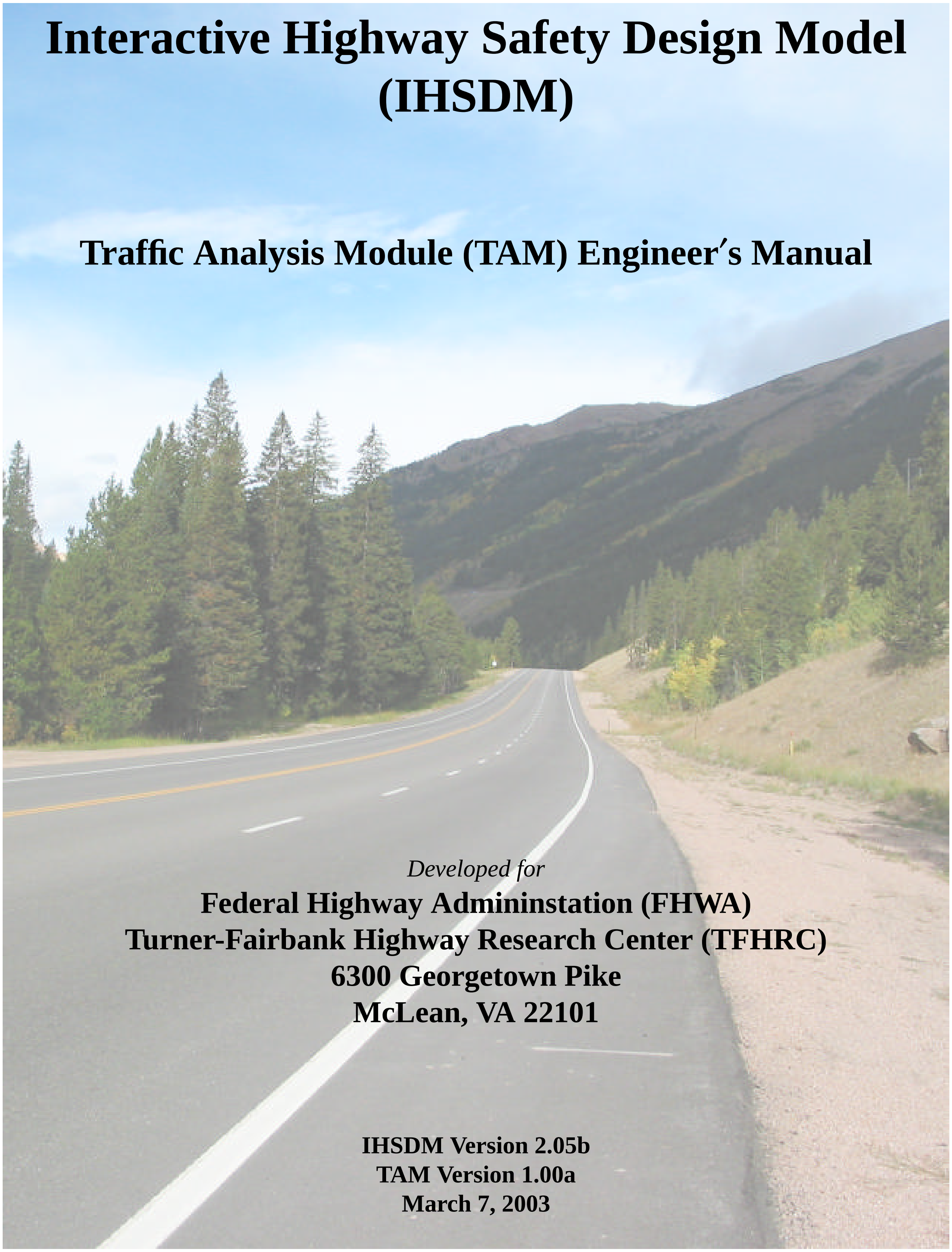
Interactive Highway Safety Design Model (IHSDM)

Traffic Analysis Module (TAM) Engineer′s Manual



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IHSDM Version 2.05b
TAM Version 1.00a
March 7, 2003

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1. Introduction

The Traffic Analysis Module (TAM) Engineer’s Manual is one component of the documentation supporting the Interactive Highway Safety Design Model (IHSDM). This introductory section: (1) provides a brief overview of IHSDM, (2) summarizes the capabilities and intended uses of the Traffic Analysis Module, and (3) states the purpose and outlines the organization of the manual.

1.1 Overview of IHSDM

IHSDM is a suite of software analysis tools for evaluating safety and operational effects of geometric design in the highway project development process. The scope of the current release of IHSDM is two-lane rural highways.

IHSDM is intended as a supplementary tool to augment the design process. This tool is designed and intended to predict the functionality of proposed or existing designs by applying chosen design guidelines and generalized data to predict performance of the design. This tool is NOT a substitute for engineering judgment and does not create a standard, guideline or prescriptive requirement that can be argued to create any standard of care upon a designer, highway agency or other governmental body or employee. The use of this tool for any purpose other than to aid a qualified design engineer in the review of a set of plans is beyond the designed scope of this tool and is not endorsed by the Federal Highway Administration (FHWA).

The suite of IHSDM tools includes the following evaluation modules. Each module of IHSDM evaluates an existing or proposed geometric design from a different perspective and estimates measures describing one aspect of the expected safety and operational performance of the design.

- Policy Review Module (PRM) - The Policy Review Module checks a design relative to the range of values for critical dimensions recommended in AASHTO design policy.
- Crash Prediction Module (CPM) - The Crash Prediction Module provides estimates of expected crash frequency and severity.
- Design Consistency Module (DCM) - The Design Consistency Module estimates expected operating speeds and measures of operating-speed consistency.
- Intersection Review Module (IRM) - The Intersection Review Module leads users through a systematic review of intersection design elements relative to their likely safety and operational performance.
- Traffic Analysis Module (TAM) - The Traffic Analysis Module estimates measures of traffic operations used in highway capacity and quality of service evaluations.

Intended users of IHSDM results are geometric design decision makers in the highway design process, including project managers, planners, designers, and reviewers. The Federal Highway Administration’s Flexibility in Highway Design document (Publication No. FHWA-PD-97-062) explains the context within which these decision makers operate:

> An important concept in highway design is that every project is unique. The setting and character of the area, the values of the community, the needs of the highway users, and the challenges and opportunities are unique factors that designers must consider in each highway project. Whether the design to be developed is for a modest safety improvement or 10 miles of new-location rural freeway, there are no patented solutions. For each potential project, designers are faced with the task of balancing the need for the improvement with the need to safely integrate the design into the surrounding natural and

human environment.

The measures of expected safety and operational performance estimated by IHSDM are intended as inputs to the decision making process. The value added by IHSDM is in providing quantitative estimates of effects that previously could be considered only in more general, qualitative terms. The advantage of these quantitative estimates is that, when used appropriately by knowledgeable decision makers, they permit more informed decision-making.

The following general cautions should be considered in using IHSDM:

- Measures of expected safety and operational performance from IHSDM are only a subset of the large number of inputs that must be considered in making design decisions.
- Estimates from IHSDM are expected values, in the statistical sense, i.e., they represent the estimated average performance over a long time period and among a large number of sites with similar characteristics. Actual performance may vary over time and among sites. The estimates from IHSDM should not substitute for, but rather should supplement and complement local knowledge.
- While derived from the best available data using the best available methods, both the available data and methods have limitations. The engineer's manuals for each module document limitations that should be understood to apply appropriately the resulting estimates.

1.2 Overview of Traffic Analysis Module

The Traffic Analysis Module (TAM) may be used to evaluate the operational effects of existing and projected future traffic on a highway section and the effects of alternative road improvements such as realignment, cross-sectional improvements, and addition of passing lanes or climbing lanes.

The core of the TAM is the TWOPAS rural traffic simulation model. TWOPAS is a microscopic simulation model of traffic on two-lane two way highways that takes realistic account of geometric, traffic control, driver behavior, and vehicle characteristics. Microscopic models can be very accurate and realistic because they trace through time the movements of individual vehicles and the decisions of individual drivers. Providing this realism requires extensive logic and computations. Most aspects of the model have been validated against traffic operational field data. Spot speed and platooning data as well as overall travel time, speed, delays and percent time spent following are accumulated and reported.

TWOPAS was used exclusively to develop the capacity and quality of service procedures for two-lane highways contained in the Transportation Research Board Highway Capacity Manual since 1985. The version of TWOPAS used within the TAM is the same version enhanced and used to develop the 2000 Highway Capacity Manual.[1] Unlike the Highway Capacity Manual procedures, which are based on simulation of a generic road with a sample of traffic conditions, the TWOPAS simulation results from the TAM are for a specific road and specific traffic conditions.

1.3 Purpose of This Manual

The purpose of the Engineer's Manual is to provide sufficient information about the functionality and scope of the Traffic Analysis Module that users can make appropriate judgments about whether and how to use it beneficially at appropriate stages of a design project, and can make appropriate interpretations and applications of Traffic Analysis Module outputs based upon an understanding of the Module. The manual includes useful information about data requirements, TWOPAS simulation model capabilities, and TAM outputs. Sections of this manual draw extensively on the original user's manual[2] and NCHRP task report.[3]

The manual is organized into the following sections: Section 2., *TWOPAS Rural Traffic Simulation Model* provides background information on the underlying TWOPAS model, simulation approach, and features of interest to engineers. Section 3., *TAM Inputs* describes the input data for the Traffic Analysis Module and Section 4., *TAM Outputs* describes the TAM output. Section 5., *TAM Configuration File* provides details on configuration data that may be edited, but normally only by advanced users.

