peak hour level. Daily and hourly heavy vehicle percentage can vary greatly. For example, an arterial roadway may have 9% trucks on it daily. However, the peak hour may only experience 2%.

STAKEHOLDER COORDINATION

Finally, it is important to realize that other agencies may play a role in the study area roadways. In some cases, these agencies may have jurisdiction over roadways either within the study area or in close proximity to the study area. Traffic forecasts in one area may influence forecasts developed in another area. It is important to solicit stakeholder input early in the process to gain valuable information which may influence the development of traffic forecasts in a particular study area. Similarly, stakeholders should have the opportunity to review traffic forecasts, once created, to provide consistency and conformity among forecasts.

6.3 Model Use for Long Range Transportation Plan Development

6.3.1 Project Selection

Travel demand models provide a platform for testing impacts from changes in socio-economic and transportation system elements. However, if a demand model does not include a transit element, the model will not be able to evaluate the impacts of increased headways of a bus system, for example. It is recommended to evaluate the types of projects that will be evaluated during the long range transportation planning process ahead of developing the travel demand modeling tool.

6.3.2 Project Evaluation

Transportation projects are coded into the travel demand model network, or route system for transit projects. It is recommended to evaluate each potential project as a standalone project, gathering various metrics from the travel demand model including regional measures such as VMT, VHT and miles of congested roadways, as well as local measures along and near the project including volume to capacity ratios and projected travel time changes. The metrics from each project are then compared, along with an anticipated construction cost for the project, to determine the relative effectiveness of each project. Projects may be packaged together to determine the net effect of multiple projects.

3rd party software may also be used to help facilitate the evaluation of transportation projects. One example is Federal Highway Administration's Surface Transportation Efficiency Analysis Model (STEAM). The documentation and software are available at: http://bca.transportationeconomics.org/models/steam

6.3.3 Project Prioritization

Once the costs and benefits of a project, or group of projects, is determined, the projects are ranked based on a set of established criteria. This process provides defensible documentation to support the ranking and provides helpful information to stakeholder decision makers.

6.3.4 Outside influences on project selection/prioritization

While the travel demand modeling process is a valuable tool providing detailed information on the benefits and costs of projects, the final approved list of projects included in a long-range transportation plan often must also consider the political realities of the region. The goal of the travel demand modeling process is to provide defensible facts on which to base project priorities. This process ignores political districts and evaluates the project in terms of the potential benefit to the entire region. The result of this could lead to infrastructure investments being focused in certain geographies, rather than being distributed to across the region. A continued pattern of investment in this manner could drive socio-economic disparity within the region.

6.4 Corridor and Sub-Area Planning

6.4.1 Subarea extraction

Travel demand models can extract trip table information from subareas within the overall model coverage area. These subarea trip tables include the trip purposes of the overall assignment including both autos and trucks as separate tables. The subareas are defined by the user and can be made to mimic the extents of other traffic analysis tools such as microsimulation models. The resulting subarea tables can then be reformatted for direct input into these tools, at which point additional calibration is required to further enhance the trip table information to better reflect observed conditions, typically for one to two specific hours of analysis.

6.4.2 Select link matrices

The select link analysis allows for an analysis of the travel patterns of users of a specific segment or segments of a transportation network, typically one or multiple roadway segments. The select link output data includes link specific info on the number of vehicles on any particular roadway segment that used the link being analyzed. A trip table is also output, indicating the origin to destination patterns of all users that used the selected link. This data is often useful in evaluating weave segments, and potential impacts of modifying the geometrics of the weave.

6.4.3 Subarea disaggregation process

The subarea disaggregation process allows for increased detail in the TAZ and network structure for a specific study area. The process separates selected TAZ's into smaller TAZ's nested inside the original TAZ, then separates the trip tables accordingly. The network is modified accordingly, adding new centroid connectors and local roadways to better reflect the detailed traffic loading patterns in the area. This process maintains the overall trip distribution patterns of the original model, while providing more detailed traffic assignments within the area of interest. While not a specific option within the ISMS prototype, the standard modeling tools within TransCAD allow for this operation to be conducted with minimal trip table effort and network additions.

6.4.4 Shortest Path

The shortest path analysis feature provides the analyst with an efficient visual assessment of the modeling results. By analyzing the shortest path, the analyst can determine whether the model is assigning trips in a realistic manner. This visual check can be used to identify possible coding errors within the model or possible locations where minor manual reassignments may be needed during the development of traffic forecasts. This tool could also be utilized to modify turn penalties to better replicate existing travel patterns. Shortest path assessment can be completed on either the input or congested output speeds.