The IHSDM User Documentation Summary lists and briefly describes other useful manuals, including: user's manuals, data import and editing manuals, frequently asked questions, and a trouble-shooting guide. A companion to the Traffic Analysis Module (TAM) Engineer's Manual is the Traffic Analysis Module (TAM) User's Manual. The User's Manual provides details on the mechanics of using the software.

2. TWOPAS Rural Traffic Simulation Model

This section provides background information on TWOPAS, including the history of its development and application and the fundamentals of its simulation approach and features.

2.1 History and Application

The TWOPAS computer program was originally developed by Midwest Research Institute (MRI) between 1971 and 1974 as part of the NCHRP, Project 3-19. The results of this project and model documentation are presented in NCHRP Report 185, "Grade Effects on Traffic Flow Stability and Capacity."[4] The program, then known as TWOWAF, was developed to run on mainframe computers.

The original TWOWAF program was extensively modified and supplemented to include the capability for climbing lanes (one lane added on the right). This work was performed at the Institute of Transportation Studies at the University of California-Berkley, as part of the project, for the California Department of Transportation.[5]

The original TWOWAF program was also modified and applied by MRI in a study of the "Implications of Light-Weight, Low-Powered Future Vehicles in the Traffic Stream."[6] Major additions made to the model at this time included an expansion in the number of individual vehicle types and the number of levels of desired speeds considered by the program. [7] Another major addition made at this time was a capability for output of packed fuel data for post processing in a fuel consumption model program also developed under the contract.[8]

The revised TWOWAF model was employed by Texas Transportation Institute and KLD Associates in NCHRP Project 3-28A, "Two-Lane, Two-Way Rural Highway Capacity".[9] Several major additions were made to the model at this time including an expansion in the number of individual vehicle types and the number of levels of desired speeds considered by the program. However, only limited documentation is available.[10]

The TWOPAS model is an updated version of TWOWAF that incorporates four additions: (a) capability to simulate passing and climbing lane sections; (b) entering traffic streams with user-specifiable percent of traffic platoon; (c) platoon leaders that are rationally selected to reflect the consequences of upstream geometric; and (d) user-specifiable stations and subsections where spot data and overall data are collected. The additions were made by MRI as part of an FHWA project on passing lanes and other low cost improvements to enhance safety and operations on two-lane highways. Both a Users Manual and Programmers manual were prepared as part of the project.[11] The ability of the model to simulate traffic operations in passing lane sections has been validated.[12]

In 1988, FHWA ported TWOPAS from mainframe computers to run on personal computers under DOS. In addition, a separate utility program known as TWOSUM was developed to read the detailed output from TWOPAS and convert it into a summary file that would be of most use to practitioners.

In the mid 1990's, the University of California Berkeley incorporated TWOPAS into a graphical user interface previously develop for the TRARR simulation model. The interface, called UCBRURAL, was developed for the California Department of Transportation and greatly simplified the data input process and reduced the chance for input errors.[13] No changes were made to the TWOPAS simulation program.

As part of an investigation for the Pan American Highway Institute, an extensive sensitivity analysis comprising nearly twenty-three hundred simulation runs was carried out to identify key input parameters and verify the TWOPAS simulation model behaves as intended for a wide range of conditions. In order to identify important embedded parameter values and assumptions, the program logic was examined in detail and the logic of five major subroutines documented.[14]

Most recently, significant enhancements were made to TWOPAS and UCBRURAL interface as part of NCHRP Project 3-55(3), Capacity and Quality of Service on Two-Lane Highways" with financial support from FHWA. The enhanced model, referred to as TWOPAS98, was used to develop the analytical procedures in the two-lane highway chapter of the 2000 Highway Capacity Manual. The major enhancements include: (a) the capability to simulate reduced speed zones due to roadside development or narrow lanes and shoulders, b) automatic calculation of available sight distances and generation of no passing zone based on a few user specified parameters, c) increased array dimensions to permit simulation of highways up to 50 km (30 mi) in length, d) updated vehicle performance characteristics and e) converted embedded data and constants to variables with default values that could be modified by advanced users.[3] The enhancements to the TWOPAS model were preceded by upgrading the program source code to reflect modern programming techniques. Based upon the clarity of existing code and the importance of the subroutine, fifteen of the ninety-nine (99) subroutines in the TWOPAS program were upgraded, tested, and documented.[15]

2.2 Simulation Approach and Features

The TWOPAS model simulates traffic operations on two-lane highways by reviewing the position, speed, and acceleration each individual vehicles along the highway at 1-sec intervals and advancing those vehicles along the highway in a realistic manner. The model takes into to account driver preferences, vehicle size and performance characteristics, and the oncoming and same direction vehicles that are in sight at any given time. The model incorporates realistic passing and pass abort decisions by drivers in two-lane highway passing zones. The model can also simulate traffic operations in passing and climbing lanes added in one or both directions on two-lane highways including the operation of the lane addition and lane drop transition data, space data, vehicle interaction data, and over all travel data area accumulated and processed, and various statistical summaries are printed. The model does not currently simulate traffic turning on or off the highway at intersections and driveways although work is underway to incorporate this capability.

In order to achieve realistic results, the program incorporates the major features:

- Highway Geometry
    - Grades
    - Horizontal curves
    - Lane and shoulder width
    - Passing sight distance
    - Passing and climbing lanes
- Traffic Control
    - Passing and no-passing zones
    - Reduced speed zones
- Vehicle Characteristics
    - Vehicle acceleration and speed capabilities
    - Vehicle lengths
- Driver Characteristics and Preferences
    - Desired speeds
    - Preferred acceleration levels
    - Limitations on sustained use of maximum power
    - Passing and pass-abort decisions
    - Realistic behavior in passing and climbing lanes
- Entering Traffic
    - Flow rates
    - Vehicle mix
    - Platooning
    - Immediate upstream alignment

The characterization and application of the major geometric, traffic, driver and vehicle features incorporated into the simulation model is described in Table 1., *Major Geometric Features of the TWOPAS Simulation Model* , Table 2., *Major Traffic Control Features of the TWOPAS Simulation Model* , Table 3., *Major Vehicle Characteristics Features of the TWOPAS Simulation Model* , Table 4., *Major Driver Characteristics and Preferences Features of the TWOPAS Simulation Model* , and Table 5., *Major Entering Traffic Features of the TWOPAS Simulation Model* . Further details about employing these features are given in the remainder of this manual.

Table 1. Major Geometric Features of the TWOPAS Simulation Model

Features	Characterization in Simulation	Application in Model
Grades	Linear functions of position on user-specified sections.	***Directly*** affect the maximum acceleration and speed maintenance capabilities of cars, RVs and trucks.
		Indirectly (through other user input) Provide crawl speeds for trucks on steep sustained downgrades.
		Indirectly (through other user input) influence the passing sight distances.
Horizontal curves	Radius, superelevation and degrees of alignment change; spirals treated as part of tangent.	***Directly*** - may reduce speeds desired by vehicles in curve and its approach if radius and superelevation are sufficiently small
		Directly - will reduce passing opportunity acceptances in approach to curvature to the right.
		Indirectly - may reduce passing sight distance (through other user input)
Lane width and shoulder width	Indirectly through user-specified distribution of desired speeds	***Directly*** - vehicles will attempt to travel at their desired speeds and, when free in most alignments, will exhibit the distribution associated with free speeds.
Passing sight distance	Separately in each direction as linear functions of position in user-specified sections.	***Directly*** - oncoming vehicles are **seen** and affect the passing and pass abort decisions only if within the locally defined passing sight distance.
		Directly - the downstream end of a passing zone is **seen** and affects pass/abort decisions only if it is within sight.
Passing and climbing lanes	Specific locations of lane addition and lane drop. Specified geometrics of lane addition and lane drop	***Directly*** - initial lane choice of each entering vehicle category, state (free vehicle, platoon leader, platoon member), performance capability, desired speed, and effect of lane favored by local geometric and markings. Subsequent lane choices described below under Driver Characteristics and Preferences.
Driveways and roadside development	Specific locations of reduced speeds due to roadside development	***Indirectly*** - user may specify zones with reduced desired speeds

Table 2. Major Traffic Control Features of the TWOPAS Simulation Model

Features	Characterization in Simulation	Application in Model
Passing & no-passing zones on a conventional two-lane highway	Specific locations of zones by direction of travel.	***Directly*** - drivers do not start passes in no-passing zones. They attempt to avoid initiating a pass that will extend into the no-passing zone if that boundary is in sight.
		Directly -when he driver is not committed to complete a pass, the pass will be aborted if the projected pass indicates that the end of the zone will be overrun. When driver is committed to complete a pass, the driver will attempt to avoid or minimize overrunning the end of the passing zone.
		Directly - impeded vehicles are motivated to examine pass opportunities when passing zone is first entered.
Passing and no-passing zones in the opposing directing to a passing or climbing lane	Specified by location and direction	***Directly*** - drivers observe the same constraints as above. They see opposing vehicles in either oncoming lane as potential conflicts.
Reduced speed zones	Specified by location and applied in both directions	***Directly*** - drivers will reduce desired speed based on user-specified distribution of speeds

Table 3. Major Vehicle Characteristics Features of the TWOPAS Simulation Model

Features	Characterization in Simulation	Application in Model
Acceleration and speed capabilities	Individual capabilities assignable to 13 vehicle types (four trucks, four RVs, and five cars/light trucks).	***Directly*** - maximum acceleration and speed capability depends on vehicle type and local grade.
		Directly -maximum acceleration and speed capability is always a potentially limiting constraint.
		Directly -driver has an approximate concept of vehicle capability and uses it as part of the projection of passing maneuvers and their outcomes.
		Directly -lack of a threshold acceleration or speed capability eliminates interest in passing.
Lengths	Assignable for each of 13 vehicle types.	***Directly*** - vehicles **follow** the rear of an impeder.

Features	Characterization in Simulation	Application in Model
		Directly -in passing an impeder, the passing vehicle must **clear**, taking its own length into account.

Table 4. Major Driver Characteristics and Preferences Features of the TWOPAS Simulation Model

Features	Characterization in Simulation	Application in Model
Desired speeds	Assigned stochastically from a truncated normal distribution with user-specified mean and standard deviation.	***Directly*** -each vehicle attempts to travel at its desired speed. It is also the basis for determining reduced speeds that may be preferred in horizontal curves and (for trucks) on downgrades.
		Directly -the desired speed is increased for vehicles during passing maneuvers.
		Directly -the difference between desired speed and impeder speed is one factor that helps determine how an impeded vehicle will **follow** and consider whether to pass.
Preferred acceleration on levels	Incorporated in program logic	***Directly*** - unless otherwise restrained, vehicles use accelerations that are partly dependent on the difference between their current and desired speeds.
		Directly - if currently speed exceeds desired speed, the deceleration used is dependent on the traffic situation.
Sustained use of maximum power performance	Behavior of cars and RVs is controlled by input and program logic.	***Directly*** - vehicles will use maximum power performance if required in a pass or for acceleration toward a desired speed. However, for sustained periods, cars and RVs will use only a fraction (usually 70%) of maximum power, if user so designates.
Examination of passing possibilities (vehicle in direction of travel with only one lane)	Program logic plus user-specified probability.	***Directly*** - impeded vehicles examine passing possibilities and become motivate to pass only when they have first overtaken an impeder, entered a passing zone, cleared oncoming vehicles, and possess adequate vehicle performance capability to pass.

Features	Characterization in Simulation	Application in Model
Acceptance/rejection of passing opportunities (vehicle in direction of travel with only one lane)	Built-in tables of acceptance probabilities are dependent on leader speed, type, and measure of constraint (i.e., sight distance or oncoming vehicles in sight), position in platoon, horizontal curvature, and location within, passing zone.	***Directly*** - passing opportunities are rejected if: projected time safety margin too small, truck already passing impeder, two other leaders already passing impeder, leader aborting pass of same impeder, follower (s) in pass (es) that may produce conflict, pass maneuver time projected to be too long, or insufficient gap in front of impeder. Otherwise, acceptance based on stochastic decision and probability tables.
Extend pass in progress to additional impeder (vehicle in direction of travel with only one lane)	Incorporated in program logic.	***Directly*** - dependent on distance to next impeder, projected time to complete extended pas, gap in front of next impeder, and stochastic decision based on projected time safety margin.
Behavior while being passed (vehicle in directions of travel with only one lane)	Incorporated in program logic.	Unless otherwise more constrained, a vehicle being passed will use only limited acceleration.
Behavior in passing and climbing lane sections	Incorporated in program logic.	There are no arbitrary assignments of preferred lanes. Drivers use foresight and attempt to avoid being trapped behind an impeding vehicle in the right lane or being trapped in the closed lane at a lane drop. Drivers are increasingly motivated to move to the right lane of two unidirectional lanes when they will not be delayed in the near term by right lane vehicles, when their acceleration capability is small or negative and their speed is slow, and when they are impeding other vehicles. Trucks are slightly biased to move to the right lane. RVs have a lesser bias and cars have none.

Table 5. Major Entering Traffic Features of the TWOPAS Simulation Model

Features	Characterization in Simulation	Application in Model
Flow rates	Program logic creates entering traffic stream in response to user-specified proportion of individual vehicle types by direction.	Flow rate in entering traffic stream is near user-specified value.
Vehicle mix	Program logic responds to user-specified proportion of individual vehicle types by direction.	Vehicle mix in entering traffic stream is near user-specified value.
Platooning in entering traffic stream	Program logic responds to user-specified percentage of traffic platoon by direction, and the upstream alignment in which platoons formed.	Percentage of traffic platoon in entering traffic stream is near user-specified value, with platoon leaders chosen logically on the basis of vehicle performance, driver desired speed, and user-specified upstream alignment.
Immediate up-stream alignment	User-specified maximum entrance speeds by direction for each vehicle type.	User-specified maximums are imposed at entrances when they are a limiting constraint.

3. TAM Inputs

This section describes the input data needed to perform a traffic analysis. The input data items are identified and briefly discussed. A sample input data set is presented with the test case presented in Section 4., *TAM Outputs* of this manual.

Input data are saved in a TWOPAS input file in the IHSDM project directory. The naming convention for this file is analysis.AnalysisName.TAM.INP, where AnalysisName is the name of the IHSDM analysis that is being run.

3.1 Position Coordinate System

The TWOPAS model simulates traffic in both directions of travel on a two-lane highway. The direction of increasing stations in the TAM is sometimes referred to as the No. 1 direction and decreasing stations as the No. 2 direction in the program documentation. All input data use the direction of increasing stations to define positions.

The input data are entered into TAM in the form that traffic engineers using the model are most likely to have available. In particular, it is anticipated that the program user will have a unidirectional coordinate system in mileposts or stations from highway plans or from a highway inventory for the highway section to be simulated.

3.2 Input Data Requirements

The following types are data are needed to perform a traffic analysis:

- Road attributes such as grades, curves, passing sight distance, no passing zones,
- Traffic attributes such as flow rates, composition, directional split, desired speeds, and vehicle performance characteristics
- Simulation controls such as duration of traffic simulation, warm-up time, and random number seeds

- Evaluation data that defines the locations where simulated traffic data will be collected and defines the sections and subsections over which this information will be aggregated and reported.

All of the required and optional inputs for the TWOPAS model are available from within IHSDM. The inputs most likely to be changed by the user are available from within the Traffic Analysis Module. The inputs less likely to be needed by the user have been set to reasonable defaults and may be modified by editing the TAM configuration data using the Administration Tool discussed in Section 3.7, *TAM Configuration Data* . These defaults are then written out to the standard input file for the TWOPAS simulation along with the input data that has been entered by the user. There are also variables imbedded in the TWOPAS code which have been assigned values by the developers of the TWOPAS model and which are used during a simulation run. These imbedded variables may be modified outside of the IHSDM interface by editing the TWPSUSER.TDF file described in Section 3.5.4, *TWOPAS Defaults* and should only be changed by experienced TWOPAS users.

3.3 Road Data

The road data needed to run the Traffic Analysis Module are:

- Horizontal Curves (Note: spiral transitions are treated as part of the tangent)
  - Start Station
  - End Station
  - Curve Radius
  - Direction of Curve
  - Superelevation (extracted from the Cross Section/Cross Slope data element)
- Vertical Curves
  - VPI Station
  - Back Grade
  - Back Length
  - Forward Grade
  - Front Length
  - Elevation
- Passing lanes
  - Start Station
  - End Station
  - Side of Road
  - Lane Width
  - Begin Full Width
  - End Full Width
  - Passing prohibited/not prohibited in opposing lane
- Passing sight distance regions (automatically calculated from the results of the available passing sight distance computed by TAM)

- No-passing zones (automatically generated by TAM, editable by the user)
  - Start Station
  - End Station
  - Side of Road
- Reduced Speed Zones
  - Start Station
  - End Station
  - Reduced Mean Speed (may be automatically estimated by TAM and edited by user)
  - Standard Deviation of Reduced Speed (may be automatically estimated by TAM and edited by user)
- Downgrade crawl regions
  - Start Station
  - End Station
  - Side of Road
  - Mean Crawl Speed
  - Standard Deviation of Crawl Speeds
- Upstream Alignment (explains the upstream alignment beyond the highway limits)

Most of the highway data is input through the edit/view master highway elements button on the main IHSDM interface screen. Exceptions are sight distance regions, which are calculated automatically from the highway geometry, and no-passing zones, which are accessed from the TAM attributes screen.

3.3.1 Shoulder and Lane Width

Recent research suggests that narrow lanes and shoulders can reduce the mean speed of vehicles on two-lane rural highways.[16] However speed reductions due to narrow lanes and shoulder are not implemented in this version of the TAM. Thus, user input of lane width and shoulder width at this time will have no effect on the TWOPAS simulation. If lane and shoulder widths remain fairly constant throughout the length of the road, the effects of narrow lane and shoulder can be handled indirectly by reducing the mean desired speeds input on the TAM attribute screen (see Section 3.4.2, *Desired Speed*). If only certain sections have narrow lanes and shoulder, their effects can be treated indirectly by using the reduced speed zone feature described in Section 3.3.4, *Reduce Speed Zones* . Suggested reductions in the desired speed due to narrow lanes and shoulders, based on recent research, are given in Table 6., *Estimated Reduction in Desired Speed due to Narrow Lanes* and Table 7., *Estimated Reduction in Desired Speed due to Narrow Lanes* .

Table 6. Estimated Reduction in Desired Speed due to Narrow Lanes

Lane Width	Lane Width	Reduction in Desired Speed	Reduction in Desired Speed
(ft)	(m)	(mi/h)	(km/h)
9	2.7	2.2	3.5
10	3.0	1.1	1.7
11	3.3	0.4	0.7
12	3.6	0	0

Table 7. Estimated Reduction in Desired Speed due to Narrow Lanes

Shoulder Width	Shoulder Width	Reduction in Desired Speed	Reduction in Desired Speed
(ft)	(m)	(mi/h)	(km/h)
0	0	4.2	6.8
2	0.6	2.6	4.2
4	1.2	1.3	2.1
6+	1.8	0	0

The standard deviation of speeds for a narrow road section should be computed by multiplying the reduced desired speed in the narrow road section by the ratio of the standard deviation of desired speed to mean desired speed specified in the traffic attribute screen for the overall road.