6.5 Air Quality Analysis

The ISMS prototype develops trip tables and traffic assignment outputs by time period, which may be used within air quality analysis tools such as the Environmental Protection Agency's Motor Vehicle Emission Simulator (MOVES). Specific information about developing a MOVES model and the data needs from a regional travel demand model are available at: https://www.epa.gov/moves. Coordination with both Iowa DOT and Iowa Department of Natural Resources should be conducted prior to initiating the development of a MOVES model and associated reformatting of data from ISMS.

6.6 Benefit/Cost Analysis

3rd party software may also be used to conduct benefit/cost analysis. One example is Federal Highway Administration's Surface Transportation Efficiency Analysis Model (STEAM). The documentation and software are available at: http://bca.transportationeconomics.org/models/steam

Other DOT recommended benefit/cost tools might include HERS-ST, IMPLAN and REMI.

6.7 Integration with other Models and Tools

6.7.1 Land Use Models

Travel demand models may also be used to test the effects of various land development strategies. With technological advances in the transportation industry coming at ever increasing rates, the impact of these changes on how we live, work, and play is still being deciphered. The travel demand model provides a tool to run hypothetical scenarios varying land use densities and socioeconomic data to reflect the various predictions being made on the impact of our changing industry.

6.7.2 Dynamic Traffic Assignment Models

The traffic assignment process used within ISMS considers network features (capacity, travel time, delay, etc.) and travel demands (number of trips between origin-destination pairs) to be homogeneous within an analysis period. For this reason, the standard ISMS model separates travel into 3 or 4 time periods to more accurately distinguish between travel decisions within the typical day. This assumes all trips within a given time period experience the same network attributes throughout the entire time period.

Dynamic traffic assignment (DTA) may be worth considering when existing or anticipated travel conditions have unique temporal characteristics that would adversely impact vehicle routing and/or traffic operations. An example may be existing traffic counts indicate volume is at capacity for 45 minutes of the PM period (and well below capacity the remainder of the period), and the demand model projects a 20% increase in traffic demand in the corridor. DTA would add insight into how traffic would respond, such as diversion to other routes for approximately one hour, or changing departure time (peak spreading). These two outcomes cannot be explicitly modeled within the context of a static, 3-hour time period assignment used within ISMS currently.

DTA models work by further subdividing transportation decisions into discrete time slices. Depending on the specific modeling approach, these time slices may range from a portion of a second to multiple minutes. Within Caliper's suite of transportation software, DTA may be conducted in different ways on different platforms. TransCAD's DTA process (mesoscopic in nature) builds upon the traditional four-step modeling approach, with volume-delay functions estimating travel time delays along links, but managed for discrete time slices. TransModeler uses a traffic microsimulation approach, with simulated vehicles interacting within simulation environment to estimate travel time and delays to influence the routing of on-going and future trips within the model system.

The decision of the need for and the type of DTA to implement should be based on the needs of the project. Regionwide DTA to more accurately predict large scale congestion may be accomplished through mesoscopic modeling. Detailed analysis of specific corridors may be better served through a microsimulation approach. The model development team or project development team for specific projects should discuss the benefits and additional effort required to implement DTA.

6.7.3 Traffic Microsimulation Models

Traffic microsimulation models vary in their recommended input of traffic demand. Intersection-specific turning movement forecasts may be used to develop the microsimulation model's travel demands. If the microsimulation model is studying a large and complex area, consideration should be given to the use of subarea extractions from the ISMS model. The subarea trip tables may be loaded into some microsimulation models. This provides more accurate analysis of weave conditions and complex urban signalized corridors.

The traffic demands from the ISMS model may require additional refinement based on observed data and microsimulation model results. For example, intersection delays experienced in the field may need to be incorporated at a higher level of detail in the ISMS model to replicate travel patterns on a local scale. An updated subarea extraction would then be conducted on the revised ISMS model to capture the improved travel patterns for subsequent use in the microsimulation model.

The microsimulation model will provide more ability to fine-tune travel patterns in the existing condition, and at some point, in the calibration process, no further refinements will be beneficial in the ISMS model. At this point, the base and scenario ISMS models will be used to predict relative changes in travel patterns, and these relative differences are then applied to the final microsimulation model trip table that matches observed conditions. This process is akin to traffic volume forecasting, where the demand model is improved to an acceptable level of accuracy, then the model is used to predict changes in traffic volume, which are applied to the observed data.