3.3.2 Sight Distance Regions

Passing sight distance regions are generated automatically in IHSDM by calculating the available passing sight distance every 2 m in each direction based on road geometry and obstruction offset specified by the user on the "Roadside" data page accessed through the "Edit View Highway Element" interface. Once the calculated sight distance reaches the nominal sight distance specified in the TAM configuration file, the algorithm stops looking further at that point and jumps to the next point to calculate available passing sight distance. The rate of change in sight distance from each 2-m segment to the next is determined and the number of sight distance regions is reduced by merging contiguous segments within a given tolerance for the rate of change. The merge starts with a tolerance of zero difference in the rate of change and increases the difference until the number of sight distance regions in each direction is less than the maximum of 600 that TWOPAS can handle.

3.3.3 No Passing Zones

No passing zones can be established automatically on sections with inadequate sight distance or specified manually by clicking on the No Passing Zone button on the TAM attribute screen. In order to obtain passing/no passing zones automatically, the sight distance along the road is needed. This information either has to be entered by the user or calculated automatically as explained in the previous section.

To generate passing zones automatically, the TAM interface requests the user to input: (1) the minimum sight distance required for safe passing, and (2) minimum length of a passing zone. When the Automatic Calculation button is pressed, the TAM will establish no passing zones where the passing sight distance available is less than the minimum specified by the user. The minimum sight distance for safe passing recommended by the MUTCD for various operating speeds is shown in Table 8., *Recommended Minimum Passing Sight Distance in the MUTCD, Millennium Edition* .

Table 8. Recommended Minimum Passing Sight Distance in the MUTCD, Millennium Edition

85th-Percentile Speed	Minimum Passing Sight Distance	85th-Percentile Speed	Minimum Passing Sight Distance
(km/h)	(m)	(mi/h)	(ft)
40	140	25	450
50	160	30	500
60	180	35	550
70	210	40	600
80	245	45	700
90	280	50	800
100	320	55	900
110	355	60	1,000
120	395	65	1,100
		70	1,200

In addition no passing zones are established in sections with adequate sight distance for passing but located between no passing sections separated by a small distance specified by the user. This in effect limits the minimum length of a passing zone. MUTCD recommends a minimum distance between consecutive no passing zones of 120 m [400 ft], which is the default value used in the TAM. This minimum distance may be changed by the user.

By creating the passing/no passing zones automatically, the user needs to manually change the no passing zones only for the sections in which the computed no passing zones disagree with the field markings. These changes are made through the User Entry button on the TAM No Passing Zones Edit screen. Even though the purpose of the automatic calculation is to make user input easier, it might also be used to verify field markings against calculated available passing sight distances.

In summary, two conditions must be met to create a passing zone. First, the sight distance on the zone must be adequate for passing (user specified); and second, the length of the zone must be at least 120 m [400 ft] (or any other value specified by the user.)

In passing and climbing lane sections, no passing zone markings are applied to the full length of auxiliary lanes in the direction that has the auxiliary lane. In the opposite direction however, marking decisions are sometimes based on traffic volumes or other agencies' policies (and of course on sight distance availability). The TAM interface allows the user to control the treatment of the barrier line in the opposite direction to a passing lane during the automatic calculation of passing zones. If the value of the passing lane attribute "Passing Prohibited on Opposing Lane(s)" is "true", then during the automatic calculation of passing zones a barrier line will be added to the opposing lane for the entire length of the passing lane, including a taper in and a taper out of the passing lane. Otherwise, during the automatic calculation of passing zones the barrier line in the opposite direction to a passing lane will be determined only by the sight distance and the user supplied minimum sight distance required for passing and minimum length of a passing zone.

Passing is also restricted in both directions along the diverge taper at the beginning of each auxiliary lane and along the merge taper at the end of each auxiliary lane. If users consider using double barrier lines on both types of taper, the users can edit the no passing zone elements and delete these zones manually (the number of tapers will be small in most applications so this should not be a major problem.)

The user may manually edit/add no passing zones by selecting the User Entry button. It should be noted that all such settings will be lost if the user asks for the TAM interface to recalculate the no passing zones.

The following steps summarize the procedure by which the "No Passing Zones" are calculated:

1. Use the PRM routine for calculating the available PSD. Create "No Passing Zones" for sections of the highway where the available PSD is less than the required SD chosen by the user in the "Minimum Sight Distance" field in the "Add/Edit No Passing Zone Elements for the Traffic Analysis Module" interface.
2. If the user has chosen to prohibit passing in "Reduced Speed Zones", expand the "No Passing Zones" for these zones for both directions. ("Reduced Speed Zones" are discussed in Section 3.3.4, *Reduce Speed Zones* .)
3. For both passing and climbing lanes, expand the "No Passing Zones" for the direction in which these auxiliary lanes appear.
4. For passing lanes, if passing is prohibited on the opposite direction expand the "No Passing Zones" accordingly.
5. For both passing and climbing lane tapers, expand the "No Passing Zones" for both directions.
6. Make all short segments of "Passing Zones" (less than the "Min. Length for Passing Zones") "No Passing Zone."

3.3.4 Reduce Speed Zones

Speed reductions due to grades, horizontal curves, and crawl regions each require their own user input and are modeled separately in TWOPAS. The reduced speed zone feature allows the user of TWOPAS to specify zones where the speed of vehicles is reduced for some other reason such as roadside development or narrow lanes and shoulders. The input for reduced speed due to narrow lanes and shoulders can also be handled in the interface by reducing the desired speeds on the TAM attributes screen.

The approach used to model reduced speed zones is similar to the speed reductions due to curve/crawl effects so that the handling of reduced speeds are consistent throughout the program. In this approach the speeds on the reduced speed zone are considered to have a normal distribution whose mean and standard deviation have to be specified as input to TWOPAS.

The user defines the reduced speed zones by entering the start and end points and the mean speed and standard deviation of speeds within each zone. If the speeds are not known, the user can have the interface estimate them by pressing the "Estimate from posted speed" button and entering the speed limit in the zone. The speed data generated using this option is based on the following equations derived from field data collected by Harkey, et al.:

$V_{ave} = 0.79*LIMIT + 12$

$SD = 0.15*V_{ave}$

Where,

V_{ave} = average speed in mi/h
LIMIT = posted speed limit in mi/h
SD = standard deviation of speeds in mi/h

The reduced speed zones are applied in both directions of travel. In any zone, if there is a reduced speed due to narrow lanes and/or shoulders and a reduced speed due to a reduced speed zone, the user should input the slower of the two reduced speeds. The selected mean speed on the zone and standard deviation of speeds are then written to the TWOPAS input file. These reduced speed zones are the same for both directions in the input file, but are modeled in TWOPAS with approach zones at the beginning of each reduced speed zone in the direction of travel. A maximum of 100 reduced speed zones may be specified.

3.3.5 Downgrade Crawl Regions

Crawl regions are sections of the simulated highway where trucks use crawl speeds on steep downgrades. Crawl regions are added by clicking on the crawl region button on the main TAM attribute screen. The input data supplied by the user specifies only the regions in which steady crawl speeds are used by trucks (and recreational vehicles if specified elsewhere), direction of travel and the mean crawl speed and standard deviation. If not known, the following equation can be used to estimate the mean crawl speed on downgrades:[4]

$V_{crawl} = 200/(g)$, for $g > 4$

Where,

V_{crawl} = mean crawl speed in mi/h

g = absolute value of downgrade in percent

The standard deviations of crawl speeds vary widely; however, 6.8 mi/h was the average of the standard deviations observed in one study.[4]

The program logic adds approach regions and uninfluenced regions, as required, and permits crawl speeds to increase when trucks get to within 600-900 m (2000-3000 ft) from the foot of the downgrade. A maximum of 12 crawl regions may be specified. If no data are entered, the highway contains no crawl regions.

3.4 Traffic Data

The traffic data needed to run the Traffic Analysis Module are:

- Flow rate, vehicles per hr
- Entering percent platooned
- Percentage of recreation vehicles in traffic stream
- Percentage of trucks in traffic stream
- Desired speed and standard deviation by vehicle type:
  - Cars
  - Trucks
  - Recreational vehicles

3.4.1 Entering Perent Platooned

This input variable is the percent of the total vehicles in the direction of travel that are following in platoons as they enter the road being analyzed. This value normally should be greater than zero and less than or equal to 100. If no field data is available for this variable, clicking the auto generate button will estimate and display the percent platooned based on the flow according to the following equation from the 2000 Highway Capacity Manual:[1]

PPL = 100*(1-e$^{(-.00176*Flow)}$)
Where,

PPL = percent following in platoons
Flow = vehicles per hour in one direction of travel

3.4.2 Desired Speed

Desired speed is defined as the unimpeded speed on a level straight alignment. It is the speed at which drivers would choose to travel if unimpeded by other vehicles or alignment, grade and cross-section constraints. This should not be confused with the unimpeded speed, which is the speed that vehicles would traverse a particular road feature if unimpeded by other traffic. It is impossible to measure the desired speed distribution in the field, but it can be estimated by measuring the unimpeded or free-speed distribution on a level, straight alignment.

An analysis of the field data and simulated results suggest that the mean desired speed of the overall traffic stream should have a value between 58.5 and 61 mi/h and that the standard deviation of speeds observed in the field overestimates the variation of desired speed.[14] Thus, the standard deviations of desired speed input into the model should be less than the standard deviations observed in the field. For example, entering a standard deviation of desired speed that is 8 percent of the mean will produce standard deviations in the simulated output that are 9 percent of the mean or higher and more closely match field data. Table 9., *Recommended Default Values for Desired Speed by Vehicle Type* summarizes recommended default values for mean and standard deviation for desired speed by vehicle type for both directions.

Table 9. Recommended Default Values for Desired Speed by Vehicle Type

	Passenger cars	Recreational Vehicles	Trucks
Mean desired speed (mi/h)	61.5	59.5	59.5
Standard deviation (mi/h)	5.0	4.0	3.5

For most situations the desired speed distribution for a given vehicle type should be the same in both directions. One notable exception would be when trucks travel heavily loaded in one direction and empty in the other.

3.5 Simulation Control Data

The data needed to control the simulation are accessed by clicking on the simulation control button on the main TAM attributes page and described below. Figure 1, *TAM Simulation Control Window* illustrates the simulation control window.

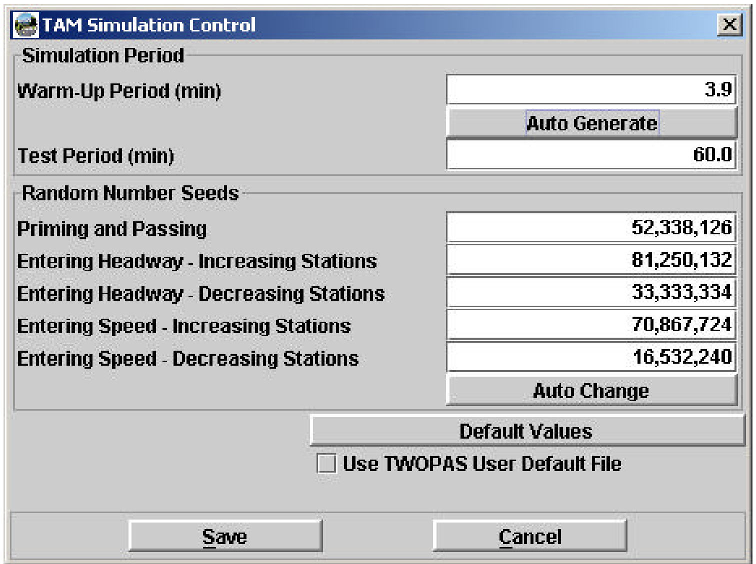

Figure 1 TAM Simulation Control Window

3.5.1 Simulation Period

The warm-up period is number of minutes of simulation before traffic data is collected. It allows time for the model to realistically populate the road with traffic and for traffic to settle down and reach equilibrium. The warm-up period should be long enough for the slowest vehicle to travel the road length. The auto generate button will calculate a warm-up time that equals the time it would take a vehicle traveling three standard deviations below the lowest desired speed specified on the traffic attributes screen to traverse the full length of the road.

The test period is the length of time in minutes that traffic is simulated and data collected once the warm-up period has elapsed.

3.5.2 Random Number Seed

TWOPAS uses five 8-digit random number seeds for generating the traffic streams and other randomly occurring events. Clicking on the Auto Change button will generate and display five new random number seeds. Clicking the Default values button will restore the random number seeds to the original defaults.

The first seed in the list is used during priming to select desired speeds of vehicles being placed on the road, and then used subsequently to make stochastic decisions on pass initiation and pass extension during simulation. It corresponds to seed 4 in the TWOPAS input file (*.INP).

The second seed is used to select entering headways and vehicle types in direction of increasing stations. It corresponds to seed 1 in the TWOPAS input file (*.INP).

The third seed in the list is used to select entering headways and vehicle types in direction of decreasing stations. It corresponds to seed 2 in the TWOPAS input file (*.INP).

The fourth seed is used to select desired speeds for entering vehicles in direction 1. It corresponds to seed 3 in the TWOPAS input file (*.INP).

The last seed in the list is used to select desired speeds for entering vehicles in direction 2. It corresponds to seed 5 in the TWOPAS input file (*.INP).

If the same random number seeds are used in two runs with the same traffic inputs but different highway geometry, then *identical* traffic streams will be simulated for each geometric condition.

On the other hand, if the random number seed is varied without changing the geometric or traffic inputs, then replicate runs can be made with random variations in traffic stream composition while maintaining approximately the same flow rate and vehicle mix.

3.5.3 Time Step

The basic time step for all simulations in this version of the TAM is fixed at 1 second. This is the length of time between reviews and updates of the vehicle positions and states. Although the time step is fixed in the current version, future versions may allow the time step to be changed through the IHSDM Administration Tool.

3.5.4 TWOPAS Defaults

If the box is checked next to TWOPAS user-supplied default file, default values are read from an external TWPSUSER.TDF file in addition to those being transferred from the TAM interface. This feature should be used only by advance users. If the box is not selected, defaults imbedded within the TWOPAS model are used in addition to those being transferred from the TAM interface.

Defaults for the TWOPAS program are divided into two categories: (1) required and optional input to TWOPAS model, and (2) data imbedded in the TWOPAS code. This option allows the user to change many of TWOPAS imbedded defaults by changing values in an external user-supplied file called TWPSUSER.TDF. The user-supplied file TWPAUSER.TDF can be edited only OUTSIDE of the IHSDM. The user may change the defaults values in columns 19-26; no other values should be changed. A text editor such as Notepad that does not reformat the file should be used. THE FORMAT OF THIS FILE MUST BE MAINTAINED. This means that the position of each number and character in the file must be maintained and no extraneous characters added. If errors are made in this input file, the simulation may abort or "hang" with no useful error messages. There is a backup copy of this file called TWPSUSER.BAK in case the TDF file gets corrupted. Future versions of the TAM may make all the imbedded default values accessible to advance users for viewing and editing through the IHSDM Administration Tool.

3.6 Evaluation Data

The TAM collects and reports two type of operational data:

- Section data accumulated over user specified sections:
    - Average travel time
    - Average speed
    - Percent time spent following
    - Number of passes
    - Traffic delay, geometric delay and total delay
    - Vehicle miles of travel
    - Vehicle hours of travel
- Spot data collected at user specified stations along the road:
    - Flow rate
    - Mean operating speed for cars, trucks, rv and all vehicles
    - Percent following

- Average platoon size

The spot data are collected and reported separately for each direction of travel. The section data are collected and reported for each direction of travel and both directions combined. The output data elements are explained in more detail in Section 4., *TAM Outputs* .

The TAM evaluation screen allows users to specify where the traffic operational data is collected and reported. The user must specify the locations of the first and last data collection stations and the spacing or interval between intermediate data collection stations through the Traffic Analysis/Evaluation/Report Options Tab. Clicking the Generate button will automatically determine the location of the stations. Data is collected in each direction at every station. TAM allows up to a maximum of 300 data collection stations. If the user-specified interval results in more than 300 stations, the TAM notifies the user and suggests the closest interval to the user-specified interval that results in less than 300 stations.

Data collection stations placed at the very beginning and ends of the roads sometime result in the output of unrealistically low values at the end points for some traffic measures such as percent following. To avoid this problem, the TAM interface automatically places the first data collection station 1 m [3.28 ft] from the start of the road to provide a small buffer for vehicles entering in the direction of increasing stations. Similarly the last data collection station is placed 1 m [3.28 ft] before the end of the road to provide a buffer for vehicles entering in the direction of decreasing stations. Based on limited testing the 1 m buffer seems to produce reasonable results. More tests on different highways are needed to provide guidance on the minimum buffer distance.

3.7 TAM Configuration Data

The configuration box on the main TAM attribute page shows the name of the TAM configuration file containing vehicle and driver characteristics not normally changed by the user. In fact, only advanced users of TWOPAS should consider modifying these simulation parameters.

These characteristics can be changed only within the IHSDM System Administration Tool, by clicking on the TAM Tab. Section 5., *TAM Configuration File* provides additional details on the characteristics that can be changed.

4. TAM Outputs

The output of the TAM consists of four main tables and two graphs:

- Simulation data
- Traffic input data
- Section summary data of operational effects
- Station summary data of operational effects
- Plot of percent following
- Plot of speed by vehicle

This remainder section of the manual describes the output in more detail and the interpretation of the traffic operational data.

4.1 Simulation Data

Figure 2, *TAM Simulation Data Output Table* illustrates the simulation data output table. This table includes the specifications for the run, including the simulation time, warm-up time, and the total length of road simulated. Figure 3, *Random Number Seeds Output Table* illustrates the table that summarizes the random number seeds used in the simulation run.

Random Number Seeds

Entering Traffic in Platoons / Direction of Increasing Stations	81,250,132		Desired Speed / Direction of Increasing Stations	70,867,724
Entering Traffic in Platoons / Direction of Decreasing Stations	33,333,334		Desired Speed / Direction of Decreasing Stations	16,532,240
Passing Decisions	52,338,126			

Figure 2 TAM Simulation Data Output Table

Random Number Seeds

Entering Traffic in Platoons / Direction of Increasing Stations	81,250,132		Desired Speed / Direction of Increasing Stations	70,867,724
Entering Traffic in Platoons / Direction of Decreasing Stations	33,333,334		Desired Speed / Direction of Decreasing Stations	16,532,240
Passing Decisions	52,338,126			

Figure 3 Random Number Seeds Output Table

4.2 Traffic Input Data

Figure 4, *Traffic Input Data Output Table* illustrates the traffic input data used in the simulation run, including flow rate, distribution of traffic, desired speed, standard deviation of speed, and percent entering traffic following in platoons and percent no passing zones. Percent no passing zones is calculated by summing up the length of no passing zones, dividing by the total road length, and multiplying by 100.

Traffic Input Data

Traffic Input Data	Direction of Travel	
	Increasing Station	Decreasing Station
Flow Rate (v/hr)	300	300
Distribution (%) CARS	100.0	100.0
Distribution (%) TRUCKS	0.00	0.00
Distribution (%) RVs	0.00	0.00
Mean Desired Speed (km/h) CARS	100	100
Mean Desired Speed (km/h) TRUCKS	95	95
Mean Desired Speed (km/h) RVs	95	95
Desired Speed Standard Speed Deviation (km/h) CARS	5	5
Desired Speed Standard Speed Deviation (km/h) TRUCKS	5	5
Desired Speed Standard Speed Deviation (km/h) RVs	5	5
Entering Traffic in Platoons (%)	41.00	41.00
No Passing Zone (%)	0.00	0.00

Figure 4 Traffic Input Data Output Table

4.3 Section Summary Data

Figure 5, *TAM Traffic Output Data Table* illustrates the traffic output data table for the main road section and any user specified subsections. This table reports the actual simulated flow rate, percent time spent following, average speed, trip time, traffic delay, geometric delay, total delay, number of passes, vehicle-distance traveled, and vehicle-hours of travel. These simulation outputs are reported for each direction and both directions combined.