6.7.4 Statewide initiatives

With the increased consistency in modeling practices anticipated among the various MPOs in the State of Iowa through the use of the ISMS procedures, it will improve the ability to analyze various statewide initiatives. It is plausible that individual MPO models may someday be nested into a statewide model for testing of larger scale initiatives. Reversing this idea, iTRAM model runs can be used to update ISMS models allowing for statewide initiatives (example of I-80 statewide expansion, truck only lanes, or speed limit increases) to be tested first in iTRAM, and those results input into the respective ISMS models to evaluate the impacts to those MPO's more thoroughly.

6.7.5 Freight Modeling

ISMS does incorporate the Quick Response Freight Manual process, providing trip purposes for single unit and combination trucks. Parcel level data and the ability to add new land use types into the trip generation process provides flexibility to generate truck trips as needed. Additionally, ISMS incorporates external trip information from iTRAM, which includes a more robust freight component. Analysis of large-scale freight producing projects could be first tested within iTRAM to determine magnitude, mode and distribution of trips from the freight generator throughout the Iowa network, then extract that data and update the respective ISMS model(s) with the revised freight data and rerun ISMS accordingly.

6.7.6 CAV Modeling

Connected and Autonomous Vehicles (CAV) promise a fundamental revolution in mobility. They are expected to make traveling safer, cheaper, more comfortable, more sustainable, and more equitable. They will open car travel to children, elderly and the disabled. Depending on the scenario, they may also trigger a substantial reduction of the total vehicle fleet and substantial road capacity gains. If all those assumptions are realized, CAVs will not only revolutionize transportation, but could dramatically change the urban form. By substantially reducing the real and perceived cost of travel, they may induce substantial amounts of additional travel demand and boost a new wave of suburbanization and urban sprawl. Alternatively, by reducing onsite parking needs and enabling road diets in the urban core, they may encourage a more compact urban growth pattern.

Modeling of CAV impacts within ISMS is accomplished through the modification of a variety of input parameters. Trip generation rates may be expected to increase, especially in households with people currently unable to drive. Trip distribution may be impacted by CAV's reducing the stress of travel and freeing occupants to conduct other activities. Mode choice may be altered by CAV's, likely combined with car-sharing services such as Lyft and Uber, and traffic assignment will be impacted due to anticipated capacity, reaction and potentially speed increases from the CAV's. Furthermore, the land use assumptions driving transportation demand must be revisited with CAV's in mind. All these potential changes can be tested as scenarios within ISMS.

- Trip generation impacts through P_Rates.bin in All_Input/Distribution
- Trip distribution impacts through various tdcoef*.bin files in All_Input/Distribution
- Mode split impacts through All_Input/default_transit.bin
- Reaction time (i.e., less delay as intersections) through turnpen.bin in All_Input/Network
- Capacity and Assignment parameters through assign_parameters.bin in All_Input/AssignmentUtilities
- Land use impacts through parcels.bin in All_Input/TAZ

A similar exercise was previously conducted with the iTRAM model for the I-380 corridor between Iowa City and Cedar Rapids. In that case, iTRAM was used to capture the effects of CAV across the two urbanized areas. Further assessment of impacts within either urbanized area could be accomplished by similarly updating input parameters within ISMS coupled with extracting data from the iTRAM model and updating ISMS external data accordingly.

7: POTENTIAL ISMS UPGRADES

7.1 Intermediate Stops/Work Tour

7.1.1 Overview

Traditional four-step trip-based travel demand models typically contain a non-home based (NHB) trip purpose. As the name implies, these trips have both ends at locations that are not the home of the trip maker, and the actual purpose of the trip is not known. The trip could be the continuation of a work trip that includes stopping at an intermediate point along the route, or dropping a passenger at school. The trip could also be a trip from work for lunch, or to make a second stop as part of a shopping trip. Each of these various reasons for the intermediate stop affects the likely characteristics of the trip, such as number of occupants, average trip length and the most likely intermediate destination for the intermediate stop.