Traffic Output Data / Main Section (from 100.000 to 4+200.000)

Traffic Output Data	Direction of Travel		
	Increasing Station	Decreasing Station	Combined
Flow Rate from Simulation (v/hr)	306	303	609
Percent Time Spent Following (%)	43.5	47.4	45.4
Average Travel Speed (km/h)	83.7	82.1	82.9
Trip Time (min/veh)	3.0	3.0	3.0
Traffic Delay (min/veh)	0.18	0.21	0.20
Geometric Delay (min/veh)	0.31	0.31	0.31
Total Delay (minutes/vehicle)	0.50	0.53	0.51
Number of Passes	0	0	0
Vehicle km Traveled	1251	1242	2493
Total Travel Time (veh-hrs)	15.1	15.1	30.2

Figure 5 TAM Traffic Output Data Table

4.3.1 Flow Rate from Simulation

Flow rate from simulation is the actual number of vehicles per hour of simulation that travel the road section. It is computed from the total distance traveled by all vehicles during each review period during the simulation as follows:

$$FlowRate = \frac{\text{Vehicle km (or mi) Traveled}}{\text{RoadLength}} \; x \; \frac{60}{\text{Simulated Time (min)}}$$

Figure 6 Flow Rate Equation

Because of the stochastic nature of the model, the simulated flow rate will be close but not necessarily equal to the flow rate specified by the user.

4.3.2 Percent Time Spent Following

Percent time spent following is the percent of travel time that vehicles were impeded by other vehicles and not traveling freely according to the TWOPAS logic. This output measure is the quality of traffic service measure used in the 2000 Highway Capacity Manual. This measure is different than the percent time following based on a headway criterion. However, the percent time following at less than a 3 second headway closely matches percent time spent following based on TWOPAS logic.

4.3.3 Average Travel Speed

Average travel speed is the space mean speed of the vehicles in the section for entire simulation. It is the total travel time for all vehicles based on the number of vehicles in each 1-second review interval divided by the total distance traveled.

4.3.4 Trip Time

Trip time is the average travel time in minutes for vehicles to travel the entire road section or subsection. It is computed by dividing the total travel time of all vehicles during the simulation period by the total number of vehicles traveling the entire road section or subsection.

4.3.5 Traffic Delay

The traffic delay is the difference between the average measured travel time (in the simulation results) and the average time for a random sample of vehicles to travel the simulated highway unimpeded, i.e., zero other traffic. In a large sample, this difference would normally be a positive number that represents delay and can be attributed to traffic interactions on the simulated highway. In the small samples for trucks and RVs, the influences of small number atypical desired speeds can sometimes cause the traffic delay to be a negative number. Negative values for traffic delay can be taken as in indicator that the sample size is too small to be meaningful.

4.3.6 Geometric Delay

The geometric delay is the difference between the travel time for a random sample of vehicles on the actual alignment with zero other traffic and the ideal travel time on an empty straight level road. This measure represents the average delay to a vehicle when it travels along the specified alignment rather than on ideal (straight and level) alignment.

4.3.7 Total Delay

The total delay is the algebraic sum of geometric and traffic delays. It is also the difference between the measured travel time and the ideal travel time.

4.3.8 Number of Passes

Number of passes is the total number of times vehicles overtake other vehicles during the simulation time. On normal two-lane sections (i.e., sections without auxiliary lanes) TWOPAS records a pass whenever a vehicle moves from state 5 (passing) to a free moving or following state in the normal lane. In sections with an auxiliary lane TWOPAS records a pass each time a vehicle moves ahead of another.

4.3.9 Vehicle km or miles Traveled

Vehicle km/mile traveled is the total vehicle-distance traveled in the section for entire simulation.

4.3.10 Total Travel Time

Total travel time is the total time in hours that all vehicles spent traveling in the section during the simulation time.

4.4 Station Summary Data

Figure 7, *TAM Station Summary Output Table* illustrates the station summary output table. This table reports spot traffic operational data collected by the simulation at each data collection station. These data are analogous to data that would be collected by a traffic data recorder placed at the specified location on the highway during the simulation time. The data include hourly traffic volume; measured mean speed of cars, trucks, and recreational vehicles; mean and standard deviation speed for all vehicles combined; percent of vehicles following at a headway of less than 3 sec; the average platoon size; and number of passes. A separate table is produced for each direction of travel. The data in the station summary data tables are used to create graphs.

Station Summary (direction of increasing stations)

Station Number	Station	Number of Lanes	Traffic Volume (v/hr)	Simulation Speed Characteristic Mean				Percent Following (%)	Platoon Size	Number of Passes
				CARS	TRUCKS	RVs	ALL			
1	100.000	1	305	85	0	0	85	41.00	3.0	0
2	200.000	1	306	87	0	0	87	40.80	3.0	0
3	300.000	1	305	87	0	0	87	40.70	3.0	0
4	400.000	1	305	90	0	0	90	41.00	3.0	0
5	500.000	1	305	93	0	0	93	42.00	3.0	0
6	600.000	1	305	90	0	0	90	42.30	3.0	0
7	700.000	1	305	87	0	0	87	42.60	3.0	0
8	800.000	1	305	85	0	0	85	42.60	3.0	0

Figure 7 TAM Station Summary Output Table

4.4.1 Station Number

Station number is the number associated with the station starting with 1 for the first station in the direction of travel being reported.

4.4.2 Station

Station is the location along the road (in meters, feet, miles or kilometers) where the data were collected.

4.4.3 Number of Lanes

Number of lanes is the number of lanes at the station for the direction of travel.

4.4.4 Traffic Volume (v/hr)

Traffic volume is the actual volume of the vehicles on a per-hour basis passing the station during the simulation. It is computed by multiplying the number of vehicles passing the station by 60 and divided by the simulation time in minutes.

4.4.5 Simulation Speed Characteristics Mean

Simulation speed characteristics include the average operating speed measured for cars, trucks and buses, recreational vehicles, and all vehicles combined passing the data collection station.

4.4.6 Percent Following (%)

Percent following is the percentage of vehicles that are in an impeded state while passing this station.

4.4.7 Platoon Size

Platoon size is the average number of the vehicles in the platoons passing this station. It is the sum of platoon leaders and followers divided by the total number of platoon leaders. Platoon leaders are vehicles with time headways greater than 3.0 sec and one or more followers. A follower is a vehicle with time headway at the station of 3.0 sec or less. Platoon size includes both the platoon leader and the followers. The platoon size does not include free vehicles.

4.4.8 Number of Passes

Number of passes reported for a given station is the number of passes between that station and the next data collection station. Therefore the reported number of passes for the last station in each direction will always be equal to zero.

4.5 Graphs

The user can select from a series of graphs to display in the analysis report. The graphs may illustrate highway elements as well as operational performance measures.

- Intersection Series: Shows intersections lines along the highway
- Vertical Curvature Series: Shows K values for vertical curves
- Vertical Elevation Series: Shows the elevation along the highway
- Horizontal Radius Series: Shows radii of horizontal curves as well as the curvature direction
- Horizontal Degree of Curve Series: Shows degrees of curves as well as the curvature direction
- Flow Series: Shows traffic flow rate along the highway
- Following Series: Shows percent of vehicle following at various stations along the highway
- Speed Series: Shows average speed of the vehicles along the highway. Speeds may be displayed for cars, trucks, recreational vehicles and all vehicles combined.

Figure 8, *Traffic Analysis Summary Graph* illustrates a traffic analysis summary graph. This graph includes plots of elevation, degree of curve, percent following, flow rate, and mean speed.

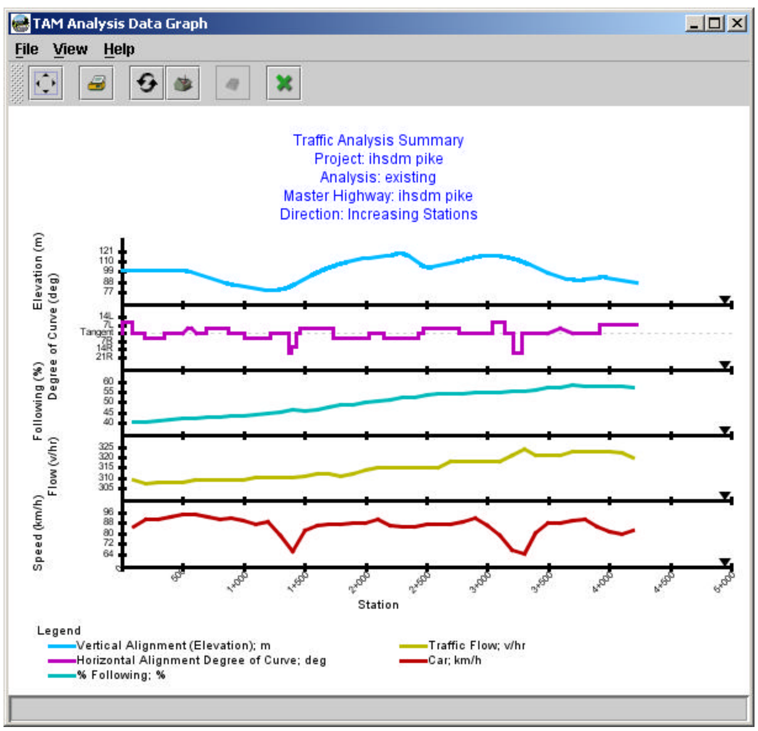

Figure 8 Traffic Analysis Summary Graph

5. TAM Configuration File

5.1 Overview

The TAM configuration file contains TWOPAS input variables not normally changed by the user. The TAM configuration data set is accessed by launching the IHSDM System Administration Tool and clicking on the TAM tab. A list of saved TAM configuration files is displayed. To modify the values and create a new configuration file, users must clone an existing data set, rename it, then select the renamed configuration file to open and edit values. After modify the file, pressing the SAVE button at the bottom of the input screen will save all edits to the configuration values. The five types of data that can be set in the configuration file are described in the following sections.

5.2 Scalars

The scalar screen, illustrated in Figure 9, *Scalars Screen of TAM Configuration Data Window* allows input of vehicle and driver characteristics that apply to all vehicle or driver types.

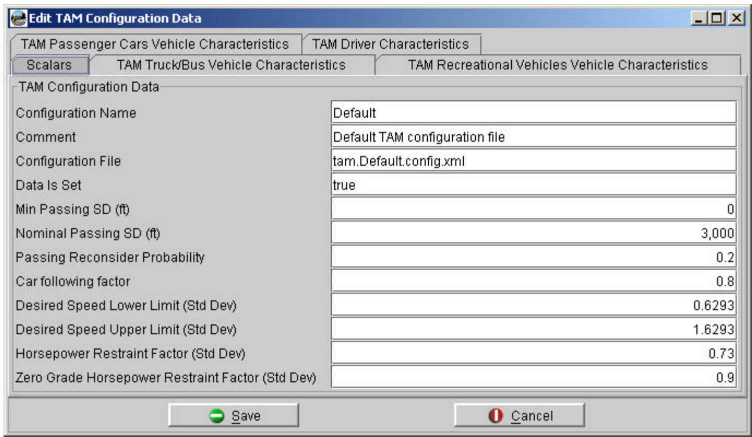

Figure 9 Scalars Screen of TAM Configuration Data Window

The variables on the scalars screen include the following:

Min Passing SD (ft) is the minimum sight distance to use in creating sight distance regions. If the calculated passing sight distance is less than the specified minimum passing sight distance, the specified minimum will be used to create the sight distance region.

Nominal Passing SD (ft) is the maximum sight distance beyond which passing decisions will not be affected and sets the upper limit to be used in creating sight distance regions. Once the sight distance algorithm determines the available passing sight distance at a point is equal or greater than the nominal passing SD, it stops analyzing sight distance at that point, sets the available sight distance to the nominal passing SD, and then proceeds to analyze the next point along the road.

Passing Reconsider Probability is the probability that simulation driver will reconsider starting a pass during one review period; the value 0.2 has been used with 1-sec review periods, indicating impeded drivers will reconsider passing opportunities at stochastically determined intervals of once every 5 sec on average. (Note: drivers are always motivated to consider a pass when they enter a passing zone or when they clear an opposing vehicle.)

Car following factor is a proportionality constant used in calibrating the car following model.

Desired Speed Lower Bound (Std Dev) is the lower limit of desired speed of passenger cars for sample used in calculating operating speed; the value is in standard deviations from the unbiased mean. The operating speed is estimated from the average overall travel speed of a sample of the fastest passenger cars (vehicle type 12 and 13) with a normal desired speed in the range indicated by the lower and upper bound.

Desired Speed Upper Bound (Std Dev) is the upper limit of desired speed for sample of passenger cars used in calculating operating speed; value is in standard deviations from the unbiased mean. The centroid (not the center) of the default operating speed range is at the 85th percentile speed. Therefore, the operating speed is calculated as the arithmetic mean of overall speeds for high performance cars that attempted to travel with desired speeds within this range.

Horsepower Restraint Factor (Std Dev) is a factor to be used on maximum acceleration to account for the horsepower restraint; the value used should be 0.73 for 70% power or 0.81 for 80% power; a blank field will cause the default value of 1.0 for 100% power to be used.

Zero Grade Horsepower Restraint Factor (Std Dev) is a factor to be used on maximum, zero-grade speed to account for horsepower restraint; the value used should be 0.90 for 70% power; a blank field will cause the default value of 1.0 to be used; the fractional power restraint is applied to passenger cars and recreational vehicles. (Note: Field data collected on sustained grades do indicate that restraint is used when high power is required for long time periods.)

5.3 Vehicle Characteristics

There are thirteen vehicle types in the TAM - four types of trucks and buses; four types of recreational vehicles such as campers, motor homes, and passenger vehicles pulling boats; and five types of passenger cars. It is recommended that vehicles be coded so that in order of performance, with the lowest performance vehicle as type 1, and the highest performance as type 13. Figure 10, *TAM Truck/Bus Vehicle Characteristics Screen of the TAM Configuration Data Window* shows the TAM Truck/Bus Vehicle Characteristics screen.

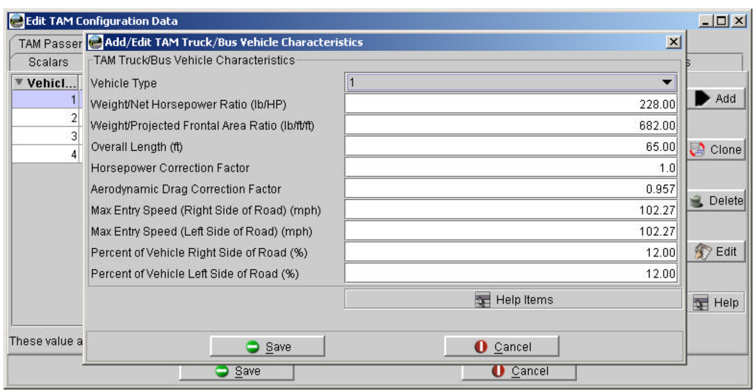

Figure 10 TAM Truck/Bus Vehicle Characteristics Screen of the TAM Configuration Data Window

5.3.1 Trucks and Buses

Vehicle characteristics for trucks (types 1-4) include the coefficients calculated by the simulation program that will be used to represent the acceleration capabilities of vehicles, as well as length, and the weight - to-power and weight -to-frontal-area ratios used by program logic to compute performance coefficients. The maximum speed shown on the printed output is for zero grade and zero wind. The characteristics include:

Weight/Net Horsepower Ratio (lb/HP) is the gross weight of the truck or tractor and trailer combination divided by the net horsepower at sea level conditions.

Weight/Projected Frontal Area Ratio (lb/ft^2) is the gross weight of the truck or tractor and trailer combination divided by the frontal area.

Overall Length is the length of the truck or bus including tractor and trailer.

Horsepower Correction Factor (CPE) is a factor for correcting horsepower to local elevation for given truck type (normally set to 1.0); CPE = 1 - 0.00004*Elevation (in feet) for gasoline engines. Table 10., *Horsepower Correction Factors and Aerodynamic Drag Correction Factors for a Range of Elevations* provides values for a range of elevations.

Aerodynamic Drag Correction Factor (CDE) is factor for correcting aerodynamic drag to local elevation (normally 0.957); CDE = $(1.0 - 0.000006887*\text{Elevation})^{4.255}$ where elevation is in feet. Table 10., *Horsepower Correction Factors and Aerodynamic Drag Correction Factors for a Range of Elevations* provides values for a range of elevations.

Table 10. Horsepower Correction Factors and Aerodynamic Drag Correction Factors for a Range of Elevations

Elevation(ft)	Horsepower Correction Factor	Aerodynamic Drag Correction Factor	Elevation(m)
0	1	1	0
1000	0.96	0.97	300
2000	0.92	0.94	600
3000	0.88	0.91	900
4000	0.84	0.89	1200
5000	0.80	0.86	1500
6000	0.76	0.84	1800
7000	0.72	0.81	2100
8000	0.68	0.79	2400
9000	0.64	0.76	2700
10000	0.60	0.74	3000
11000	0.56	0.72	3300
12000	0.52	0.69	3600

Maximum Entry Speed is the maximum speed that the vehicle type can enter the road. It is specified by direction for each truck type. The default values assume a relatively level terrain so maximum entry speeds could be relatively high. Where the road section begins or ends on steeper grades, lower maximum entry speeds could be used to limit the initial speed for vehicle categories such as trucks and recreational vehicles.

Percent of Vehicles is the percentage of a given truck type expressed as a percentage of all trucks.

5.3.2 Passenger Cars and Recreational Vehicles

Figure 11, *TAM Add/Edit Recreational Vehicles/Passenger Cars Vehicles Characteristics Screen* shows the eight different characteristics that can be specified for cars and RVs.

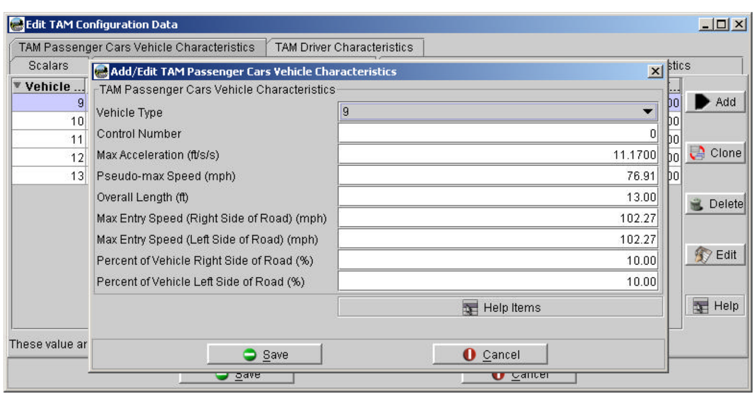

Figure 11 TAM Add/Edit Recreational Vehicles/Passenger Cars Vehicles Characteristics Screen

The characteristics are:

- Control number is an indicator of which vehicle types other than trucks will use crawl speeds on downgrade crawl regions and will deter multiple passing. A control number set greater than zero indicates that vehicle type and all lower numbered vehicle types will respond to crawl regions. If the control number is blank for all recreational vehicles and passenger cars, then only trucks and buses will respond to downgrade crawl zones and influence multiple passes.