7.1.2 Recommended Architecture

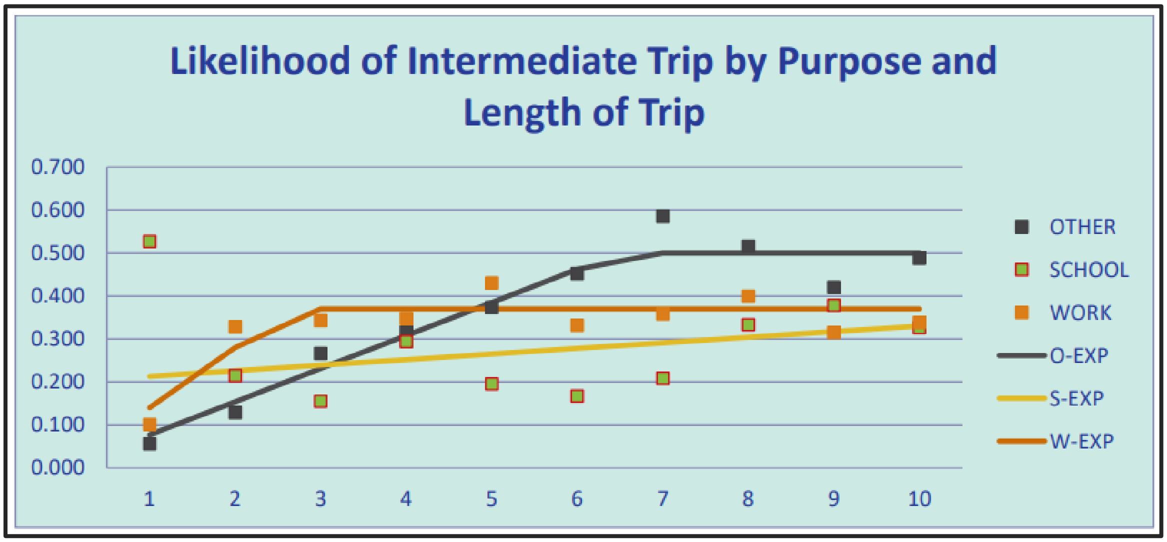
Activity based and tour-based models are more adequately equipped to handle these intermediate stops, as these processes maintain information about the trip's characteristics through the modeling process. While implementation of activity and tour-based models were deemed to be unnecessary for the intended uses of models within Iowa, the ISMS team explored a hybrid approach to handling a unique portion of the non-home-based trips within the ISMS prototype.

Work trips that include an intermediate stop are considered to be one home-based other trip (leg 1) and a non-home-based trip (leg 2). The trip length frequencies and auto-occupancy rates of these two trip rates are typically different than the home-based work (HBW) purpose. Maintaining the unique characteristics of the work trip through the intermediate stop is desirable.

The difference in definition between the home-based work trip and all work trips is often documented when incorporating Census Journey to Work (JTW) data into the model validation process. The JTW includes work trips that connect directly from home to work (the definition of HBW), as well as trips that were for the purpose of getting to work, but included intermediate stops. The proposed hybrid process utilizes the JTW as the universe of work trips (which requires revised trip generation and distribution parameters), then determines the likelihood and location of an intermediate trip while on the work tour. This process also requires non-home-based trip ends be separated into those affiliated with work tours versus those that are not.

The likelihood of making an intermediate stop was estimated using the Des Moines household travel survey. Figure 7- below shows that the likelihood of a work trip having an intermediate stop does increase initially as the length of the original work trip increases, but generally falls between 30 and 40%.

Figure 7-1: Likelihood of Intermediate Trip by Purpose and Length of Trip



The premise for the hybrid NHB approach is to determine the likelihood and intermediate stop location for work tours within the ISMS TransCAD prototype. Two concepts for implementing the process within TransCAD were developed by the ISMS Team. The first process uses multi-dimensional arrays within TransCAD using GISDK coding. The second process uses an activity-based model (ABM) engine under development by Caliper and made available to the ISMS Team as part of TransCAD Version 7.

The use of multi-dimensional arrays allows for storage of various data elements for not only each origin to destination pair, but the various intermediate stops available to each OD pair, forming a 3-dimensional OID (origin-intermediate-destination) array that is not compatible with the 2-dimensional matrix format. The 3-dimensional array requires extensive computer memory, necessitating the aggregation of zones into districts. Due to this limiting constraint, the multi-dimensional array process was abandoned.

The activity-based model engine within TransCAD Version 7 creates an asymmetrical matrix to represent the OID pairs used in the intermediate stop process. Each row represents the respective origin to destination, with each column representing the intermediate stop location. The ABM engine produces the increase in skim utility by connecting between the origin and destination through the intermediate stop location. The OID example in Figure below shows the distance from A directly to C is 5 miles, while the distance from A to C through B to be 6 miles. The ABM engine would return a value of 1 for the cell representing the A-C row in column B. Table below shows results of the simplistic example.

Figure 7-2: OID Example Figure

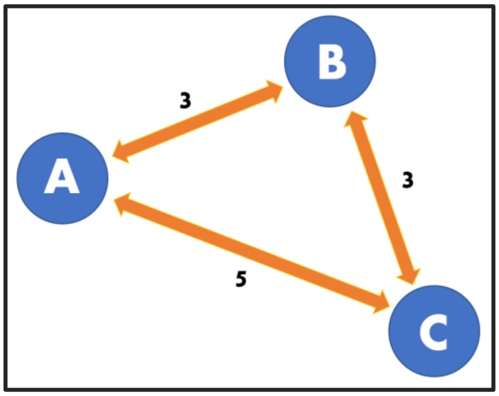


Table 7-1: OID Example Table

DELTA	A	B	C
A-A	0	6	10
A-B	0	0	5
A-C	0	1	0
B-A	0	0	5
B-B	6	0	6
B-C	5	0	0
C-A	0	5	0
C-B	5	0	0
C-C	10	6	0

The sub-model separates the work trip table into three bins based on the number of intermediate stops made during the tour, specifically zero, one or two intermediate stops. Trips that have no intermediate stops are pulled out of the process and set aside for later use. Those trips that will be a tour with one or two intermediate stops are then further processed.

The utility of stopping at any particular intermediate zone while traveling between each OD pair is calculated using equation below.

Equation 7-1: Utility of Stopping Equation

$$\text{Utility} = \text{A's@I} * K * \left(\frac{(OID\ Time)}{(OD\ Time + OID\ Time)}\right)\text{\^{}}B$$

Where:

- A's@I is the number of intermediate trip ends at zone I
- K is the K-factor used to control intrazonal movements

- OD Time is the travel time between the origin and destination
- OID Time is the travel time between the origin and destination via the intermediate stop
- B = 4.5, subject to calibration

The number of intermediate trip ends at each intermediate zone is calculated during trip generation. The skim between the origin and destination is acquired from the highway skimming process.

The utility of going to each intermediate zone for a given OD pair is summarized, and a probability of going to each intermediate zone is then calculated. This probability is applied to the number of trips between the OD pair, resulting in the number of OID tours. A fratar process is used to adjust the OID totals going through each intermediate zone to match the number of trips generated at that zone, adjusting for tours with a second stop. The portion of tours assigned to have only one stop are then reformatted into trip tables, while those trip tours that are to have a second stop are put back into the process for determining the second stop location. The second stop is determined in a similar fashion as the first stop, except the origin point is now assumed to be the first intermediate stop and a new intermediate stop is estimated.

The intermediate stops process is quite computationally extensive, requiring approximately 100 Gigabytes of memory and 10 hours to execute the Des Moines model. These requirements become excessive for some typical demand modeling applications. Therefore, a GISDK script was developed to provide an option to retain from a baseline model set the probabilities of making intermediate stops between given OD pairs by weekday/weekend and time of day. These probabilities are applied at run time for subsequent model runs, thereby maintaining the functionality with a much lower time and resource commitment. Rerunning the intermediate stops process is recommended when major land use or network changes are being tested.

7.1.3 Data Sets

INPUT DATA

Data calculated by previous ISMS steps, including initial home-based work tour, intermediate trip ends and travel time skims.

ESTIMATION DATA

Household travel survey data may be used to estimate parameters and coefficients for the intermediate stops model.

VALIDATION DATA

Traveler surveys may be used to validate parameters and coefficients for the intermediate stops model.

7.1.4 ISMS Application

The intermediate stops process is currently not built into the ISMS prototype, but the scripting is available for testing purposes.

7.2 Integration of TransModeler

7.2.1 Overview

The Iowa DOT is looking into adding the integration of a microsimulation tool, TransModeler, into the plan updates of the Travel Demand Models. A microsimulation model can look at individual intersections and determine how traffic will flow including what potential que times are present, LOS, and other characteristics that would impact the function of the area. Travel Demand Models are macrosimulations where they look at an entire region, and how each intersection actually functions isn't considered, at least not at the same level of detail that a microsimulation model can do. Reference the following link for more details: https://www.caliper.com/transmodeler/default.htm

7.2.2 ISMS Application

This is currently an exploratory effort and details will be made available soon.

7.3 Upgrade to TransCAD 8.0

7.3.1 Overview

To remain current on Travel Demand Modeling technologies and procedures, the Iowa DOT is committed to keeping ISMS up to date on these same items. Work will soon begin on upgrading the ISMS Script from TransCAD 7.0 to 8.0.

7.3.2 ISMS Application

Once complete, the ISMS script will be distributed to all MPOs with a user's guide on the best method to utilize the new script. If any new files are needed, they will also be provided.

Future Upgrades, some of which mentioned in this section, may be included in these updates.

7.4 Merger of Models for Validation/Calibration Purposes

7.4.1 Overview

The Iowa DOT is looking into merging together models for exploratory purposes only, especially for Validation/Calibration. The CMPO (Cedar Rapids) and MPOJC (Iowa City) Travel Demand Models share an external station and further research is wanted to be done to see how ISMS could potentially be used to measure the travel demand between the two cities. I-380 has grown substantially over the last decade and modeling this growth accurately has extreme benefit.