- Maximum acceleration is the maximum acceleration capability (ft/sec^2) at zero speed on zero grade using maximum available horsepower for given vehicle type.
- Pseudo-Maximum speed is a speed that can be sustained on zero grade using maximum available power (without restraint) for given vehicle type. It is less than the maximum attainable speed.
- Overall length is the length of the vehicle type.
- Percent of vehicles is the percentage of a given car type expressed as a percentage of all cars and percentage of a given RV type as a percentage of all RVs.

A.4 Driver Characteristics

There are 10 driver types in TAM. The driver characteristic input screen, illustrated in Figure 12, *TAM Driver Characteristics Screen* , is used to define the risk-taking characteristics of each of the 10 driver types. The stochastic driver type factor is multiplicative parameter from a stochastic distribution of time headways used in car following. The default values of these parameters range from 0.43 sec (aggressive driver) to 2.12 sec (timid driver).

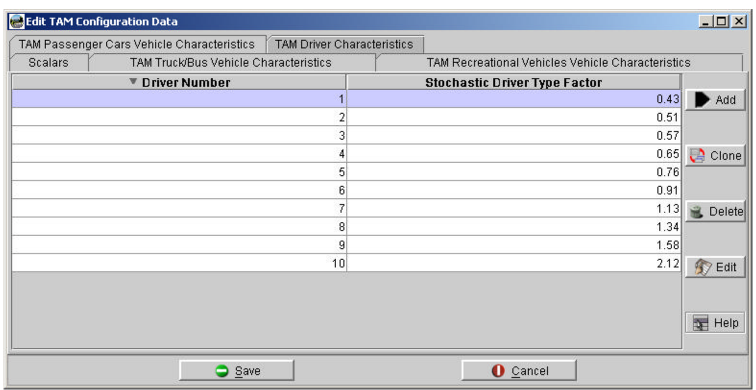

Figure 12 TAM Driver Characteristics Screen

6. IHSDM Documentation

IHSDM documentation is organized in a series of manuals oriented to specific user types and information needs. User types include first-time users, regular users, and system administrators. Information needs include: installing and configuring IHSDM, the mechanics of using the various features of the software, engineering insights to ensure appropriate use of the software and interpretation of outputs, and administering and maintaining the software installation.

The structure of the series of manuals is illustrated in the User Documentation Map. The manuals are listed and described below by the users and information needs they support:

- Manuals for First-Time Users: These manuals are oriented to assist new users in installing and configuring IHSDM and running it for the first time. Manuals include:
  - Getting Started Guide - An overview of the installation and use of IHSDM. This Guide should be sufficient for stand-alone installations. For client-server installations, the more detailed IHSDM Installation Manual will be needed.

  - Installation Manual - A detailed reference to the installation and configuration of IHSDM.
  - Running IHSDM Software Manual - An overview of the basic operations in running the IHSDM software. The intent is to provide new users the information they need to run IHSDM for the first time.
- User’s Manuals: These Manuals are intended as references that regular users can consult when issues arise about the mechanics of using the IHSDM graphical user interface. Manuals include:
  - IHSDM User’s Manual - A reference for using the primary IHSDM graphical user interface. Other User’s Manuals provide additional details on specific components of the IHSDM graphical user interface:
    - Policy Review Module (PRM) User’s Manual - A reference for using the (stand-alone) Policy Review Module software graphical user interface.
    - Crash Prediction Module (CPM) User’s Manual - A reference for using the (stand-alone) Crash Prediction Module software graphical user interface.
    - Design Consistency Module (DCM) User’s Manual - A reference for using the (stand-alone) Design Consistency Module software graphical user interface.
    - Intersection Review Module (IRM) User’s Manual - A reference for using the (stand-alone) Intersection Review Module software graphical user interface.
    - Traffic Analysis Module (TAM) User’s Manual - A reference for using the (stand-alone) Traffic Analysis Module software graphical user interface.
    - Using the IHSDM Graphical User Interface - A reference for the operation of the individual components of the graphical user interface.
    - User Properties and Defaults Manual - A reference for editing IHSDM system properties, user properties, and user default values.
  - Frequently Asked Questions - A list of frequently asked questions related to the IHSDM software.
  - IHSDM Troubleshooting Guide - A reference for troubleshooting IHSDM software problems.
- Documentation of IHSDM Data: These documents provide detailed descriptions of all IHSDM data elements and references for importing and editing data.
  - IHSDM Highway Model - A reference for the IHSDM highway model, including descriptions of the data elements comprising the model.
  - LandXML Support - A reference for IHSDM support for the LandXML data standard.
  - Editing Highway Elements - A reference for using the Edit/View Highway Elements graphical user interface.
  - GEOPAK-TO-IHSDM Application Programmer’s Interface (API) User’s Manual - A reference for using the Application Program Interface (API) to export data from GEOPAK into a format that IHSDM can import.
- Engineer’s Manual: The intent of these Manuals is to provide the engineering information necessary to make appropriate use of IHSDM evaluation capabilities and interpretation of results. Manuals include:

- Policy Review Module (PRM) Engineer's Manual - A reference for the engineering issues of using the Policy Review Module.
- Crash Prediction Module (CPM) Engineer's Manual - A reference for the engineering issues of using the Crash Prediction Module.
- Design Consistency Module (DCM) Engineer's Manual - A reference for the engineering issues of using the Design Consistency Module.
- Intersection Review Module (IRM) Engineer's Manual - A reference for the engineering issues of using the Intersection Review Module.
  - **Intersection Policy Review Sub-Manual** - Describes the procedures for checking an intersection design element against relevant policy, including references to the section of the AASHTO policy that contains the information used to develop the module and check the design. **(The Intersection Policy Review Sub-Manual is not available in the current release of IHSDM.)**
  - Intersection Diagnostic Review Engineer's Sub-manual - Describes in detail the concerns that the diagnostic review component considers and the models used to evaluate those concerns.
- Traffic Analysis Module (TAM) Engineer's Manual - A reference for the engineering issues of using the Traffic Analysis Module.

• Manuals for System Administrators: These Manuals provide system administrators the information they need to maintain IHSDM installations.

- System Administrator's Manual - A reference for using the IHSDM Administration Tool software graphical user interface. This manual also discusses customizing variable components of IHSDM, including analysis report templates, data dictionaries, and policy files.
- PRM/IRM Policy Table Maintenance - A reference for editing design policy tables used in the Policy Review Module and Intersection Review Module.

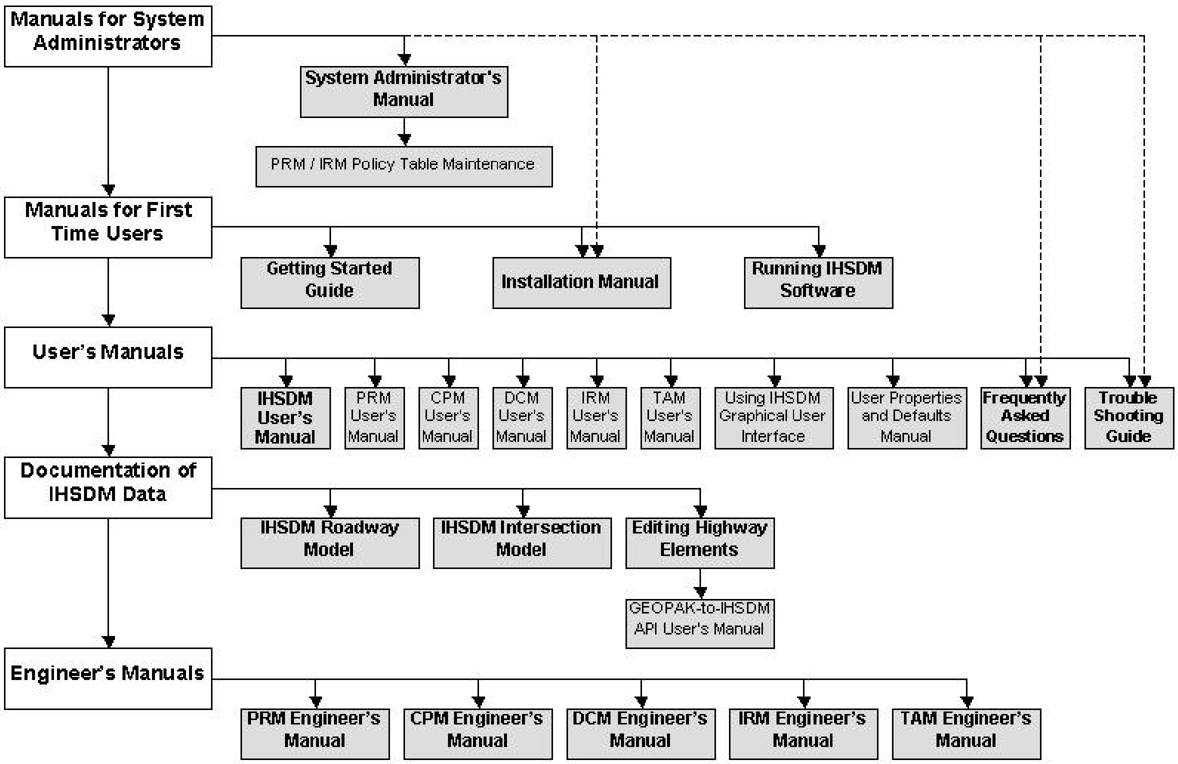

Figure 13 User Documentation Map

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